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DRODZY CZYTELNICY

Zbliża się lato, urlopy i nadzieja na lepsze jutro. Wydajemy pięćdziesiąty szósty numer „Postępów Techniki Przetwórstwa Spożywczego". Rozpoczęliśmy dwudziesty dziewiąty rok działalności na rynku naukowych wydawnictw periodycznych. Publikujemy jedynie recenzowane, oryginalne artykuły naukowo – badawcze, badawczo – rozwojowe i analityczno – przeglądowe, promujące postęp w technice przetwórstwa spożywczego. Dotychczas opublikowaliśmy ponad 1100 artykułów. Każdy z nich posiada dwie recenzje, w większości uzyskane od specjalistów zagranicznych.

W bieżącym numerze zamieszczamy 26 artykułów.

Trudno jest omówić wszystkie z nich, choć są interesujące, dlatego sygnalizuję tylko niektóre.

Zależność pomiędzy warunkami przechowywania biszkoptów i rodzajem dodanego środka spulchniającego a ich właściwościami sensorycznymi, udowodnili pracownicy Uniwersytetu Technologiczno-Humanistycznego w Radomiu.

Badania przeprowadzone na Politechnice Opolskiej potwierdziły, że sposób rozdrobnienia miękiszu ziemniaka wpływa w sposób istotny na jakość gotowych placków ziemniaczanych, a przez to na ich akceptowalność sensoryczną.

W ramach wspierania działań na rzecz ochrony środowiska Profesor Instytutu Inżynierii Mechanicznej SGGW we współpracy z naukowcami z zagranicy zaproponowali metodę matematycznego modelowania kształtu na użytek projektowania naczyń biodegradowalnych /talerze, kubki, półmiski/.

Z badań rynku spożywczego przeprowadzonych przez pracowników SGGW we współpracy międzynarodowej, dotyczących analizy produktów bez laktozowych w wybranych sklepach stacjonarnych i internetowych na terenie Polski wynika, że większą dostępnością tych produktów cechowały się sklepy internetowe, niemniej ten asortyment w sklepach stacjonarnych ciągle wzrasta. Szczegóły w artykule.

Zastosowanie koncentratów soków owocowych lub warzywnych do osmotycznego odwadniania jabłek umożliwia wytworzenie produktów atrakcyjnych pod względem cech sensorycznych i pozwala kształtować barwę, smak, teksturę oraz zwiększa zawartość naturalnych składników w suszach — twierdzą pracownicy SGGW w Warszawie.

Sałatki z pomidorów jedzmy bez dodatku świeżego ogórka, ponieważ zawiera on enzym askorbinazę, który rozkłada witaminę C — informują Zespoły pracowników naukowych Państwowej Wyższej Szkoły Informatyki i Przedsiębiorczości w Łomży oraz SGGW w Warszawie.

Im niższy typ mąki, tym naleśniki są delikatniejsze i smaczniejsze. Mąki te zawierają więcej glutenu, który wpływa na lepkość i smakowitość a dodatkowo spulchnia ciasto. Potwierdzają to prace badawcze naukowców z Politechniki Opolskiej.

Niedokrwistość, osteoporoza, zaburzenia psychiczne, problemy z zajściem w ciążę, ryzyko nowotworów przewodu pokarmowego — do tych poważnych problemów zdrowotnych może dojść w przypadku nie przestrzegania diety bezglutenowej przez ludzi z nietolerancją glutenu. Potwierdza to analiza dostępnej literatury przez naukowców SGGW w Warszawie.

Pracownicy Katedry Dietetyki Instytutu Nauk o Żywieniu Człowieka SGGW w Warszawie zebrali aktualną wiedzę na temat wpływu składników zawartych w rybach na działanie tarczycy i wydzielanie przez nią hormonów oraz na przebieg procesu zapalnego w gruczole.

Panowie jedzcie owoce, warzywa i orzechy! - apelują naukowcy zatrudnieni w Pracowni Dietetyki SGGW. Zawarte w nich składniki wspomagają funkcje rozrodcze mężczyzn.

Dziękuję Autorom krajowym i zagranicznym, Recenzentom, Członkom Rady Redakcyjno — Programowej oraz Zespołowi Redakcyjnemu i zachęcam zarówno Ich, jak też nowych Autorów i Recenzentów do współpracy z naszym Czasopismem.

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STUDYING MOISTURE CONTENT OF SPONGE CAKE PRODUCTS STORED IN VARIOUS CONDITIONS, CONTAINING DIFFERENT LEAVENING AGENT®

Badanie zawartości wody w ciastach biszkoptowych przechowywanych w zmiennych warunkach, zawierających różny środek spulchniający®

The aim of the study was to evaluate sponge cakes containing various leavening agents. *Sponge cakes with the addition of sodium bicarbonate and ammonium bicarbonate as a leavening agent and without leavening agent have been subjected to a moisture test. Determinants at work were variable ambient conditions, storage time, and the type of packaging in which the cakes were stored. Moisture determination was carried out using a standardized method, and then the method of testing moisture in cakes using a moisture analyzer was validated against this method. The work also carried out sensory evaluation of cakes made. A relationship was found between the conditions for storage of sponge cakes and the type of leavening agent. Given the storage conditions of cakes, biscuits stored in refrigeration conditions were characterized by a higher water content compared to biscuits stored in room conditions. Considering the type of packaging, it was found that the biscuits stored in breakfast paper had the lowest water content (cooling and room conditions). Among sponge cakes stored in aluminum foil, the lowest water content was found in cakes with the addition of sodium bicarbonate. Among the biscuits stored in food film, the lowest water content was found for biscuits without a leavening agent (day 8 and 10) and cakes with sodium bicarbonate (day 15 and 22). Generally, according to respondents, sponge cake with ammonium bicarbonate stored in room conditions in aluminum foil showed the best sensory properties on the 8th and 15th day of storage.*

Key words: sponge cakes, water content, leavening agent, moisture analyzer.

Celem artykułu jest przedstawienie uzyskanych wyników badań dotyczących oceny ciast biszkoptowych zawierających różny środek spulchniający. *Ciasta biszkoptowe z dodatkiem wodorowęglanu sodu i wodorowęglanu amonu jako środka spulchniającego oraz bez dodatku środka spulchniającego zostały poddane badaniu na zawartość wilgoci. Determinantami w pracy były zmienne warunki otoczenia, czas przechowywania oraz rodzaj opakowania w jakim ciasta były przechowywane. Oznaczenie wilgoci przeprowadzono metodą znormalizowaną a następnie względem tej metody zwalidowano metodę badania wilgoci w ciastach, wykorzystującą wagosuszarkę. W pracy przeprowadzono również ocenę sensoryczną wytworzonych ciast. Stwierdzono zależność pomiędzy warunkami przechowywania biszkoptów, a rodzajem środka spulchniającego. Biorąc po uwagę warunki przechowywania ciast, biszkopty przechowywane w warunkach chłodniczych charakteryzowały się większą zawartością wody w porównaniu z biszkoptami przechowywanymi w warunkach pokojowych. Biorąc pod uwagę rodzaj opakowania stwierdzono, że biszkopty przechowywane w papierze śniadaniowym charakteryzowały się najniższą zawartością wody (warunki chłodnicze i pokojowe). Wśród ciast biszkoptowych przechowywanych w folii aluminiowej najniższą zawartością wody charakteryzowały się ciasta z dodatkiem wodorowęglanu sodu. Wśród biszkoptów przechowywanych w folii spożywczej najniższą zawartość wody wykazały biszkopty bez środka spulchniającego (8 i 10 dzień oznaczenia) oraz ciasta z wodorowęglanem sodu (15 i 22 dzień oznaczenia). Generalnie w opinii respondentów ciasto biszkoptowe z wodorowęglanem amonu przechowywane w warunkach pokojowych w foli aluminiowej wykazywało najlepsze właściwości sensoryczne w 8,10 i 15 dniu przechowywania.*

Słowa kluczowe: ciasta biszkoptowe, zawartość wody, środek spulchniający, wagosuszarka.

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INTRODUCTION

Water is present in practically every food product. The water content has significant importance for a number of reasons. Determination of water content is the most common general analysis carried out on foodstuffs and sponge cakes in them [9]. The water content and water activity correlated with it affect the texture of the cakes, i.e. their crispness, brittleness and plasticity. In cakes with a water content higher than the relative humidity corresponding to the capacity of the monomolecular layer, there are many adverse changes leading to loss of quality. There may be a feeling of loss of tenderness, hardening, foreign taste and smell, as well as microbial growth may occur [13]. Many components are used in the production of cakes such as flour, water, sugar, milk, salt, leavening agent, flavors, additives and other food are allowed in the specifications. The quality and quantity of these components are important and influence on the properties of the final product as well as the stability of quality during shelf life [1]. The quality of biscuits is significantly affected by its ingredients, production parameters and storage conditions. Sponge cakes owe their typical texture and structure to their high egg content, absence of fat and a combination of three main methods during production: the use of chemical raising agents at the stage of formulation, whipping or steam injection during mixing, and thermal expansion during baking [2, 3].

The goal of sponge cake producers is to obtain products with porosity, volume, appearance and composition satisfying consumers. Nowadays, the consumer interest in durable products that are visually attractive is clearly visible [8, 4]. At the same time, the storage method and the type of packaging are not insignificant in this respect.

However it is important to know that cakes stored at increased relative humidities can lost a negligible amount of moisture but continued to increase in firmness and adhesiveness [14].

In general, the texture of sponge cakes is of great importance for both consumers and producers, because it greatly affects our eating habits, shapes our preferences and is an indicator of freshness. Obtaining the desired texture and at the same time maintaining it for a specific period of time requires, among others, the use of suitable substances, e.g. leavening agents, followed by the use of appropriate storage methods and conditions. Taking the above into consideration in the presented work, research was undertaken that allowed to obtain information by answering the cited issues [7].

The aim of the study was to assess the effect of leavening agents on the quality of sponge cakes stored in different conditions.

MATERIAL AND METHODS

Material

Sponge cakes with the addition of sodium bicarbonate and ammonium bicarbonate as a leavening agent and without the addition of a leavening agent were prepared according to the cold method as follows: the yolks were separated from the proteins; the foam with the addition of sugar was whipped with a mixer (ZELMER Robi Mix ", type 381.6) operating in the highest speed range; to the whipped foam, yolks and wheat flour are alternately added mixed with a leavening agent and aerated by sieving it into the mass; the dough was gently mixed with a wooden spoon and laid out into a 40x25 cm mold. The dough was baked in the laboratory in an oven (BOSCH "HBA 43T350) at 180°C for 13 minutes with the hot air function on. After removing from the oven, the sponge cake was allowed to cool at room temperature.

The cooled sponge cakes, after cutting lengthwise (in half), were wrapped in three different packaging materials (aluminum foil, food foil, breakfast paper). The cakes were stored in various conditions, i.e. in the fridge-freezer (POLAR "type CZ250 version 3007), in which the following conditions were present: temperature 5.30°C, relative humidity 55% and in ambient conditions at 21.10°C and relative humidity 35,8% (Table 1). The research material consisted of sponge cakes baked based on our own recipe. The composition of the recipe was as follows: 5 chicken eggs from own breeding; 150 g white sugar (Polski Cukier – Krajowa Spółka Cukrowa S.A.); 150 g wheat flour (Queen of Cuisine type 390, PZZ Kraków); leavening agent: sodium bicarbonate about 5g (PHU "MARSYL" s.c.) or ammonium bicarbonate about 3g (APETTITA – home secrets, "COLIAN" sp.z o.o.).

Table 1. Types of sponge cake and codes assigned to them

Tabela 1. Rodzaje ciasta biszkoptowego i przypisane im kody

Cake types / Sample code	
Storage Conditions	
Room temperature*	Refrigerator conditions*
Sponge cake without the leavening agent	
C1FA	C2FA
C1FS	C2FS
C1PS	C2PS
Sponge cake with the addition of ammonium bicarbonate	
C1FAA	C2FAA
C1FSA	C2FSA
C1PSA	C2PSA
Sponge cake with the addition of sodium bicarbonate	
C1FAS	C2FAS
C1FSS	C2FSS
C1PSS	C2PSS

Legend: FA, FAA, FAS – aluminum foil;
FS, FSA, FSS – food wrap;
PS, PSA, PSS – breakfast paper
* conditions in which the sponge cake was stored

Legenda: FA, FAA, FAS – folia aluminiowa;
FS, FSA, FSS – folia spożywcza;
PS, PSA, PSS – papier śniadaniowy
* warunki w jakich ciasto było przechowywane

Source: Own study

Źródło: Opracowanie własne

Methods

A cyclical organoleptic assessment and cyclical examination of the water content of stored cakes were carried out.

Organoleptic assessment

Sponge cakes were subjected to an organoleptic assessment made by a group of people who are students of the third semester of Master's studies in Commodity Science at the University of Technology and Humanities. Kazimierz Pulawski in Radom. After baking and cooling the sponge cakes they were subjected to visual assessment (without the help of other senses such as smell or touch). From among the three samples presented, the respondents chose the one that best suited their visual impressions. Then, cakes containing a different leavening agent and sponge cake not containing this agent were subjected to organoleptic assessment. Respondents evaluated the following parameters: porosity, color, smell, texture, elasticity, taste, fragility, solubility in the mouth. The assessment was made on a numerical scale from 1 to 5. The assessment was carried out after baking, 48 hours after baking on 3, 8, 10, 15 and 22 days of storage of sponge cakes at ambient temperature and in the fridge in three different packages.

Determination of water content

Technical method (130oC/1h)

The water content in all types of sponge cakes was tested using the technical method. The test was carried out after baking and cooling the sponge cake. Determination of water content was carried out as follows: weighing of vessels; measuring approx. 5 g of sample (each type of dough, three samples); inserting the vessels with the sample into the laboratory balance (AS 220 R.2 checked with mass standards No. K-1493/18 having calibration certificate No. 1755/608/18) (vessels without cover); drying the samples at 130°C for 1 hour; cooling the samples in a desiccator (covered vessels); weighing the dishes, together with the sample and lid. The water content is the average value obtained from three measurements and calculated according to the formula:

$$x = \frac{(b - c) \cdot 100}{b - a} \quad (1)$$

where:

- cell mass [g]
- cell mass with the sample before drying [g]
- cell mass with the sample after drying [g].

Standardized method [11]

The examination was carried out on the 3rd day of storage of the sponge cake. Samples stored under refrigeration conditions in aluminum foil were taken for determination. Determination of the water content was carried out in the same way as in the technical method (weighing of vessels, measuring the sample, drying, cooling the samples, weighing the vessels with the sample). The exceptions were a drying temperature of 105°C and a drying time of 3 hours.

Moisture dryer method

The test consisted of crushing the biscuit in a coffee grinder, measuring off approx. 3 g of the sample and drying in a MAX500 moisture analyzer (RADWAG), checking the correct temperature indications of the device using control thermometer No. 0811/13 having calibration certificate No. 6/2014. The analysis temperature was 90°C, the end of the analysis was set at automatic point 2 meaning product stability of 1 mg/25 seconds. The results of the determinations were the average value of three water content measurements calculated according to the formula:

$$x = \frac{W_1 + W_2 + W_3}{3} \ \% \quad (2)$$

where: W1, W2, W3 – water content determined in individual measurements.

The test duration lasted on average about 10 minutes. Measurements of the water content in the sponge cake by means of the moisture analyzer method were carried out on 3, 8, 10, 15, 15 and 22 days of storage of the biscuits at ambient temperature and in the fridge. The products were stored in three different packages.

Preparation of the sample for the determination of watercontent

A sample was taken from each type of sponge cake stored in different conditions and packages immediately before the measurement. Each sample was taken as follows: cutting a sample about 2 cm wide from the stored sponge cake; fragmentation of the sample (entirely without division into crumb and „crust") in a coffee grinder type RK-0145 by OPTIMUM; measuring the appropriate amount (depending on the method of determination) of the test sample.

RESULTS AND DISCUSSION

Determinations for water content in sponge cakes were carried out using the PN 98/A-74252 [11] standard method and, alternatively, a moisture analyzer. The standardized test requires 3 hours of drying the product at 105°C, which is sometimes quite long, especially when the analysis concerns many unit products with a deliberately modified structure stored under ambient conditions and refrigerated conditions.

According to the authors [5, 12], the type of product structure significantly affects water migration. For this reason, the work attempts to determine the water content of sponge cakes using the technical method by which the product is analyzed at 130°C for 1 hour. At the end of the study, the product color changed from light yellow to brown. This indicated the surface combustion of the analyzed product, which in turn suggested that the technical drying method could not be used for sponge cake. Water content of sponge cake was determined according to standardized test PN 98/A-74252 measuring at 105°C and time 3 hours. The result of the water content in the sponge cakes obtained by the standardized method was the starting point (reference) for the optimization of the moisture analyzer method based on infrared radiation.

The method based on infrared radiation according to the authors [6, 15] is less time consuming, which means that it can

be used for quick determination of water content in products with different structures. A moisture analyzer device was used for the above determinations at work. Thanks to the optimized measurement using a moisture analyzer, each subsequent determination of water content was carried out on 3, 8, 10, 15 and 22 days on the storage of sponge cakes at ambient temperature and in the fridge. The authors [10, 16] came to similar conclusions indicating the legitimacy of using the moisture analyzer, indicating at the same time, the short test time, repeatability and reliability of the results. Determination of water content of sponge cakes using a standardized method was carried out on the third day after baking the sponge cake. In each of the three types of dough, the water content was determined above 20%. The smallest differences were noted between a sponge cake without the addition of a leavening agent (28.74%) and a sponge cake with the addition of ammonium bicarbonate (28.09%) (Table 2).

Table 2. Content of water in the sponge cake determined according to PN 98/A-74252

Tabela 2. Zawartość wody w cieście biszkoptowym oznaczona wg PN 98/A-74252

Type of sponge cake	Content of water [%]
Sponge cake without the leavening agent	28.74
Sponge cake with the addition of ammonium bicarbonate	28.09
Sponge cake with the addition of sodium bicarbonate	25.39

Source: Own study

Źródło: Opracowanie własne

Subsequent determinations of water content were carried out on days 8, 10, 15 and 22 of the storage of sponge cakes in various conditions and packaging. Determinations were carried out using a moisture analyzer.

Cakes with the addition of ammonium bicarbonate stored in room conditions were characterized by a lower water content compared to the same biscuits stored in refrigeration conditions. The highest water content each day of the study (from 8 to 22 days) was determined in a sponge cake stored in a food foil in room and refrigerated conditions (C1FSA, C2FSA). Changes in the moisture content of sponge cakes packed in food foil and stored at both room temperature and refrigeration conditions showed comparable decreases in the value of this parameter over the entire storage period, on average about 9%. The lowest water content was found in the cakes stored in breakfast paper in room and refrigeration conditions (C1PSA, C2PSA).

In this product, also the smallest changes in moisture content were recorded especially for sponge stored at room temperature (0.5%). In sponge dough stored at room temperature in aluminum foil (C1FAA) on the 22nd day of the test, the water content was not determined due to the appearance of mold on the product. In the same sponge cake, but stored under refrigeration conditions, the largest differences in the moisture content parameter were noted during the entire storage period (Fig. 1 A).

On the 8th and 22nd day of the test, the cake with the addition of sodium bicarbonate stored in aluminum foil and in food foil under refrigerated conditions (C2FAS, C2FSS) had the highest water content compared to all cakes stored in room and refrigerated conditions. It was also observed that after 8 days of storage of the C2FSS sponge cake, slight changes in moisture content were noted. Similarly, C2FAS, C1FAS and C2PSS cake behaved on day 15 and 22 - no significant changes in moisture content in the dough. A practically unchanged value of the parameter described above was recorded for the C1PSS cake, slightly by 0.3% of the value between the measurement made on the 8th day of storage and the last day of storage (Fig. 1 B).

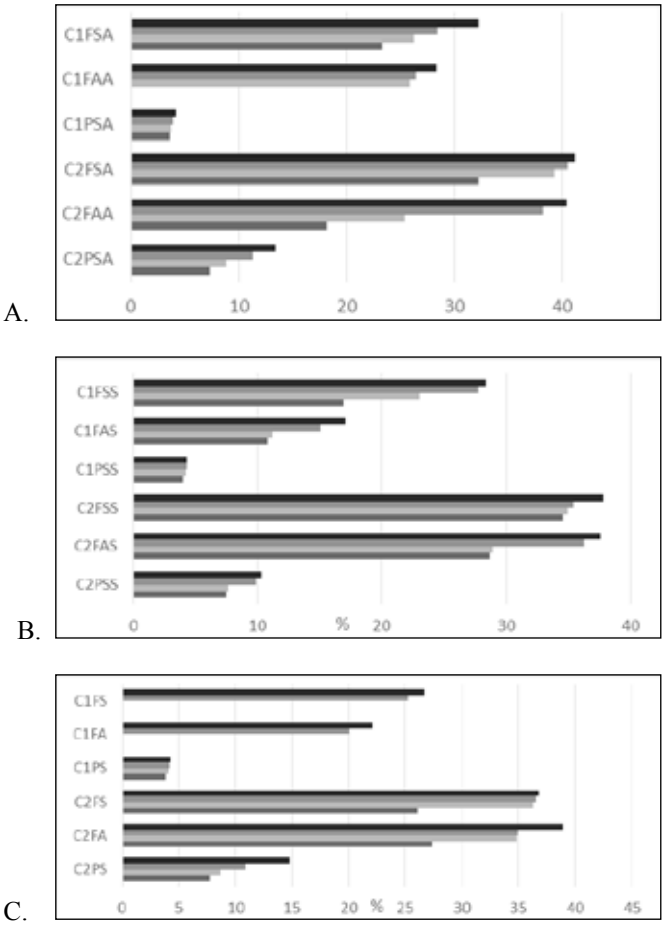

Fig. 1. Average water content in a sponge cake stored in room and cooling conditions [%] (A. sponge cake with the addition of ammonium bicarbonate, B-sponge cake with the addition of sodium bicarbonate; C-sponge cake without the addition of a leavening agent. Legend: (first measurement 8 days after making the dough, next 10, 15, 22 from the top of the picture).

Rys. 1. Średnia zawartość wody w biszkopcie przechowywanym w warunkach pokojowych i chłodniczych [%] (A. biszkopt z dodatkiem wodorowęglanu amonu, B-biszkopt z dodatkiem wodorowęglanu sodu; C-biszkopt bez dodatku środka spulchniającego. Legenda: (pierwszy pomiar 8 dzień od wytworzenia ciasta, kolejne 10, 15, 22 licząc od góry rysunku).

Source: Own study

Źródło: Opracowanie własne

Among sponge cakes without the addition of leavening agent, the highest content of water on the 8th day of storage was characterized by sponge cake stored in refrigerated conditions in aluminum foil (C2FA). In the next days of the study, i.e. the 10th and 15th, the C2FS product had the highest water content. On day 22 of the study, the highest water content was recorded for the C2FA product. In general, the C2FS cake was characterized by a slight variation in water content up to 22 days of refrigerated storage. Similar behavior was observed in C1PS sample stored at room temperature in which only on the last day of measurement a greater change was observed compared to the values obtained on 8, 10 and 15 days of storage.

In the cake stored at room conditions in food and aluminum foil (C1FS, C1FA) on the 15 and 22 day of the test the water content was not determined because mold appeared on the cake.

On the other hand, when comparing the type of cake packaging (breakfast paper), it was observed that the highest water content was characteristic for the product without the addition of leavening agent stored in refrigeration conditions (C2PS) in the first measurement period - on the eighth day after manufacturing the product. On the 22nd day of the test, the water content of cakes stored in refrigerated conditions wrapped in breakfast paper oscillated around 7% regardless of the type of leavening agent used. Sponge cakes stored at room conditions and wrapped in breakfast paper had comparable water content ranging from 3.59 to 4.33 throughout the entire storage period. Cakes prepared on the basis of sodium bicarbonate remained practically unchanged. Figure 2A presents the average water content of sponge cakes stored in breakfast paper for a period of 22 days.

Among sponge cakes stored in aluminum foil, the highest content of water was found in the C2FAA cake on the 8th and 10th day of the study (40.4% and 38.26%, respectively). The lowest water content was recorded on the 8th day of the test in a C1FAS sponge cake (17.09%). The dough stored at room conditions without leavening agent on the 15th and 22nd day of the test was not evaluated due to mold (C1FA) present on the product. Sponge cake with the addition of ammonium bicarbonate on the 22nd day of the test also showed the presence of mold (C1FAA). It was generally found that the dough packed in aluminum foil and stored in room conditions showed lower values of this parameter and smaller decreases during all measurements (Fig. 2B). Definitely, the refrigeration conditions had a larger impact on this parameter. A similar trend was observed for products wrapped in breakfast paper (Fig. 2A). Among the sponge cakes stored in food foil, the cake with the addition of ammonium bicarbonate (C1FSA, C2FSA) was characterized by the highest water content in the case of sponge cakes stored in room and refrigeration conditions. In the cake containing no leavening agent stored at room conditions, mold was observed. Therefore, it was not tested on the 15th and 22nd day of the study (C1FS). The lowest water content was found in the C1FSS sponge cake during the 15th and 22nd day of the determination (23.03%; 16.89%) (Fig. 2C). It was generally found that the C2FSS product was best protected. Changes in moisture content between the first and last measurement were at 3.26% (Fig. 2C). Unsignificant change in the moisture content of the cake, stored under refrigeration was observed for the product without any leavening agent for 15 days of storage (0.48% change). The above information sets that the food foil would be indicated for storing the cake without adding leavening agent for a specified time but not longer than two weeks. Generally, comparing the same cakes (stored at different conditions), higher water content was always recorded for those stored in refrigeration conditions (Fig. 2C).

The largest differences in water content between the first and last day of the test were recorded in the biscuit stored in aluminum foil under refrigeration conditions with the addition of ammonium bicarbonate (C2FAA). This sponge cake lost 22.26% of its water content throughout the entire study period (from 8 to 22 days). The smallest water loss showed cakes stored in breakfast paper under room conditions (C1PS, C1PSS, C1PSA). Among sponge cakes stored in refrigeration

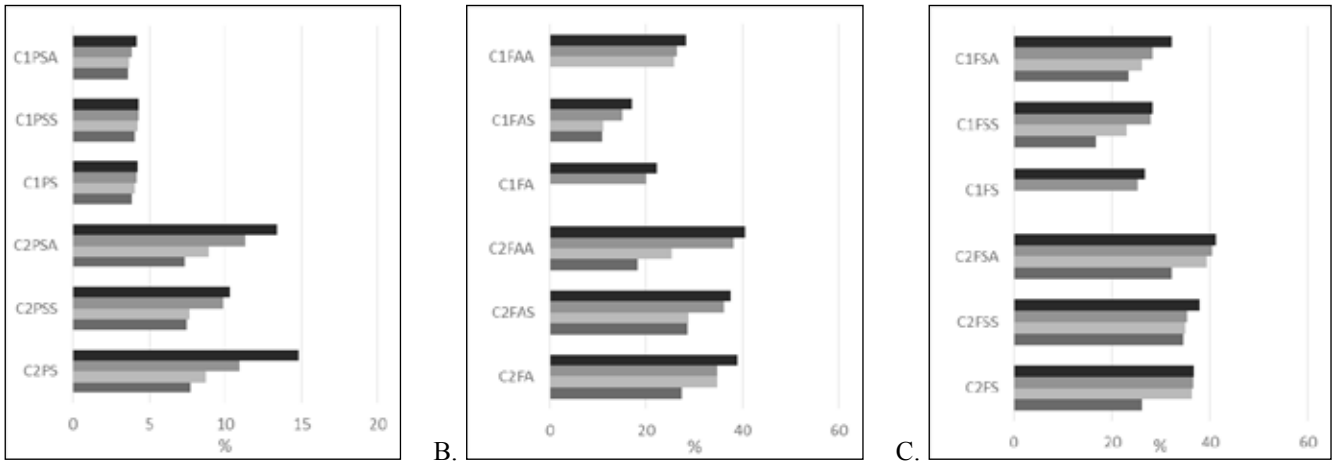

Fig. 2. Average water content in sponge cakes stored in A. breakfast paper, B. aluminum foil, C. food foil. Legend the same as Figure 1.

Rys. 2. Średnia zawartość wody w ciastach biszkoptowych przechowywanych w A. papierze śniadaniowym, B. folii aluminiowej, C. folii spożywczej. Legenda taka sama jak na rysunku 1.

Source: Own study

Źródło: Opracowanie własne

conditions, the smallest water loss showed a product with the addition of sodium bicarbonate (C2PSS) stored in breakfast paper. Considering the type of leavening agent used in cakes stored in refrigerated conditions, the smallest losses of water content were recorded in a product with the addition of sodium bicarbonate, while the largest in cakes without the addition of a leavening agent (C2FS, C2PS). Among the cakes stored at room conditions, the largest loss of water content was observed in the food foil with sodium bicarbonate (C1FSS) (Fig. 3).

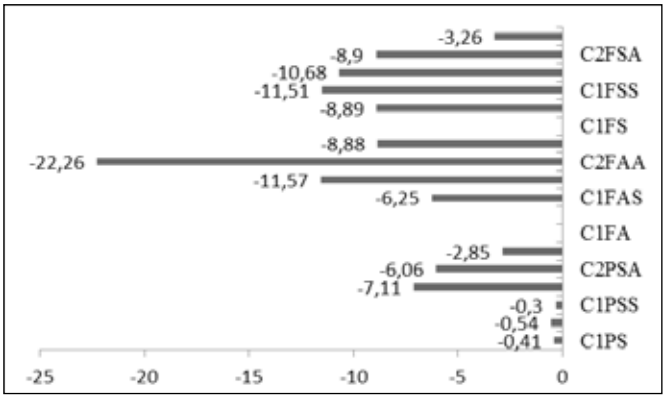

Fig. 3. The difference in water content in sponge cakes between the first and last day of determination.

Rys. 3. Różnica zawartości wody w ciastach biszkoptowych między pierwszym, a ostatnim dniem oznaczenia.

Source: Own study

Źródło: Opracowanie własne

The respondents made a visual assessment immediately after baking cakes, choosing from three products the one that best suited their visual impressions (the respondents did not evaluate the samples by smell or taste). The highest score was obtained by a cake sample in which sodium bicarbonate was used as a leavening agent. This was also confirmed in the organoleptic assessment of baked products in which respondents assessed such features as: porosity, color, smell, texture, elasticity, taste, brittleness and solubility in the mouth on a scale of 1 to 5. Respondents gave the highest access of product elasticity (5.0). The following features were also highly rated: color (4.67), texture (4.67) and porosity (4.33). The fragrance and crispness of sponge cake (3.0) were rated the lowest by respondents. The average of the above ratings was 3.83.

The biscuit product without the addition of leavening agent was rated the lowest (3.67). Especially low marks were given for the fragrance. Texture and flexibility were rated he highest. In the cake with the addition of ammonium bicarbonate, the solubility in the mouth was accessed the lowest, while features such as elasticity, texture and color were rated higher. The average rating for this product was 3.71.

Among the sponge cakes with the addition of ammonium bicarbonate, the dough stored for 8 days in breakfast paper in refrigerated conditions (C2PSA) was rated the highest. In turn, respondents rated the dough stored in aluminum foil at room conditions (C1FAA) the lowest (2.75). However, it should be noted that the assessment on day 22 of storage was absolutely influenced by the appearance of mold on the product. According to respondents the best protected product stored in room conditions was a sponge cake packed in aluminum foil (C1FAA) (3.88). However, in cooling conditions, the

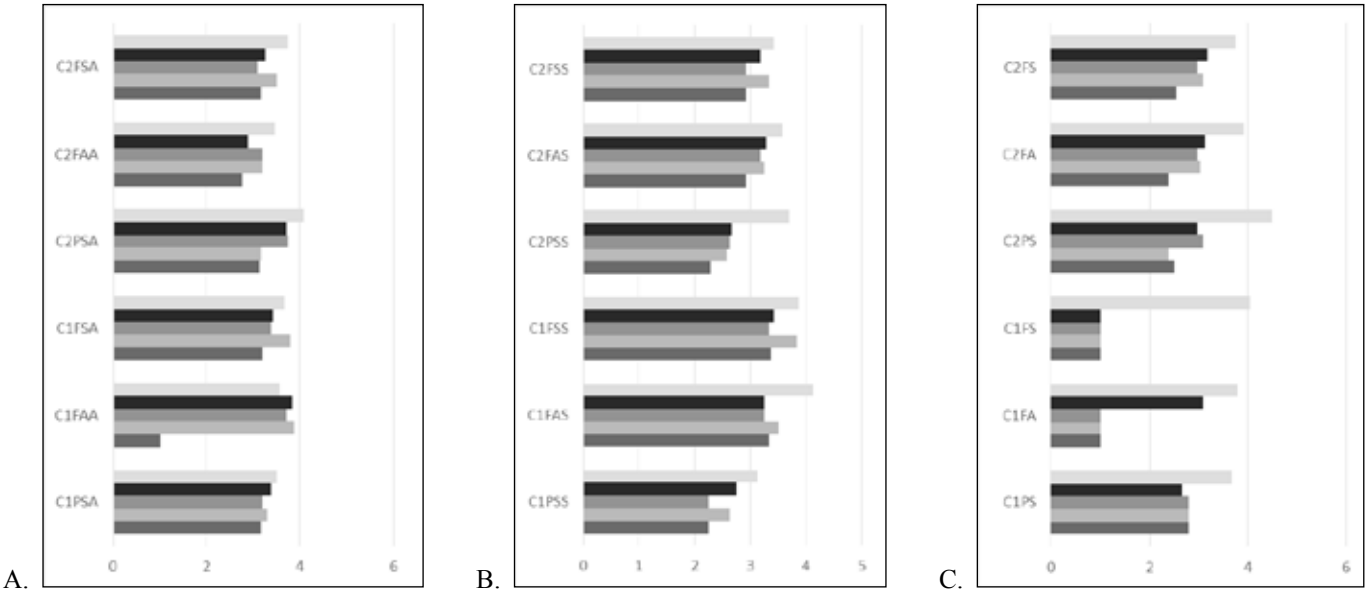

Fig. 4. Average grades of sponge cake with the addition of: A. ammonium bicarbonate, B. sodium bicarbonate, C. without leavening agent. Legend (first measurement 3 days after making the dough, next 8, 10, 15, 22 from the top of the picture).

Rys. 4. Średnie oceny ciasta biszkoptowego z dodatkiem: A. wodorowęglanu amonu, B. wodorowęglanu sodu, C. bez środka spulchniającego. Legenda (pierwszy pomiar 3 dzień od wytworzenia ciasta, kolejne 8, 10, 15, 22 licząc od góry rysunku).

Source: Own study

Źródło: Opracowanie własne

dough was the best stored when packaged in breakfast paper (C2PSA) (4.08) (Fig 4.) Considering the storage time, on the 10th day of the cake's storage the best quality was observed for the product packed in aluminum foil and stored at room temperature. In turn, cakes stored in refrigerated conditions and wrapped in breakfast paper received the highest marks. On the 15th day of the study, amongst sponge cakes stored in room conditions, those that were wrapped in aluminum foil was rated the highest. Among the cakes stored in refrigeration conditions, the respondents rated the highest cake packed in food foil (Fig. 4A). It should be noted, however, that it was not possible to clearly determine the decrease in cake ratings during storage. In general, the passage of time did not mean a negative impact on the quality of this product.

Among the sponge cakes with the addition of sodium bicarbonate, the sponge cakes stored in breakfast paper at room conditions were rated the lowest (C1PSS). Cake kept in room conditions wrapped in aluminum foil was rated the highest by respondents (C1FAS) (4.13). According to the respondents, for both sponge cakes stored in room and cooling conditions, the packaging from breakfast paper was the least favorable. (C1PSS, C2PSS) (Fig.4B). The exception was the 3rd day of assessment, on which cakes stored in breakfast paper were evaluated similarly to other cakes on that day of study, obtaining a note above 3.1. Except for one sponge cake (C2PSS), it was not possible, (similarly to the case of sponge cakes based on ammonium bicarbonate), to determine the decrease in ratings during the entire storage period. This means that the decrease in moisture that was recorded for these products during storage did not affect the lower rating given to these products by respondents.

In the group of cakes without the addition of leavening agent, stored in refrigeration conditions, the respondents rated the cake wrapped in breakfast paper (note 4.5) as the best on the third day of storage. On the same day, a C1FS sponge cake (4.04) got a slightly lower note. Unfortunately, in the following days of the study, the sponge cake received the lowest marks due to the development of mold on the product. A similar situation occurred for the C1FA product for which the rating was equal to 1 from the 10th day of storage (Fig. 4C).

The respondents pointed out the cake with the addition of ammonium bicarbonate as a sponge cake with the best sensory properties (this concerned 8th, 10th and 15th day of storage). On the other hand, on the 3rd and 22nd day of research, the respondents indicated a sponge cake with the addition of sodium bicarbonate as the cake with the best sensory properties [7] came to similar conclusions. She observed that sponge cake with the addition of baking powder had the best sensory properties. In addition, the same author said that a slightly worse sensory properties had sponge cake without the addition of leavening agent.

SUMMARY AND CONCLUSIONS

The effect of adding ammonium bicarbonate on sponge cake quality was observed. The product with this type of leavening agent stored in room conditions in aluminum foil showed the best sensory properties on 8, 10 and 15 days of storage. Considering the assessment of the respondents, it can be concluded that aluminum foil best protected sponge cake in room conditions. In refrigeration conditions, this packaging was food film and breakfast paper (regardless of the type of leavening agent in the cake), which, in turn, in room conditions did not completely protect the biscuit. This conclusion can be made based on the assessment of the respondents, who 3, 8, 10, 15 and 22 studies rated the cakes stored in breakfast paper the lowest.

In sponge cakes stored in room conditions in aluminum and food foil, mold growth was found on the surface of the cakes. Mold was observed in samples wrapped in food foil (test day 8) and aluminum foil (test day 10), which proves that both aluminum foil and food foil create favorable conditions for mold development, probably due to increased water content compared to products stored in paper breakfast and less air available for the product.

A relationship was found between the conditions for storage of sponge cakes and the type of used leavening agent. Given the storage conditions, cakes stored in refrigeration conditions were characterized by a higher water content compared to products stored in room conditions. Such a relationship occurred throughout the entire study cycle (days 8-22) regardless of the leaving agent used. Probably the reason for this relationship was the conditions in the refrigerator (temperature 5.3^{o}C, relative humidity 55%). Lower temperature and higher humidity compared to ambient conditions (temp. 21.1^{o}C, relative humidity 35.8%) prevented water from being drained.

Sponge cakes stored in breakfast paper had the lowest water content (cooling and room conditions). The effect of the type of leavening agent on the water content of sponge cakes stored in breakfast paper was observed. Among cakes stored on breakfast paper on the 10th and 15th day of the test, the highest content of water was found in sponge cake with the addition of ammonium bicarbonate. On the other hand, on the 8th and 22nd day of evaluation, the maximum content of water was characterized by cakes without the addition of leavening agent stored in breakfast paper.

Among sponge cakes stored in aluminum foil, the lowest water content was found in cakes with the addition of sodium bicarbonate. The highest water content was recorded for cakes with the addition of ammonium bicarbonate (test days 8 and 10). The high water content of these products may have been caused by the structure of the dough (a large number of air bubbles).

The effect of the leavening agent on the water content of cakes stored in food foil was also observed. The highest water content in this group was characteristic for product with the addition of ammonium bicarbonate. Among the cakes stored in food foil, the lowest water content was found for products without a leavening agent (day 8 and 10) and cakes with sodium bicarbonate (days 15 and 22).

It is not recommended to use chemical leavening agents for baking sponge cakes, but referring to the results obtained, it can be concluded that sponge cakes with leavening agents have better organoleptic properties. The research shows that a sponge cake based on ammonium bicarbonate was rated best by respondents.

PODSUMOWANIE I WNIOSKI

Zaobserwowano wpływ dodatku wodorowęglanu amonu na jakość ciasta. Wyrób z tym rodzajem środka spulchniającego przechowywany w warunkach pokojowych w foli aluminiowej wykazywał najlepsze właściwości sensoryczne w 8,10 i 15 dniu przechowywania.

Uwzględniając ocenę ankietowanych można wnioskować, że folia aluminiowa najlepiej chroniła ciasto biszkoptowe w warunkach pokojowych. W warunkach chłodniczych tym opakowaniem była folia spożywcza i papier śniadaniowy (bez względu na rodzaj środka spulchniającego), który z kolei w warunkach pokojowych zupełnie nie chronił biszkoptu. Wniosek ten można wysunąć na podstawie oceny ankietowanych, którzy 3,8,10,15 i 22 badania najniżej oceniali ciasta przechowywane w papierze śniadaniowym.

W ciastach biszkoptowych przechowywanych w warunkach pokojowych w foli aluminiowej i spożywczej stwierdzono rozwój pleśni na powierzchni ciast. Pleśń zaobserwowano w próbkach opakowanych w folię spożywczą (8 dzień badania) oraz w folię aluminiową (10 dzień badania) co dowodzi, że zarówno folia aluminiowa i folia spożywcza stwarzają dogodne warunki dla rozwoju pleśni prawdopodobnie spowodowane zwiększoną zawartością wody w porównaniu do biszkoptów przechowywanych w papierze śniadaniowym i mniejszą dostępnością powietrza do wyrobu.

Stwierdzono zależność pomiędzy warunkami przechowywania biszkoptów, a rodzajem środka spulchniającego. Biorąc po uwagę warunki przechowywania ciast, biszkopty przechowywane w warunkach chłodniczych charakteryzowały się większą zawartością wody w porównaniu z biszkoptami przechowywanymi w warunkach pokojowych. Taka zależność występowała w całym cyklu badań (8-22 dzień oceny) niezależnie od użytego środka spulchniającego. Prawdopodobnie powodem wystąpienia takiej zależności były warunki panujące w lodówce (temp.5,30C, wilgotność względna 55%). Niższa temperatura oraz większa wilgotność w porównaniu z warunkami otoczenia (temp.21,10C wilgotność względna 35,8%) przeciwdziałała oddawaniu wody z produktu.

Biszkopty przechowywane w papierze śniadaniowym charakteryzowały się najniższą zawartością wody (warunki chłodnicze i pokojowe). Zaobserwowano wpływ rodzaju środka spulchniającego na zawartość wody w ciastach biszkoptowych przechowywanych w papierze śniadaniowym. Wśród ciast przechowywanych w papierze 10 i 15 dnia oznaczenia najwyższą zawartością wody charakteryzował się biszkopt z dodatkiem wodorowęglanu amonu. Natomiast 8 i 22 dnia oceny maksymalną zawartością wody charakteryzowały się biszkopty bez dodatku środka spulchniającego przechowywane w papierze śniadaniowym.

Wśród ciast biszkoptowych przechowywanych w folii aluminiowej najniższą zawartością wody charakteryzowały się ciasta z dodatkiem wodorowęglanu sodu. Najwyższą zawartość wody wykazały biszkopty z dodatkiem wodorowęglanu amonu (8 i 10 dzień badania). Duża zawartość wody w tych biszkoptach mogła być powodowana strukturą ciasta (duża ilość pęcherzyków powietrza).Zaobserwowano również wpływ środka spulchniającego na zawartość wody w biszkoptach przechowywanych w folii spożywczej. Najwyższą zawartością wody w tej grupie charakteryzowało się ciasto z dodatkiem wodorowęglanu amonu. Wśród biszkoptów przechowywanych w folii spożywczej najniższą zawartość wody wykazały biszkopty bez środka spulchniającego (8 i 10 dzień oznaczenia) oraz ciasta z wodorowęglanem sodu (15 i 22 dzień oznaczenia).

Do wypieku ciast biszkoptowych nie jest zalecane używanie chemicznych środków spulchniających ale odnosząc się do uzyskanych rezultatów można wnioskować, że biszkopty z środkami spulchniającymi charakteryzują się lepszymi właściwościami organoleptycznymi. Z przeprowadzonych badań wynika, że ciasto biszkoptowe na bazie wodorowęglanu amonu zostało najlepiej ocenione przez ankietowanych.

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IMPACT OF THE GRATING THICKNESS ON THE QUALITY OF POTATO PANCAKES®

Wpływ rozdrobnienia miękiszu ziemniaka na cechy jakościowe placków ziemniaczanych®

The article presents the results obtained during the research on the impact of the type of potato grating thickness on the quality of potato pancakes. Four mixtures were made, each by means of blades with different size of grating holes. The mixtures differed in consistency and appearance, which resulted in different quality parameters of fried potato pancakes. The pancakes were subjected to organoleptic assessment with the 5-point method. The evaluation team consisted of a group of fifteen trained reviewers. Based on the obtained assessments, the results were analyzed and discussed. Potato pancakes made with a rotary grinding machine with a drum blade for potato grating were rated the highest. Their appearance, smell, taste and consistency were characteristic of this dish. Pancakes made on blades with medium holes were rated the worst. During frying, these pancakes quickly browned from the outside, but inside the mass of potato mixture remained raw. The conducted research confirmed that the way of grinding vegetables into potato mass has a large impact on the quality of ready potato pancakes, and thus on their sensory acceptability.

Key words: potato pancakes, organoleptic evaluation, sensory evaluation, grating thickness, production technology, food quality.

Artykuł przedstawia wyniki uzyskane podczas badań wpływu rodzaju rozdrobnienia ziemniaków na jakość placków ziemniaczanych. Sporządzono 4 ciasta, każde z wykorzystaniem różnych grubości oczek do tarcia. Ciasta różniły się między sobą konsystencją oraz wyglądem, co skutkowało różnicą parametrów jakościowych usmażonych placków ziemniaczanych. Placki zostały poddane ocenie organoleptycznej metodą 5 punktową. Zespół oceniający stanowiła piętnastoosobowa grupa przeszkolonych ankieterów. Na podstawie uzyskanych ocen dokonano analizy i dyskusji wyników. Najwyżej ocenione zostały placki ziemniaczane wykonane maszynką do mięsa z funkcją tarcia ziemniaków na placki ziemniaczane. Ich wygląd, zapach, smak i konsystencja była charakterystyczna dla tej potrawy. Najgorzej oceniono placki sporządzone na ostrzach z grubymi oczkami. Placki te podczas smażenia szybko ulegały zarumienieniu się z zewnątrz, lecz w środku masa ciasta ziemniaczanego pozostawała surowa. Przeprowadzone badania potwierdziły, że sposób rozdrobnienia warzyw do masy ziemniaczanej ma duży wpływ na jakość gotowych placków ziemniaczanych, a przez to na ich akceptowalność sensoryczną.

Słowa kluczowe: placki ziemniaczane, ocena organoleptyczna, rozdrobnienie, technologia produkcji, jakość żywności.

INTRODUCTION

Root crops are those whose utility parts are underground, called tubers or roots. The usable parts contain a lot of carbohydrates, compared to the protein or fiber content. In the group of root crops we find annual and biennial species, which combine a similar cultivation method from sowing to weeding and ridging. Potatoes belong to the root crops, to the family of solanaceous plants, they propagate vegetatively through tubers. They are annual plants, the usable part is the tuber, and their purpose is wide as they can be used for edible purposes for both humans and animals. They are also used for industrial purposes to produce, among other things, potato flour. Due to their shape and taste we can distinguish a large number of varieties [9]. Potatoes belong to the most popular vegetables not only in Poland but also in the world. They are commonly used in such countries as: Cyprus, Russia, Germany and the Netherlands. In terms of cultivation area, they occupy seventh

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place among eleven most important plants in the world [9]. It is worth to pay special attention to the composition of potatoes as they are rich in energy components, vitamins and, most of all, they do not belong to the indigestible plants. Potatoes and their products are the main source of carbohydrates in human nutrition next to wheat and rice [11]. They are consumed in boiled, baked and fried forms. The share of potatoes in the diet has decreased in recent years and thus its production has been limited. This trend is mainly caused by the change in dietary trends [11,12]. Potato products are characterized by high content of starch, vitamin C, B group vitamins as well as potassium, magnesium, iron, copper and iodine. It is worth noting that the daily intake of 200g of potatoes covers 50% of the daily vitamin C requirement [1,2,3,8,10,11,12]. The alkaline reaction of potatoes allows to neutralize the acid reaction of other consumed products. Therefore, potatoes are widely used in the diet of people with sensitivity and gastrointestinal diseases, potassium deficiency and heart diseases [5,6,7]. Boiled potatoes are characterized by a relatively high glycemic index and therefore they are not recommended for people with fluctuating blood glucose levels [11,12]. For many years, they have been the basis of Polish meals mainly due to their rich nutritional and culinary value, as well as low price and access to this product all year round. An average Pole consumes even 130 kg of potatoes per year. The number of potato varieties is impressive. In 2011, 137 varieties were recorded in the National Register, 108 of them were edible and 29 starch varieties [4].

PURPOSE AND SCOPE OF WORK

The aim of the study was to assess the effect of the degree of potato grinding on the quality of obtained potato pancakes. The scope of work included preparation of four types of potato pancakes using four different sizes of potato grating blades. Fried potato pancakes were subjected to organoleptic evaluation. On the basis of the obtained results an analysis was made and conclusions from the conducted research were presented.

RESEARCH METHODOLOGY

The research material was potato pancakes prepared according to the same recipe.

Two devices were chosen to prepare the mixture for potato pancakes: a rotary grinding machine with two different blades and a vegetable box grater using also two blades. Four mixtures were prepared according to the prepared recipe.

Mixture No. 1 – prepared using a rotary grinding machine equipped with blades for grating potatoes for pancakes (ground pancakes).

Mixture No. 2 – prepared with the use of a rotary grinding machine equipped with blades for shredding vegetables.

Mixture No. 3 – prepared on a box grater with the use of shredding blades.

Mixture No. 4 – prepared on a box grater with the use of blades for fine grating.

The potato mixture was fried in the shape of pancakes and subjected to organoleptic evaluation. The evaluation team consisted of 15 people of different ages, but the majority of them were between 22 and 24 years old. The evaluators received a card with a 5-point scale of evaluation of selected quality features of finished products. During the preparation of potato mixture (using different blades for processing raw materials) a significant difference in consistency of mass, mass density and appearance was noticed. Figure 1 shows the blades used for grounding and grating the potatoes and the mixture mass obtained.

Device	Mixture
Rotary grinding machine – drum blade for grating potato pancakes. 	Mixture No. 1 
Rotary grinding machine – drum blade for shredding vegetables with medium holes. 	Mixture No. 2 
Box grater – blade to shred vegetables with large holes. 	Mixture No. 3 
Box grater – blade to grate vegetables with small holes. 	Mixture No. 4 

Fig. 1. Blades and the obtained mass of potato mixture.
Rys. 1. Ostrza oraz masa uzyskanego ciasta placków ziemniaczanych.

Source: Own study
Źródło: Opracowanie własne

Figure 2 shows the process of frying the pancakes and the blade used to grate the potatoes.

Device	Mixture
Rotary grinding machine – drum blade for grating potatoes. 	Potato pancakes made of mixture No. 1 
Rotary grinding machine – drum blade for shredding vegetables with medium holes. 	Potato pancakes made of mixture No. 2 
Box grater – blade to shred vegetables with large holes. 	Potato pancakes made of mixture No. 3 
Box grater – blade to grate vegetables with small holes. 	Potato pancakes made of mixture No. 4 

Fig. 2. Comparison of the appearance of fried potato pancakes made on four different grater blades.

Rys. 2. Porównanie wyglądu smażonych placków ziemniaczanych sporządzonych na czterech różnych oczkach tarki.

Source: Own study

Źródło: Opracowanie własne

ANALYSIS AND DISCUSSION OF RESULTS

The examined characteristics of the quality of the cakes were: external appearance, color, taste, smell, texture and cross-section. The results of the analysis are presented below in the form of bar charts.

Figure 3 presents the results of the organoleptic evaluation of potato pancakes, where the tested quality was determined by their external appearance. According to the respondents, the most favorable appearance was achieved by potato pancakes processed with a drum blade for grating potatoes. A slightly lower result was achieved by potato pancakes grated on a box grater with small hole blade. The respondents assessed equally potato pancakes grated with large holes and medium holes in the same way.

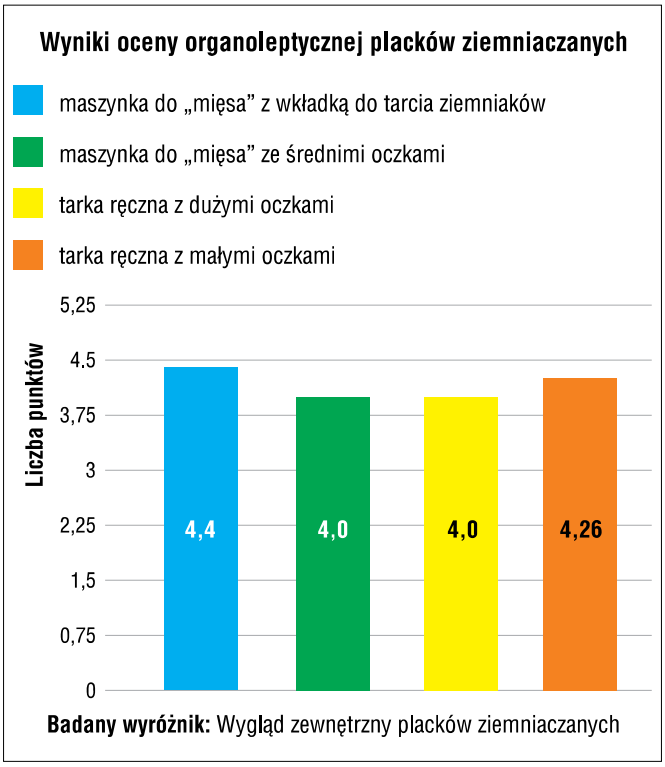

Fig. 3. Results of organoleptic assessment of potato pancakes in terms their external appearance.

Rys. 3. Wyniki oceny organoleptycznej placków ziemniaczanych ze względu na ich wygląd zewnętrzny.

Source: Own study

Źródło: Opracowanie własne

The color of the potato pancakes was considered to be the second most important quality marker in the evaluation of potato pancakes. The analysis concluded that the respondents assessed the appearance of potato pancakes grated with different blades quite similarly. However, the results slightly differ from each other, the research group assessed the potato pancakes grated on medium holes in the most favorable way. Potato pancakes grated on small holes assessed the least favorably in terms of the color obtained.

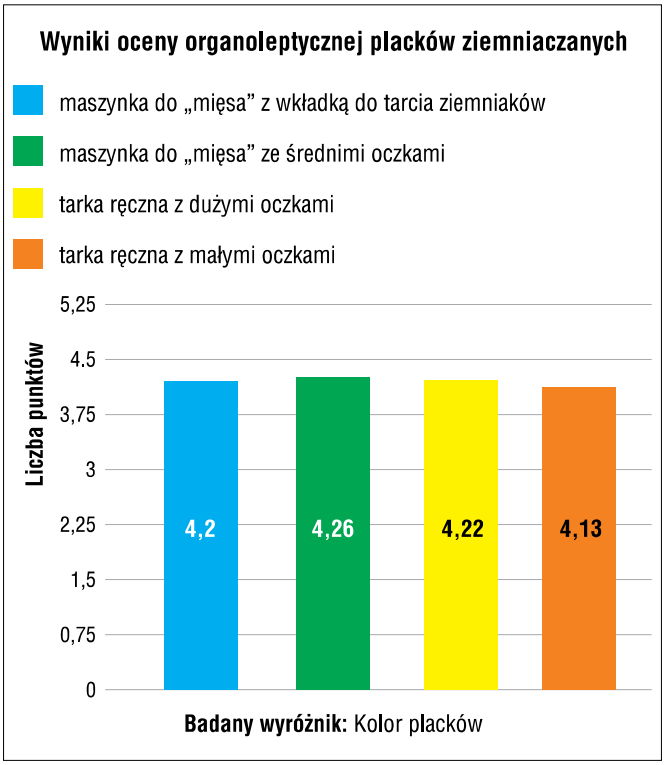

Fig. 4. Results of organoleptic evaluation of potato pancakes in terms of the obtained color.

Rys. 4. Wyniki oceny organoleptycznej placków ziemniaczanych ze względu na uzyskany kolor.

Source: Own study

Źródło: Opracowanie własne

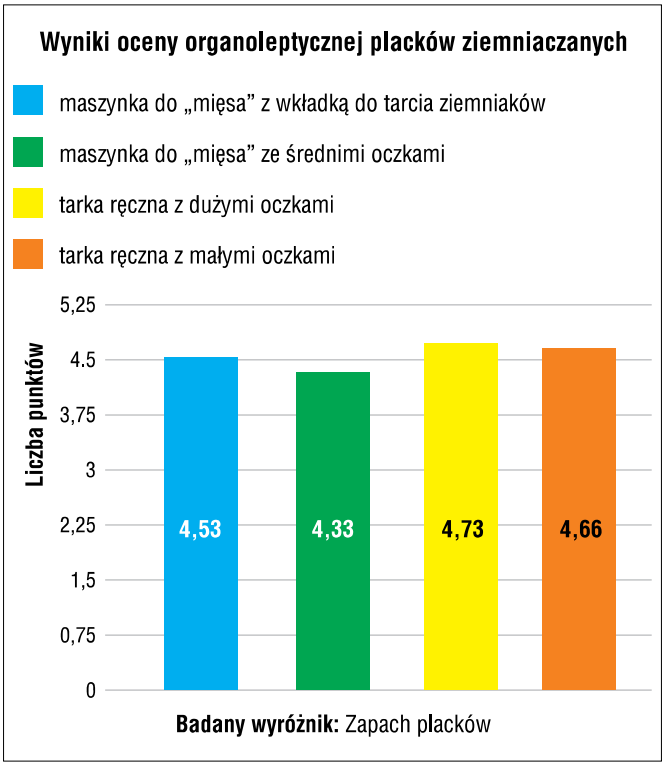

Fig. 5. Results of the organoleptic evaluation of potato pancakes in terms of smell.

Rys. 5. Wyniki oceny organoleptycznej placków ziemniaczanych ze względu na zapach.

Source: Own study

Źródło: Opracowanie własne

The smell of potato pancakes was also evaluated organoleptically. The respondents found that potato pancakes grated on medium holes smell best. The second place in this classification was taken by the potato pancakes grated on small holes of the box grater and those prepared with the grating blade of the rotary grinding machine. The respondents found pancakes grated on medium holes to be the least attractive in terms of color.

A very important quality feature in organoleptic evaluation is taste. In the case of conducted research, it turned out that the taste of potato pancakes depends on the thickness of grating. The potato pancakes ground in the rotary machine were considered the best by the research group. Not as good as the best pancakes but still highly rated were the potato pancakes grated on medium holes. Potato pancakes grated on small and large holes scored the lowest and thus were considered to be the least tasty according to the respondents.

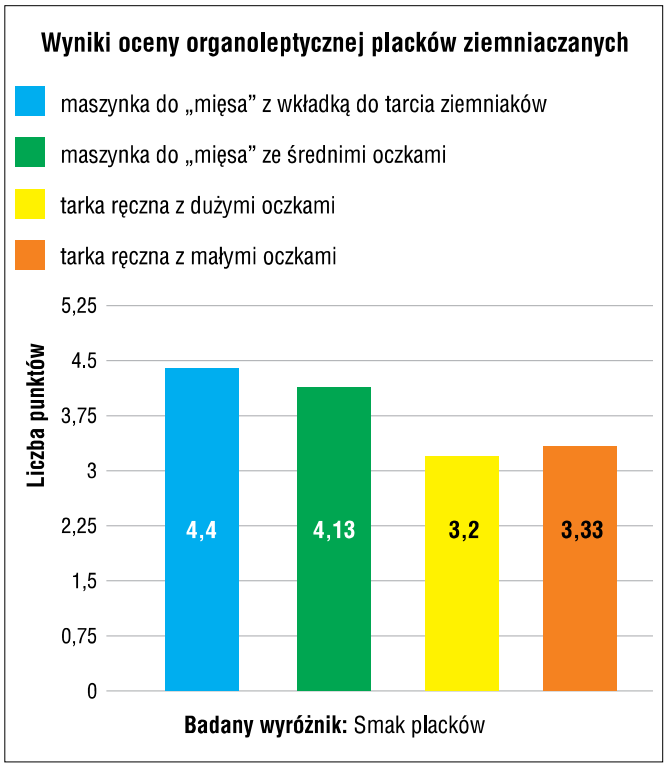

Fig. 6. Results of the organoleptic evaluation of potato pancakes in terms of taste.

Rys. 6. Wyniki oceny organoleptycznej placków ziemniaczanych ze względu na smak.

Source: Own study

Źródło: Opracowanie własne

The last quality marker examined was the cross-section and texture of potato pancakes. The respondents found that the potato pancakes grated by means of a grating blade of the rotary machine were the best in this category. Potato pancakes grated on small and medium holes were assessed much worse. While the potato pancakes grated on large holes are the worst.

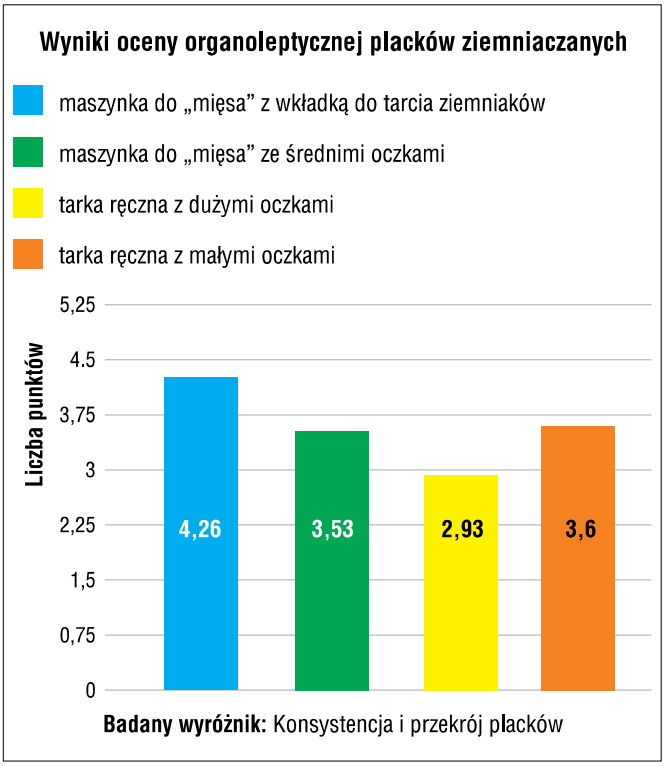

Fig. 7. Results of organoleptic evaluation of potato pancakes in terms of their texture and cross-section.

Rys. 7. Wyniki oceny organoleptycznej placków ziemniaczanych ze względu na ich konsystencję oraz przekrój.

Source: Own study

Źródło: Opracowanie własne

CONCLUSIONS

On the basis of the tests carried out, it is concluded:

1. The method of preparing the potato mixture in terms of grating thickness affects the quality parameters of the fried potato pancakes.
2. The method of grating potatoes with a rotary grinding machine has a positive effect on the taste, texture and cross-section of potato pancakes. Fine texture has a positive effect on the frying degree of potato pancakes.
3. Grating potatoes on medium holes can make the inside of the pancakes raw and the outer layer of the pancakes burnt. This has a significant effect on the deterioration of the taste of potato pancakes.
4. The thickness and method of grating of the potatoes does not significantly affect the differences in color of the fried potato pancakes.

WNIOSKI

Na podstawie przeprowadzonych badań, stwierdza się:

1. Sposób przygotowywania masy ziemniaczanej ze względu na stopień rozdrobnienia warzyw ma wpływ na parametry jakościowe gotowych placków ziemniaczanych.
2. Metoda przecierania ziemniaków za pomocą maszynki do mielenia korzystnie wpływa na smak, konsystencję, przekrój placków ziemniaczanych. Drobna konsystencja wpływa pozytywnie na wysmażenie placków ziemniaczanych.
3. Ścieranie ziemniaków na grubych oczkach może przyczynić się tego, iż środek placków pozostanie surowy, a zewnętrzna warstwa placków zostanie przypalona. Ma to istotny wpływ na pogorszenie smaku placków ziemniaczanych.
4. Stopień oraz metoda rozdrobnienia ziemniaków nie wpływa istotnie na różnice w kolorze wysmażonych placków ziemniaczanych.

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W pracy prezentowanej w artykule wyznaczono izotermy adsorpcji wody oraz badano kinetykę sorpcji wody dla wybranych mąk niechlebowych (kukurydziana jaglana, owsiana i ryżowa) w temperaturze 25°C. Izotermy adsorpcji wody wyznaczono metodą statyczno-eksykatorową w zakresie aktywności wody od 0,113 do 0,932. Krzywe kinetyczne sorpcji wody wyznaczono w środowisku o zróżnicowanej wilgotności względnej powietrza (32,8, 52,9, 75,3 i 100,0%).

Stwierdzono, że izotermy adsorpcji wody badanych mąk miały kształt sigmoidalny i zgodnie z klasyfikacją Brunauera i współpracowników odpowiadały II typowi izoterm. Model GAB dobrze opisywał otrzymane izotermy adsorpcji wody (RMS < 8%). Model kinetyczny Ficka poprawnie opisywał dane sorpcyjne badanych mąk (R^2 > 0,99). Najmniejszą zdolnością chłonięcia pary wodnej charakteryzowała się mąka owsiana, a największą mąki jaglana i kukurydziana.

Słowa kluczowe: mąki niechlebowe, izotermy adsorpcji wody, kinetyka sorpcji, modele GAB i Ficka.

In the paper water adsorption isotherms and water sorption kinetics for selected non-bread flour (corn, millet, oat and rice) at 25°C were determined. The water adsorption isotherms were determined by the static gravimetric method in the water activity range from 0,113 to 0,932. The kinetics curves of water vapor sorption in the environment of different relative humidity of the air (32,8, 52,9, 75,3 and 100,0%) were investigated. The water adsorption isotherms of the tested flours had a compatible course with second type of isotherms according to the Brunauer's classification. The GAB model gave good fit to the experimental sorption data (RMS < 8%). The Fick's kinetic model correctly described the sorption data of the flours tested (R^2 > 0,99). Oat flour characterized by the lowest ability to adsorb water vapor, while the highest was millet and corn flour.

Key words: non-bread flours, water adsorption isotherms, sorption kinetics, GAB and Fick's model.

WSTĘP

Mąka jest sypkim surowcem uzyskanym wskutek przemiału ziarna różnych rodzajów zbóż. W głównej mierze jest wykorzystywana do produkcji pieczywa, chociaż jej zastosowanie ciągle się poszerza. W zależności od jej wykorzystania można ją podzielić na mąkę chlebową i niechlebową. Mąka chlebowa produkowana jest głównie z pszenicy i żyta, natomiast mąka niechlebowa z kukurydzy, gryki, owsa, prosa, ryżu lub innych roślin alternatywnych uprawianych w określonych obszarach klimatycznych.

Początkowo zastosowanie mąk niechlebowych było niewielkie i stanowiło niekiedy dodatek kilkuprocentowy w odniesieniu do mąki pszennej lub żytniej ze względów oszczędnościowych. W obecnej chwili ich popularność i zastosowanie znacznie wzrasta. Jest to związane ze zmieniającymi się preferencjami konsumentów, które są kształtowane przez modę żywieniową [5].

Mąki niechlebowe posiadają wysoką wartość odżywczą. Oprócz węglowodanów są cennym źródłem błonnika, białka, witamin i składników mineralnych. Istotną zaletą mąk niechlebowych jest fakt, iż nie zawierają glutenu, dzięki czemu mają zastosowanie w produkcji żywności dla osób chorych na celiakię [5, 6, 21].

Podczas przechowywania mąki może dochodzić do pochłaniania przez nią wody z otoczenia. Zjawisko to określane jest jako sorpcja pary wodnej. Jej przebieg obrazują izotermy sorpcji będące graficznym przedstawieniem zależności równowagowej zawartości wody od aktywności wody, jak również krzywe kinetyczne procesu sorpcji, będące graficzną interpretacją zmian zawartości wody w materiale w czasie, a tym samym informują o zdolności chłonięcia wody przez materiał i wyrażają również jego higroskopijność [17].

Zarówno wyznaczenie izoterm adsorpcji i desorpcji wody jak i krzywych kinetycznych tych procesów stanowi cenny materiał na podstawie którego można projektować m. in. procesy technologiczne związane z usuwaniem wody z materiałów spożywczych, warunki ich transportu i przechowywania oraz przewidywać zmiany w żywności, które mogą pogarszać jej jakość i bezpieczeństwo zdrowotne [17, 18]. W dostępnej literaturze, praktycznie brak jest informacji na temat izoterm

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adsorpcji i przebiegu krzywych kinetycznych procesu sorpcji wody dla mąk niechlebowych. Poniższe rozważania będą stanowiły uzupełnienie wiedzy na ten temat.

Celem artykułu jest przedstawienie wyników badań dotyczących określenia właściwości sorpcyjnych wybranych mąk niechlebowych na podstawie wyznaczonych izoterm i przebiegu krzywych kinetycznych procesu adsorpcji wody w temperaturze 25°C oraz ich analizy.

METODYKA BADAŃ

1. Materiał badawczy

Do badań użyto 4 rodzaje mąk niechlebowych: kukurydzianą, jaglaną, owsianą i ryżową. Materiał zakupiono w dużej sieci supermarketów w Warszawie.

2. Metody analityczne

2.1. Oznaczenie początkowej zawartości wody

Początkową zawartość wody w mąkach oznaczano metodą suszenia pod obniżonym ciśnieniem w suszarce próżniowej Memmert VO500. Próbki materiału suszono w temperaturze 70 ±1°C, pod ciśnieniem 1 kPa, przez 24 godziny [1]. Oznaczenie wykonano w 3 równoległych powtórzeniach.

2.2. Oznaczenie początkowej aktywności wody

Początkową aktywność wody w mąkach zmierzono przy użyciu aparatu Rotronic w temperaturze 21,0 ± 0,5°C. Pomiar przeprowadzono w 3 równoległych powtórzeniach.

2.3. Wyznaczenie izoterm adsorpcji wody

Izotermy adsorpcji wody wyznaczono metodą statyczno -eksykatorową [22], stosując nasycone roztwory soli jako czynniki higrostatyczne (LiCl, CH_3COOK, $MgCl_2$, K_2CO_3, $Mg(NO_3)_2$, $NaNO_2$, NaCl, $(NH_4)_2SO_4$ i $(NH_4)H_2PO_4$) [8, 10, 20]. W eksykatorach z roztworami o większej aktywności wody (NaCl, $(NH_4)_2SO_4$ i $(NH_4)H_2PO_4$ umieszczono naczynka z tymolem, w celu ochrony przed rozwojem mikroflory w materiale. Przed procesem adsorpcji próbki mąk suszono w suszarce próżniowej w temperaturze 70°C, przy ciśnieniu 1 kPa, w czasie 24 godzin. Tak przygotowane próbki materiału przeniesiono do eksykatorów z roztworami soli o a_w od 0,113 do 0,932. Czas przetrzymywania próbek wyniósł 3 miesiące. Badania wykonano w temperaturze 25±0,5°C w 3 powtórzeniach.

2.4. Wyznaczenie kinetyki procesu adsorpcji wody

Do wyznaczenia kinetyki procesu adsorpcji wody w mąkach w warunkach nieustalonych wykorzystano układ pomiarowy, którego zasadniczym elementem była waga analityczna RADWAG WAS 220/C/2 znajdująca się w pomieszczeniu o stałej temperaturze 25°C, podłączona do komputera z oprogramowaniem Pomiar-Win v.3.0.24 (Radwag) [23]. Jako czynniki higrostatyczne zastosowano trzy nasycone wodne roztwory soli ($MgCl_2$, $Mg(NO_3)_2$, NaCl) oraz wodę destylowaną, które gwarantowały w otoczeniu badanej próbki stałą wilgotność względną powietrza na poziomie 32,8, 52,9, 75,3 i 100,0% [8]. Materiał, po otworzeniu opakowania, poddano suszeniu pod obniżonym ciśnieniem zgodnie z metodyką podaną w p. 2.3. Suchy materiał umieszczono w naczynku pomiarowym wykonanym z folii aluminiowej (masa próbki ok. 1 g). Z kolei, naczynko z próbką wstawiono na szalkę wagi, zamontowano pojemnik z czynnikiem higrostatycznym i natychmiast zapisywano początkową masę próbki oraz uruchamiano program komputerowy. Program komputerowy rejestrował przyrost masy próbki z dokładnością ±0,0001 g co 5 minut i gromadził dane przez 24 h. W celu sprawdzenia reprezentatywności pomiaru, wykonano go w dwóch powtórzeniach dla każdej wilgotności względnej środowiska.

3. Metody obliczeniowe

3.1. Obliczenie równowagowej zawartości wody

Równowagową zawartość wody w mąkach po procesie adsorpcji obliczono ze wzoru [11]:

$$u = \left[\frac{d}{c\frac{b}{a}} - 1 \right] \cdot 100 \qquad (1)$$

gdzie: u – równowagowa zawartość wody, g wody/100 g s.s.,
a – początkowa masa próbki z eksykatora z $CaCl_2$, g,
b – końcowa masa próbki, po trzymiesięcznym przetrzymywaniu w eksykatorze z $CaCl_2$ (po suszeniu w temperaturze 70°C, pod obniżonym ciśnieniem, przez 24 h), g,
c – początkowa masa próbki z eksykatora z określonym roztworem, g,
d – końcowa masa próbki, po trzymiesięcznym przetrzymywaniu, z eksykatora z określonym roztworem, g.

3.2. Obliczenie zawartości wody w materiale po czasie τ

Zawartość wody w mąkach, przeliczona na 100 g suchej substancji, obliczono ze wzoru [23]:

$$u_\tau = \frac{m_\tau - m_o}{m_o} \cdot 100 \qquad (2)$$

gdzie: u_τ – zawartość wody po czasie τ, g wody/100 g s.s.,
m_0 – pierwotna masa próbki suchej, g,
m_τ – masa próbki po czasie τ, g.

3.3. Opis izoterm adsorpcji wody mąk

Do opisu izoterm adsorpcji wody mąk zastosowano model GAB [2]:

$$u = \frac{u_m C k a_w}{(1 - k a_w)\left[1 + (C - 1) k a_w\right]} \qquad (3)$$

gdzie: a_w – aktywność wody,
u_m – zawartość wody w monowarstwie, g wody/100 g s.s.,
C i k – stałe.

Aproksymację izoterm przeprowadzono na bazie wszystkich punktów pomiarowych (3 powtórzenia). Programu Table Curie 2D (Jandel Scientific) użyto do dopasowania testowanego modelu do danych doświadczalnych.

3.4. Wyznaczenie parametrów modelu kinetycznego

Parametry kinetyczne procesu adsorpcji wody wyznaczono z modelu Ficka [7] wykorzystując program komputerowy TableCurve™ 2D v.5.01.01:

$$\frac{u_r - u_\tau}{u_r - u_o} = A \cdot \exp(-K \cdot \tau) \quad (4)$$

gdzie: u_0 – początkowa zawartość wody, g wody/100 g s.s.,
u_r – równowagowa zawartość wody, g wody 100 g s.s.,
A – współczynnik kształtu (stała),
K – stała powiązana ze współczynnikiem dyfuzji,
τ – czas, min.

Jakość dopasowania modelu do danych sorpcyjnych określono na podstawie wartości współczynnika determinacji (R^2) obliczonego w programie TableCurve™ 2D v.5.01.01.

3.5. Obliczenie średniego błędu kwadratowego (RMS)

Przydatność modelu GAB do opisu danych doświadczalnych adsorpcji wody oceniono na podstawie średniego błędu kwadratowego (RMS) wyrażonego w % [12]:

$$RMS = \sqrt{\frac{\Sigma\left(\frac{u_e - u_p}{u_e}\right)^2}{N}} \cdot 100 \quad (5)$$

gdzie: u_e – doświadczalna równowagowa zawartość wody, g wody/100 g s.s.,
u_p – prognozowana równowagowa zawartość wody, g wody/100 g s.s.,
N – liczba danych.

OMÓWIENIE I DYSKUSJA WYNIKÓW

1. Charakterystyka badanych mąk

Tabela 1. Początkowa zawartość wody i aktywność wody w badanych mąkach niechlebowych

Table 1. Initial water content and water activity in studied non-bread flours

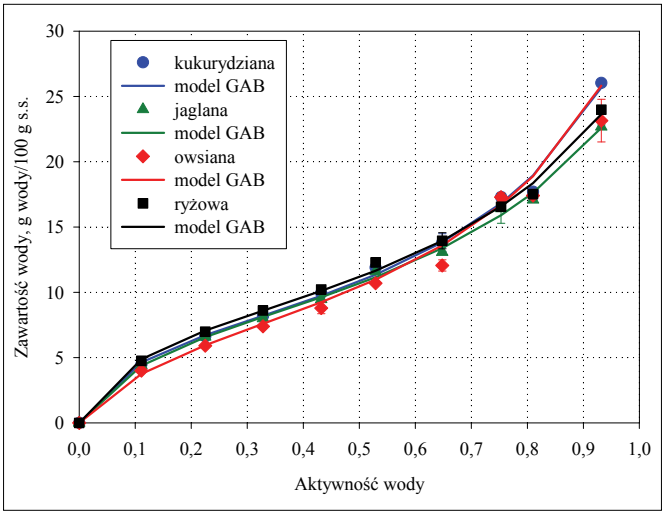
Rodzaj mąki niechlebowej	Zawartość wody [%]	Aktywność wody [-]
Mąka kukurydziana	8,33 ± 0,09	0,348 ± 0,008
Mąka jaglana	7,60 ± 0,04	0,291 ± 0,003
Mąka owsiana	6,76 ± 0,03	0,314 ± 0,005
Mąka ryżowa	7,61 ± 0,06	0,284 ± 0,002

Źródło: Badania własne

Source: The own study

W tabeli 1 przedstawiono średnią początkową zawartość i aktywność wody w badanych mąkach niechlebowych. Stwierdzono, że największą początkową zawartość i aktywność wody posiadała mąka kukurydziana (8,33%, 0,348). Mąki jaglana i ryżowa posiadały zbliżoną początkową zawartość i aktywność wody, wynoszącą odpowiednio 7,60 i 7,61% oraz 0,291 i 0,284. Natomiast, najmniejszą początkową zawartość miała mąka owsiana (6,76%), a jej początkowa aktywność wody wyniosła 0,314. Wszystkie badane mąki, ze względu na poziom aktywności wody, zalicza się do żywności o niskiej zawartości wody, ponieważ mieszczą się w przedziale a_w od 0 do 0,55 [17].

2. Izotermy adsorpcji wody



Rys. 1. Izotermy adsorpcji wody mąki kukurydzianej, jaglanej, owsianej i ryżowej.

Fig. 1. Water adsorption isotherms for corn, millet, oat and rice flour.

Źródło: Badania własne

Source: The own study

Na rysunku 1 przedstawiono przebieg izoterm adsorpcji wody badanych mąk. Uzyskane izotermy adsorpcji wody, bez względu na rodzaj mąki, posiadały typowy kształt sigmoidalny, charakterystyczny dla izoterm typu II, zgodnie z klasyfikacją Brunauera i wsp. [3]. Izotermy typu II są charakterystyczne dla produktów skrobiowych i białkowych [17]. Generalnie, izotermy wszystkich czterech rodzajów mąk miały zbliżony przebieg, a linie izoterm przebiegały blisko siebie. Tym niemniej należy stwierdzić, że w początkowym przedziale aktywności wody od 0,0 do 0,6 najwyżej przebiegała izoterma dla mąki ryżowej, a najniżej dla mąki owsianej. Powyżej a_w 0,6 najwyżej przebiegała natomiast izoterma dla mąki kukurydzianej, a najniżej dla mąki jaglanej. Na taki przebieg izoterm adsorpcji wody największy wpływ miał ich skład chemiczny. Otóż, mąka ryżowa posiadała najwyższą zawartość węglowodanów (79,2%) i najniższą zawartość tłuszczu (0,7%) [9]. Z kolei, mąka owsiana posiadała najniższą zawartość węglowodanów (66,0%) i najwyższą zawartość tłuszczu (8,0%) [9]. Tym samym, liczba hydrofilowych centrów aktywnych, szczególnie przy niskim poziomie aktywności wody, decydowała głównie o większej adsorpcji wody przez mąkę ryżową, i znacznie mniejszej adsorpcji wody przez mąkę owsianą. Powyżej aktywności wody 0,6, struktura wewnętrzna materiału miała większy wpływ na przebieg izoterm adsorpcji wody. Rozmiar porów i ich kształt decydowały o przebiegu kondensacji kapilarnej i miały wpływ na bardziej zróżnicowany przebieg izoterm badanych mąk.

Podobny przebieg i kształt izoterm adsorpcji wody dla mąk chlebowych (pszenna, żytnia) stwierdzili Moreira i wsp. [14], Ocieczek [15], Pałacha i Walczak [19], oraz dla mąk

niechlebowych (tapioka, pochrzyn, sezam) Chisté i wsp. [4], Menkow i Durakowa [13], Owo i wsp. [16].

3. Dopasowanie modelu GAB do danych adsorpcji wody

Do opisu izoterm adsorpcji wody badanych mąk wykorzystano model GAB. W tabeli 2 zestawiono obliczone parametry odnoszące się do 4 rodzajów mąk w zastosowanym modelu izoterm adsorpcji oraz pokazano zgodność dopasowania tego modelu, wyrażoną przez współczynnik determinacji (R^2) i średni błąd kwadratowy (RMS).

Tabela 2. Obliczone parametry modelu GAB izoterm adsorpcji wody badanych mąk niechlebowych

Table 2. Calculated parameters of GAB model of water adsorption isotherms of studied non-bread flours

Parametry modelu GAB	Mąki niechlebowe			
	kukurydziana	jaglana	owsiana	ryżowa
u_m	7,387	7,868	7,583	8,001
C	14,332	12,231	9,200	14,724
k	0,772	0,714	0,741	0,721
R^2	0,9939	0,9955	0,9880	0,9963
RMS, %	4,36	2,84	7,11	2,85

Źródło: Badania własne

Source: The own study

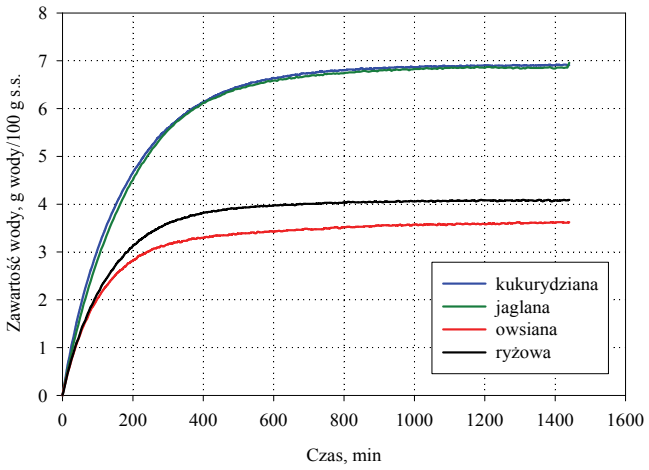
Analiza danych wskazuje, że współczynnik determinacji nie jest wystarczającą miarą dla zgodności dopasowania modelu sorpcji, a znacznie lepszym kryterium zgodności dopasowania jest średni błąd kwadratowy. Przyjmując wartość RMS na poziomie niższym od 10%, jako dobrą zgodność dopasowania modelu do danych sorpcyjnych, należy stwierdzić, że założenie to spełnił model GAB. Wartości liczbowe błędu RMS dla modelu GAB kształtowały się na poziomie od 2,84% dla mąki jaglanej do 7,11% dla mąki owsianej. Graficzne dopasowanie danych uzyskanych z modelu GAB do izoterm adsorpcji wody badanych mąk przedstawiono na rysunku 1.

Wartości stałych (tab. 2), uzyskane z modelu GAB dla badanych mąk, tj. zawartość wody w monowarstwie (u_m) oraz C i k związane z energią oddziaływań między pierwszą a dalszymi adsorbowanymi cząsteczkami wody przez indywidualne centra adsorpcji matrycy, poprawnie opisują sigmoidalny kształt izotermy [12].

Największą zawartość wody w monowarstwie w procesie adsorpcji wody stwierdzono dla mąki ryżowej (8,001 g wody/100 g s.s.). Mąka jaglana posiadała zawartość wody na poziomie monowarstwy mniejszą o 1,66%, mąka owsiana o 5,22%, a mąka kukurydziana o 7,67% od u_m mąki ryżowej. Podobne wartości u_m stwierdzili Pałacha i Walczak [19] dla mąk pszennej i żytniej.

Stała C odzwierciedla wartość czystego izosterycznego ciepła adsorpcji wody na poziomie monowarstwy [17]. Określa ona dodatkowy nakład energii (oprócz ciepła parowania) jaki musi być dostarczony do materiału, aby usunąć z niego wodę. Pośrednio, określa więc siłę wiązania wody przez matrycę materiału na poziomie monowarstwy. Z przytoczonych danych wynika (tab. 2), że najmocniej woda była związana z suchą matrycą w mąkach ryżowej (C = 14,724) i kukurydzianej (C = 14,332), a najsłabiej w mące owsianej (C = 9,200).

4. Przebieg krzywych kinetycznych adsorpcji wody

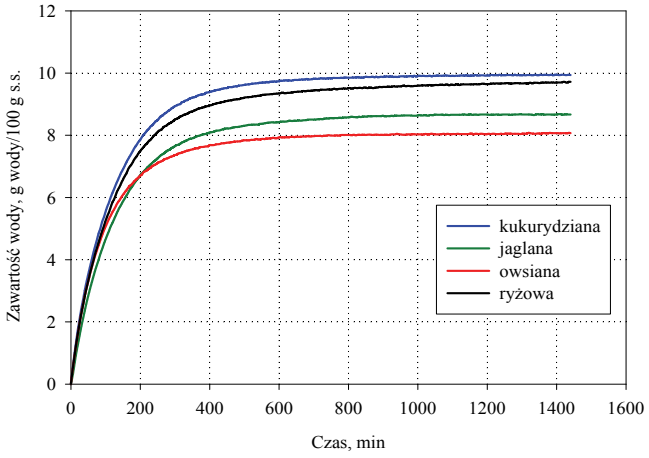


Rys. 2. Krzywe kinetyczne adsorpcji wody w mąkach w środowisku o wilgotności względnej 32,8% (a_w = 0,328).

Fig. 2. Kinetic curves of water adsorption in flours in an environment with a relative humidity of 32,8% (a_w = 0,328).

Źródło: Badania własne

Source: The own study



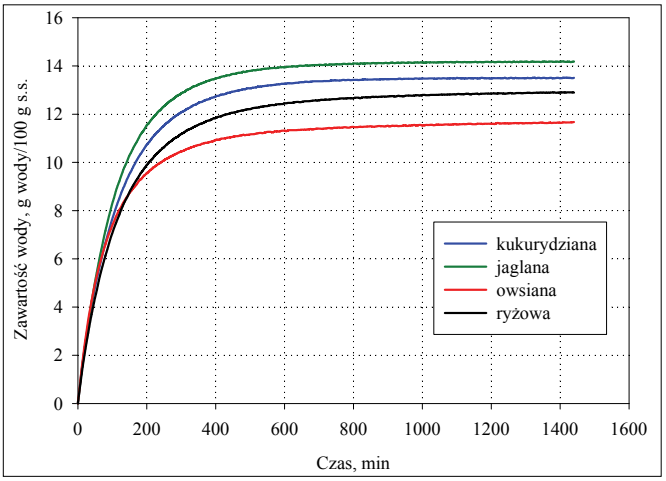
Rys. 3. Krzywe kinetyczne adsorpcji wody w mąkach w środowisku o wilgotności względnej 52,9% (a_w = 0,529).

Fig. 3. Kinetic curves of water adsorption in flours in an environment with a relative humidity of 52,9% (a_w = 0,529).

Źródło: Badania własne

Source: The own study

Na rysunkach 2-5 przedstawiono przebieg krzywych kinetycznych adsorpcji wody dla mąki kukurydzianej, jaglanej, owsianej i ryżowej w środowisku o różnej wilgotności względnej. W środowisku o najniższej wilgotności względnej 32,8% (rys. 2) największą zdolnością adsorpcji wody, a tym samym największą higroskopijnością, wykazały się mąki kukurydziana i jaglana, których krzywe kinetyczne były bardzo zbliżone

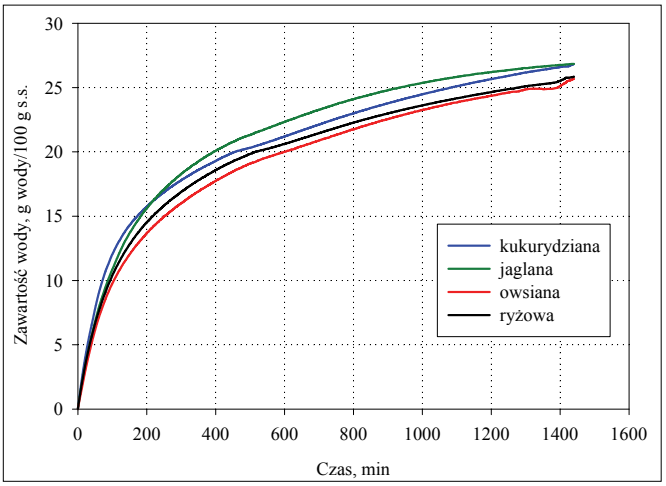


Rys. 4. Krzywe kinetyczne adsorpcji wody w mąkach w środowisku o wilgotności względnej 75,3% (a_w = 0,753).

Fig. 4. Kinetic curves of water adsorption in flours in an environment with a relative humidity of 75,3% (a_w = 0,753).

Źródło: Badania własne

Source: The own study



Rys. 5. Krzywe kinetyczne adsorpcji wody w mąkach w środowisku o wilgotności względnej 100,0% (a_w = 1,000).

Fig. 5. Kinetic curves of water adsorption in flours in an environment with a relative humidity of 100,0% (a_w = 1,000).

Źródło: Badania własne

Source: The own study

do siebie. Znacznie słabiej chłonęła wodę mąka ryżowa, a najmniej higroskopijną okazała się mąka owsiana. W środowisku o wilgotności względnej 52,9% (rys. 3), ponownie największą higroskopijność wykazała mąka kukurydziana, nieco mniejszą cechowała się mąka ryżowa. Z kolei mąka jaglana charakteryzowała się mniejszą higroskopijnością w odniesieniu do nich, a ponownie najmniejszą higroskopijność posiadała mąka owsiana. W środowisku o wilgotności względnej 75,3% (rys. 4) najbardziej chłonęła wodę mąka jaglana, nieco gorzej mąki kukurydziana i ryżowa, a ponownie najsłabiej mąka owsiana. W środowisku o największej wilgotności względnej 100% (rys. 5) krzywe kinetyczne wszystkich mąk posiadały najbardziej zbliżony do siebie przebieg, zachowując tę samą kolejność jak w środowisku o φ = 75,3%.

Ogólnie, bez względu na wilgotność względną środowiska, największą zdolność adsorpcji wody przez mąki stwierdzono w czasie do 500 minut procesu sorpcji. Po tym czasie, krzywe kinetyczne zbliżały się do stanu równowagi wilgotnościowej, przy czym przebieg krzywych kinetycznych w środowisku o φ = 100%, zdecydowanie odbiegał od pozostałych środowisk.

5. Dopasowanie modelu Ficka do danych sorpcyjnych

W tabeli 3 zestawiono obliczone parametry kinetyczne modelu Ficka oraz pokazano zgodność dopasowania modelu, wyrażoną przez współczynnik determinacji (R^2). Wartości R^2 generalnie były wyższe od 0,99, co świadczy o bardzo dobrym dopasowaniu modelu do danych sorpcyjnych.

Tabela 3. Parametry modelu Ficka dopasowanego do danych sorpcyjnych badanych mąk

Table 3. Parameters of the Fick's model fitted to the sorption data of studied flours

Rodzaj mąki	Parametry modelu Ficka	Wilgotność względna środowiska, φ [%]			
		32,8	52,9	75,3	100,0
Kukurydziana	u_r	6,896	9,885	13,437	25,931
	A	0,9731	0,9623	0,9618	0,7832
	K	0,0055	0,0077	0,0078	0,0028
	R^2	0,9998	0,9992	0,9988	0,9762
Jaglana	u_r	6,689	8,610	14,101	26,240
	A	0,9684	0,9790	0,9805	0,8630
	K	0,0049	0,0074	0,0084	0,0033
	R^2	0,9988	0,9987	0,9990	0,9848
Owsiana	u_r	3,540	7,994	11,471	24,875
	A	0,9473	0,9461	0,9188	0,8440
	K	0,0075	0,0090	0,0087	0,0027
	R^2	0,9929	0,9967	0,9920	0,9814
Ryżowa	u_r	4,055	9,570	12,741	25,499
	A	0,9799	0,9547	0,9493	0,8399
	K	0,0072	0,0073	0,0071	0,0031
	R^2	0,9993	0,9976	0,9967	0,9810

Źródło: Badania własne

Source: The own study

Ogólnie, najniższe wartości równowagowej zawartości wody (u_r), bez względu na rodzaj mąki, zanotowano w środowisku o wilgotności względnej 32,8%, a najwyższe w środowisku o φ = 100%. W środowisku o φ = 32,8% najwyższą wartość posiadała mąka kukurydziana 6,896 g wody/100 g s.s., i nieco mniejszą mąka jaglana 6,689 g wody/100 g s.s.. Wartości u_r dla mąki ryżowej były o 41,2%, a dla mąki owsianej o 48,7% niższe od wartości u_r dla mąki kukurydzianej.

W środowisku o φ = 52,9% ponownie najwyższą wartość u_r posiadała mąka kukurydziana 9,885 g wody/100 g s.s., i nieco mniejszą mąka ryżowa 9,570 g wody/100 g s.s. Z kolei wartości u_r dla mąki jaglanej były o 12,9%, a dla mąki owsianej o 19,1% niższe od wartości u_r dla mąki kukurydzianej.

W środowisku o φ = 75,3% największą wartość u_r stwierdzono w mące jaglanej 14,101 g wody/100 g s.s., mniejszą o 4,7% w mące kukurydzianej, mniejszą o 9,6% w mące ryżowej, a najmniejszą w mące owsianej (o 18,6%).

W środowisku o φ = 100% największą wartość u_r stwierdzono ponownie w mące jaglanej 26,240 g wody/100 g s.s., nieco mniejszą w mąkach kukurydzianej i ryżowej, odpowiednio o 1,2 i 2,8%. Najmniejszą wartość u_r posiadała mąka owsiana o 5,2% mniejszą od mąki jaglanej.

Stała A (współczynnik kształtu) praktycznie dla wszystkich rodzajów mąk (poza jaglaną) zmniejszała swoją wartość wraz ze wzrostem wilgotności względnej środowiska (tab. 3). Z kolei, na wartość parametru K, powiązanego ze współczynnikiem dyfuzji, wilgotność względna środowiska nie miała jednoznacznego wpływu.

Tabela 4. Wartości równowagowej zawartości wody wyznaczone metodą statyczno-eksykatorową (ue) oraz obliczone z modelu Ficka (ur) przy aktywności wody 0,328; 0,529; 0,753 i 1,000

Table 4. The equilibrium water content values determined by the static gravimetric method (ue) and calculated from the Fick model (ur) at 0,328, 0,529, 0,753 and 1,000 water activity

Rodzaj mąki	a_w = 0,328		a_w = 0,529		a_w = 0,753		a_w = 1,000	
	u_e	u_r	u_e	u_r	u_e	u_r	u_e	u_r
Kukurydziana	8,181	6,896	11,984	9,885	17,297	13,436	-	25,931
Jaglana	7,990	6,689	11,589	8,610	16,427	14,101	-	26,240
Owsiana	7,395	3,540	10,693	7,994	17,285	11,471	-	24,875
Ryżowa	8,611	4,055	12,286	9,571	16,555	12,741	-	25,499

Źródło: Badania własne

Source: The own study

Dokonano porównania wartości równowagowej zawartości wody (u_e) uzyskanych w metodzie statyczno-eksykatorowej z prognozowanymi wartościami u_r wyznaczonymi z modelu Ficka (tab. 4). Ogólnie, wartości u_e wyznaczone w metodzie statyczno-eksykatorowej były większe od wartości u_r otrzymanych z modelu Ficka dla wszystkich rodzajów mąk w środowisku o wilgotności względnej od 32,8 do 75,3%. Świadczy to o tym, że czas w metodzie dynamicznej wynoszący 24 godziny był za krótki, aby materiał zbliżył się do stanu równowagi wilgotnościowej z otaczającym go środowiskiem. Wydłużenie czasu w metodzie dynamicznej do 72 lub 96 godzin, prawdopodobnie bardziej zbliżyłoby wartości u_r do u_e.

WNIOSKI

1. Izotermy adsorpcji wody wszystkich badanych mąk niechlebowych należały do II typu izoterm, zgodnie z klasyfikacją Brunauera i współpracowników.
2. Model GAB dobrze opisywał dane sorpcyjne badanych mąk. Obliczony średni błąd kwadratowy nie przekroczył wartości 8%.
3. Największą zawartość wody na poziomie monowarstwy wyznaczoną z modelu GAB posiadała mąka ryżowa, a najmniejszą mąka kukurydziana.
4. Sorpcja wody oraz zawartość wody w badanych mąkach wzrastała wraz ze wzrostem wilgotności względnej środowiska i była uwarunkowana różnicą wilgotności między otoczeniem a materiałem.
5. Najmniejszą zdolnością chłonięcia pary wodnej charakteryzowała się mąka owsiana, a największą mąki jaglana i kukurydziana.
6. Model kinetyczny Ficka poprawnie opisywał dane sorpcyjne badanych mąk. Uzyskane wartości współczynnika determinacji ogólnie były większe od 0,99.
7. Badane mąki po 24 godzinach procesu sorpcji wody nie osiągnęły równowagowej zawartości wody w środowisku o zróżnicowanej wilgotności względnej.

CONCLUSIONS

1. The water adsorption isotherms of the tested non-bread flours belonged to second type of isotherms according to the Brunauer's classification.
2. The GAB model well described the sorption data of the tested flours. The calculated root mean square error did not exceed 8%.
3. Rice flour had the highest water content at the monolayer level determined from the GAB model, and corn flour the lowest.
4. Water sorption and water content in the tested flours increased with the increase of the relative humidity of the environment and was conditioned by the difference in humidity between the environment and the material.
5. The lowest ability to adsorb water vapor was fund in oat flour, and the highest in millet and corn flour.
6. The Fick kinetic model correctly described the sorption data of the tested flours. The obtained coefficient of determination values were generally greater than 0,99.
7. Tested flours after 24 hours of water sorption did not achieved equilibrium water content in an environment with differential relative humidity.

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THE METHOD OF MATHEMATICAL SHAPE MODELLING FOR THE USE OF THE DESIGN OF BIODEGRADABLE VESSELS®

Metoda matematycznego modelowania kształtu na użytek projektowania naczyń biodegradowalnych®

A method of mathematical modelling of shape was proposed for the design of biodegradable vessels (plates, cups, platters). In order to describe the shape of the contour lines of the vessels, a third-degree polynomial was used, known as the Bézier curve. The model also used parametric cylinder equations. The rotational surfaces of the vessel components (external and internal surfaces of the vessel sidewalls, external and internal surfaces of the bottom of the vessel and the surface connecting the sidewalls) were described using equations. The individual components of the vessel surface were scaled. The 3D models of the vessels were created after putting together their mathematically described rotational surfaces.

Key words: vessels, shape, 3D models, mathematical modelling.

Zaproponowano metodę matematycznego modelowania kształtu na użytek projektowania naczyń biodegradowalnych (talerzy, kubków, półmisków). Do opisu kształtu linii konturowych naczyń zastosowano wielomian trzeciego stopnia, znany pod nazwą krzywej Béziera. W modelu zastosowano również parametryczne równania cylindra. Opisano za pomocą równań obrotowe powierzchnie składowych elementów naczynia (powierzchnie zewnętrzną i wewnętrzną ścianek bocznych naczynia, powierzchnie zewnętrzną i wewnętrzną dna naczynia oraz powierzchnię łączącą ścianki boczne). Dokonano skalowania poszczególnych składowych powierzchni naczynia. Modele 3D brył naczyń powstały po złożeniu opisanych matematycznie powierzchni obrotowych.

Słowa kluczowe: naczynia, kształt, modele 3D, modelowanie matematyczne.

INTRODUCTION

Ceramic dishes have been known since the earliest times. Tableware was used in the Cretan, Greek, Etruscan and Roman civilizations, so the history of tableware begins with these civilizations. Pottery, faience, stoneware, porcelain, glass and other products were made. It was their shape that constituted the practical and artistic value of these dishes, apart from ornaments and decorations. Clay bowls, platters, plates, cups with handles were made. Over the years of the Middle Ages, the shapes of the dishes produced varied, as did the raw materials for their production. In the glass industry, the basic ingredient for kitchen utensils was tin-lead. Porcelain appeared in Europe at the beginning of the 18th century, and it had been known to the Chinese as early as the third century BC. The Phoenicians produced transparent glass containers. Mass production of ceramics in Europe began to develop in the 19th century. Models, templates and various moulds were widely used. The glass industry has been known in Polish lands since the 15th and 16th centuries, and flourished in 1960–1980. In recent years, the production of glassware has mainly been directed to the creation of attractive designs and shapes. The use of modern design methods and production technologies was an important factor that affected the development of manufacturers of dishes [1, 7, 61]. The needs and expectations of customers are an actuating factor for the company's operations [8, 12]. According to Zabrocki and Cordice's research in the field of gastronomy services [63], English consumers pay particular attention to the form of dishes. According to Gheribi [11], gastronomy services are among important forms of the service activity. The patterns on manufactured dishes are protected by industrial patents [1, 58, 59]. Contemporary development of tourism [35] forces entrepreneurs to produce vessels of high quality. Over 150,000 items from the wide range of stoneware vessels manufactured in only one factory in Poland [7, 38, 61] are characterized by

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a large variety of shapes, patterns and decorations. These goals are achievable because modern computer techniques are used to support design decisions. The plate bowl, protected by the invention law, is equipped with a cast ornament in the form of flowers with leafs, which is distributed over the entire surface [58, 59]. The dynamic development of computer programs to support numerical calculations, e.g. Matlab, Mathcad, Maple, Mathematica, enables mathematical modelling of the surface of objects, including dishes used in gastronomy. Computer aided design, particularly process simulation and animation, is the basic tool of a modern designer. Geometric models forming 2D and 3D lines are visualized using methods classified as computer graphics. Searching for new shapes of the lines in the modelled vessels', particularly solids representing vessel shapes, have a great cognitive value, especially for numerical testing of many working processes, e.g. packaging, storage [6, 56, 60]. The shapes of the dishes are dictated by the current fashion and aesthetic tastes of customers. The shapes used in the vessels are usually irregular, which is why they cannot be represented by regular geometric forms, such as: sphere, ellipsoid, cylinder, cube, etc., [4]. In the initial phase of vessel design, especially when developing many concepts, solids presented in a discrete form are of great importance. The connected points of the modelled discrete surface form a grid which is a set of connected oblique triangles. Surface models represent the coordinates of points, segments and curves in 2D and 3D systems, with which the shapes of modelled objects are defined, along with the attributes assigned to them. According to Prusakowski et al. [48], when modelling 3D objects that are complex in shape, it is preferable to use curvilinear representation, due to the use of a small number of parameters. Vessel shapes can be represented by Bézier curves and surfaces [27, 28] during mathematical modelling. Bézier curves and surfaces are used in computer aided design (CAD), such as: CorelDRAW, Adobe Illustrator, Solid Edge, Solid Works, Catia and others [19, 24, 37,49]. The creator of polynomial curves was Pierre Bézier, a French engineer and mathematician [16, 49, 50]. The implementation of the 3D object design using CAD systems in digital space is applicable to static and dynamic analyses, from the simplest of transformations to complex animations [10, 22]. Mieszkalski [36] proposed the use of Bézier curves to model the shape of biological objects, characterized by a variety of unique shapes. A method of transforming Bézier curves into B-spline curves for surface measurements used in numerically controlled machine tools was proposed by Kawalec and Magdziak [26]. Another method that enables the visualization of the line of solid penetration in a projection on a selected plane was proposed by Dworecki et al. [9]. Reclik and Koc [53] recognize the need to develop a module for off-line programming of industrial robots based on spatial B-spline curves. The use of spline functions in parametric notation as well as the proper selection of boundary conditions and approximation functions [31, 32, 33, 34] increase the accuracy of mapping objects with large distortions. The set of parametric curves is used to model the objects that vary in shape [64]. Biegelbauer and Vincze [3] developed a method for detecting laser-scanned 3D objects by adjusting the formula of a special curve. The proposed method can be used in the automation of the detection of object shapes occurring in the real environment and can be helpful in detecting product damage on production lines, and even in detecting deformation [55]. This method is used to describe volumetric models during the gripping operation of robot manipulators with grips [25]. The adjustment occurs when the coordinates of the points are known from the 3D model and belong to the parts involved in the work process. Ramamoorthi and Arvo [52] proposed an innovative approach to creating models from images of real objects using data from various acquisition techniques. In modelling vessels, Cálin-Şerban Bárbat [5] presents interesting surface shapes in his work.

As a result of diverse human activities, problems emerge that are related to environmental protection [13, 17, 65]. It is common practice nowadays to use plastics that biodegrade over a very long time in the production of packaging and disposable dishes. Most of the plastics used for packaging is made of synthetic polymers, mainly derivatives of crude oil processing. In the food industry, plastics such as polystyrene (PS), polypropylene (PP), polyethylene (PE), polyester (PET) are used to a large extent. Biological (natural) plastics may be competitive to classic petroleum-based plastics [30, 39, 66, 67]. Biodegradable materials are subject to decomposition into components naturally occurring in nature – therefore they do not remain in the environment for many years, and their decomposition occurs similarly to that of organic matter.

Mitrus et al. [39, 40] conducted research whose results helped to determine the effect of extrusion process parameters on selected physical properties of modified potato starch. In agricultural and food processing, the extrusion technique is used, similar to the thermoplastic extrusion technique used in the plastics industry [40, 45]. On the basis of their research, Kucharek and Janas [29] obtained polysaccharide gel and edible foil intended for use in the food packaging industry. Basiak and Lenart believe that edible starch coatings based on both proteins and polysaccharides can be used to produce packaging that extend the durability of some food products [2, 46]. The main process in the transformation of thermoplastic starch is the pressure-thermal process [42]. Mościcki et al. [41, 44, 51] claim that an increase in elasticity and strength of thermoplastic starch can be achieved by using plasticizers in the form of glycerine, propylene glycol, glucose, sorbitol and additives such as emulsifiers, cellulose or pectin. Biomaterials can also be used in 3D printing methods [23, 43].

There have been unsuccessful attempts to produce plates and disposable packaging from waste materials from fruit and vegetable processing, as well as beet pulp, banana and orange peels, and potato peels. Wheat bran proved to be a good material for making disposable dishes. Dishes made from bran behave like traditional dishes do not affect flavours or smells and can be used for cold and warm dishes and drinks. Dishes made from bran will be biodegradable after just about 3 months [http://www.ekonsument.pl/news-show-377.php]. They also have additional advantages: they are functional, aesthetic, they can have different sizes and shapes. Dishes from bran can be used in restaurants, in small gastronomy, as well as in cafes and tea shops. Most importantly – they are edible; they can be food for both humans and animals. If they get into the soil, then the soil microorganisms will have eventually made compost from them. Biodegradable materials can be used for the production of e.g. plates, knives, cups for cold and warm drinks, trays, moulds and all other kinds of

packaging. The material for the production of biodegradable moulds as well as dishes and packaging is specified in Patent No. 195130 [62]. According to this patent, wheat bran trays are produced and available on the Polish market (Fig. 1) without any additives harmful to health, which are single-use packaging, biodegradable and useful for composting.

Fig. 1. Examples of currently produced wheat bran dishes, according to the idea of J. Wysocki [21].
Rys. 1. Przykładowe naczynia z otrąb pszennych obecnie produkowane według pomysłu J. Wysockiego [21].
Saurce: Own study
Źródło: Opracowanie własne

In order to produce a suitable shape of a biodegradable vessel made of wheat bran, a mould is needed in which the applied mass is compressed [21]. An example of such a mould is shown in Figure 2.

Fig. 2. The mould for a divided tray [21].
Rys. 2. Forma dzielonej tacki [21].
Saurce: Own study
Źródło: Opracowanie własne

Research is being carried out in many scientific centres (e.g. Szczecin, Warsaw) on edible protective coatings applied directly to the surface of chopped vegetables and fruits.

From a strategic point of view, in the effective implementation of biodegradable materials, the great challenge is to inspire graphic and industrial designers to create projects that guarantee the achievement of intended goals, and, above all, to develop the desire to search for original concepts for the creation of new products.

Shape description techniques are mainly implemented on the basis of 2D contour models or simplified 3D models, e.g. sphere, ellipsoid [18], which leads to the loss of shape data. The shape model developed analytically or with the help of 3D scanners contains much more information, which can lead to better and more precise design decisions. Polynomial curve notation was used to describe the cross-sectional contours of biodegradable vessels. The described shapes of 3D biodegradable objects in digital space using computer graphics tools and differential geometry are then used for static and dynamic analyses in CAD systems, from the simplest transformations to complex animations.

According to Jakubicki [20], the emergence of new tools in the field of computer design causes a change of the entire work system in the production engineering of furniture and utensils for catering, hotels or restaurants. The introduction of virtual space into the design, in which you can model any objects, triggers a large potential of design possibilities, especially in connection with the Internet. Designers have at their disposal systems of computer-aided design and CAD calculations that enable the design of complex objects in 3D systems [14, 15, 54]. Stolarewicz [57] believes that, despite the advantages of CAD systems, they are still labour-intensive, because they require a lot of data input in order to gain insight into the final effect. Computational algorithms and mathematical modelling in the process of creating new products constitute the basis of the design process. Mathematical models enable generation of various forms by introducing parameterization of the structure. Computational algorithms enable simulation and analysis of the impact of various factors on the shape of the object mould. In the modern design procedure, it is before building the prototype that a simulation and numerical research is carried out in the scope of correctness of construction, functionality, strength and parameterization of the structure [47, 54, 57]. The development of computer-aided calculation methods sets a modern trend in the modular system for the production of products and utensils used in catering, restaurant and hotel establishments.

THE AIM OF THE PAPER

The aim of the paper is to develop a method of mathematical modelling of the shape of selected biodegradable vessels, e.g. soup and dinner plates, low and tall cups and a platter.

List of important symbols: N – number of meridians and parallels on a discrete spatial surface describing the shape of the vessel, i – number of rows in the matrix, j – number of columns in the matrix, j, J – angles of range variables [rad], r – radius of the vessel [mm], b – vessel height [mm], hd – vessel wall thickness [mm], a, b, c, d, aw, bw, cw, dw, m, p, f – shape control parameters.

THE DESCRIPTION OF THE METHOD

The method of mathematical modelling of shape for the purpose of designing biodegradable dishes (plates, cups, platters) consists in obtaining the component surfaces of the vessel by turning the curves of given shapes. The contour lines of the vessels are described using a third-degree polynomial (Bézier curve). The model also uses parametric cylinder equations. The equations describe the rotational surfaces of the vessel components, such as: the outer and inner surfaces of the side walls of the vessel, the outer and inner surfaces of the bottom of the vessel, and the surface connecting the side walls. The individual components of the vessel were scaled. The 3D models of the vessels were created after putting together their mathematically described rotational surfaces.

MATHEMATICAL MODEL OF THE VESSEL SHAPE

The number of meridians and parallels on the surface of the modelled vessel as well as the parameters for determining range variables are given in vector 1.

$$\begin{bmatrix} N \\ i \\ j \end{bmatrix} = \begin{bmatrix} 50 \\ 0 \cdots N \\ 0 \ldots N \end{bmatrix} \tag{1}$$

The angles for range variables that occur in the mathematical model describing the shape of the vessel's body are given below:

$$\varphi_i = \frac{i \cdot 2 \cdot \pi}{N} \tag{2}$$

$$\vartheta j = \frac{j}{N} \tag{3}$$

The equation of the curve, which upon rotation describes the outer surface of the vessel, has the following form:

$$E_j = (1 - \vartheta_j)^2 \cdot a + \vartheta_j (1 - \vartheta_j)^2 \cdot b + (\vartheta_j)^2 \cdot (1 - \vartheta_j) \cdot c + (\vartheta_j)^2 \cdot d \tag{4}$$

The equations for the rotation of curve 4 have the form of:

$$Xa_{ij} = \frac{E_j \cdot \cos \varphi_i}{N} \tag{5}$$

$$Ya_{ij} = \frac{E_j \cdot \sin \varphi_i}{N} \tag{6}$$

Obtaining the given dimensions for the outer surface of the vessel model requires scaling of equations 5, 6. Matrix equations of coordinates describing (for a given shape) the basic dimensions of the model of the outer surface of the vessel have the following form:

$$Xz = \frac{2 \cdot \mathrm{r}}{max\,(Xa) - min\,(Xa)} \cdot Xa \tag{7}$$

$$Yz = \frac{2 \cdot \mathrm{r}}{max\,(Ya) - min\,(Ya)} \cdot Ya \tag{8}$$

$$Zz_{i,j} = \frac{\mathrm{h} \cdot j}{N} \tag{9}$$

The equation of the curve, which upon rotation describes the outer surface of the bottom of the vessel, has the following form:

$$E\mathbf{1}_j = (1 - \vartheta_j)^2 + m \cdot \vartheta_j (1 - \vartheta_j)^2 + p \cdot (1 - \vartheta_j)^2 \cdot (\vartheta_j) + (\vartheta_j)^2 \cdot f \tag{10}$$

The equations for the rotation of curve 10 have the form of:

$$X\mathbf{1}a_{i,j} = \frac{E\mathbf{1}_j \cdot \cos \varphi_i}{N} \tag{11}$$

$$Y\mathbf{1}a_{i,j} = \frac{E\mathbf{1}_j \cdot \sin \varphi_i}{N} \tag{12}$$

In order to obtain the given dimensions of the vessel bottom compliant with the dimensions of the outer surface of the vessel model requires scaling of equations 11, 12. Matrix equations of coordinates describing the basic dimensions of the model of the outer surface of the bottom of the vessel have the following form:

$$X\mathbf{1} = \frac{2 \cdot max(X_{N,0})}{max\,(X\mathbf{1}a) - min\,(X\mathbf{1}a)} \cdot X\mathbf{1}a \tag{13}$$

$$Y\mathbf{1} = \frac{2 \cdot max(Y_{N,0})}{max\,(Y\mathbf{1}a) - min\,(Y\mathbf{1}a)} \cdot Y\mathbf{1}a \tag{14}$$

$$Z\mathbf{1}_{i,j} = 0 \tag{15}$$

The equation of the curve, which upon rotation describes the inner surface of the vessel, has the following form:

$$Ew_j = (1 - \vartheta_j)^2 \cdot aw + \vartheta_j (1 - \vartheta_j)^2 \cdot bw + (\vartheta_j)^2 \cdot (1 - \vartheta_j) \cdot cw + (\vartheta_j)^2 \cdot dw \tag{16}$$

The equations for the rotation of curve 16 have the form of:

$$X\mathbf{2}a_{i,j} = \frac{Ew_j \cdot \cos \varphi_i}{N} \tag{17}$$

$$Y\mathbf{2}a_{i,j} = \frac{Ew_j \cdot \sin \varphi_i}{N} \tag{18}$$

After scaling of equations 17, 18, matrix equations of coordinates describing (for a given shape) the basic dimensions of the model of the inner surface of the vessel have the following form:

$$Xw = \frac{2 \cdot r}{max\,(X\mathbf{2}a) - min\,(X\mathbf{2}a)} \cdot X\mathbf{2}a \tag{19}$$

$$Yw = \frac{2 \cdot r}{max\,(Y\mathbf{2}a) - min\,(Y\mathbf{2}a)} \cdot Y\mathbf{2}a \tag{20}$$

$$Zw_{i,j} = \frac{\mathrm{h} \cdot j}{N} + hd \tag{21}$$

The inner surface of the bottom of the vessel is described by the following equations:

$$X\mathbf{3} = \frac{2 \cdot max(X\mathbf{2}_{N,0})}{max\,(X\mathbf{1}a) - min\,(X\mathbf{1}a)} \cdot X\mathbf{1}a \tag{22}$$

$$Y\mathbf{3} = \frac{2 \cdot max(X\mathbf{2}_{N,0})}{max\,(Y\mathbf{1}a) - min\,(Y\mathbf{1}a)} \cdot Y\mathbf{1}a \tag{23}$$

$$Z\mathbf{3}_{i,j} = hd \tag{24}$$

The lateral surface connecting the outer and inner surfaces of the vessel is described by the equation of the cylinder:

$$X\mathbf{4}\mathrm{a}_{i,j} = \cos \vartheta \mathbf{4}_j \tag{25}$$

$$Y\mathbf{4}\mathrm{a}_{i,j} = \sin \vartheta \mathbf{4}_j \tag{26}$$

Where:

$$\vartheta 4_j = \frac{j \cdot 2 \cdot \pi}{N} \tag{27}$$

After scaling of equations 25, 26, matrix equations of coordinates describing (for a given shape) the basic dimensions of the model of the lateral surface connecting the outer and inner surfaces have the following form:

$$X4 = \frac{2 \cdot r}{max\,(X4a) - min\,(X4a)} \cdot X4a \tag{28}$$

$$Y4 = \frac{2 \cdot r}{max\,(Y4a) - min\,(Y4a)} \cdot Y4a \tag{29}$$

$$Z4_{i,j} = \frac{\mathrm{hd} \cdot \cos \varphi_i}{2} + h + \frac{hd}{2} \tag{30}$$

After submitting the obtained matrices of coordinates of individual vessel elements and inputting the assumed dimensions and shape control parameters, a 3D model of the vessel shape is obtained.

EXAMPLE SHAPES OF SELECTED VESSELS GENERATED ON THE BASIS OF THE MATHEMATICAL VESSEL MODEL

The assumed basic dimensions and shape control parameters that occur in the mathematical model of the vessel shape required to generate a soup plate are written in matrix 31:

$$\begin{bmatrix} r & h & hd & a & b & c & d \\ f & m & p & aw & bw & cw & dw \end{bmatrix} = \\ = \begin{bmatrix} 120 & 50 & 3 & 25 & 150 & 72 & 57.5 \\ 5^{10} & 3 & 3 & 15 & 135 & 72 & 57.5 \end{bmatrix} \tag{31}$$

Figure 3 presents a mesh 3D model of a soup plate generated using a mathematical model of the shape of the vessel and the data contained in matrix 31.

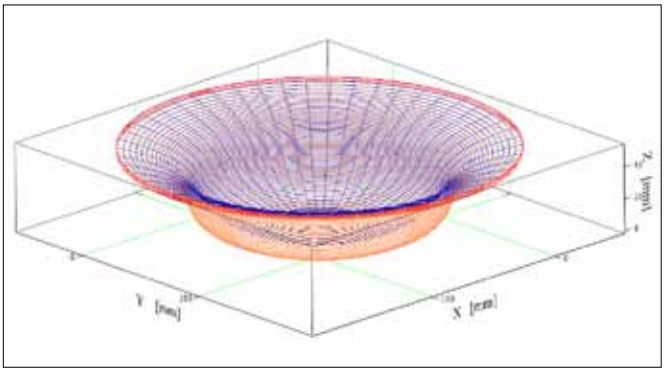

Fig. 3. A mesh 3D model of the shape of a soup plate: *X*, *Y* – radius length [mm], *Z* – height [mm].

Rys. 3. Siatkowy model 3D kształtu talerza głębokiego: *X*, *Y* – wymiar promienia [mm], *Z* – wysokość [mm].

Saurce: Own study

Źródło: Opracowanie własne

The assumed basic dimensions and shape control parameters appearing in the mathematical model of the shape of the dish required to generate the shape of a dinner plate are written in matrix 32:

$$\begin{bmatrix} r & h & hd & a & b & c & d \\ f & m & p & aw & bw & cw & dw \end{bmatrix} = \\ = \begin{bmatrix} 130 & 15 & 3 & 15 & 150 & 72 & 47.5 \\ 5^{10} & 3 & 3 & 15 & 135 & 72 & 57.5 \end{bmatrix} \tag{32}$$

Figure 4 presents a mesh 3D model of a dinner plate generated using a mathematical model of the shape of the dish and the data contained in matrix 32.

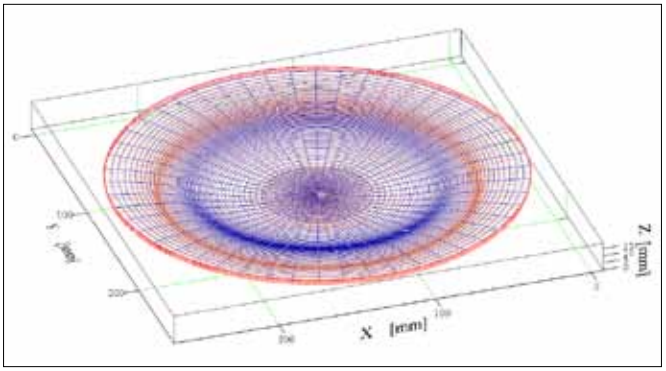

Fig. 4. A mesh 3D model of the shape of a dinner plate: *X*, *Y* – radius length [mm], *Z* – height [mm].

Rys. 4. Siatkowy model 3D kształtu talerza płaskiego: *X*, *Y* – wymiar promienia [mm], *Z* – wysokość [mm].

Saurce: Own study

Źródło: Opracowanie własne

The assumed basic dimensions and shape control parameters appearing in the mathematical model of the shape of the dish required to generate a low cup are written in matrix 33:

$$\begin{bmatrix} r & h & hd & a & b & c & d \\ f & m & p & aw & bw & cw & dw \end{bmatrix} = \\ = \begin{bmatrix} 55 & 65 & 3 & 15 & 150 & 72 & 47.5 \\ 5^{10} & 3 & 3 & 15 & 135 & 72 & 47.5 \end{bmatrix} \tag{33}$$

The assumed basic dimensions and shape control parameters appearing in the mathematical model of the shape of the dish required to generate a tall cup are written in matrix 34:

$$\begin{bmatrix} r & h & hd & a & b & c & d \\ f & m & p & aw & bw & cw & dw \end{bmatrix} = \\ = \begin{bmatrix} 45 & 100 & 3 & 30 & 165 & 120 & 50 \\ 5^{10} & 3 & 3 & 30 & 165 & 120 & 53 \end{bmatrix} \tag{34}$$

Figure 5 presents a mesh 3D model of a low cup generated using a mathematical model of the shape of the dish and the data contained in matrix 33.

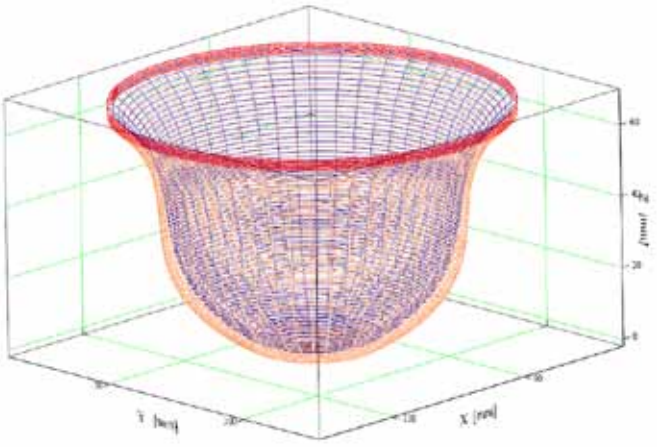

Fig. 5. A mesh 3D model of the shape of a low cup: *X, Y* – radius length [mm], *Z* – height [mm].
Rys. 5. Siatkowy model 3D kształtu kubka niskiego: *X, Y* – wymiar promienia [mm], *Z* – wysokość [mm].
Saurce: Own study
Źródło: Opracowanie własne

Figure 6 presents a mesh 3D model of a tall cup generated using a mathematical model of the shape of the dish and the data contained in matrix 34.

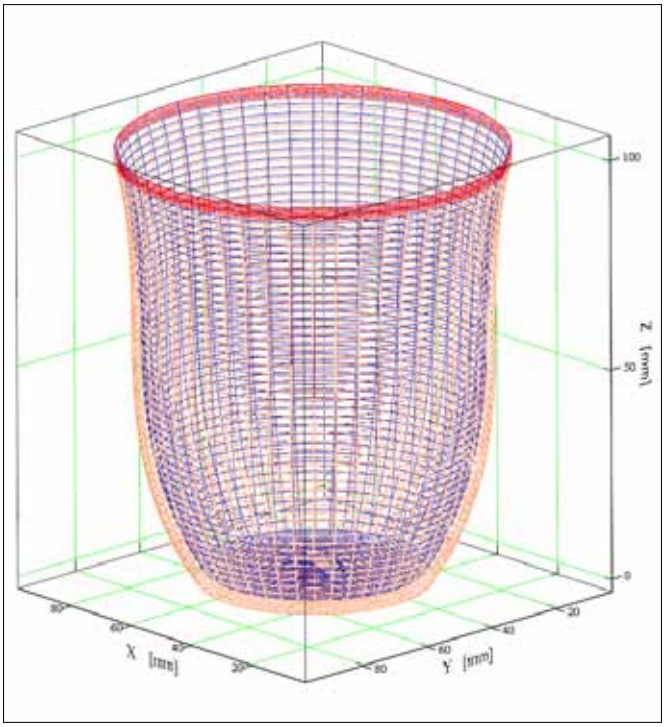

Fig. 6. A mesh 3D model of the shape of a tall cup: *X, Y* – radius length [mm], *Z* – height [mm].
Rys. 6. Siatkowy model 3D kształtu kubka wysokiego: *X, Y* – wymiar promienia [mm], *Z* – wysokość [mm].
Saurce: Own study
Źródło: Opracowanie własne

The assumed basic dimensions and shape control parameters appearing in the mathematical model of the shape of the dish required to generate a platter are written in matrix 35:

$$\begin{bmatrix} r & h & hd & a & b & c & d \\ f & m & p & aw & bw & cw & dw \end{bmatrix} = \begin{bmatrix} 150 & 80 & 5 & 30 & 141 & 105 & 45 \\ 5^{10} & 3 & 3 & 30 & 141 & 105 & 48 \end{bmatrix} \quad (35)$$

Figure 7 presents a mesh 3D model of a platter generated using a mathematical model of the shape of the dish and the data contained in matrix 35.

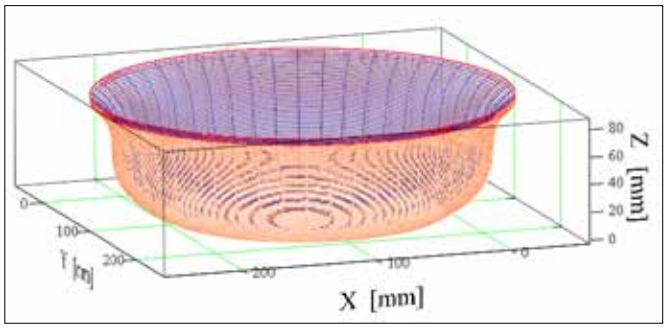

Fig. 7. A mesh 3D model of the shape of a platter: *X, Y* – radius length [mm], *Z* – height [mm].
Rys. 7. Siatkowy model 3D kształtu półmiska: *X, Y* – wymiar promienia [mm], *Z* – wysokość [mm].
Saurce: Own study
Źródło: Opracowanie własne

Changing the value of parameters contained in matrices 28, 29, 30 results in a change in the basic dimensions (radius, height, thickness) and the shape of the modelled vessel.

SUMMARY

The dish designer receives a tool to support the process of creating new shapes that will be used in new projects. In the proposed mathematical model, the contour line is obtained by changing the value of four parameters; the line creates a rotational surface as a result of rotation. Changing the value of the next three parameters results in a change in the basic dimensions of the vessel. The matrix notation of the coordinates of the vertices of the mesh arranged on the modeled surface provides a discreet image of the 3D model of the designed vessel and can be used e.g. for designing moulds.

PODSUMOWANIE

Projektant naczyń dostaje narzędzie wspomagające proces tworzenia nowych kształtów, które znajdą zastosowania w nowych projektach. W proponowanym modelu matematycznym przez zmianę wartości czterech parametrów otrzymuje się kształt linii konturu, która w wyniku obrotu tworzy powierzchnię obrotową. Zmiana wartości kolejnych trzech parametrów skutkuje zmianą podstawowych wymiarów naczynia. Macierzowy zapis współrzędnych wierzchołków siatki ułożonej na modelowanej powierzchni daje dyskretny obraz modelu 3D projektowanego naczynia i może być wykorzystany np. do projektowania form.

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TYPES OF LACTOSE-FREE PRODUCTS AND THEIR AVAILABILITY ON THE POLISH MARKET®

Rodzaje produktów bezlaktozowych i ich dostępność na polskim rynku®

The article reviews the range of lactose-free products, analyzing the information placed on the label in selected stationary and online stores in Poland. 75 lactose-free dairy products were identified, including pasteurized and UHT milk, natural, drinkable and flavored yoghurt, cream, quark cheese, cottage cheese, ripened cheese, spreadable fats and infant formula. It has been shown that online stores were characterized by greater availability of lactose-free products. Nevertheless, the range of these products in stationary stores is constantly increasing. Among the analyzed groups of lactose-free dairy products, the most easily available products were milk and flavored yoghurt. Cottage cheese and cream were the least available. The most lactose-free products available on the market were produced by the Mlekovita Dairy Cooperative. There were no significant differences in composition and nutritional value between the lactose-free and conventional products. However, the differentiating factor was the price of products, which in the case of lactose-free products was from 4 to even 166% higher than in the case of conventional products. There has also been an increasing availability of alternative products for lactose-free dairy products on the Polish market, i.e. drinks or yoghurts based on vegetable raw materials, as well as products in which lactose-free milk was used as an additive i.e. ice-cream, cakes, chocolate.

Key words: lactose-free products, dairy products, lactose, lactose intolerance.

W artykule dokonano przeglądu asortymentu produktów bezlaktozowych, analizując informacje umieszczone na etykiecie, w wybranych sklepach stacjonarnych i internetowych na terenie Polski. Zidentyfikowano 75 produktów mlecznych bezlaktozowych, wśród których znajdowały się mleka pasteryzowane i UHT, jogurty naturalne, pitne oraz smakowe, śmietany, twarogi, serki wiejskie, sery żółte, tłuszcze do smarowania oraz odżywki dla niemowląt. Wykazano, że większą dostępnością produktów bezlaktozowych cechowały się sklepy internetowe. Niemniej jednak asortyment tych produktów w sklepach stacjonarnych ciągle wzrasta. Wśród analizowanych grup produktów mlecznych bezlaktozowych najłatwiej dostępnymi produktami było mleko oraz jogurty smakowe. Najmniejszą dostępnością cechowały się serki wiejskie i śmietany. Najwięcej dostępnych na rynku produktów bezlaktozowych wyprodukowanych zostało przez Spółdzielnię Mleczarską Mlekovita. Nie wykazano istotnych różnic w składzie oraz wartości odżywczej pomiędzy produktami bezlaktozowymi a konwencjonalnymi. Czynnikiem różnicującym była cena produktów, która w przypadku produktów bezlaktozowych była od 4 do nawet 166% wyższa od konwencjonalnych produktów. Zaobserwowano również, wzrastającą dostępność na polskim rynku produktów alternatywnych dla mlecznych produktów bezlaktozowych, tj. napoi czy jogurtów na bazie surowców roślinnych, jak również produktów, w których zastosowano jako dodatek mleko bez laktozy, tj. lodów, ciast, czekolad.

Słowa kluczowe: produkty bezlaktozowe, produkty mleczne, laktoza, nietolerancja laktozy.

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INTRODUCTION

The problem of lactose intolerance is becoming more and more common both in Poland and in the world. It is influenced by various factors, i.e. ethnicity, gastrointestinal tract history, restriction of milk and milk products consumption, or lack of β-D-galactosidase activity [9]. In Poland, every third person suffers from lactose intolerance [18]. In response to consumer needs, the market for lactose-free products is growing dynamically. In 2015, its global value was USD 6.7 billion, of which 80% was dairy. It is estimated that until 2020, the average annual growth rate of the global lactose-free food market will remain at 6% [15]. Despite the growing problem, in Poland and in the European Union there are no legal regulations in the field of food safety that would contain requirements for labeling food products with information on the absence, low or reduced lactose content [6]. The presence of such provisions would significantly facilitate the marketing of lactose-free products on the market and protect consumers.

The purpose of this article is to show the availability of lactose-free products on the Polish market and their characteristics.

MATERIALS AND METHODS

The research material consisted of the information contained on the labels of lactose-free products and conventional products selected for comparison, as well as the information placed on these products on the websites of stores. Lactose-free products in which milk was used as an additive and not as the main product base or its alternatives were also analysed.

The analysis of the availability of lactose-free products and their characteristics was carried out at the turn of March and April 2019 in online stores: www.ezakupy.tesco.pl, www.frisco.pl (lactose-free dairy products), www.koral.com.pl, www.anita.pl, www.tesco.pl, www.guiltfree.pl, www.ekologisfood.pl, www.biodyskont.pl, www.biozona24.pl, www.polskikoszyk.pl, www.zdroweslodycze.pl, www.ekosfera24.pl, www.bezgluten.pl (other lactose-free products) and stationary stores in the Świętokrzyskie province: discount Lidl in Kielce, Tesco Hypermarket in Kielce and at the discount Biedronka in Włoszczowa.

RESULTS AND DISCUSSION

Lactose-free dairy products

75 different lactose-free products were identified in the stores selected for the study (Fig. 1). Some product ranges repeated and appeared in several stores.

Online stores had the largest range of lactose-free products (58% of available products). There were 36 different products (31%) available in the Tesco online store, and 32 products (27%) in the Frisco online store. In the case of stationary stores, as in the case of online stores, the largest range of lactose-free products was in the Tesco stationary store. There were 29 lactose-free dairy products available (25%). The fewest lactose-free products were available in discount stores such as Lidl (12%) and Biedronka (5%).

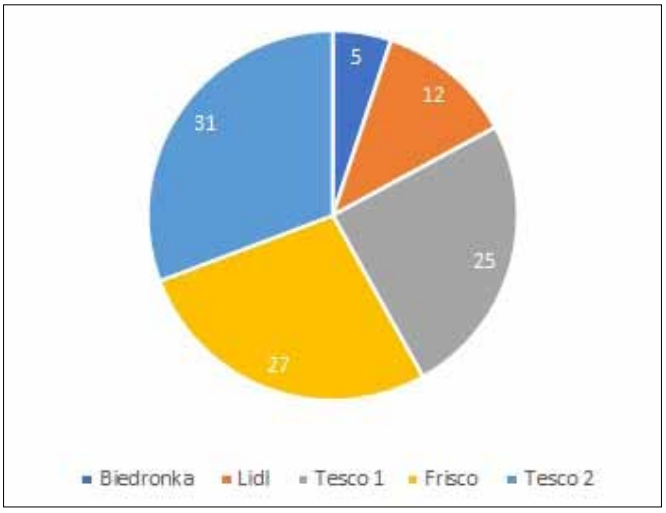

Fig. 1. Availability of lactose-free products in stationary (Biedronka, Lidl, Tesco 1) and online stores (Frisco, Tesco 2) (%).

Rys. 1. Dostępność produktów bezlaktozowych w sklepach stacjonarnych (Biedronka, Lidl, Tesco 1) oraz internetowych (Frisco, Tesco 2) (%).

Source: Own study

Źródło: Badania własne

Unfortunately, most of this assortment - 61% was available only in individual stores, which was difficult for the consumer to buy all the necessary products in one place (Fig. 2).

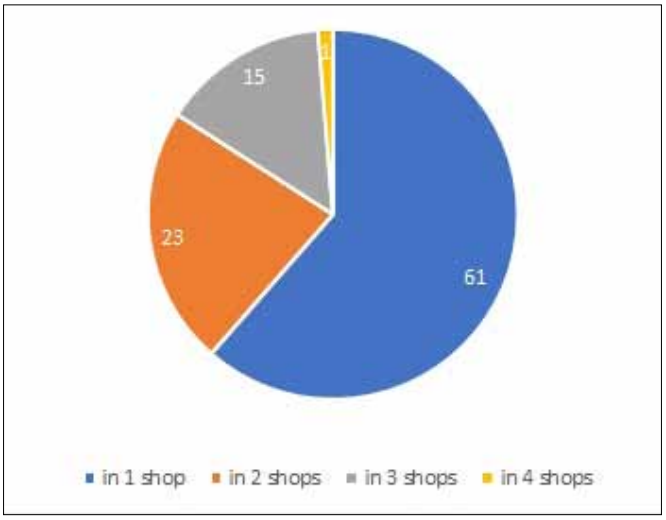

Fig. 2. Availability of lactose-free products in individual stores (%).

Rys. 2. Dostępność produktów bezlaktozowych w poszczególnych sklepach (%).

Source: Own study

Źródło: Badania własne

The availability of lactose-free products varied depending on the type and size of the store and this assortment was much more easily available in online stores. Only one product was available in as many as 4 analyzed stores, and it was 2% fatmilk in a bottle of OSM Piątnica. However, none of them repeated in all the analyzed stores.

Almost half of the products available in the five analyzed stores could be bought in the Tesco and Frisco online store, and then in the Tesco stationary store. There was the lowest availability of such products in the Biedronka discount store.

Dairy products found in various analyzed stores belong to various assortment groups. Fig. 3 presents the distribution of availability of individual groups of dairy products.

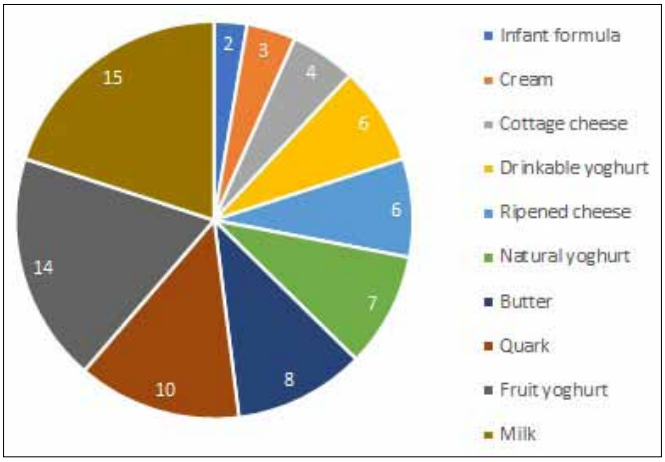

Fig. 3. Availability of various dairy products in the analyzed stores (%).

Rys. 3. Dostępności różnych produktów mleczarskich w analizowanych sklepach (%).

Source: Own study

Źródło: Badania własne

The basic dairy product, i.e. milk, was easily available in all the analyzed stores. 15 types of drinking milk were found, produced by 8 different producers, which constituted 20% of the available range. Flavored yoghurt was another popular dairy product, which accounted for 19% of the lactose-free range. Then quark (13%), spreadable fats (11%), natural yoghurt (9%), ripened cheese and drinking yoghurt (8%). Cottage cheese (5%), cream (4%) as well as baby food (3%) were available in the smallest quantities.

Not many companies are involved in the production of dairy lactose-free products on the Polish market. In the study, products from 25 manufacturers from different countries were available.

The most available products (23%) were produced by the Polish Dairy Cooperative Mlekovita (Fig. 4). This company definitely outperforms other producers in its lactose-free range. The product range offered by Tesco (9%), which produces its lactose-free products under its own brand in Hungary, was much smaller. Only 9% of lactose-free products from the Polish company Mlekpol were available. OSM Łowicz (8%) and Magda Yoghurt (8%) are slightly less, and Bakoma the least (4%). The German company Breisgaumilch provided 7% lactose-free products, and Molkerei Gropper 4%.

Products available from one or two producers accounted for 28% and were German companies (AF Deutschland GmbH, Heirler, MinusLZott, Hochland), Swedish-Danish (Arla), Polish (Bielmar, Lumiko, OSM Grodzisk Mazowiecki, OSM Koło, OSM Maluta, Piątnica), Swiss (Nestle), Italian (Nuova Castelli, Sterilgardaalimenti), French (Nutricia), Dutch-British (Unilever).

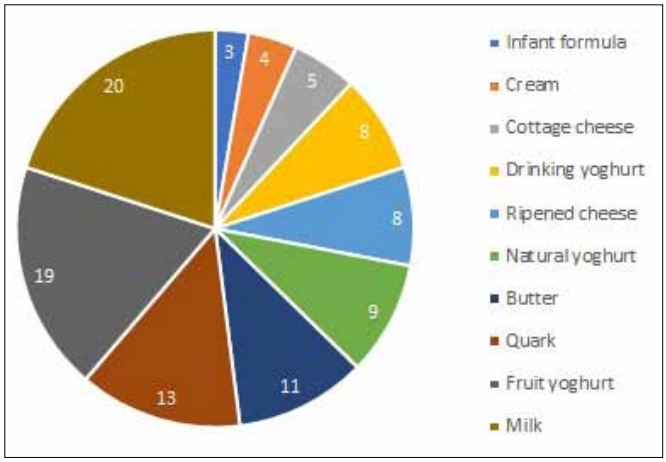

Fig. 4. Availability of the lactose-free product range by manufacturer (%).

Rys. 4. Dostępność asortymentu produktów bez laktozy z podziałem na producentów (%).

Source: Own study

Źródło: Badania własne

In order to achieve the best market position, world producers introduce innovative products and change their production technology. Companies such as Arla Foods, McNeil Nutritionals, Omira, Parmalat and Valio are the leading players on the global market for this type of products [7].

The first Polish company that produced UHT lactose-free milk was the "Maćkowy" District Dairy Cooperative in Gdańsk, which was then taken over by Polmlek [7]. This took place over 30 years ago, and the authors of the technology used were employees of the Department of Food Biotechnology at the University of Warmia and Mazury in Olsztyn [3]. However, until 2010, only Spółdzielnia Mleczarska Gostyń, Polmlek, Okręgowa Spółdzielnia Mleczarska Garwolin and Candia Polska were involved in the production of lactose-free milk. And these products began to be produced on a larger scale only in 2015. At the moment, the range of lactose-free products has developed significantly. In addition to milk, cream or butter, these are also more processed products, i.e. ice cream or ripening cheese [16, 17].

Manufacturers wanted their products to be noticed by potential customers and meet their expectations. Therefore, on the label of each of the available articles it was easy to see the words "lactose-free". However, with careful analysis of the label, we come across the information that the lactose content is <0.01g per 100g / 100ml of product. This is due to the fact that the lactose has not been removed but has only been degraded by the lactase enzyme, so that small amounts may remain. Only 24% of dairy products did not have the information about the lactose content on the label, which may indicate the use of another technology.

Regulation 1169/2011 regulates the list of substances and products causing allergies or intolerances, which include lactose-containing milk [11]. In contrast, the use of the term 'lactosefree' in accordance with the scientific opinion of the Food Safety Authority [5] and the opinion of GIS [6] can be used in the context of the presence of a substance that can cause allergic or intolerance reactions only if the final product

does not contain lactose or if the consumer would expect the presence of lactose in a given product. The maximum allowable level of lactose in "non-lactose" products can be 0.01% (10 mg lactose per 100 g of product), which is at the limit of detection of lactose in the product [14].

Customers who are looking for lactose-free products are particularly worried about their high price. Unfortunately, they are right. The prices of these food products outweigh those of their conventional counterparts. This is due to the increase in the costs of production at which enzyme or membrane methods should be used. The treatment that is most often used for this purpose is enzymatic hydrolysis of lactase, but also membrane filtration – ultrafiltration and diafiltration. These processes are expensive, which means a higher price of the product in the store [2].

For the production of lactose-free milk, enzymatic hydrolysis is applied using preparations of β-galactosidase, which are obtained in the process of microbial biosynthesis using selected strains of bacteria, filamentous fungi or yeast. Manufacturers most often use yeast strains – *Kluyveromyceslactis, Kluyveromycesfragilis* or fungi – *Aspergillus niger* [3]. There are two methods for introducing lactase into the product. The simplest method of producing milk with reduced lactose content is the addition of lactase to the milk batch before UHT treatment. However, the development of aseptic packaging allowed for sterile addition of the enzyme to each milk carton. This reduces the cost of production by using less lactase, and also saves storage time, which is necessary for hydrolysis to be carried out properly [13]. Alternative methods for obtaining lactose-free milk are membrane techniques [3]. In their work, Morlock et al. [10] described a process that consists of three stages based on membrane filtration, followed by reconnection. The stages of this process are: ultrafiltration – the so-called permeate, nanofiltration – filtrate, reverse osmosis. Thanks to this technology, you can separate half of the lactose contained in milk without any other changes in its composition. To eliminate it completely, you can use lactase additionally. Ultimately, milk has the same organoleptic characteristics as a conventional product and is in line with consumer expectations.

Figure 5 shows a comparison of average prices for 100g / 100ml lactose-free and conventional product.

Lactose-free products were more expensive than the conventional ones. The biggest difference in price was visible on the example of lactose-free cream, which was 166% more expensive than conventional cream and ripening cheese, more expensive by 126%. Among lactose-free ripening cheeses, there were cheeses from BIO crops, which further contributed to their much higher price. Pasteurized milk was more expensive by 32% and UHT milk by 62%. Lactose-free drinking yoghurts were more expensive by 30% on average and natural yoghurts by 33%. Lactose-free spreads cost 44% more than conventional spreads, and cottage cheese 48% more.

The smallest price difference was recorded for fruit yoghurt (10%) and lactose-free infant formula (4%).

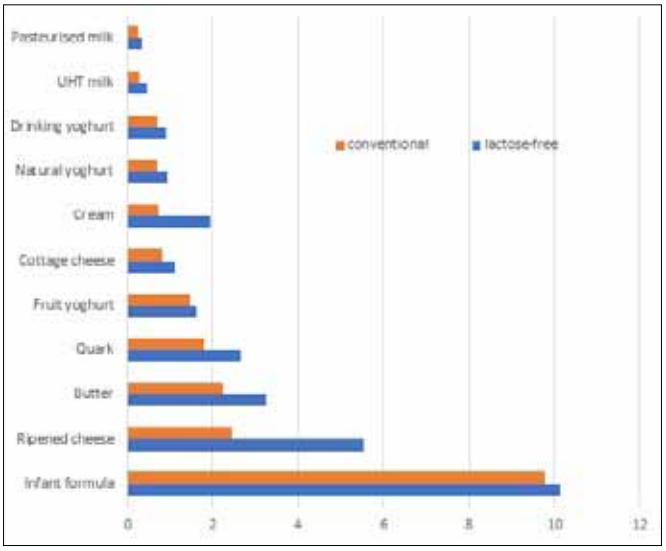

Fig. 5. Average price in PLN for 100g / 100ml lactose and conventional products.

Rys. 5. Średnia cena w PLN za 100g/100ml produktów bezlaktozowych i konwencjonalnych.

Source: Own study

Źródło: Badania własne

The prices of the products largely depended on their producers. The chart below (Fig. 6) presents average prices of selected lactose-free dairy products depending on the manufacturer.

In the analyzed stores, the most expensive lactose-free products were offered by the German company Breisgaumilch (new name Schwarzwaldmilch). The UHT milk produced by this company was by about 150% more expensive than milk offered by Polish producers. Few lactose-free products produced by OSM Piątnica were found in the analyzed stores. However, the price of drinking lactose-free milk 2% Piątnica was almost 50% higher than milk of OSM Koło or Łowicz.

In Poland, currently the two largest producers of lactose-free foodstuff are the Mlekovita group and the Łowicz District Dairy Cooperative [12].

Among the available lactose-free products, SM Mlekovita offered the widest range. Some products, however, were slightly cheaper in the case of other Polish producers.

Despite the lack of differences in the composition and nutritional value of lactose-free and conventional products, these products differed organoleptically. Lactose-free milk is much sweeter, and in the study of Adhikari and colleagues [1] some respondents felt a chalky taste in it [3].

OTHER LACTOSE-FREE PRODUCTS

Speaking of lactose, we immediately associate it with milk and its products. However, there are also other products that are not made from milk but still contain lactose. The addition of this sugar to the product increases the viscosity of food products, which is accompanied by a pleasant feeling while chewing. Lactose is used, among others, as an addition in the production of e.g. fries, bread or croquettes, because during baking it causes a brown color, which is a beneficial feature of these products. Sweets loved by all children, can also contain lactose, which is added to prevent the formation

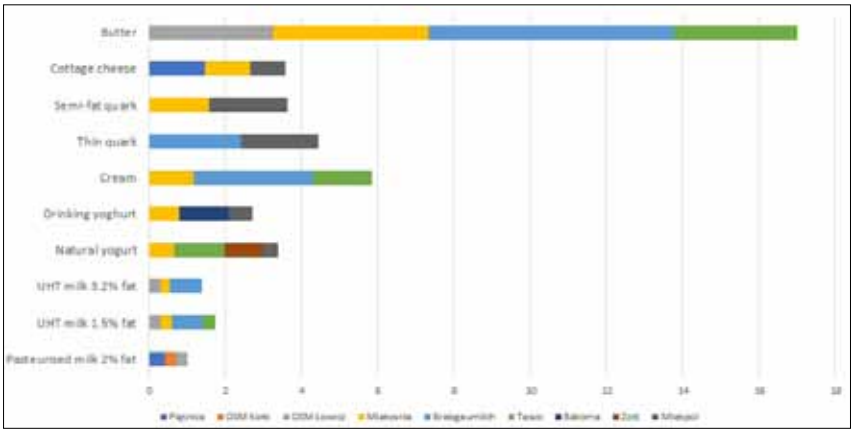

Fig. 6. Average price in PLN for 100g / 100ml lactose-free product depending on the manufacturer.

Rys. 6. Średnie ceny w PLN za 100g/100ml produktów bezlaktozowych w zależności od producenta.

Source: Own study

Źródło: Badania własne

of sugar crystals in solutions. It is also used as a carrier of the active substance in the production of medicines, for aromatic ingredients, flavor enhancers and sweeteners. Products that we would not expect the presence of lactose at all are meat products, where it is used to improve the smell, taste and texture [8].

In order to meet the expectations of customers, the Polish market also offers alternative lactose-free products to lactose-free dairy products. In addition, they are often also gluten-free products that are safe for people suffering from celiac disease.

Of these products found on the Polish market, ice-cream (26.7%) was the largest part, followed by cookies (20%), chocolate and chocolate products (20%), followed by frozen pizzas (13.2%), but also available: iced coffee, banana chips or different types of bread (6.7% each).

The market for non-dairy lactose-free products is still growing. The Belgian company Damhert offers its customers a wide range of non-dairy lactose-free products, including ketchup, frozen fruit cakes, baguettes, hamburger rolls, dark and light bread, Kaiser rolls, breadsticks, macaroni, fishsticks, fruit muesli, honeyballs, biscuits, a large assortment of cookies, chocolate, preserves, a mixture of pancakes, powdered soups and sweetener tagatosis [4]. The lactose-free market has great potential. The main development factor is the continuous increase in the number of people intolerance to lactose [7]. However, it should mainly be directed to people with lactose intolerance, because for healthy people these products are unnecessary and even harmful to the body. By consuming lactose-free products, the lactase enzyme found in healthy people will cease to be active, because it will not have the possibility to work. If we all consume lactose-free products, we will reverse evolutionarily, because our enzyme system will cease to be active [16].

CONCLUSIONS

1. Much greater availability of lactose-free products was offered by online stores, but the range of this product group in stationary stores is still increasing.
2. Among the analyzed groups of lactose-free dairy products such as pasteurized and UHT milk, natural, drinkable and flavored yoghurt, cream, quark cheese, cottage cheese, ripened cheese, spreadable fats and infant formula, the most easily available products were milk and flavored yoghurt. Cottage cheese, cream and infant formula were the least available.
3. The most lactose-free products available on the market were produced by the Mlekovita Dairy Cooperative.
4. Based on the analysis of the labels, no differences were found in the composition of lactose-free products compared to conventional ones. The differentiating feature was the higher price of lactose-free products compared to the conventional ones from 4 to even 166%. The most expensive lactose-free products were offered by the German company Breisgaumilch.
5. There are more and more alternative products to lactose-free dairy products available on the Polish market i.e. drinks or yoghurts based on vegetable raw materials, as well as products in which lactose-free milk was used as an additive i.e. ice-cream, cakes, chocolate.

WNIOSKI

1. Dużo większa dostępność produktów bezlaktozowych oferowana była przez sklepy internetowe, niemniej jednak asortyment tej grupy produktów w sklepach stacjonarnych ciągle wzrasta.
2. Wśród analizowanych grup produktów mlecznych bezlaktozowych takich jak mleka pasteryzowane i UHT, jogurty naturalne, pitne oraz smakowe, śmietany, twarogi, serki wiejskie, sery żółte, tłuszcze do smarowania oraz odżywki dla niemowląt, najłatwiej dostępnymi produktami było mleko oraz jogurty smakowe. Najmniejszą dostępnością cechowały się serki wiejskie, śmietany oraz odżywki dla niemowląt.
3. Najwięcej dostępnych na rynku produktów bezlaktozowych wyprodukowanych zostało przez Spółdzielnię Mleczarską Mlekovita.
4. Na podstawie analizy etykiet nie wykazano różnic w składzie produktów bezlaktozowych w porównaniu do konwencjonalnych. Cechą różnicującą była wyższa cena produktów bezlaktozowych w stosunku do konwencjonalnych od 4 do nawet 166%. Najdroższe produkty bezlaktozowe oferowała niemiecka firma Breisgaumilch.
5. Na polskim rynku dostępnych jest coraz więcej produktów alternatywnych dla mlecznych produktów bezlaktozowych, tj. napoje czy jogurty na bazie surowców roślinnych, jak również produkty, w których zastosowano jako dodatek mleko bez laktozy, tj. lody, ciasta, czekolady.

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THE INFLUENCE OF FERMENTATION TEMPERATURE ON THE GROWTH OF YEAST BIOMASS IN BEER PRODUCED ON AN INDUSTRIAL SCALE®

Wpływ temperatury fermentacji na przyrost biomasy drożdży w piwie produkowanym w technologii wielkozbiornikowej®

The article presents the results of the influence of different fermentation temperature on biomass growth in beer produced on an industrial scale. Worts were aerated with sterile air in an amount of 10 mg per dm³. Yeast pitching rate were the same for all processes tested – 7 mln cells per cm³ wort.

The examined parameter was a variable fermentation temperature: 8.5; 10 and 11.5°C. Other parameters of the beer fermentation and maturation process in tank fermenters were carried out under the same technological conditions.

Studies have shown that a varied fermentation temperature has a significant impact on the growth of yeast biomass in the fermentation process. As the fermentation temperature increased, the amount of biomass multiplied increased. The greater number of new yeast cells contributes to greater beer loss during the fermentation of the wort.

Key words: wort, tankfermentor, fermentation temperature, yeast biomass, extract losses.

Celem artykułu jest przedstawienie wyników badań dotyczących wpływu temperatury fermentacji na szybkość procesu fermentacji oraz zaniki piwa wytwarzanego w technologii wielkozbiornikowej. Doświadczenia wykonano w warunkach przemysłowych – fermentacja i dojrzewanie w tankofermentorach o pojemności 3800 hl. Do brzeczki dodawano drożdże zebrane po drugiej fermentacji (trzeci pasaż) w tej samej ilości do każdego tankofermentora. Brzeczkę napowietrzano sterylnym powietrzem w ilości 10 mg na dm³. Procesy fermentacji głównej przebiegały w trzech badanych temperaturach: 8,5; 10 i 11,5°C. Proces dojrzewania piwa w wymienionych tankofermentorach prowadzono w tych samych warunkach technologicznych. Doświadczenia wykazały, że zróżnicowana temperatura fermentacji ma istotny wpływ na przyrost biomasy drożdży w piwie. Wraz ze wzrostem temperatury fermentacji zwiększała się ilość namnożonej biomasy. Większa ilość nowych komórek drożdży przyczynia się do większej straty piwa na etapie fermentacji brzeczki.

Słowa kluczowe: brzeczka piwna, tankofermentor, temperatura fermentacji, biomasa drożdży, zanik piwa.

WPROWADZENIE

Beer is the world's most widely consumed and probably the oldest alcoholic beverage, it is the third most popular drink overall, after water and tea. The production of beer is called brewing. Each ingredient has its own function. Barley provides the starch which is converted to maltose and other sugars, and finally to alcohol and carbon dioxide [5].

The principal raw materials used to brew beer are water, malted barley, hops, and yeast.The brewing process involves extracting and breaking down the carbohydrate from themalted barley to make a sugar solution (called "wort"), which also contains essential nutri-ents for yeast growth, and using this as a source of nutrients for "anaerobic" yeast growth. During yeast fermentation, simple sugars are consumed, releasing energy and producing ethanol and other flavoring metabolic by-products.

The major biological changes that occur in the brewing process are catalyzed by naturally produced enzymes from barley (during malting) and yeast [4].

Yeast has the ability to adjust its metabolism to aerobic as well as to anaerobic conditions. The yeast doubles or triples its mass during fermentation. For the build-up of cell substance (proteins and enzymes) the yeast needs mostly amino acids, which are taken either from the fermentation substrate or synthesized by itself. Besides proteins, lipids are also synthesized for yeast propagation because they are important components of the cell wall, and are needed for the uptake of nutrients. For the synthesis of these lipids from acetyl coenzyme A, molecular oxygen is needed; after lautering, wort

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itself contains only few lipids. Finally, the yeast also requires minerals for the stabilization of its enzyme systems [3].

The wort transforms into beer during alcoholic fermentation and maturation, which are the longest processes in brewing. The primary fermentation lasts between 3–6 days and the maturation – up to 2 weeks depending on the fermentation type and the used equipment. The ethanol fermentation occurs as a result of enzymatic activity of the yeast at Embden-MeyerhofParnas pathway, which leads to glucose conversion to pyruvate. Under anaerobic conditions the yeasts convert pyruvate to ethanol and CO_2. In aerobic conditions, yeasts consume sugars, mainly for biomass accumulation and CO_2 production (Boulton and Quain, 2001) [7]. The Balling's equation suggests, that from 2.0665 g wort extract, we received 0.11 g yeasts biomass and all sugars in the wort are fermentable monosaccharaides [7].

The aim of the article is to present the results of the impact of different wort fermentation temperature carried out in industrial conditions on the growth of yeast biomass and losses of beer.

MATERIALS AND METHODS

Experimental design

This study investigates the parallel process of beer production in three different cylindro-conical tanks (CCT), sampled during 18 days of the production cycle. Each cylindro-conical tank was filled with three brews (each batch taking 4.5 h) Total filling time for three fermenters was 13.5 h. High Gravity worts (15.5°P) were prepared from the same batch of malt under identical conditions.

Sample collection started after filling the CCT and continued during the following days at the same time every day. Sampling used a device equipped with an installed small pump working in a closed loop, enabling to be taken at vessel. The sampling point was located above the cone, 5 m from the bottom of the tank The CCT had a total capacity of 3850 hl with a 20% headspace. In order to obtain representative samples, the circulation pump was kept running during the process, but was switched off (approximately 24 hours) before yeast cropping.

In this work, a third generation bottom fermenting yeast was used and stored in the same yeast storage tank (YST). Yeast was pitched using ABER system for rate control. The wort was aerated with sterile air. The fermentation was performed at (Fig. 1): 8.5; 10 and 11.5°C. The beer maturation was carried out in the same technological conditions.

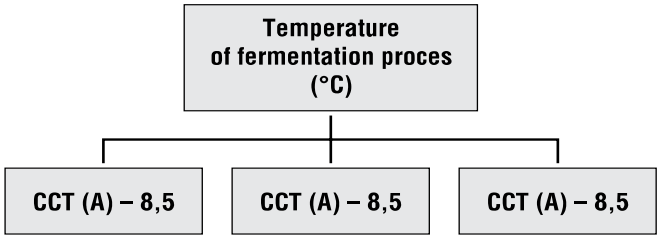

Fig. 1. Temperature of the wort fermentation.
Rys. 1. Temperatura fermentacji brzeczki.
Source: The own study
Źródło: Badania własne

Fermentation analysis

The measurement of the volume of collected biomass was obtained from the reading of flow meters placed in the yeast collection line from individual tank fermenters. Volume registration was carried out automatically using an automatic production program.

Measurements included the number of yeast cells in the fermenting wort and beer and the percentage of dead cells, measured using a NucleoCounter cell analyzer (Chemometec, Lillerod, Denmark).

Measurement of biomass and yeast vitality

The total yeast concentration and the content of dead cells during fermentation and maturation of beer and in yeast slurry was determined using the NucleoCounter YC-100. This system identifies and counts single cells with stained DNA. A fluorescent microscope built into the device consists of light-emitting diodes, very high emission filters, optics, and a CCD camera. Propidium iodide combined with coloured DNA begins to emit red fluorescent light. The NucleoCounter is equipped with advanced software for final image analysis.

Measurement of extract losses

The disappearance of beer, also known as the loss of extract expressed as a percentage, was calculated on the basis of the difference in the amount of fermented wort and the obtaining beer to the initial amount of wort.

Statistical analysis

The results presented in this work were the average of three independent experiments with the bars representing the standard deviation. The data was analysed by one-way analysis of variance (ANOVA) to test the significance of the different fermentation temperatures on the fast of fermentation and beer losses produced on industrial scale. Significant differences between the means were verified by Duncan test ($P < 0.05$). Analyses of variance ANOVA were made with the use of Statistica v.10 (StatSoft Polska, Kraków, Poland).

RESULTS AND DISCUSSION

Fermentation temperature is one of the most important process parameters of beer production. Higher fermentation and maturation temperature of processes are used in industrial production using tank fermentors – differently to classical technology.

The wort fermentation and beer maturation temperatures in the tested fermenters are presented in Fig. 2. The wort temperature of pitching the yeast in each case was 8.5°C. Then, depending on the preset fermentation temperature (8.5°C, 10.0°C, 11.5°C), the special Fermos program controlled the conditions in each tank fermenter through a remote-controlled refrigeration system. To ensure a predetermined temperature (set point) for each process (experiment), during the first days of fermentation (from the 4th to the 6th day), after droping the apparent extract to 7.8°Blg (set point in the Fermos program), fermenter cooling was turned off to raise the temperature to 15°C - the first stage of maturation.

The slow increase in temperature (an increase of 1°C corresponded to a reduction of the extract by 1°Blg) lasted

from 2 to 5 days, depending on the intensity of the main fermentation.

Diacetyl content (< 35 µg per dm^{-3}) was assumed to be the indicator of the end of the first stage of maturation at 15°C. Then the contents of the tankfermentor were cooled in about 4 days to a temperature of about -0.7°C and the lagering process was carried out (further maturing), which lasted a minimum of 3 days. Based on the course of the graph line (Fig. 2), it can be concluded that the increase in fermentation temperature from 10 to 11.5°C caused acceleration of fermentation, and thus the reduction of the required process time by 24 hours. In turn, the decrease in temperature from 10 to 8.5°C slowed down the process by one day. It should be noted that the speed of the process is mainly the result of an intense increase in yeast biomass due to the higher fermentation temperature.

Figure 3 shows the formation of yeast cell content during the fermentation process of wort, depending on the fermentation temperature (8.5; 10 and 11.5°C).

The obtained results indicate that the cell number reached the highest values at 11.5°C. By day 5 of the process, the number of cells had increased more than 6-fold (to 42 million CFU in cm^3). Increasing the temperature by 0.5°C caused a multiplication of the amount of yeast density collected from the fermentation tank. Figures 4 and 5 show the appropriately pumped quantity of yeast slurry and the percentage increase in biomass, depending on the fermentation temperature.

After the set yeast collection time (100 ± 4 hours from the beginning of maturation), biomass was discharged (pumped) from tank fermenters to yeast tanks.

During the fermentation process, yeast uses the extract available in the wort to produce ethyl alkohol, carbon dioxide, and fermentation by-products. From 100 g of fermenting sugars, it has been proven that about 6-7 g is used for the growth of yeast biomass [1].

The conducted research measured the increase in yeast biomass after each fermentation. Significant differences were found in the biomass growth, depending on the change in the parameters studied.

The effect of temperature on the increase in yeast propagation is comparable to the temperature coefficient of transformation (Q10) determined by Arrhenius. The yeast biomass doubles when the fermentation temperature is increased by 10°C until the maximum and optimal temperature is reached 25°C for Saccharomyces carlsbergensis [6]. The assessment of the effect of process temperature on cell budding and biomass growth was the goal of research, among others Claro et al. [2] and Saerensa et al. [8]. The authors showed a close relationship between temperature and viability as well as the rate of yeast propagation.

Our experiments showed that at 11.5°C, there was an over 6-fold increase in cell number. The volume

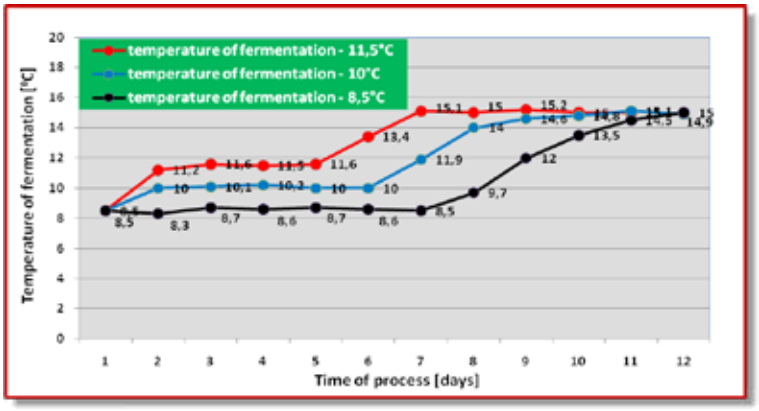

Fig. 2. Course of temperature in the process of wort fermentation.
Rys. 2. Kształtowanie się temperatury w procesie fermentacji brzeczki.
Source: The own study
Źródło: Badania własne

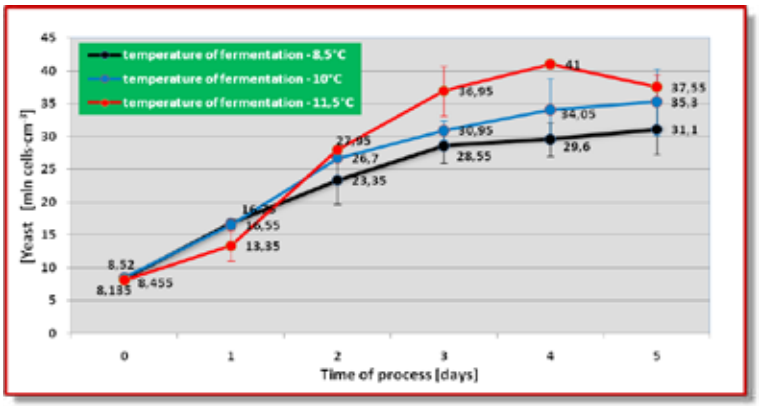

Fig. 3. The number of yeast cells in the fermenting wort, depending on the fermentation temperature.
Rys. 3. Liczba komórek drożdży w fermentującej brzeczce w zależności od temperatury procesu.
Source: The own study
Źródło: Badania własne

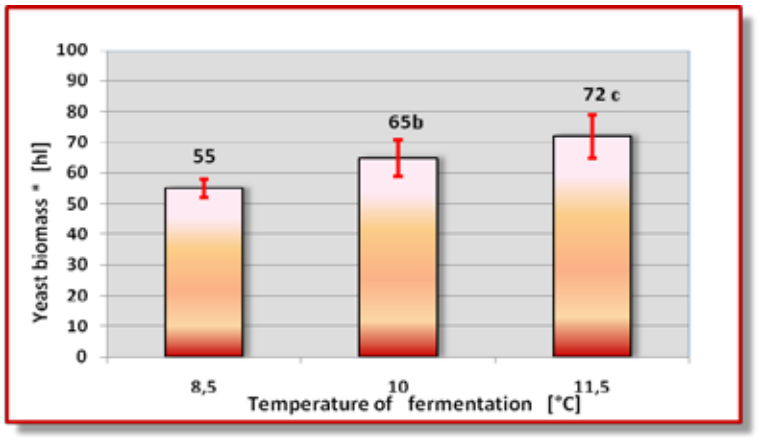

Fig. 4. Volume of yeast slurry collected depending on fermentation temperature. (*slurry with biomass concentration – 109 mln cells·cm-3)
Rys. 4. Objętość gęstwy drożdżowej w zależności od temperatury fermentacji. (*gęstwa drożdżowa o koncentracji - 10^9 mln komorek·cm^{-3})
Source: The own study
Źródło: Badania własne

increase in biomass at 8.5, 10 and 11.5°C was 245, 290 and 355%, respectively. Both temperature and aeration are the main factors determining yeast growth and biomass efficiency.

Important indicators of the profitability of the brewery are loss of beer, currently converted into „extract losses", which is determined as the percentage of extract lost during the entire production process.

Extract losses are mainly associated with the disappearance of small amounts of beer in technological lines and the increase in yeast biomass, which during fermentation consumes part of the carbohydrates contained in the wort to build cell structures during reproduction.

Figure 6 illustrate the loss of extract depending on the factors examined. As the fermentation temperature increases the extract losses also increase. At the fermentation temperature of 8.5°C, its average disappearance was 1.03%, while at 11.5°C the loss of extract was already 2.5 times higher. This state of affairs is mainly due to the increased biomass of yeast.

CONCLUSION

1. A significant effect of fermentation temperature on the growth of yeast biomass during the fermentation process was found. At higher fermentation temperatures, more new yeast biomass is produced.
2. Studies have shown the start of sedimentation of yeast cells from the fifth day of the fermentation process.
3. Greater multiplication of yeast biomass at higher temperatures contributes to higher losses of fermented wort (extract losses) and simultaneously produced beer.

WNIOSKI

1. Stwierdzono istotny wpływ temperatury fermentacji na przyrost biomasy drożdży podczas procesu fermentacji. Wyższe temperatury fermentacji powodują większe namnożenie młodych komórek drożdży.
2. Badania wykazały, że w doświadczeniach prowadzonych w warunkach przemysłowych, proces flokulacji drożdży rozpoczyna się od 5 dnia procesu fermentacji.
3. Większe namnażanie biomasy drożdży w wyższej temperaturze przyczynia się do większych strat fermentowanej brzeczki (strata ekstraktu) i jednocześnie wyprodukowanego piwa.

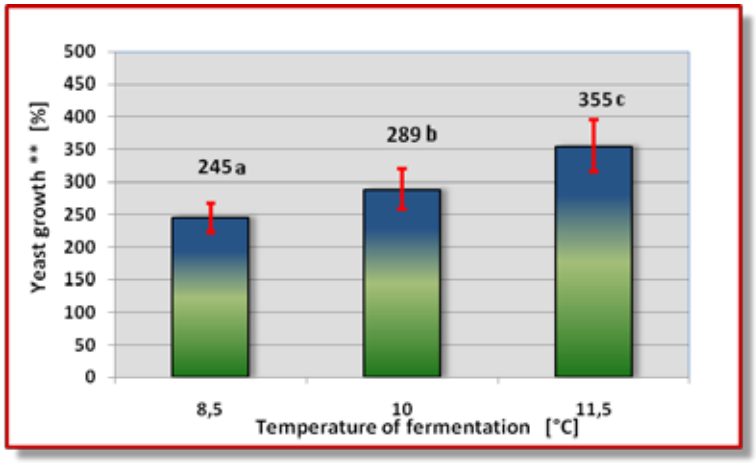

Fig. 5. Percentage increase of yeast growth depending on fermentation temperature. (ratio of biomass after fermentation to the amount of pitching yeast per biomass concentration - 10^9 mln cells·cm^{-3})**

Rys. 5. Procentowy przyrost biomasy drożdży w zależności od temperatury fermentacji. (współczynnik ilości uzyskanej biomasy drożdży po fermentacji do ilości zadanych drożdży w przeliczeniu na koncentrację biomasy - 10^9 mln komórek·cm^{-3})**

Source: The own study

Źródło: Badania własne

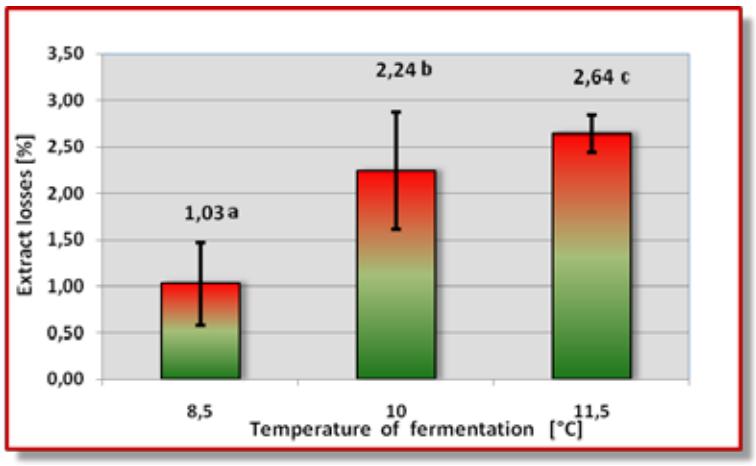

Fig. 6. Extract losses depending on temperature of fermentation.

Rys. 6. Straty ekstraktu w zależności od temperatury fermentacji.

Source: The own study

Źródło: Badania własne

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THE USE OF APPLE AND BEETROOT JUICES TO OSMOTIC DEHYDRATION OF APPLES®

Zastosowanie soków z jabłek i buraków ćwikłowych do osmotycznego odwadniania jabłek®

The article presents the possibilities of using apple and beetroot juice concentrates for osmotic dehydration of apples. The use of such concentrates or their mixtures in the process has proved even more advantageous to the commonly used sucrose. Osmotic substances that are concentrates of fruit or vegetable juices allow obtaining products with health-promoting properties. They also influence the forming of sensory features (colour, taste), which increases the attractiveness of the product in the customer's opinion.

Key words: osmotic dehydration, mass exchange, sensory properties.

W artykule przedstawiono możliwości wykorzystania koncentratów soków z jabłek i buraków ćwikłowych do osmotycznego odwadniania jabłek. Zastosowanie takich koncentratów lub ich mieszaniny okazało się nawet bardziej korzystne od powszechnie stosowanej sacharozy. Substancje osmotyczne będące koncentratami soków owocowych lub warzywnych pozwalają na uzyskanie produktów o właściwościach prozdrowotnych. Wpływają też na kształtowanie cech sensorycznych (barwa, smak), co zwiększa atrakcyjność produktu w opinii klienta.

Słowa kluczowe: odwadnianie osmotyczne, wymiana masy, właściwości sensoryczne.

INTRODUCTION

Apples are among the most popular fruits in the world. They are consumed fresh and a valuable raw material in food processing. Apples are noteworthy components in innumerable diets as being the sources of polyphenolic compounds having bioavailability such as monomeric and oligomeric flavonols (e.g. phloridzin), flavonols (e.g. quercetin), p-hydroxybenzoic acids, p-hydroxycinnamic acids and anthocyanidins [4]. Głównym kierunkiem przetwarzania jabłek jest produkcja klarownego soku i koncentratu. Około 70% zbioru stanowi surowiec do produkcji zagęszczonych soków owocowych. Z jabłek powstają również wina owocowe, przeciery, kremogeny, konserwy i susze. The red beetroots are also rich in valuable active compounds such as betanin, carotenoids, saponins [5]. The average amount of red pigment (belatains and batanins) is about 200 mg per 100 g of beetroot [14]. Red beetroot is widely used in food industry as a natural red colourant [6], and to improve the red colour of food (tomato pastes, soups, desserts, jams, sweets) [7]. Beetroot is a raw material for many products. In recent years, dried beetroot chips have appeared on the market, but they have not gained many buyers. There is no information on the use of fresh beet juice concentrate for osmotic dehydration of plant raw materials.

For osmotic dehydration, glucose, sucrose, corn syrup and sodium chloride solutions are most often used. However, excessive carbohydrate intake can contribute to negative health effects. Many health benefits resulting from the consumption of juices have been shown in the literature, including providing vitamins, fiber minerals and other bioactive substances that have a beneficial effect on the human body. Many studies have shown the positive effect of juices (fruit) on reducing the risk of cardiovascular disease, cancer and neurodegenerative diseases [3]. They showed that the use of grape juice concentrate allowed to obtain a product with a higher dry matter content and lower water activity compared to dehydrated melon in sucrose solution. Akharume et al. [1] studied the possibility of replacing the standard sucrose solution with apple juice concentrate during osmotic dehydration of fresh and frozen blueberries. It has been proven that the use of concentrate as a medium resulted in a comparable increase in the amount of

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sugar in the frozen raw material from an initial content of 12.5 to 30.3° Brix; using a sucrose solution up to 32.9° Brix.

Fruit juices can be successfully used for osmotic dehydration of plant tissue [12]. Osmotic solutions can be used in the dehydration process several times. This has benefits, because during the mass exchange some compounds contained in the dehydrated raw material the medium penetrates each other without causing losses as in a traditional process with the use of sugar or salt solutions, which also allows the enrichment of dehydrated material [16].

On the other hand, the use of fruit or vegetable concentrates allows not only to enrich products with additional bioactive ingredients, but also to shape and stabilize colour and taste, which translates into the sensory and nutritional attractiveness of the product. **The aim of the study was to examine the impact of using selected fruit and vegetable juice concentrates for osmotic dehydration of apples on their selected properties, such as mass exchange rates, water activity and colour.**

METHODOLOGY

Material

Apples of the Szampion variety provided from the Experimental Fields of the Department of Horticulture of the University of Life Sciences SGGW were used for the tests, stored in refrigeration conditions for about 3 weeks at a temperature of about 5°C and a relative humidity of 85–90%. Apples washed and hollowed out of the seed nests are cut, using an electric slicer, into 5 mm thick discs (with skin). To stop the colour changes of the samples, before dehydration were placed in a 0.5% citric acid solution at a temperature of about 20°C. For the preparation of osmotic solutions, sucrose as control and concentrates of beet and apple juices purchased from the manufacturer (Döhler Poland Company) were used. The extract content in apple and beetroot concentrates and their 1:1 mixture was approx. 73.0, 68.0 and 70.0° Brix, respectively. The water activity of these solutions was about 0.85.

Technological methods

Osmotic dehydration was carried out in a JW water bath ELECTRONIC type T-OSM enabling maintaining a constant temperature 55˚C for 0 to 180 min and shaking of samples. The process was carried out at a temperature of. The ratio of the solution to the fruit mass was 4: 1.

Table 1. Coding of osmotic dehydration assay designations used in the figures

Tabela 1. Kody próbek jabłek odwadnianych osmotycznie stosowane na rysunkach

CODE	MEANING – osmotic dehydration in:
Apple	apple juice concentrate
Beetroot	beetroot juice concentrate
Apple + Beetroot	1:1 apple and beet juice concentrates
Sucrose	sucrose solution

Source: The own study

Źródło: Opracowanie własne

Analytical methods

Determination of mass loss

Mass loss ML [%] was determined based the equation:

$$ML = \frac{m_p - m_k}{m_p} \cdot 100 \quad (1)$$

m_p – sample mass before osmotic dehydration [g],

m_k – mass of samples after osmotic dehydration [g].

Water loss WL [g H_2O/g i. d.m.] and solids gain SG [g/g i. d.m.] were calculated on the basis of the equations:

$$WL = \frac{m_p \cdot (1 - dm_o) - m_k - \cdot (1 - dm_k)}{m_p \cdot dm_o} \quad (2)$$

$$SG = \frac{m_k \cdot dm_k - m_p \cdot dm_o}{m_p \cdot dm_o} \quad (3)$$

dm_o – dry matter content of raw apples [g],

dm_k – dry content of dehydrated apples [g].

Determination of the water activity was measured in the AQUA LAB CX-2 device at a temperature of about 25°C, according to the manufacturer's instructions. The dry matter content (PN-90 /A-75101/03) was carried out in a chamber drier at a temperature of 70°C for 24 hours.

Colour measurement was carried out using the Konica Minolta CR-300 chromameter in the CIE L*, a*, b* system. The results were presented as the calculation of absolute colour difference DE, reffering to the colour of the raw material (fresh apple).

For sensory evaluation, the samples were subjected to freeze-drying at 30°C and 63 Pa for 24 hours. Samples were evaluated by a team of 15 trained persons who acquainted with the methodologies for assessing individual distinctors in accordance with the standard (PN-ISO 5492: 1997). The five dried samples were evaluated on a 5-point scale.

Statistical analysis

The effect of the type of osmotic solution on selected mass exchange rates and sample properties was determined by one-way analysis of variance in the Statgraphics Plus 12 PL program. Inference was made taking into account significance at the level of $\alpha = 0.05$. Homogeneous groups were also determined (Fisher's post-hoc test).

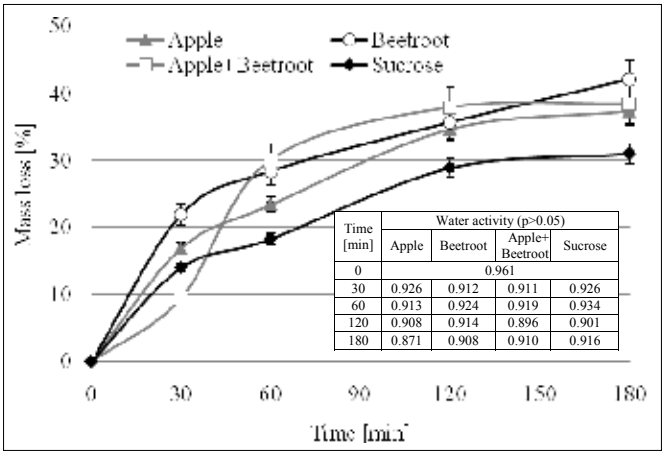
RESULTS AND DISCUSSION

Mass loss of osmotically dehydrated apples

Osmotic dehydration is a process that allows partial removal of water from tissue-based material, which results in a change in mass loss.

The type of osmotic solution did not significantly affect the mass loss of dehydrated apples (Fig. 1). However, in dehydrated apples the effect of process time on the mass loss of samples was noted (Fig. 1). Analyzing mass losses throughout the entire measuring range (0-180 min), some trends were observed. Regardless of the drainage time of apples, larger mass loss concerned the use of beet juice

concentrate and its mixture with apple juice concentrate. However, compared to these indications, the values obtained in apples dehydrated in sucrose solution were lower by 31–39%. With the extension of time, in the range of 0 to 180 min, there was asignificant increase in mass loss. In addition, based on the obtained homogeneous groups, it was shown that after 30 and 60 min the mass loss values were significantly lower compared to using a longer time (120 and 180 min). Kowalska [10] obtained similar result by dehydrating apples in sucrose solution. The mass loss statistically significantly depended on the duration of the process. Along with extending the time in which samples were dehydrated, their weight loss increased.



Time [min]	Water activity (p>0.05)			
	Apple	Beetroot	Apple+ Beetroot	Sucrose
0	0.961			
30	0.926	0.912	0.911	0.926
60	0.913	0.924	0.919	0.934
120	0.908	0.914	0.896	0.901
180	0.871	0.908	0.910	0.916

Fig. 1. Mass loss in osmotically dehydrated apples in apple depending on the type of osmotic solution (p>0.05) and time (p<0.05); designations as in in tab. 1.

Rys. 1. Ubytek masy w jabłkach odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego (p> 0,05) i czasu (p <0,05); oznaczenia jak w tab. 1.

Source: The own study

Źródło: Badania własne

The initial water activity in the raw material was about 0.961 (Fig. 1). Osmotic dehydration reduced the water activity to 0.87-0.92 after 180 min, the lowest values were achieved in dehydrated fruit in apple juice concentrate. Due to the large variation in value, both the time and type of osmotic solution did not have a significant impact on the level of water activity. Similarly, Kowalska and Domurat [9] proved that under mild osmotic dehydration conditions, the water activity of dehydrated apples did not depend on the type of solution and the time of the process.

Water loss, solid gain and water activity of osmotically dehydrated apples

During osmotic dehydration simultaneously with the migration of water from tissues, the osmotic substance penetrates into the dehydrated material. During the osmotic dehydration of apples in juice concentrates and sucrose solution, there was no significant effect of the type of osmotic solution on the water loss and solid gain in the samples, only the water loss from apples significantly dependent on the dehydration time (Fig. 2). As in the case of mass loss, the use of juice concentrates resulted in a slightly higher water loss than the commonly used sucrose solution. A significant water loss was obtained from dehydrated apples, which increased significantly after 60 min and doubled or even tripled after a longer time in the range of 120–180 min.

During the osmotic dehydration of apples in sucrose solution, significant water loss occurred for 120 minutes of the process, and after a longer time changes in this indicator were low. However, dewatering of apples in juice concentrates did not show a desire to achieve a state of equilibrium, and the use of a longer time could result in a further increase in water loss. This demonstrates the possibility of using juice concentrates as osmotic solutions containing sugars and other substances of different molecular weight, which allow obtaining a comparable and even more favourable dehydration effect than sucrose solution.

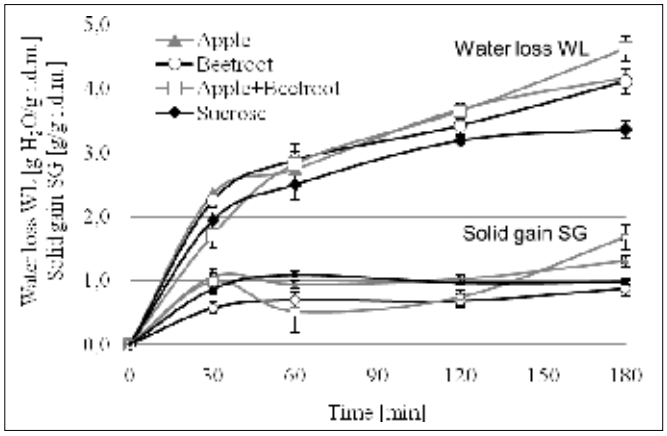


Fig. 2. Water loss in osmotically dehydrated apples in apple depending on the type of osmotic solution (p> 0.05) and time (p <0.05); designations as in in tab. 1.

Rys. 2. Ubytek wody w jabłkach odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego (p> 0,05) i czasu (p <0,05); oznaczenia jak w tab. 1.

Source: The own study

Źródło: Badania własne

Extending the time of the process contributed to the increase in water loss, which in turn translated into a reduction in the mass loss of dehydrated apples.

Solid gain for apples was several times lower than water loss and quite various. The increase of its value was observed after 30 min (Fig. 2). After a longer time (60–120 min) there was a decrease or no change in solid gain, and after 180 min inhibition or a slight increase. In apples dehydrated in a mixture of apple and beet juice concentrates after 180 minutes, the highest value was recorded (1.68 g / g i.d.m.). Similarly, in the studies of Bchir et al. [2010] it was found that the largest increase in the value of dry matter weight gain in pomegranate seeds was achieved during the first 20 minutes of dehydration, and then the dry weight gain stabilised.

Compared with the initial water content in apples, after 180 min dehydration in sucrose solution it decreased by about 28.0 and 33.5%, while in samples dehydrated in a mixture of concentrates and apple concentrate, by about 40.0 and 50.0%, respectively. Piasecka et al. [17] proved that the osmotic

dehydration process allows to remove 40 to 70% of the initial water content. Konopacka et al. [8] showed that the use of apple juice concentrate increased the drainage efficiency of apples compared to the use of other solutions. It is related to the molecular weight of the components of the solutions. Research carried out by Stawarska et al. [19] showed that apple juice contains a high content of simple sugars, in particular glucose and fructose. This chemical composition contributes to the effective penetration of dry substance into the drained samples. Cranberry juice as a rich source of polyphenols and reducing sugars was also used as an osmotic substance [2].

Colour changes of osmotically dehydrated apples

Colour is one of the most important indicators of food quality assessment. It affects the decisions taken by consumers when choosing products on store shelves. Colour measurement is also used to evaluate technological processes [21]. Under the influence of osmotic dehydration and drying of plant materials, physicochemical changes occur causing colour changes. The intensity of changes depends, among others on the duration of the process, temperature, type and concentration of the osmotic solution. Osmotic dehydration significantly changed the colour of apples (Fig. 3). The total colour change DE was determined on the basis of differences in the L *, a * and b * colour parameters between the raw material and the dehydrated apples.

Apples dehydrated in sucrose solution characterized the smallest changes in colour in relation to the raw material. They were at the level of 2.6–6.3, therefore the colour difference of these samples could be noticed (Fig. 3). As expected, in the case of apples dehydrated in beet juice concentrate or its mixture with apple juice concentrate, the values of the ΔE parameter were the highest; reached values of 70.

According to Samborska [18], increasing the proportion of dry substance in the material as a result of osmotic dehydration, it inhibits enzymatic activity, preventing the phenomenon of enzymatic browning of food, which allows the original colour of fruits and vegetables to be preserved. In addition, osmotic dehydration carried out in juice concentrates under moderate temperature (55°C) conditions resulted in an attractive colour for dehydrated fruit. Similar observations have previously been made by Kowalska et al. [11].

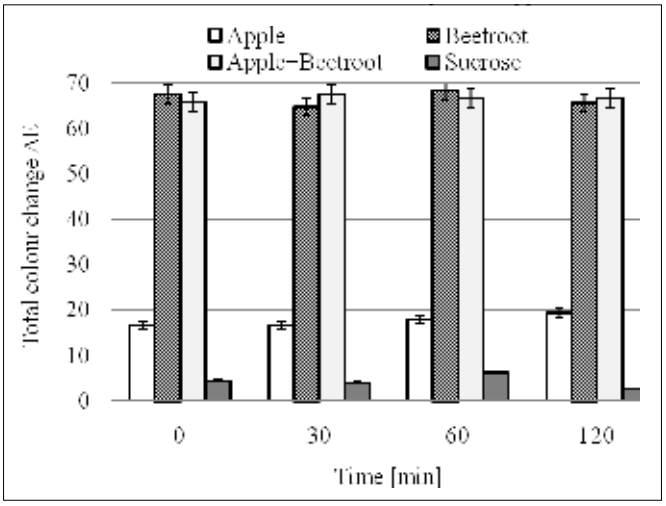


Fig. 3. Total colour change of osmotically dehydrated apples in apple depending on the type of osmotic solution (p>0.05) and time (p<0.05); designations as in in tab. 1.

Rys. 3. Bezwzględna różnica barwy jabłek odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego (p> 0,05) i czasu (p <0,05); oznaczenia jak w tab. 1.

Source: The own study

Źródło: Badania własne

Sensory evaluation of osmotically dehydrated apples and dried by freeze-drying method

To determine the preference of dehydrated apples in the tested solutions, they were dried by freeze-drying and sensory evaluation by scaling (Table 2). It was observed that all dried samples were rated high. Of all the distinguishing features, the highest scores were obtained for dried apples dehydrated in sucrose solution and mixtures of beetroot and apple juice concentrates (4.4–4.6 points).

The parameter most differentiating all variants of samples was texture. Samples dehydrated in sucrose solution and concentrated apple juice turned out to be too soft and gummy, less attractive for consumers. The highest marks (4.7 points)

Table. 2. Sensory evaluation of osmotically dehydrated apples in apple depending on the type of osmotic solution (p<0.05) and time (p>0.05); designations as in in tab. 1.

Tabela 2. Ocena sensoryczna jabłek odwadnianych osmotycznie w zależności od rodzaju roztworu osmotycznego (p< 0,05) i czasu (p >0,05); oznaczenia jak w tab. 1.

Osmoticaly pre-treated samples in:	Appearance [point]]	Colour [point]	Texture [point]	Taste [point]	Overall quality [point]	Average
Without osmotic dehydration	4,4±0,43	4,5±0,34	4,7±0,27	4,5±0,50	4,7±0,37	4.6±0.13
Sucrose solution	4,3±0,61	4,4±0,31	3,6±0,21	4,0±0,52	4,3±0,21	4.1±0.33
Apple juice concentrate	4,0±0,35	3,5±0,54	3,7±0,43	4,2±0,40	4,0±0,27	3.9±0.28
Beetroot juice concentrate	4,2±0,51	4,0±0,47	4,2±0,52	4,2±0,40	4,1±0,47	4.1±0.09
Mixture of beetroot and apple juice concentrates	4,7±0,15	4,7±0,12	4,0±0,30	4,3±0,44	4,4±0,36	4.4±0.29

Source: The own study

Źródło: Badania własne

were obtained by samples obtained by freeze-drying without osmotic treatment. The dried apples were characterised by crunchiness and tenderness. Also other distinguishing features, i.e. taste and overall quality, indicated that this dried fruit was the most attractive to consumers. Literature data shows that freeze-dried products retains taste and aroma due to low drying temperatures [13, 15], and also has an attractive colour [20]. On the other hand, the increased sugar content resulting from the initial osmotic treatment makes it difficult the drying [12]. The dried apples subjected to the initial osmotic dehydration treatment in a mixture of beetroot and apple juice concentrates deserves attention. Samples of these dries were characterized by attractive colour, regular shape and uniform surface.

CONCLUSIONS

The use of apple and beetroot juice concentrates and a mixture of these juices in the osmotic dehydration process proved to be as or more beneficial as the widely used of sucrose solution. Simultaneously, osmotic substances in the form of concentrates of fruit or vegetable juices allow obtaining products with health-promoting properties. The use of juice concentrates for osmotic dehydration of apples enables the production of very attractive products in terms of sensory features. They influence the colour, taste, texture and increase of the content of natural ingredients present in these concentrates.

WNIOSKI

Zastosowanie koncentratów soków jabłkowego i buraczanego oraz mieszaniny tych soków do odwadniania osmotycznego jabłek okazało się równie lub bardziej korzystne niż zastosowanie powszechnie stosowanego roztworu sacharozy. Jednocześnie substancje osmotyczne w postaci koncentratów soków owocowych lub warzywnych pozwalają uzyskać produkty o właściwościach prozdrowotnych. Zastosowanie koncentratów soków do osmotycznego odwadniania jabłek umożliwia wytwarzanie produktów atrakcyjnych pod względem cech sensorycznych. Pozwala też kształtować barwę, smak teksturę oraz zwiększa zawartość naturalnych składników w suszach.

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THE STABILITY OF VITAMIN C IN MODEL SALADS PREPARED FROM TOMATOES WITH FRESH CUCUMBER®

Stabilność witaminy C w modelowych sałatkach przygotowanych z pomidorów z dodatkiem świeżego ogórka zielonego®

Celem artykułu jest prezentacja uzyskanych wyników badań dotyczących stabilności wit. C w modelowych sałatkach sporządzonych z pomidorów bez dodatku oraz z dodatkiem świeżego ogórka zielonego, zawierającego enzym askorbinazę, który rozkłada wit. C. Zawartość wit. C oznaczano metodą Tillmansa w surowcach po obróbce wstępnej (myciu i rozdrabnianiu) oraz w modelowych sałatkach przechowywanych w temp. 10°C, w czasie 2, 4 i 24 godz. Stwierdzono, że obróbka wstępna świeżych pomidorów i ogórków (mycie i rozdrabnianie) powoduje straty wit. C w ilości odpowiednio 20,7 i 37,4%, a wymieszanie tych surowców w stosunku 1:1 dodatkowo zwiększa straty tej witaminy o kolejne 25–40%. Straty wit, C po 2 godz. przechowywania sałatki pomidorowo-ogórkowej wynosiły ponad 50% wobec 12,7% strat tej witaminy z rozdrobnionego pomidora bez dodatku ogórka. Po 24-godzinnym przechowywaniu modelowych sałatek straty te wzrosły do ponad 80% (z udziałem ogórka) lub poniżej 65% (bez udziału ogórka świeżego). Większe straty wit. C z sałatki z udziałem świeżego ogórka wynikały z enzymatycznego oddziaływania obecnej w nim askorbinazy.

Słowa kluczowe – sałatki, pomidor, ogórek świeży, przechowywanie, zawartość i straty wit. C.

The aim of the article is to present the results of research on the stability of vitamin C in model prepared from tomatoes without the addition and with the addition of fresh green cucumber, containing the ascorbinase enzyme, which breaks down vit. C. The contents of vitamin C was determined by the Tillmans method in raw materials after pre-processing (washing and shredding) and in model salads stored at 10°C for 2, 4 and 24 hours. It was determined that pre-treatment of fresh tomatoes and cucumbers (washing and shredding) causes loss of vit. C in amounts of 20.7 and 37.4%, respectively, and mixing these raw materials in the 1:1 ratio additionally increases the loss of this vitamin by another 25–40%. Losses of vit. C after 2 hours of storing the tomato-cucumber salad was over 50%, compared to the 12.7% loss of this vitamin from a fragmented tomato without the addition of cucumber. After 24-hour storage of model salads, these losses increased to over 80% (with cucumber) or below 65% (without fresh cucumber). Greater losses of vit. C from salad with the share of fresh cucumber resulted from the enzymatic impact of ascorbinase present in it.

Key words – salads, tomato, fresh cucumber, storage, vitamin C content and loss.

INTRODUCTION

One of the important aspects for preserving health and proper functioning of the human body is the adequate supply of vitamins [2]. Special attention should be given to vitamin C, which, according to the amended nutrition standards for the Polish population, is defined as *„a water-soluble organic compound with strong reducing properties"* [8].

Vitamin C is an unstable substance, which is water-soluble, sensitive to light, oxygen, increased temperature or the presence of catalysts. It is easily decomposed in an alkaline or neutral environment. However, it is relatively stable in the range of pH 4–6 [7, 11]. Loss of vitamin from food can be caused by improper storage, processing or inadequate selection of raw materials [2, 11]. During storage, L-ascorbic acid is oxidised to dehydroascorbic acid, which in further transformations undergoes irreversible hydrolysis to 2,3-dioxo-L-gulonic acid, which lacks vitamin activity [3].

It is known that the best source of vitamin C are fruit and vegetables, which is why attention is paid to frequent consumption in various forms, most often in a raw or in low-processed form, e.g. as salads [9, 14]. It is recommended to eat at least 4 portions of vegetables and 3 portions of fruit during the day [8].

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In accordance with the principles of good technological practice, salads made of fresh fruit and vegetables should be prepared at least 30 minutes before serving and should be stored in refrigerated conditions. Nevertheless, at home, these recommendations are often not followed, and the literature does not provide detailed data on the loss of vitamins during storage of salads for the period longer than 30 minutes.

The objective of the study was to examine the stability of vitamin C in model salads made of tomatoes and tomatoes with fresh green cucumber containing the ascorbase enzyme, which breaks down vitamin C.

MATERIAL AND METHODS

The study material consisted of plum tomatoes (Caniles variety) and fresh, long trellis cucumber of the Atar variety from market purchases. The model tomato and cucumber salad was prepared by mixing fragmented raw materials (into particles of the same size constituting 2 cm x 0.5 cm strips) in a 1:1 weight ratio. The prepared salad and shredded single raw materials were stored for 2, 4 and 24 hours at +10°C.

The content of vitamin C was determined by the Tillmans method, in accordance with Polish Standard PN-A-04019 [13]. Vitamin C losses were calculated mathematically, taking into account the initial (100%) and final content of this vitamin in raw materials and prepared salad. The results were statistically analysed by calculating the average and standard deviation.

RESULTS

Fresh, unshredded tomato contains 18.55 mg of vitamin C in 100 g, whereas a shredded tomato contains 20.7% less, i.e. 14.72 mg. Cucumber, usually with the low content of vitamin C (4.32 mg/100g), as a result of shredding loses 37.4% of its initial content (Table 1).

Table 1. Losses and content of vit. C in tomatoes and cucumbers before and after grinding

Tabela 1. Straty i zawartość wit. C w pomidorach i ogórkach przed i po rozdrobnieniu

Type of raw material / Rodzaj Surowca	Vitamin C content in mg/100 g (x̄śr ± SD) / Zawartość witaminy C w mg/100 g (x̄śr ± SD)		Loss of vit. C [%] / Straty wit. C [%]
	before comminution / przed rozdrobnieniem	after crushing / po rozdrobnieniu	
Tomato / Pomidor	18,55 ± 0,15	14,72 ± 0,60	20,7
Fresh cucumber / ogórek	4,32 ± 0,44	2,70 ± 0,14	37,4

Source: Own study

Źródło: Badania własne

By mixing shredded tomatoes and cucumbers in a 1:1 weight ratio, after approx. 15 minutes the amount of vitamin C contained in shredded raw materials was reduced by 62.4% (Table 2).

Table 2. Losses and content of vit. C in tomato and cucumber salad before and after mixing

Tabela 2. Straty i zawartość wit. C w sałatce pomidorowo-ogórkowej przed i po mieszaniu

Type of raw material / Rodzaj Surowca	Vitamin C content in mg/100 g (x̄śr ± SD) / Zawartość witaminy C w mg/100 g (x̄śr ± SD)		Loss of vit. C [%] / Straty wit. C [%]
	before mixing (average value) / przed mieszaniem (wartość średnia)	after mixing / po wymieszaniu	
Tomato + Fresh cucumber (1:1) / Pomidor + ogórek (1:1)	8,71 ± 0,20	5,44 ± 0,24	62,4

Source: Own study

Źródło: Badania własne

In Table 3, the content of vitamin C in a model tomato and cucumber salad and individual shredded raw materials stored at different times was shown. While in Fig. 1 the losses of vit. C that occurred during the storage of a model tomato and cucumber salad and single shredded ingredients were compared. These losses were increasing over the increasing storage time.

Table 3. Loss and vitamin C content in salad and individual raw materials during storage

Tabela 3. Straty i zawartość witaminy C w sałatce oraz pojedynczych surowcach podczas przechowywania

Storage time [h] / Czas przechowywania [godz.]	Vitamin C content in mg/100 g (x̄śr ± SD) Zawartość witaminy C w mg/100 g (x̄śr ± SD)		
	Tomato and cucumber salad / Sałatka pomidorowo-ogórkowa	Tomato salad – shredded tomato without the addition of cucumber / Sałatka pomidorowa – rozdrobniony pomidor bez dodatku ogórka	Shredded cucumber Rozdrobniony ogórek
0 (kontrolna)	5,44 ± 0,24	14,72 ± 0,60	2,70 ± 0,14
2	2,63 ± 0,05	12,85 ± 0,01	1,25 ± 0,07
4	1,86 ± 0,20	10,26 ± 0,01	0,71 ± 0,09
24	0,90 ± 0,09	8,95 ± 0,003	0,15 ± 0,02

Source: Own study

Źródło: Badania własne

Vitamin C was relatively stable during storage of shredded tomatoes. After 2 hours, tomatoes lost 30.3% of their original content of vitamin C and 30.3% after 4 hours. After 24-hour-long storage, the shredded tomatoes retained nearly 60% of the initial content of vit. (Fig. 1).

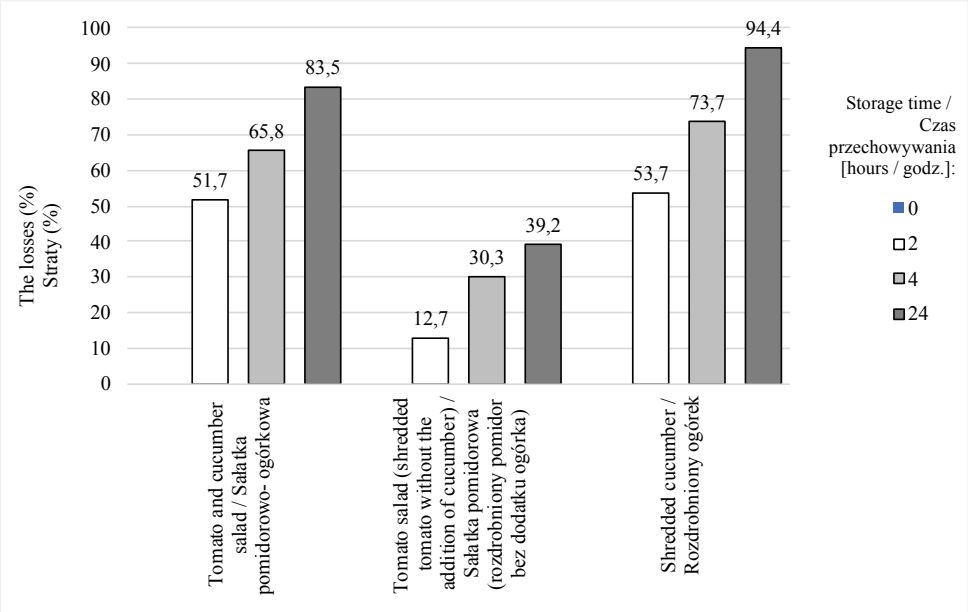

Fig. 1. Comparison of vitamin C losses from a model tomato-cucumber salad and individual salad ingredients.

Rys. 1. Porównanie strat wit C z modelowej sałatki pomidorowo-ogórkowej i pojedynczych składników sałatki.

Source: The own study

Źródło: Badania własne

Shredded cucumber lost the most of vit. C: over 50% of the original content after 2 hours, almost 75% after 4 hours and over 94% after 24-hour storage. Quite high losses were also observed for the tomato and cucumber salad. After 2 hours of storing such a salad, these losses were over 50%. After 4 hours of storage, 65.8% of the initial content of vitamin C was lost from the salad. i.e. over two times more than from tomatoes without cucumber. After 24 hours, the amount of vitamin C in the salad was less than 20% (Fig. 1).

DISCUSSION

The tomato of Caniles variety under the study contained 18.55 mg of vit. C in 100 g of fresh weight, and 14.72 mg after shredding, which corresponds with the results published by other authors.

Depending on the variety, tomatoes may contain from 12.82 to 20.51 mg/100 g of fresh product weight [16]. Georgè et al. [4] provide values ranging from 15.8-17.1 mg/100 g. It is also known that some varieties (e.g. American H9478) may contain as much as 43.01 mg of vit. C in 100 g of the product [15]. In the comparison on the content of vit. C in juices made of 4 varieties of organic and conventional tomatoes, Hallmann and Rembiałowska [6] indicate slightly different, quite low content of vitamin C in tomatoes, which on average amounts to 8.04 mg in 100 g of organic tomatoes and 6.77 mg/100 g in conventional tomatoes. However, it should be noted that the content of vit. C in plant materials is variable and depends on a number of factors, not only depending on the type of crop, but also on other soil and climatic conditions and varieties [12].

The contents of vitamin C in raw cucumber of the Atar variety was 4.32 mg/100 g of fresh weight. According to other authors, fresh cucumbers may contain from 5.5 to 10.4 mg/100 g of fresh weight [5], or 8 mg of vitamin C in 100 g of edible part on average [10]. Just like in the case of tomatoes, the content of vit. C in cucumbers is a varietal trait, also dependent on soil and climatic conditions of growth.

In this study, it has been shown that shredding tomato caused losses of vit. C in the amount of 20.7% and with the loss of 37.4% for cucumber. In the process of peeling and shredding, the tissue and cellular structure is interrupted, which facilitates the access of oxygen to the interior of the raw material and affects larger losses of vitamin C [1].

Due to the solubility of vitamin C in water, its losses occur already during the initial washing or soaking of raw materials. Thermal processing also contributes to the reduction of water-soluble vitamins, which under the influence of boiling, blanching and stewing pass into juice. Losses occurring in this way can be as high as 40% [2]. Moreover, inadequate storage of raw materials, its processing and serving meals cause 50-70% of the loss of this vitamin [11].

The conducted study shows that the content of vit. C is reduced to different extents during storage of tomatoes and cucumbers, which are shredded and mixed together in the form of a salad. These losses are higher when one of these ingredients is fresh green cucumber. Mixing shredded tomatoes and fresh cucumber in a 1:1 ratio causes over 60% loss of vitamin C after 15 minutes in relation to the content in shredded raw materials. The obtained results may be grounds for the statement that the cause of high losses of vitamin C in the salad is ascorbinase, which is an enzyme contained in fresh cucumber. This enzyme in large quantities is contained not only in raw cucumbers, but also in squash or zucchini. Hence, it is not advisable to combine vegetables rich in vitamin C (i.e. tomato, cabbage, pepper) with raw cucumber. It is recommended to replace them with pickled cucumbers, as ascorbase is destroyed in the acidic environment [1]. However, literature data does not indicate to what extent vitamin C is destroyed by the addition of vegetables containing ascorbinase, which is why the results obtained in this study are important from both a cognitive and practical point of view.

In this study, it has been shown that storage of shredded tomatoes and cucumbers causes quite significant losses of vitamin C amounting to 30-75% after 2 hours of preparation. Salad prepared by mixing these ingredients after 15 minutes loses 62.4% of vitamin C contained in shredded raw materials, therefore these ingredients should be mixed max. 15 minutes before consumption.

CONCLUSIONS

Shredding raw materials causes losses of vit. C in the amount from 20.7% (tomato) to 37.4% (fresh green cucumber). Mixing these ingredients in a 1:1 ratio after 15 minutes causes the loss of vitamin C amounting to over 60%, in relation to the content in shredded raw materials. This suggests that in order to prepare tomato and cucumber salad, shredded ingredients should be mixed at latest 15 minutes before consumption.

Storage of the salad and its individual ingredients causes further loss of vit. C. After storing the tomato and cucumber salad for 2 hours, the content of vitamin C decreases by over 50%, while the decrease for tomato not assisted by cucumber is only 12.7%. The addition of cucumber to tomatoes causes loss of vitamin C higher by almost 40%. Shredded cucumber loses the most of vit. C: over 50% of the original content after 2 hours, almost 75% after 4 hours and over 94% after 24-hour storage.

After 24 hours of storing the tomato and cucumber salad, even 83.5% of the initial vitamin C content was lost, while the salad prepared with tomatoes only (without the addition of cucumber) lost twice as less vitamin C (39.2%). Probably such a large difference in vitamin C losses in salad (tomato with fresh cucumber), compared to losses from tomato (without cucumber), results from the enzymatic impact of ascorbinase present in fresh cucumber.

PODSUMOWANIE

Rozdrabnianie surowców powoduje straty wit. C w ilości od 20,7% (pomidor) do 37,4% (świeży ogórek zielony). Mieszanie tych składników w stosunku 1:1 powoduje po 15 minutach ponad 60% straty wit. C w stosunku do zawartości w rozdrobnionych surowcach. Fakt ten sugeruje, że w celu przygotowania sałatki pomidorowo-ogórkowej należy mieszać rozdrobnione składniki max. 15 minut przed spożyciem.

Przechowywanie sałatki i pojedynczych jej składników powoduje dalsze straty wit. C. Z sałatki pomidorowo-ogórkowej po 2 godz. przechowywania ubywa ponad 50% wit. C, podczas gdy z tych samych pomidorów, ale bez dodatku ogórka, ubywa jej jedynie 12,7%. Dodatek ogórka do pomidorów powoduje więc straty wit. C wyższe prawie o 40%. Rozdrobniony ogórek traci najwięcej wit. C: ponad 50% pierwotnej zawartości po 2 godz., prawie 75% po 4 godz. i ponad 94% po 24 godzinnym przechowywaniu.

Po 24 godz. przechowywaniu sałatki pomidorowo-ogórkowej ubywało aż 83,5% początkowej zawartości witaminy C, podczas gdy z sałatki przygotowanej z samych pomidorów (bez dodatku ogórka) ubywało ponad dwukrotnie mniej wit. C (39,2%). Prawdopodobnie tak duża różnica w stratach wit. C w sałatce (pomidor z dodatkiem świeżego ogórka) wobec strat z pomidora (bez dodatku ogórka) wynika z enzymatycznego oddziaływania askorbinazy obecnej w świeżym ogórku.

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EFFECT OF THE TYPE OF FLOUR ON THE QUALITY CHARACTERISTICS OF THE PANCAKE BATTER®

Wpływ rodzaju mąki na cechy jakościowe ciasta naleśnikowego®

The article presents the results of a study on the effect of the type of flour on selected quality characteristics of pancake batter. The paper assesses three wheat and three spelt flours differing in milling degree. Pancakes made from these flours were subjected to organoleptic evaluation by a group of twenty reviewers. The results show that wheat flour pancakes with the highest milling refinement enjoyed the highest approval of the respondents, while spelt flour pancakes type 1850 received the worst rating. The research confirmed that the quality of the flour has a significant impact on the production of pancake batter. The batter made from flour of coarser milling, type 1850, was hard to spread on the surface of the pan, and the pancakes obtained were not of uniform thickness, which had a negative impact on their degree of frying and taste. The research carried out has led to the conclusion that the most popular are wheat-flour pancakes with fine milling.

Key words: wheat flour, spelt flour, organoleptic evaluation, pancakes, food quality.

Artykuł przedstawia uzyskane wyniki badań dotyczące wpływu typu mąki na wybrane cechy jakościowe ciasta naleśnikowego. W pracy dokonano oceny trzech mąk pszennych oraz trzech mąk orkiszowych różniących się przemiałem. Powstałe z tych mąk naleśniki zostały poddane ocenie organoleptycznej przez dwudziestoosobową grupę recenzentów. Uzyskane wyniki pokazują, że naleśniki z mąki pszennej o najwyższym przemiale cieszyły się największą aprobatą ankietowanych, zaś najgorszą ocenę uzyskały naleśniki z mąki orkiszowej typ 1850. Badania potwierdziły, że jakość mąki ma znaczący wpływ na produkcję ciasto naleśnikowego. Ciasta z mąk o niższym przemiale – typ 1850 ciężko rozprowadzały się po powierzchni patelni, a otrzymane naleśniki nie miały jednolitej grubości, co negatywnie wpływało na ich stopień wysmażenia i walory smakowe. Na podstawie przeprowadzonych badań można wyciągnąć wniosek, że najchętniej spożywane są naleśniki z mąki pszennej o wyższym przemiale.

Słowa kluczowe: mąka pszenna, mąka orkiszowa, ocena organoleptyczna, naleśniki, jakość żywności.

INTRODUCTION

Wheat is one of the three basic grains produced worldwide. Today it provides food for millions of people. The most popular wheat product is flour. There are about 11 types of wheat flour on the market, which differ in type, nutritional value and application. One of the wheat varieties is spelt. It is a cereal that does not require many agrotechnical treatments, is characterized by high climatic and soil resistance, as well as does not require intensive fertilization and use of plant protection products. The sowing of spelt significantly increased with the development of organic farming [2, 3, 10]. It produces spelt flour, which is not genetically modified and does not contain artificial additives. Currently, there are about 5 types of spelt flour with different degree of milling [5, 13, 14]. Studies have shown that regular consumption of spelt, in its various forms, improves the mood and ability to concentrate [10, 13]. Spelt flour products affect cholesterol reduction, regulate blood sugar level and show hypoallergenic properties. Spelt flour causes long-term satiety, and coffee from spelt improves the digestion process. In addition to its health benefits, spelt is also appreciated for its nutty taste [2, 4, 12]. Wheat is considered the most valuable cereal because it is a good milling raw material. Wheat grains are characterized by an oval shape with a white, golden, red, dark red or almost brown color. The color of the grain depends on the variety. Wheat seeds should have high purity and max. 15% moisture

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content. In purchasing centers wheat is evaluated according to quality characteristics: grain density, protein, gluten content, falling number and gluten solubility [1, 2, 6, 9, 10, 11, 12]. The ways to use the flour are increasing day by day, and pancakes successfully conquer consumers' hearts [7].

The aim of the article is to present the results of research on the influence of wheat and spelt flour type on the preparation of pancake batter and the evaluation of selected quality characteristics of finished products. The scope of work included preparation of pancakes from six different types of flour: three wheat and three spelt flours. An organoleptic evaluation of the finished products was made, and then the obtained results were analyzed and discussed.

RESEARCH METHODOLOGY

The research material was pancakes, which were prepared from 6 different types of flour, including three spelt and three wheat flours. The pancake batter was prepared with 150 ml of milk, 125 ml of water, 2 eggs and 1 teaspoon of sugar and a pinch of salt were added. Everything was stirred together using a beater to obtain a uniform consistency. Then 150 g of flour was added, which was previously sieved. After the flour was added, the pancake mixture was mixed again. Before each pouring of the pancake batter into the pan, the batter was mixed [8, 9]. Fried pancakes were served for organoleptic evaluation. The sensory evaluation was carried out by a group of twenty respondents, anonymously on a 5-degree scale score card. The evaluators assessed all pancakes with respect to color, smell, texture, taste and degree of frying.

Fig. 1. Comparison of pancakes (from the left, pancakes made from wheat flour type 405, 650, 1850, and spelt flour type 630, 812, 1850).

Rys. 1. Porównanie zawartości naleśników (od lewej naleśnik z mąki pszennej typ 405, 650, 1850, z mąki orkiszowej typ 630, 812, 1850).

Source: Own study

Źródło: Opracowanie własne

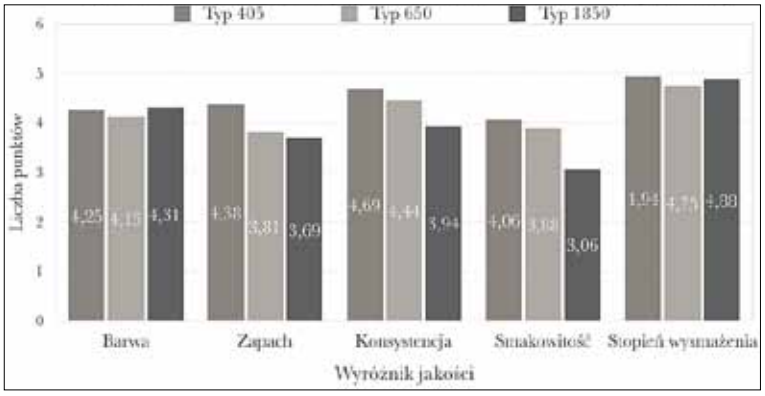

Fig. 2. Bar chart of organoleptic evaluation of wheat flour pancakes.

Rys. 2. Wykres oceny organoleptycznej naleśników z mąki pszennej.

Source: Own study

Źródło: Opracowanie własne

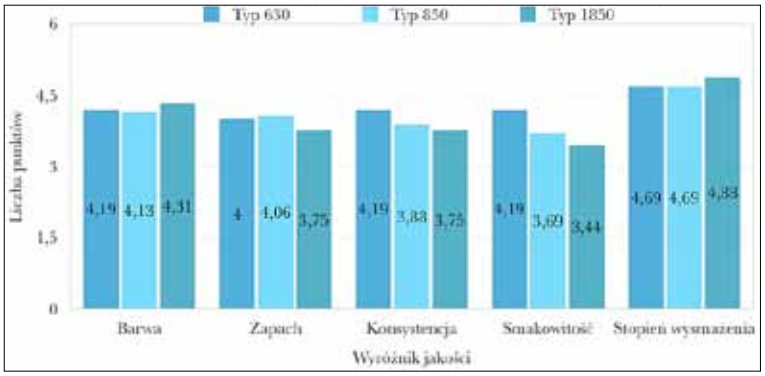

Fig. 3. Bar chart of organoleptic evaluation of spelt flour pancakes.

Rys. 3. Wykres oceny organoleptycznej naleśników z mąki pszennej.

Source: Own study

Źródło: Opracowanie własne

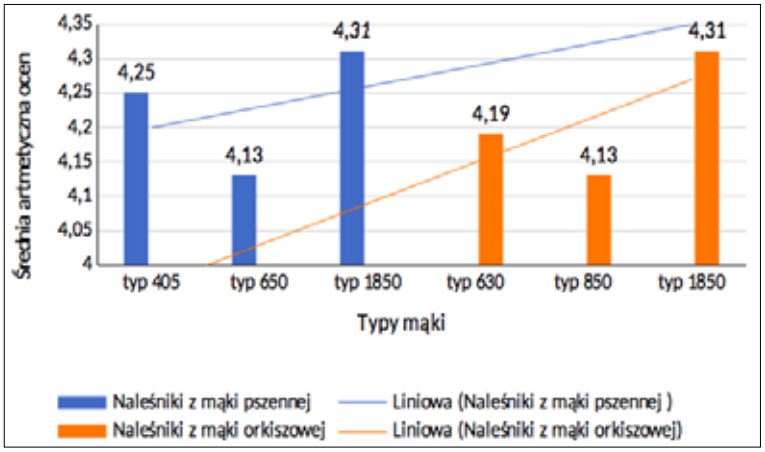

Fig. 4. Comparison of the color marker between wheat and spelt flour pancakes.

Rys. 4. Porównanie wyróżnika barwy naleśników z mąki pszennej i orkiszowej.

Source: Own study

Źródło: Opracowanie własne

ANALYSIS AND DISCUSSION OF RESULTS

After the research was performed the collected results were analyzed. Figure 2 shows the results of the evaluation of pancakes made with wheat flour. According to the respondents, pancakes made with wheat flour type 405 were the most suitable and were the best evaluated. The level of their evaluation in each quality marker ranged from 4.06 to 4.94. Obtained pancakes made of wheat flour type 650 received the lowest evaluation, in quality markers such as color and degree of frying. The remaining parameters were rated at 3,69–3,88. The respondents found that the color of type 1850 wheat flour pancakes is the best, while the smell, consistency and taste were the lowest.

Figure 3 shows the results of the evaluation of the quality characteristics of spelt flour pancakes. The study participants evaluated the texture and taste of pancakes made of spelt flour type 630 as the best. On a five-point scale, the mean score was 4.19. The lowest mean score, among spelt flours, was 4.69 – the degree of frying. Spelt flour type 850 pancakes received the mean score of 4.06 in terms of smell, while the color and degree of frying received the lowest score of 4.13 and 4.69, respectively. Some respondents assessed the taste of spelt flour pancakes with the lowest milling as bland.

Fig. 4 shows a comparison of the quality characteristics, which is the color of all pancakes made of wheat flour and spelt flour. The most attractive pancakes in this respect turned out to be products made of wheat and spelt flour type 1850. Fewer points were scored in the flour types – wheat 405 and spelt type 650. According to the respondents, pancakes made of wheat flour type 650 and spelt flour type 630 scored the least.

The vast majority of the research group concluded in the organoleptic evaluation that the texture of wheat flour pancakes was more appropriate. The highest number of points was given to wheat flour pancakes type 405, and then type 650. The lowest type of spelt flour – 630 was rated the best, but the evaluation differed from that of wheat flour. The texture of a pancake made of spelt flour type 1850 was rated lowest according to the respondents.

A quality marker such as smell was also examined. In figure 6 large differences can be seen in the preference of the desired smell. The smell of pancakes made of wheat flour type 405 was evaluated best. The remaining types of wheat flour – 650 and 1850 turned out to be unattractive for the research group. Spelt flour pancakes were also scored low, as they differed significantly from the classic pancakes.

One of the quality characteristics is the taste of the pancakes. The most suitable taste, according to the respondents, was obtained by pancakes made of spelt flour type 630. Comparable value was obtained by pancakes made of wheat flour type 405. Slightly worse in terms of taste were the pancakes made of wheat

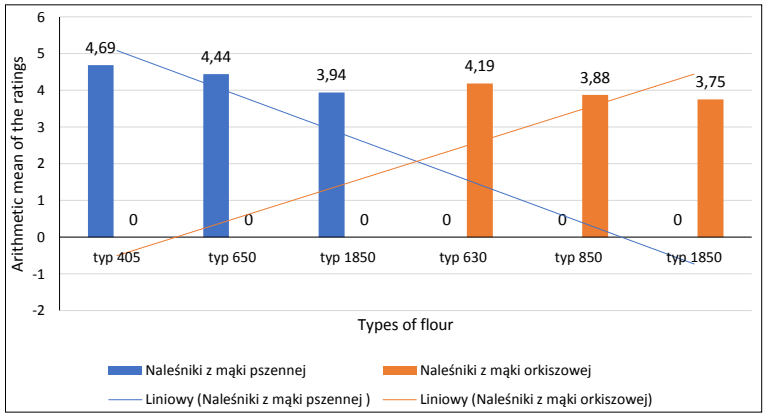

Fig. 5. Comparison of the texture characteristics of wheat and spelt flour pancakes.
Rys. 5. Porównanie wyróżnika konsystencji naleśników z mąki pszennej i orkiszowej.
Source: Own study
Źródło: Opracowanie własne

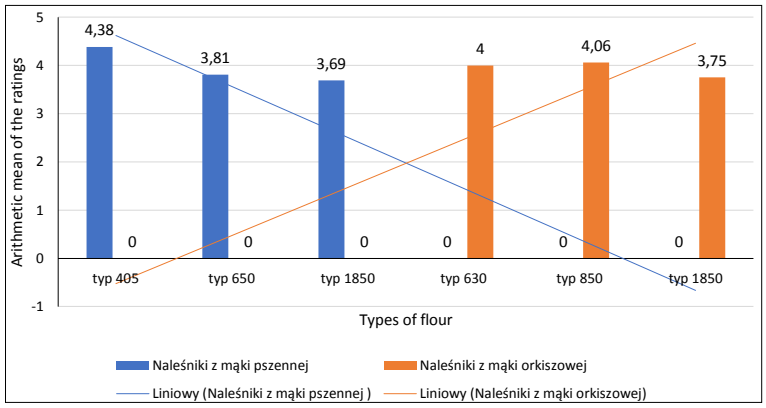

Fig. 6. Comparison of the smell marker of pancakes made of wheat and spelt flour.
Rys. 6. Porównanie wyróżnika zapachu naleśników z mąki pszennej i orkiszowej.
Source: Own study
Źródło: Opracowanie własne

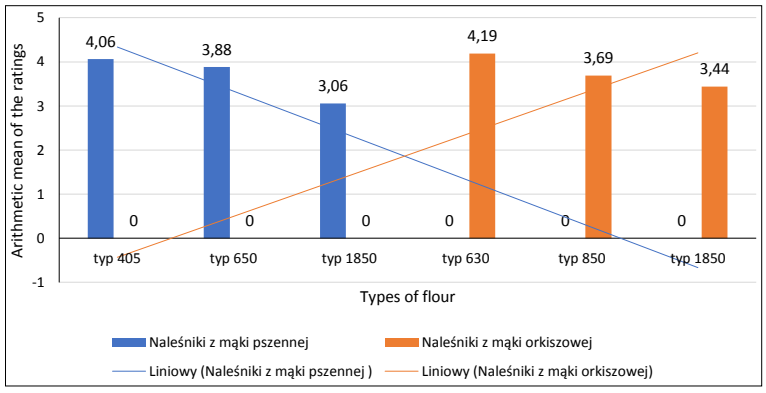

Fig. 7. Comparison of the taste marker of wheat and spelt flour pancakes.
Rys. 7. Porównanie wyróżnika smakowitości naleśników z mąki pszennej i orkiszowej.
Source: Own study
Źródło: Opracowanie własne

flour type 650 and spelt flour type 850. The highest type of wheat and spelt flour type 1850 received the lowest number of points.

The degree of frying is an important quality determinant as it directly affects the sensations during consumption. The most attractive pancakes, among the respondents, turned out to be those made of wheat flour type 405. Pancakes made of wheat and spelt flour type 1850 were also highly rated by the respondents. The least favorable degree of frying was obtained for pancakes made of wheat flour type 650 and spelt flour type 630 and type 850.

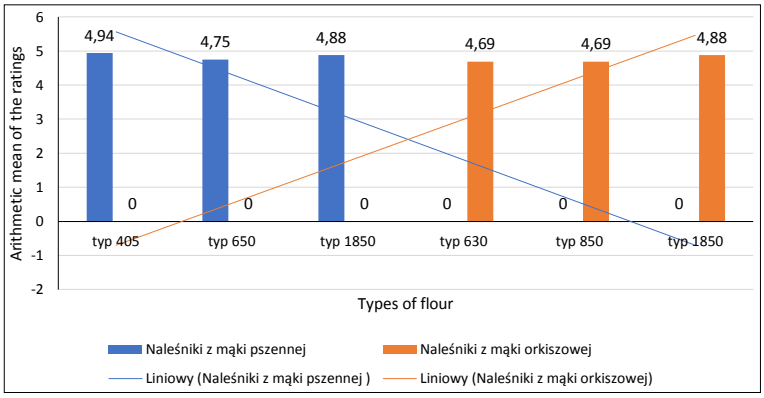

Fig. 8. Comparison of the degree of frying of wheat and spelt flour pancakes.

Rys. 8. Porównanie wyróżnionych stopni wysmażenia naleśników z mąki pszennej i orkiszowej.

Source: Own study

Źródło: Opracowanie własne

CONCLUSIONS

On the basis of the organoleptic evaluation carried out, it was concluded that:

1. The type of flour influences the quality of the pancakes obtained. The lower the type of flour, the more delicate and tastier the products are. These flours contain more gluten, which affects the viscosity and taste of the product. It also raises the batter.
2. The batter made of spelt flour is stickier, which makes it more difficult to spread it in the pan to form a thin pancake. The pancakes required longer frying time, and on the surface of spelt pancakes air bubbles were formed, which after a longer frying time cracked, so the pancakes did not have uniform thickness. The formation of bubbles was influenced by sieving the flour and mixing the batter. It follows that spelt flour is gets easily aerated.
3. The high fiber and bran content in spelt flour of a higher type affects the bland taste of pancakes, as well as their compact structure and hardness.
4. Fine-milled products, such as white flour, contain significantly less vitamins, minerals, fiber or active substances (such as enzymes) than whole-milled products, but are better evaluated in terms of their sensory qualities and therefore more readily consumed.
5. On the basis of such a small research group, it can be concluded that the most popular are wheat-flour pancakes with higher milling. Spelt flour is a healthier alternative, but you have to get used to its other taste qualities.

WNIOSKI

Na podstawie przeprowadzonej oceny organoleptycznej stwierdzono, że:

1. Typ mąki ma wpływ na jakość uzyskanych naleśników. Im niższy typ mąki tym wyroby są delikatniejsze i smaczniejsze. Mąki te zawierają więcej glutenu, który wpływa na lepkość i smakowitość produktu. Spulchnia on dodatkowo ciasto.
2. Ciasto zrobione na bazie mąki orkiszowej jest bardziej kleiste, przez co trudniej rozprowadza się na patelni, tworząc cienki placek. Naleśniki wymagały dłuższego czasu smażenia, a na powierzchni naleśników orkiszowych tworzyły się pęcherzyki powietrza, które po dłuższym smażeniu pękały, przez co naleśniki te nie miały jednolitej grubości. Na tworzenie się pęcherzyków miało wpływ przesianie mąki oraz mieszanie ciasta. Wynika z tego, że mąka orkiszowa dobrze się napowietrza.
3. Duża zawartość błonnika oraz otrębów w mące orkiszowej o wyższym wyciągu (wyższym typie) wpływa na jałowy posmak naleśników, a także na ich zbitą strukturę i twardość.
4. Produkty o wysokim przemiale, takie jak biała mąka, zawierają znacznie mniej witamin, składników mineralnych, błonnika czy substancji czynnych (jak enzymy) niż produkty z pełnego przemiału, jednak pod względem walorów sensorycznych są lepiej oceniane, a więc chętniej spożywane.
5. Na podstawie tak małej grupy badawczej można wyciągnąć wniosek, że najchętniej spożywane są naleśniki z mąki pszennej o wyższym przemiale. Mąka orkiszowa jest zdrowszą jej alternatywą, ale trzeba się przyzwyczaić do jej innych walorów smakowych.

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ASSESSMENT OF SELECTED CULINARY QUALITY TRAITS OF CARCASSES OF SLAUGHTER CHICKEN FROM THE INTENSIVE AND ECOLOGICAL HOUSING SYSTEM®

Ocena wybranych cech jakości kulinarnej tuszek kurcząt rzeźnych z towarowego i ekologicznego systemu utrzymania®

W artykule przedstawiono ocenę wybranych cech jakości kulinarnej tuszek kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania. Tuszki kurcząt rzeźnych z produkcji towarowej posiadały większą masę oraz wyższy udział elementów kulinarnych: mięśni piersiowych i skrzydeł ze skórą, a także wyższą zawartość tłuszczu sadełkowego w porównaniu do tuszek kurcząt z produkcji ekologicznej. Bulion przygotowany z elementów tuszek kurcząt rzeźnych utrzymywanych ekologicznie odznaczał się korzystniejszą barwą i lepszą smakowitością, co może mieć znaczenie praktyczne dla konsumenta.

Słowa kluczowe: tuszka, kurczęta rzeźne, jakość, produkcja towarowa, produkcja ekologiczna.

The article presents an assessment of selected culinary quality traits of carcasses of chickens for fattening from the commercial and ecological housing system. Carcasses of chickens for fattening from commercial production had a larger mass and a higher proportion of culinary elements: breast muscles and wings with the skin, also a higher fat content compared to chicken carcasses from organic production. The broth prepared from elements of carcasses of chickens kept ecologically kept had more favorable color and better palatability, which may have practical significance for the consumer.

Key words: carcass, slaughter chickens, quality, intensive production, ecological production.

WPROWADZENIE

Dynamicznie rozwijająca się produkcja drobiarska jest ściśle związana z rozwojem intensywnego systemu chowu i kontrolą środowiska życia ptaków. Chów towarowy jest głównym systemem utrzymania kurcząt rzeźnych, a mięso pozyskiwane z tego rodzaju chowu stanowi około 89% ogólnej krajowej produkcji mięsa drobiowego w Polsce [2, 24]. Zmiany, jakie zachodzą w sposobie odżywiania oraz w zakresie wymagań jakościowych powodują, że konsumenci poszukują coraz częściej produktów zwierzęcych pochodzących z produkcji organicznej [11, 12]. Skala produkcji żywca drobiowego w naszym kraju prowadzona w ekologicznym systemie utrzymania jest marginalna i stanowi niespełna 4% produkcji krajowej [15]. Współcześni konsumenci zwracają coraz częściej uwagę nie tylko na jakość produktu końcowego, ale również na sposób traktowania zwierząt [11, 13]. Cechy jakościowe tuszek drobiowych są kształtowane przez całe życie ptaka, a jednym z wiodących czynników determinujących ich jakość jest system utrzymania [1, 2, 10, 26]. Wynika to zarówno ze zróżnicowanych warunków środowiskowych, w których przebywają ptaki, żywienia dostosowanego do wieku ptaków oraz dostępu lub braku dostępu do wybiegów [3, 14, 21, 23, 24].

Celem artykułu jest prezentacja uzyskanych wyników badań dotyczących oceny cech jakości kulinarnej tuszek kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania.

MATERIAŁ I METODY BADAŃ

Badania przeprowadzono na tuszkach kurcząt rzeźnych pochodzących z towarowego oraz ekologicznego systemu utrzymania. Tuszki z chowu towarowego (n=12) pozyskano z lokalnej ubojni drobiu, natomiast tuszki z chowu ekologicznego (n=12) z gospodarstwa posiadającego Certyfikat Zgodności Produkcji Żywności Ekologicznej.

Oceny jakościowej tuszek dokonano 24 godziny po uboju ptaków. Ocenę barwy skóry wykonano metodą odbiciową z wykorzystaniem kolorymetru Chroma Meter (*Konica Minolta Osaka, Japonia*) z głowicą CR-400, parametr standardowy, obserwator D_{65}, 2º. Dokonano dwóch pomiarów powierzchni skóry na ćwiartce przedniej, po lewej i prawej stronie klatki piersiowej oraz dwóch pomiarów na ćwiartce tylnej, po lewej i prawej stronie grzbietu. Odczytu wyników pomiarowych dokonano w układzie kolorymetrycznym CIE LAB. Dla każdej próby wykonano dwa powtórzenia.

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Dokonano rozbioru tuszek drobiowych, następnie określono udział elementów kulinarnych (mięśnie piersiowe, mięśnie nóg, skrzydła ze skórą, szkielet z mięśniami grzbietu i częściami niejadalnymi oraz szyją ze skórą z tłuszczem podskórnym, tłuszcz sadełkowy). Otrzymane elementy kulinarne zważono z dokładnością do 1g, następnie określono ich udział procentowy w stosunku do masy tuszki (U), według wzoru:

$$U = \frac{Mek}{Mt \times 100\ (\%)} \quad (1)$$

gdzie: Mek – masa poszczególnych elementów kulinarnych (g),
Mt – masa tuszki (g).

Ocenę barwy tłuszczu sadełkowego wykonano kolorymetrem Konica Minolta CR-400, w skali L*,a*,b*. Wykonano dwa powtórzenia pomiarów przez przyłożenie głowicy do wcześniej wypreparowanego tłuszczu.

Buliony przygotowano z elementów tuszek bez mięśni piersiowych i udowych. W tym celu elementy tuszek zalano zimną wodą i gotowano w temperaturze około 90˚C w stosunku wody do mięsa 2:1 z dodatkiem soli (0,8%). Ocenę sensoryczną jakości bulionów drobiowych wykonano według metodyki Baryłko-Pikielna i Matuszewska [7], zgodnie z normą ISO 8587:2006 [16]. Zastosowano 5-punktową ocenę obejmującą następujące wskaźniki jakościowe: klarowność, barwę, natężenie zapachu i smaku, pożądalność zapachu i smaku (1 punkt oznaczał ocenę najgorszą, a 5 punktów ocenę najlepszą). Próbki bulionów kodowano i podawano ocenie w kolejności losowej. Ocenę sensoryczną przeprowadził 7-osobowy zespół oceniający w dwóch powtórzeniach.

Wyniki opracowano statystycznie za pomocą programu Statistica pakiet oprogramowania 13.1 [25]. W opracowaniu wyników uwzględniono podstawowe miary statystyczne średnią arytmetyczną ($\bar{x}$) i odchylenie standardowe (s). Istotność różnic pomiędzy wartościami średnimi oznaczonych parametrów weryfikowano testem t – Studenta na poziomie istotności $p \leq 0,05$.

WYNIKI I ICH OMÓWIENIE

Wyniki oceny barwy skóry tuszek kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania przedstawiono w tabeli 1. Wykazano, że skóra badanych tuszek z chowu ekologicznego cechowała się wyższym ($p \leq 0,05$) stopniem wysycenia barwy żółtej (b*) oraz niższym ($p \leq 0,05$) wysyceniem barwy w kierunku czerwieni (a*). Uzyskane wyniki pomiaru barwy skóry są wynikiem zróżnicowanego żywienia ptaków w porównywanych systemach utrzymania. W gospodarstwie ekologicznym kurczęta rzeźne miały dostęp do pasz zielonych, bogatych w karotenoidy i ksantofile. Żółtą barwę skóry tuszek drobiowych zapewniają barwniki jak: luteina, zeaksantyna, kantaksantyna, kryptokoryna. Ich skład jakościowy oraz stężenie mogą decydować o intensywności i odcieniu zabarwienia skóry tuszek [3, 9, 24]. Uzyskane rezultaty badań znajdują potwierdzenie w pracach innych autorów [2, 13, 14]. Z kolei Skoromucha i Sosnówka -Czajka [23] nie wykazały wpływu sytemu chowu na barwę skóry tuszek kurcząt rzeźnych. Ponadto na barwę skóry może wpłynąć czas odchowu ptaków determinując ilość odkładanego tłuszczu podskórnego [15].

Table 1. Skin color of chickens for fattening for slaughter from a commercial and ecological housing system

Tabela 1. Barwa skóry tuszek kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania

Badana cecha	System utrzymania	
	towarowy	ekologiczny
L*	72,80 ± 5,38	71,92 ± 3,71
a*	$5,19^{a}$ ± 1,46	$3,68^{b}$ ± 1,83
b*	$6,85^{b}$ ± 3,45	$12,05^{a}$ ± 5,75

Objaśnienia: ($\bar{x}$±s) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone literami a, b w wierszach różnią się przy $p \leq 0,05$

Source: The own study

Źródło: Badania własne

Decydującym czynnikiem wpływającym na masę tuszki oraz udział elementów kulinarnych w tuszce kurcząt rzeźnych jest końcowa masa ciała ptaka (Tab. 2). W badaniach własnych wykazano, iż większą ($p \leq 0,05$) masą odznaczały się tuszki kurcząt pochodzące z towarowego systemu utrzymania. Masę tuszki wyraźnie kształtował zróżnicowany system żywienia w porównywanych systemach utrzymania oraz aktywność ptaków. Tuszki z ekologicznej produkcji cechują się mniejszą masą w porównaniu do tuszek z chowu towarowego [24]. Wyniki Gornowicz i in. [15] wskazują, że tuszki kurcząt rzeźnych odchowywanych ekologicznie cechowały się mięsnością poniżej 40%, ale były nieznacznie otłuszczone w porównaniu do tuszek ptaków odchowywanych w intensywnej produkcji. Bartlett i in. [6] oraz Mikulski i in. [19] wykazali, że kurczęta szybko rosnące miały większą masę ciała i wydajność rzeźną w porównaniu do kurcząt wolno rosnących.

Na polskim rynku mięso drobiowe oferowane jest w postaci elementów kulinarnych oraz całych tuszek. Do najbardziej pożądanych przez konsumentów elementów kulinarnych zaliczamy mięśnie piersiowe oraz mięśnie nóg [2, 20]. Badania własne potwierdziły, że system utrzymania ptaków miał wpływ na udział elementów kulinarnych w tuszkach kurcząt rzeźnych. Istotnie ($p \leq 0,05$) wyższą zawartością mięśni piersiowych charakteryzowały się tuszki kurcząt z chowu towarowego w porównaniu do tuszek z chowu ekologicznego (Tab. 2). Zdaniem Spustek i in. [24] dostęp ptaków do wybiegu modyfikuje udział poszczególnych mięśni w tuszce. Dostęp do większej powierzchni umożliwia ptakom większą aktywność, co sprzyja rozwojowi mięśni nóg [15]. W badaniach własnych nie wykazano istotnego ($p > 0,05$) wpływu systemu utrzymania na udział mięśni nóg w tuszkach. W badaniach Castellini i in. [9] stwierdzono, że tuszki kurcząt utrzymywanych z dostępem do wybiegu cechowały się większym udziałem podudzi oraz mniejszym udziałem mięśni piersiowych. W badaniach Połtowicz i Doktor [21] wykazano wyższą zawartość mięśni nóg wśród kurcząt z chowu bezwybiegowego. Z kolei Bogosavljević-Bošković i in. [8] nie odnotowali wpływu ekologicznego systemu utrzymania kurcząt na proporcje poszczególnych części tuszek, w tym mięśni piersiowych, udowych i podudzia w porównaniu z tuszkami utrzymywanymi intensywnie. Jak podaje Gornowicz i in. [15] utrzymywanie ptaków w systemie organicznym przyczynia się także do ograniczenia

otłuszczenia mięśni nóg przy jednoczesnym braku wpływu na cechy fizykochemiczne mięśnia piersiowego. Wyższa aktywność ptaków wpływa na zwiększenie sprężystości mięśni obniżając kruchość pozyskanego mięsa [9].

Skrzydła ze skórą są atrakcyjnym elementem kulinarnym dla konsumentów ze względu na stosunkowo niską cenę. W badaniach własnych istotnie ($p \leq 0,05$) wyższym udziałem skrzydeł ze skórą [2] oraz mięśniami szkieletu i częściami niejadalnymi cechowały się tuszki kurcząt rzeźnych z chowu towarowego.

Cechą charakterystyczną intensywnej produkcji kurcząt brojlerów jest ich nadmierne otłuszczenie, gdzie skóra z widocznym tłuszczem może stanowić nawet 20% tuszki, przy czym proporcja ta rośnie wraz ze wzrostem masy ciała ptaków [24]. Na otłuszczenie tuszek ma bezpośredni wpływ zarówno system chowu, jak i tempo wzrostu kurcząt [4, 5, 6]. W badaniach własnych tuszki z chowu ekologicznego charakteryzowały się istotnie ($p \leq 0,05$) mniejszą zawartością tłuszczu sadełkowego w porównaniu do tuszek z chowu towarowego (Tab. 2). Również w badaniach Kuźniackiej i in. [18] wykazano, że tuszki kurcząt utrzymywane systemem półintensywnym z dostępem do wybiegu cechowały się mniejszą zawartością tłuszczu sadełkowego w porównaniu do tuszek kurcząt z systemu intensywnego. Podobną tendencję odnotowano w badaniach Augustyńska-Prejsnar i in. [2], dotyczących oceny tuszek kurcząt z dostępem do wybiegu w porównaniu do ptaków utrzymywanych bezwybiegowo. Duże otłuszczenie tuszek kurcząt rzeźnych uznaje się za cechę niepożądaną dla konsumentów [26].

Table 2. Share of culinary elements in carcasses of chickens for fattening from the commercial and ecological housing system

Tabela 2. Udział elementów kulinarnych w tuszkach kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania

Badana cecha	System utrzymania			
	towarowy		ekologiczny	
Masa tuszki (g)	**1968,25^{a} ± 103,45**		**1518,13^{b} ± 60,36**	
Element kulinarny:	**(g)**	**(%)**	**(g)**	**(%)**
Mięśnie piersiowe	602,68^{a} ± 2,25	30,62	394,41^{b} ± 3,83	25,98
Mięśnie nóg (udo, podudzie)	394,04 ± 3,65	20,02	328,97 ± 4,12	21,67
Skrzydła ze skórą	202,34^{a} ± 1,83	10,28	134,80^{b} ± 1,60	8,88
Szkielet z mięśniami grzbietu i częściami niejadalnymi + szyja ze skórą z tłuszczem podskórnym	732,77^{a} ± 4,26	37,23	648,11^{b} ± 4,45	42,56
Tłuszcz sadełkowy	36,41^{a} ± 0,05	1,85	13,81^{b} ± 0,02	0,91

Objaśnienia: ($\bar{x}$±s) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone literami a, b w wierszach różnią się przy $p \leq 0,05$

Source: The own study

Źródło: Badania własne

W badaniach wykazano, że tłuszcz sadełkowy kurcząt pochodzących z chowu ekologicznego cechował się mocniejszym wysyceniem barwy w kierunku żółtym b* oraz niższym parametrem jasności L*, co potwierdzono statystycznie (Tab. 3). Uzyskane wyniki barwy tłuszczu sadełkowego mogą wynikać z różnic żywieniowych kurcząt rzeźnych w porównywanych systemach utrzymania. Kurczęta z chowu ekologicznego miały dostęp do wybiegów, a karetonoidy zawarte w paszy mogą odkładać się w tłuszczu podskórnym i sadełkowym. W literaturze naukowej brak szerszych informacji na temat oceny barwy tłuszczu sadełkowego.

Table 3. Fat color of chickens for fattening from the commercial and ecological housing system

Tabela 3. Barwa tłuszczu sadełkowego kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania

Badana cecha	System utrzymania	
	towarowy	ekologiczny
L*	84,73^{a} ± 4,29	70,39^{b} ± 4,92
a*	-2,84 ± 0,95	-3,05 ± 0,91
b*	10,14^{b} ± 4,36	21,36^{a} ± 4,52

Objaśnienia: ($\bar{x}$±s) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone literami a, b w wierszach różnią się przy $p \leq 0,05$

Source: The own study

Źródło: Badania własne

Table 4. Sensory evaluation of broths prepared from culinary elements of chickens for fattening from the commercial and ecological housing system

Tabela 4. Ocena sensoryczna bulionów przygotowanych z elementów kulinarnych kurcząt rzeźnych pochodzących z towarowego i ekologicznego systemu utrzymania

Badana cecha	System utrzymania	
	towarowy	ekologiczny
Barwa	2,86^{b} ± 0,43	4,43^{a} ± 0,54
Klarowność	3,86 ± 0,41	4,14 ± 0,40
Natężenie zapachu	4,00 ± 0,45	4,14 ± 0,41
Natężenie smaku	2,71^{b} ± 0,53	4,43^{a} ± 0,44
Pożądalność zapachu	3,57^{b} ± 0,44	4,28^{a} ± 0,54
Pożądalność smaku	2,71^{b} ± 0,45	4,43^{a} ± 0,45
Ogólna pożądalność	3,28^{b} ± 0,47	4,28^{a} ± 0,43

Objaśnienia: ($\bar{x}$±s) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone literami a, b w wierszach różnią się przy $p \leq 0,05$

Source: The own study

Źródło: Badania własne

Wyniki oceny sensorycznej bulionów wskazują, że wyższą pożądalnością ocenianych wyróżników jakościowych odznaczał się bulion przygotowany z elementów kulinarnych kurcząt rzeźnych pochodzących z ekologicznego systemu utrzymania (Tab. 4). Panel oceniający wysoko ocenił natężenie i pożądalność smaku oraz kolor bulionu przygotowanego

z tuszek kurcząt ekologicznych. O smaku mięsa i przygotowanego z niego bulionu decydują peptydy, nukleotydy, aminokwasy zawarte w mięsie oraz substancje lotne pochodzące z tłuszczu jak lizyna, seryna, izoleucyna oraz kwas glutaminowy [3]. W badaniach wysoko oceniono również pożądalność zapachu bulionu przygotowanego z elementów kulinarnych kurcząt ekologicznych. Zdaniem Kołczak [17] związki karbonylowe, alifatyczne, heterocykliczne, związki siarkowe, aldehydy, ketony mają decydujący wpływ na zapach mięsa. Korzystniejszy wpływ na aromat mięsa ma obecność kwasu linolenowego, a w mniejszym stopniu linowego. Mięso starszych zwierząt charakteryzuje się intensywniejszym smakiem i zapachem [26]. W badaniach Puchała i in. [22] wykazano że buliony przygotowane z tuszek kur po okresie nieśności (różnych ras), które cechowały się większą masą - były smaczniejsze.

SUMMARY

Carcasses of chickens for fattening from ecological production were characterized by higher saturation of skin color and fat in the yellow direction (b *) and lower saturation of skin color in the direction of red (a *) compared to the skin of *commercial production* chicken carcasses.

Carcasses of chickens for fattening in commercial farming had a greater mass and share of pectoral muscles and wings with skin, also a higher fat content.

The sensory evaluation of broths prepared from carcasses of chickens for fattening showed that the broth prepared from culinary elements of chickens for fattening from ecological farming had a more favorable color and better flavor.

The conducted research indicates the need to continue research on the impact of the maintenance system on the culinary quality traits of chicken carcasses and broth prepared from them.

PODSUMOWANIE

Tuszki kurcząt rzeźnych pochodzących z produkcji ekologicznej charakteryzowały się wyższym wysyceniem barwy skóry i tłuszczu sadełkowego w kierunku żółtym (b*) oraz niższym wysyceniem barwy skóry w kierunku czerwieni (a*) w porównaniu do skóry tuszek kurcząt produkowanych intensywnie.

Tuszki kurcząt rzeźnych z chowu towarowego posiadały większą masę oraz udział mięśni piersiowych i skrzydeł ze skórą, a także wyższą zawartość tłuszczu sadełkowego.

Ocena sensoryczna bulionów przygotowanych z elementów tuszek kurcząt rzeźnych wykazała, że korzystniejszą barwą i lepszą pożądalnością smakowo-zapachową odznaczał się bulion przygotowany z elementów kulinarnych kurcząt rzeźnych z chowu ekologicznego.

Przeprowadzone badania wskazują na konieczność kontynuowania badań nad wpływem systemu utrzymania na cechy jakości kulinarnej tuszek kurcząt rzeźnych oraz przygotowanego z nich bulionu.

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OCENA MOŻLIWOŚCI PRODUKCJI FERMENTOWANEGO SOKU Z BURAKA ĆWIKŁOWEGO Z DODATKIEM SZCZEPÓW BAKTERII PROBIOTYCZNYCH I POTENCJALNIE PROBIOTYCZNYCH RODZAJU *LACTOBACILLUS*®

Assessment of production possibilities of fermented beet root juice with the addition of potentially probiotic *Lactobacillus* strains®

W ostatnich czasach obserwowany jest wzrost zainteresowania konsumentów żywnością funkcjonalną. Badacze z całego świata pracują nad otrzymaniem różnorodnych produktów probiotycznych, w tym pochodzenia roślinnego. Poszukuje się nowych mikroorganizmów potencjalnie probiotycznych, najczęściej izolowanych z żywności spontanicznie fermentowanej. Celem pracy była ocena możliwości zastosowania bakterii probiotycznych i potencjalnie probiotycznych do produkcji fermentowanego soku z buraka ćwikłowego, akceptowanego sensorycznie i zawierającego odpowiednią liczbę żywych komórek bakterii. Wyselekcjonowano szczep Lactobacillus rhamnosus K4, który charakteryzował się wysoką liczbą komórek po procesie fermentacji. Uzyskano produkt o zadowalającej jakości sensorycznej podczas przechowywania. Sok przechowywany w 4°C odznaczał się większą stabilnością cech smaku i jakości ogólnej od soku przechowywanego w 15°C. Przeprowadzone badania wskazują na możliwość zastosowania potencjalnie probiotycznego szczepu Lactobacillus rhamnosus K4 do produkcji soku z buraka ćwikłowego posiadającego korzystne cechy sensoryczne i o odpowiedniej liczbie komórek, pozwalającej na uznanie produktu za probiotyczny.

Słowa kluczowe: probiotyk, *Lactobacillus,* sok z buraka, przeżywalność.

Recently, there has been an increase in consumer interest in functional food. Researchers from all around the world are working to obtain a variety of probiotic products, including plant origin. New potentially probiotic microorganisms are introduced, most often isolated from spontaneously fermented foods. The aim of the study was to produce a beetroot juice with addition of potentially probiotic Lactobacillus strains. The assessment of number of potentially probiotic bacteria cells and sensory properties were performed after fermentation and during 21 days of storage test. Following the results obtained after fermentation Lactobacillus rhamnosus K4 strain was selected for the storage test. The sensory quality of tested beetroot juice was satisfactory during storage. The juice stored at temperature 4°C have higher overall quality then at 15°C. Studies have shown the possibility of producing beetroot juice with satisfactory sensory quality and sufficient cells numbers of potentially probiotic Lactobacillus rhamnosus K4 to allow the product to be considered probiotic.

Key words: probiotic, *Lactobacillus*, beet root juice, viability.

WPROWADZENIE

Żywność zawierająca mikroorganizmy probiotyczne zyskuje coraz większą popularność wśród konsumentów. Ugruntowaną pozycję na rynku mają produkty nabiałowe. Nie są one jednak polecane wszystkim konsumentom. Istotne ograniczenia dotyczą osób z nietolerancją laktozy, alergiami na białka mleka oraz preferujących wegetarianizm. Ponadto wysoka zawartość w niektórych produktach mlecznych tłuszczu i cholesterolu, eliminuje je z diet niskocholesterolowych, zalecanych np. pacjentom ze schorzeniami układu sercowo – naczyniowego. Cennym uzupełnieniem i alternatywą dla wyżej wymienionych grup konsumentów może być żywność pochodzenia roślinnego zawierająca mikroorganizmy probiotyczne. Zgodnie z wymaganiami FAO/WHO probiotyki powinny pochodzić z przewodu pokarmowego człowieka. Obecnie, oprócz uznanych drobnoustrojów, poszukuje się nowych mikroorganizmów potencjalnie probiotycznych, najczęściej izolowanych z żywności spontanicznie fermentowanej. Liczne prace badawcze wykazały, że potencjalnie probiotyczne szczepy Lactobacillus (LAB) mogą być izolowane nie tylko z przewodu pokarmowego ludzi, ale także z fermentowanej żywności [3, 6, 9, 13, 22]. Doniesienia naukowe [4, 10, 20] potwierdzają, że bakterie izolowane z produktów żywnościowych również mogą zasiedlać jelito grube człowieka i wpływać na jego prawidłowe funkcjonowanie, a często wykazują lepszą przydatność technologiczną. Bakterie LAB mają wiele pożądanych właściwości, które mogą mieć znaczenie w produkcji żywności fermentowanej ze

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względu na efekt biokonserwacji, tworzenia odpowiednich cech sensorycznych gotowych wyrobów oraz korzyści zdrowotnych dla konsumenta.

Właściwości probiotyczne LAB są szczepozależne i nie można ich przenosić na inne rodzaje i gatunki. Podstawowym zagadnieniem jest więc ocena poszczególnych szczepów *Lactobacillus,* głównie w zakresie przeżywalności przechowalniczej w produktach żywnościowych [12]. Liczba bakterii ma kluczowe znaczenie dla uzyskania prozdrowotnego efektu probiotyków. Wprowadzenie na rynek mikroorganizmów pochodzących ze spontanicznie fermentowanej żywności, może zwiększyć różnorodność oferowanych produktów żywności funkcjonalnej oraz ich dostępność dla konsumentów. W pracy podjęto próbę wyprodukowania soku z buraka ćwikłowego z dodatkiem szczepu bakterii mlekowych, potencjalnie probiotycznych i probiotycznych. Uważa się, że spożycie buraków ćwikłowych przynosi szereg korzyści zdrowotnych, takich jak m. in. przeciwdziałanie miażdżycy, obniżanie poziomu cholesterolu oraz wpływa na podwyższenie odporności immunologicznej, działanie antystresowe, spowalnianie procesów starzenia. Buraki zalecane są osobom z nadciśnieniem tętniczym, nadkwasotą żołądka oraz w leczeniu otyłości [5]. Warzywo to jest zasobne w składniki mineralne, takie jak potas, żelazo, wapń oraz magnez. Dodatkowo zawiera mikroelementy: cynk, mangan, miedź, kobalt. Buraki ćwikłowe zawierają znaczną ilość folianów (90-95 μg/100g surowego produktu). Analizując wartość odżywczą buraka ćwikłowego można zaobserwować stosunkowo dużą zawartość węglowodanów (10%), z czego przeważającym składnikiem jest sacharoza (6,5%), która nadaje warzywu słodki smak. Błonnik stanowi 1,8 g/100g surowego produktu. Burak ćwikłowy zawiera witaminę C oraz witaminy z grupy B. Obecnie w Polsce burak ćwikłowy nadal nie stracił na popularności, zaraz po marchwi jest najczęściej uprawianym warzywem korzeniowym, a jego roczne spożycie wynosi 12–14 kg w przeliczeniu na jednego mieszkańca [2]. W Unii Europejskiej uprawa polskiego buraka ćwikłowego stanowi aż 85% całej produkcji, co między innymi klasyfikuje Polskę na czwartym miejscu produkcji warzyw ogółem w Europie [11]. Sok z buraka ćwikłowego z dodatkiem mikroorganizmów potencjalnie probiotycznych wykazuje cechy synbiotyczne i łączy zalety żywieniowe z efektem prozdrowotnym probiotyków, co wydaje się szczególnie korzystne dla konsumentów [12].

Celem artykułu jest przedstawienie uzyskanych wyników badań dotyczących oceny możliwości zastosowania bakterii probiotycznych i potencjalnie probiotycznych do produkcji fermentowanego soku z buraka ćwikłowego, akceptowanego sensorycznie i zawierającego odpowiednią liczbę żywych komórek bakterii.

MATERIAŁ DO BADAŃ

Materiał do badań stanowił sok z buraków ćwikłowych (*Beta vulgaris* L. subs. *vulgaris*), odmiany podłużnej, pochodzący z upraw SGGW w Warszawie. Buraki przechowywano w temperaturze 4°C do momentu użycia. W badaniu zastosowano kultury starterowe probiotyczne i potencjalnie probiotyczne. Probiotyczne szczepy bakterii kwasu mlekowego: *Lactobacillus* acidophilus CH-2, *Lactobacillus acidophilus* CH-5 pochodziły z kolekcji Instytutu Technologii Fermentacji i Mikrobiologii Politechniki Łódzkiej. Szczepy bakterii *Lactobacillus rhamnosus* K4, *Lactobacillus plantarum* O21, *Lactobacillus rhamnosus* K3 i *Lactobacillus casei* O12 zostały wyizolowane z kiszonej kapusty i ogórków metodą spontanicznej fermentacji. Wykazywały wybrane właściwości probiotyczne, m.in. zdolność do przeżycia w warunkach panujących w przewodzie pokarmowym oraz adhezji do ścianki jelita [26] i pochodziły z kolekcji mikroorganizmów Zakładu Higieny i Zarządzania Jakością Żywności SGGW w Warszawie. Sok z buraków uzyskano w warunkach laboratoryjnych z zastosowaniem sokowirówki Kenwood, Wielka Brytania. Do soku dodano sacharozę w ilości 2% (przy wyborze szczepu do fermentacji) i 7% (na pozostałych etapach badań) a następnie, w celu pozbycia się mikroflory natywnej, pasteryzowano przez 15 min w temperaturze 90°C. Otrzymany sok schłodzono do 40°C i dodano inokulum w ilości 1 ml hodowli na 99 ml soku. Liczba bakterii w hodowli wyjściowej, która służyła do zaszczepienia soku wynosiła 10^9 jtk/ml.

Kultury bakteryjne przechowywano w temperaturze 80°C w bulionie MRS (Merck, Niemcy) z 20% dodatkiem glicerolu. Szczepy ożywiano przez dwukrotny pasaż na bulionie MRS z dodatkiem 1% inoculum i inkubację w temp. 37°C przez 24 godz. Po inkubacji podłoże hodowlane odwirowano (5 min., 10 000 obr./min) i zastąpiono je jałowym sokiem z buraka. Tak przygotowane szczepy posłużyły do fermentacji soku. Drugi etap badań polegał na zaszczepieniu jałowego soku z buraka ćwikłowego wybranym szczepem *Lb. rhamnosus* K4 i poddaniu procesowi fermentacji skróconej do 10 godzin, w temperaturze 37°C. Następnie sok przechowywano w temp. 4 i 15°C przez 21 dni, okresowo pobierając próbki do badań.

METODY BADAŃ

Liczbę komórek bakterii kwasu mlekowego oznaczono metodą płytkową wgłębną. Z soku pobierano 1 ml i dodawano do 9 ml sterylnej wody peptonowej (Biokar, Polska), następnie wykonywano szereg rozcieńczeń dziesiętnych. Z ostatnich dwu rozcieńczeń, przenoszono 1 ml zawiesiny na płytki Petriego, zalewano upłynnioną pożywką agarową MRS i dokładnie mieszano. Do obliczeń wybierano płytki liczące od 15 do 300 kolonii.

Wyboru szczepu dokonano na podstawie wyników oceny sensorycznej soku metodą skalowania, polegającej na określeniu stopnia pożądalności cech jakościowych: zapachu, smaku, jakości ogólnej [16].

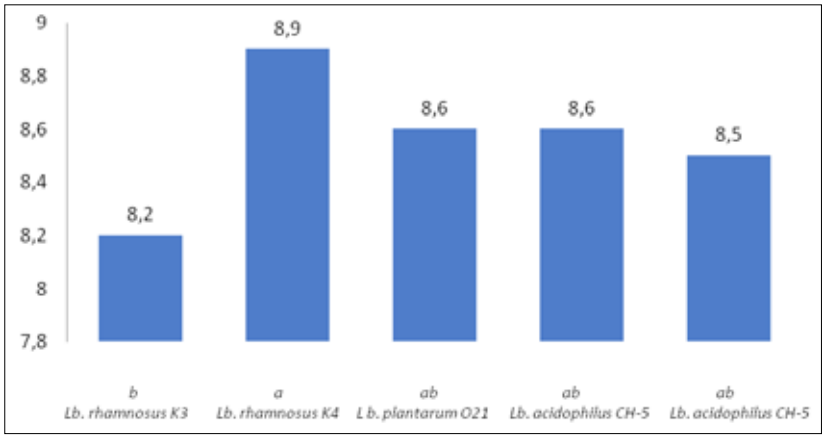
Pomiaru pH dokonywano za pomocą pH metru Elmetron CP 501 (Polska) metodą potencjometryczną z uwzględnieniem temperatury pomiaru [17].

Do oceny jakości sensorycznej soku po fermentacji oraz podczas przechowywania w 6, 12 i 18 dniu zastosowano Metodę Ilościowej Analizy Opisowej (QDA) zgodnie z normą PN-EN ISO 13299:2016-05 [15]. W ocenie sensorycznej brał udział 9-osobowy zespół oceniający, posiadający odpowiednie przeszkolenie i doświadczenie w zakresie metod stosowanych w analizie sensorycznej. Wytypowno 14 wyróżników jakościowych: 5 wyróżników zapachu, 6 wyróżników smaku oraz barwę, klarowność i jakość ogólną. Intensywność wyróżników zaznaczano pionową kreską, na niestrukturowanej skali graficznej [0–10j.u.], miejsce odpowiadające jakości ocenianej próbki [1]. Oceny przeprowadzano w sali spełniającej wymagania PN-EN ISO 8589:2010 [14]. Badania wykonano w dwu powtórzeniach.

Analizę statystyczną wyników przeprowadzono w programie Statistica. Do analizowania wyników zastosowano jednoczynnikową analizę wariancji ANOVA. Istotność różnic między wartościami średnimi weryfikowano testem Tukeya na poziomie istotności p=0,05.

OMÓWIENIE I DYSKUSJA WYNIKÓW

W celu wyselekcjonowania optymalnego szczepu bakterii, fermentowano (24 godz./37°C) sok z buraka ćwikłowego 5 szczepami bakterii probiotycznych i potencjalnie probiotycznych. Bakterie przeprowadziły proces fermentacji, o czym świadczy obniżenie pH badanych soków z 6,12 (świeżo wyciśnięty sok z buraka ćwikłowego) i 6,08 (wartość po pasteryzacji) do ok. 4. Najniższe pH (4,15) osiągnięto w przypadku soku zaszczepionego *Lb. acidophilus* LA-5, najwyższe (4,56) dla soku z użyciem *Lb. rhamnosus* K4. Dimitrovski i wsp. (2016) otrzymali synbiotyczny sok ze słonecznika bulwiastego [7]. Sok zaszczepiono *Lb. plantarum* PCS26 i fermentowano w 37°C przez 30 godzin. Wartość pH zmniejszyła się z 6,5 do 4,6. W badanym soku, po procesie fermentacji w tej samej temperaturze uzyskano podobne obniżenie wartości pH soku ze szczepem *Lb. plantarum* O21 z 6,08 do 4,34. Sionek i wsp. (2016) w badaniach probiotycznego soku z kapusty z dodatkiem soku z marchwi do fermentacji wykorzystali szczep *Lb. rhamnosus* K4 [19]. Sok fermentowano w różnych warunkach czasowo-temperaturowych. Dla procesu przeprowadzonego w 37°C przez 24 h otrzymano średnią wartość 3,8. Różnice wartości pH w badaniach mogą wynikać z właściwości poszczególnych szczepów i odmiennych matryc roślinnych.



Rys. 1. Średnia liczba komórek bakterii [log jtk/ml] po 24-godzinnej fermentacji w 37°C soku z buraka ćwikłowego z dodatkiem 2% sacharozy, z użyciem różnych szczepów bakterii kwasu mlekowego. Wartości średnie oznaczone tymi samymi literami nie różnią się istotnie statystycznie (p<0,05).

Fig. 1. The average number of various strains of lactic acid bacteria [log cfu/ml] after 24-hour fermentation in 37oC in beet root juice with the addition of 2% saccharose. Average values marked with the same letters do not differ statistically significantly (p<0.05).

Źródło: Badania własne

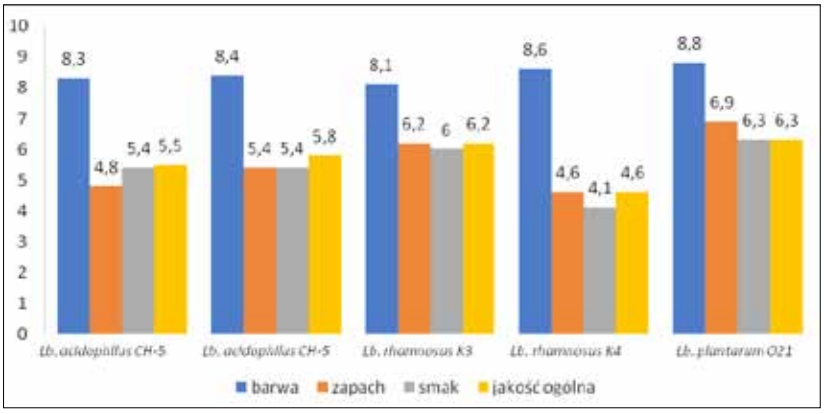
Source: The own study

Liczba komórek LAB po zaszczepieniu badanych soków wynosiła ok. 7,5 log jtk/ml. W wyniku procesu fermentacji nastąpił wzrost liczby komórek bakterii we wszystkich sokach o ponad 1 rząd logarytmiczny (rys.1). Największą liczebnością komórek charakteryzował się sok z dodatkiem szczepu *L. rhamnosus* K4 (8,9 log jtk/ml), najniższą – z dodatkiem *Lb. rhamnosus* K3 (8,2 log/ml). Wzrost liczby komórek może świadczyć o odpowiedniej zasobności matrycy, jaką był sok z buraka z dodatkiem sacharozy i dobrej adaptacji szczepu do środowiska. Podobne wyniki uzyskali Yoon i Woodans (2005), którzy wyprodukowali sok z buraka ćwikłowego z dodatkiem czterech szczepów bakterii fermentacji mlekowej [23]. Próbki fermentowano w 30°C przez 24, 48 i 72 h. Po 24-godzinnej fermentacji, sok z dodatkiem *Lb. acidophilus* LA 39 charakteryzował się zbliżoną liczebnością komórek, jak sok z użyciem *Lb. plantarum* C3, odpowiednio: 8,4 oraz 8,2 log jtk/ml.

Chwastek i wsp. (2016) wyprodukowali probiotyczny sok z buraka ćwikłowego z dodatkiem syropu z sacharozy, uzyskanej w wyniku trzykrotnego odwodnienia osmotycznego borówki wysokiej [3]. W badaniach korzystano z pięciu szczepów, między innymi z *Lb. rhamnosus* GG ATCC 53105. Procesowi fermentacji (5 dni w 30°C) poddano czysty sok z buraka ćwikłowego oraz sok z dodatkiem syropu z sacharozy. Sok z buraka charakteryzował się liczebnością bakterii fermentacji mlekowej na poziomie 8,5 log jtk/cm^3, zaś dodatek syropu spowodował spadek liczebności bakterii w zależności od ilości dodatku.

Jako kryterium doboru szczepu do fermentacji wzięto pod uwagę wyniki oceny sensorycznej soku z buraka fermentowanego różnymi szczepami. Odpowiedni dobór szczepów pozwala bowiem uzyskać produkt o akceptowanych cechach sensorycznych [21]. Wyniki oceny sensorycznej metodą skalowania wskazują, że wszystkie badane soki uzyskały wysokie oceny pożądalności ocenianych cech (rys.2). Najwyższą pożądalnością zapachu wykazała się próba soku z użyciem *Lb. plantarum* O21 (6,9 j.u.), najniższą - zaszczepiona *Lb. acidophilus* CH-5. Pod względem jakości ogólnej i pożądalności smaku najlepiej została oceniona próba z użyciem *Lb. plantarum* O21 i *Lb.rhamnosus* K4 (odpowiednio 6,3 i 6,2 j.u.; 6,3 i 6,0 j.u.). Analiza statystyczna wykazała brak istotnych różnic w preferencji wyboru fermentowanego soku z buraka zaszczepionego pięcioma szczepami, jedynie zapach soku z dodatkiem *Lb. plantarum* O21 został oceniony statystycznie wyżej w porównaniu z pozostałymi próbami Ze względu na podobne wyniki oceny sensorycznej do dalszych badań wybrano szczep *Lb. rhamnosus* K4, który charakteryzował się najwyższą średnią liczebnością bakterii w fermentowanym soku.

W drugim etapie, po zaszczepieniu soku z buraka wybranymi bakteriami szczepu *Lb. rhamnosus* K4, skrócono czas fermentacji przeprowadzanej w temp. 37 °C do 10 godz. Uzyskano istotny statystycznie wzrost średniej liczby bakterii z 7,6 log jtk/ml przed fermentacją do 9,1 log jtk/ml (p<0,05). Skrócenie czasu procesu fermentacji korzystnie wpłynęło na liczbę bakterii, co jest zgodne z wynikami innych badań. Sionek i wsp. (2016) przeprowadzili fermentację napoju probiotycznego (*Lb. rhamnosus* K4) z kapusty z dodatkiem soku

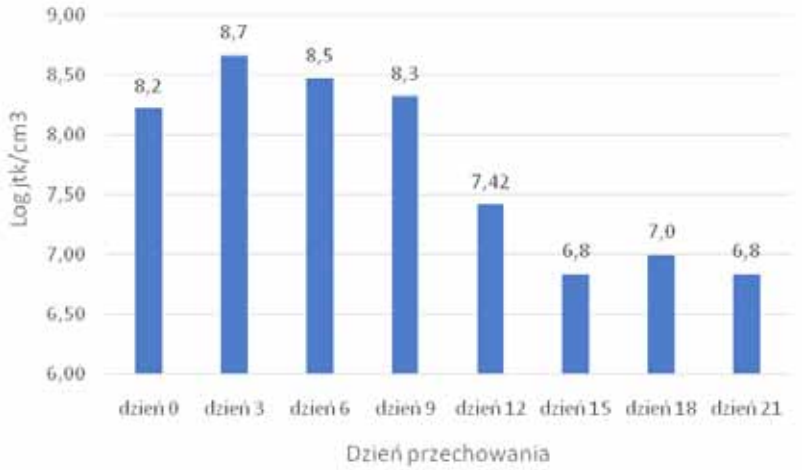


Rys. 2. Ocena sensoryczna fermentowanego soku z buraka ćwikłowego różnymi szczepami bakterii probiotycznych lub potencjalnie probiotycznych, z dodatkiem 2% sacharozy. Metoda skalowania, 10-najlepszy, 0-najgorszy.

Fig. 2. Sensory evaluation of fermented beet root juice with different strains of probiotic or potentially probiotic bacteria, with the addition of 2% saccharose. Scalling method, 10-the best, 0-worst.

Źródło: Badania własne

Source: The own study



Rys. 3. Zmiany średniej liczby komórek Lb. rhamnosus K4 w fermentowanym soku z buraka ćwikłowego z dodatkiem 7% sacharozy, przechowywanego 21 dni w 4°C.

Fig. 3. Change in the average number of Lb. rhamnosus K4 cells in fermented beet root juice with the addition of 7% saccharose, stored 21 days in 4°C.

Źródło: Badania własne

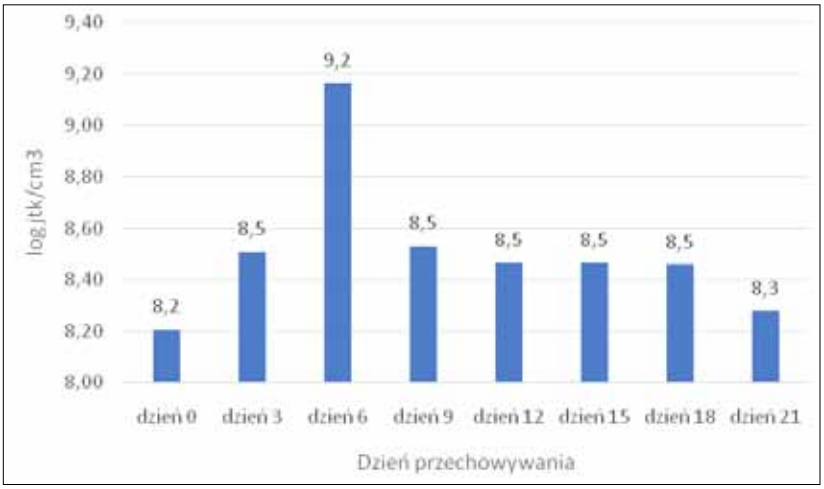
Source: The own study

z marchwi w różnych warunkach czasowo-temperaturowych [19]. Wykazano, że zastosowanie krótkiego, 6 godzinnego czasu fermentacji powodowało uzyskanie wysokiej liczby bakterii (9,1 i 8,4 log jtk/ml) i najkorzystniejszych cech smakowo-zapachowych. Zastosowane warunki fermentacji pozwoliły na otrzymanie soku o zadowalających cechach sensorycznych. Podobne wyniki uzyskała Zielińska (2005), poddając ocenie sojowy napój probiotyczny (z dodatkiem *Lb. casei* KN291), fermentowany w różnych warunkach czasowo-temperaturowych [25]. Napój inkubowany przez 6 godzin w 37°C został oceniony jako najatrakcyjniejszy pod względem smaku, zapachu, jak i oceny ogólnej z pośród badanych soków.

W ostatnim etapie badań przeprowadzono 21 dniowy test przechowalniczy w temp. 4°C i 15°C. Zgodnie z wymaganiami FAO/WHO minimalna liczba żywych komórek bakterii, dotycząca mikroflory podstawowej (naturalnie występującej) i technicznej (dodanej w procesie technologicznych) powinna wynosić w całym okresie przechowywania nie mniej niż 10^6 jtk/ml aby można je było uznać za probiotyczne [8]. W czasie 21 dni przechowywania w temp. 4°C i 15°C sok z buraka ćwikłowego zawierał odpowiednią liczbę bakterii, która spełniała minimum terapeutyczne produktów probiotycznych. Największą liczbę komórek *Lb. rhamnosus* K4 zaobserwowano trzeciego dnia przechowywania (8,7 log jtk/ml), po czym liczebność malała. W 18 dniu przechowywania nastąpił nieznaczny wzrost liczebności bakterii fermentacji mlekowej (z 6,8 do 7,0 log jtk/ml), następnie w 21 dniu liczba komórek obniżyła się do 6,8 log jtk/ml. Zmiana liczebności bakterii od 12 do 21 dnia była istotna statystycznie (rys. 3). Podobne wyniki uzyskał Yoon i wsp. (2006) dla probiotycznego soku z kapusty [24]. Początkowa liczebność komórek *Lb. planatrum* C3 w soku wynosiła 5,9 log jtk/ml, po 24 h wzrosła do 8,9 log jtk/ml, a po 48 h do 9,2 log jtk/ml. Po 72 godzinach fermentacji, napój przechowywano w 4°C przez cztery tygodnie. Sharma i Mishra (2013) poszukując alternatywnej roślinnej matrycy stworzyli probiotyczny napój z soku przepękli ogórkowatej, tykwy pospolitej i marchwi [18]. Wyciśnięte soki wymieszano w równych proporcjach i poddano fermentacji (w temp. 30°C przez 72 h) z użyciem szczepów probiotycznych. Fermentowane napoje przechowywano przez 4 tygodnie w temp. 4°C. Wszystkie analizowane szczepy w trakcie przechowywania traciły na liczebności komórek *Lb. plantarum* NCDC 414. W pierwszym tygodniu liczba komórek badanego szczepu wynosiła 8,1 log jtk/ml, zaś po trzecim tygodniu osiągnęła wartość 7,4 log jtk/ml.

Największy średni wzrost liczby komórek *Lb. rhamnosus* K4 odnotowano w szóstym dniu przechowywania (9,2 log jtk/ml) i jest to istotna statystycznie wartość. Od 9 do 21 dnia przechowywania liczba komórek bakterii spadała odpowiednio do 8,5 i 8,3 log jtk/ml (rys. 4). Duży wzrost liczby komórek bakterii zaobserwowany w początkowym okresie przechowywania mógł wynikać z odpowiedniej zasobności matrycy roślinnej.

Zbliżone wyniki uzyskali również inni badacze. Trząskowska i Kołożyn-Krajewska (2010) prowadziły test przechowalniczy fermentowanego soku marchwiowego przez 32 dni w temperaturze 15°C [21]. Średnia liczba komórek bakterii na początku badania wynosiła 9,0 log jkt/ml, w ósmym dniu przechowywania wzrosła do 9,2 log jtk/ml, i obniżyła się do uzyskania 8,8 log jtk/ml.

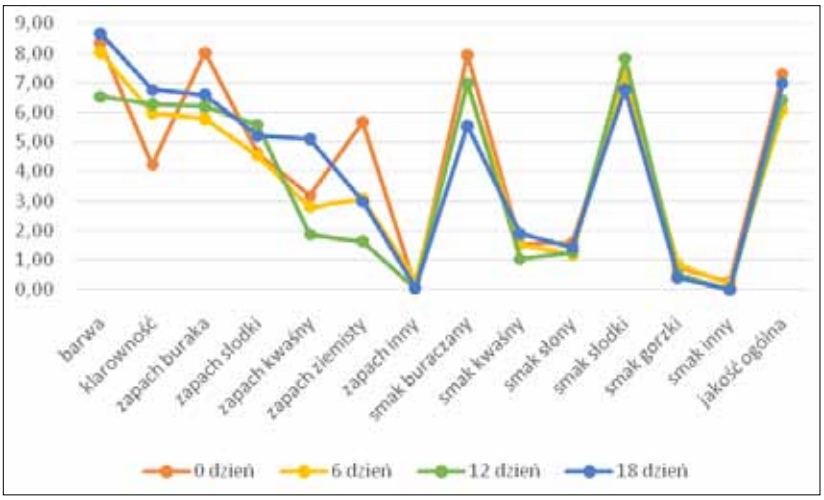


Rys. 4. Zmiany średniej liczby komórek Lb. rhamnosus K4 w fermentowanym soku z buraka ćwikłowego z dodatkiem 7% sacharozy, przechowywanego 21 dni w 15°C.

Fig. 4. Change in the average number of Lb. rhamnosus K4 cells in fermented beet root juice with the addition of 7% saccharose, stored 21 days in 15°C.

Źródło: Badania własne

Source: The own study



Rys. 5. Wartości średnie badanych wyróżników fermentowanego soku z buraka ćwikłowego z dodatkiem 7% sacharozy, zaszczepionego Lb. rhamnosus K4 i przechowywanego w temperaturze 4°C przez 18 dni (metoda QDA).

Fig. 5. Average sensory notes of fermented beet root juice with the addition of 7% saccharose, vaccinated Lb. rhamnosus K4 and stored at 4°C for 18 days (QDA method).

Źródło: Badania własne

Source: The own study

Wyniki oceny sensorycznej wskazują, że sok przechowywany w 4°C jest produktem stabilnym przez cały okres przechowalniczy, pod względem takich cech jak: smak i jakość ogólna. Stwierdzono wzrost klarowności ocenianych prób w trakcie przechowywania chłodniczego. Można przypuszczać, iż na ocenę klarowności soku mogły wpłynąć drobiny miąższu buraka znajdujące się w analizowanych próbkach. Podczas przechowywania intensywność zapachu buraczanego uległa pogorszeniu z 8,03 j.u. (dzień 0) do 5,78 j.u. (dzień 6), a następnie nieznacznemu polepszeniu. W 8 dniu przechowywania zapach kwaśny był najintensywniej odczuwalny i jest średnią statystycznie istotną. Zapach ziemisty najbardziej wyczuwalny był po fermentacji (dzień 0, różnica istotna statystycznie), zaś w ciągu kolejnych dni przechowywania uległ obniżeniu do 1,64 j.u. Intensywność smaku buraczanego malała wraz z długością przechowywania. W ocenianych próbkach nie wyczuwano obcego zapachu i smaku. Przez cały okres przechowalniczy intensywność smaku słodkiego była wyraźnie wyczuwalna (6,78–7,84 j.u.). Intensywność zapachu oraz smaku buraczanego mają bezpośredni wpływ na jakość ogólną, która utrzymywała się na stosunkowo wysokim poziomie, od 6,07 do 7,30 j.u. (rys. 5).

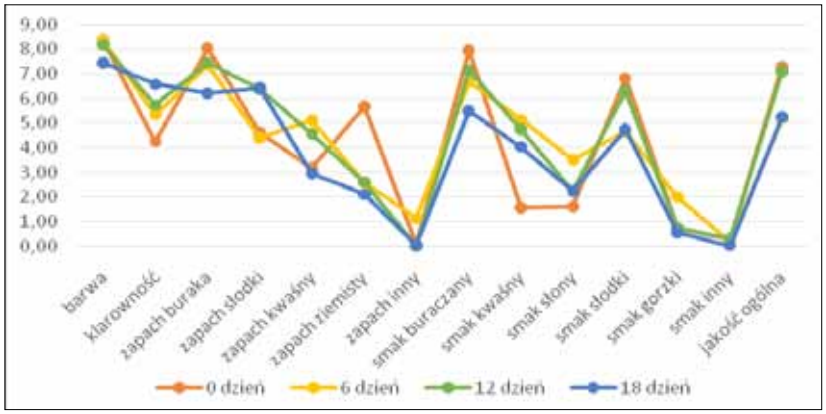
Probiotyczny sok z buraka ćwikłowego przechowywany w 15°C w porównaniu z sokiem przechowywanym w temperaturze 4°C był produktem wykazującym większe wahania w zakresie stabilności jakościowych cech sensorycznych. Odczuwalność zapachu buraczanego, ziemistego oraz smaku buraczanego malała wraz z wydłużającym się okresem przechowalniczym. Wyżej wymienione cechy są ze sobą silnie powiązane, burak ćwikłowy jest warzywem korzeniowym, który nabiera aromatów ziemistych przez swoisty kontakt z glebą. W trakcie okresu przechowalniczego odczuwalność zapachu słodkiego wzrosła, zaś smaku zmalała. Smak kwaśny najmniej wyczuwalny był po fermentacji (dzień 0: 1,56 j.u.). Zarówno smak, jak i zapach kwaśny był najintensywniej wyczuwalny w 6 dniu przechowywania. W ocenianych próbkach nie zaobserwowano obecności smaku i zapachu obcego. Jakość ogólna uległa znacznemu pogorszeniu z 7,11 po fermentacji do 5,17 j.u. w 6 dniu przechowywania (wartość średnia istotna statystycznie) (rys. 6). Trząskowska i Kołożyn-Krajewska (2010) otrzymały probiotyczny sok marchwiowy, który przechowywano przez 32 dni w różnych warunkach temperaturowych [21]. Produkt przechowywany w 5°C uzyskał najkorzystniejsze noty i jako jedyny wykazał się zadowalającymi cechami sensorycznymi przez cały okres przechowalniczy. W soku przechowywanym w 15°C, już po ósmym dniu przechowywania nastąpiło znaczne pogorszenie cech smakowo-zapachowych, co klasyfikowało go do produktu nieakceptowalnego sensorycznie.

PODSUMOWANIE

W wyniku przeprowadzonej selekcji szczepów bakterii probiotycznych i potencjalnie probiotycznych, do fermentacji soku z buraka ćwikłowego wybrano szczep *Lactobacillus rhamnosus* K4, który uzyskał odpowiednią ilość bakterii i wysokie oceny sensoryczne.

Warunki skróconej fermentacji soku z buraka ćwikłowego 10 godzin w temp 37°C pozwalają na uzyskanie wysokiej liczby bakterii fermentacji mlekowej (powyżej 6 log jtk/ml).

Otrzymany produkt charakteryzował się zadowalającą jakością sensoryczną. Sok przechowywany w 4°C odznaczał się większą stabilnością cech smaku i jakości ogólnej od soku przechowywanego w 15°C. W przeprowadzonych badaniach udowodniono, iż istnieje możliwość produkcji probiotycznego soku z buraka ćwikłowego, o odpowiedniej liczbie komórek bakterii szczepu potencjalnie probiotycznego *Lactobacillus rhamnosus* K4 oraz akceptowalnymi cechami smakowo-zapachowymi.



Rys. 6. Wartości średnie badanych wyróżników fermentowanego soku z buraka ćwikłowego z dodatkiem 7% sacharozy, zaszczepionego Lb. rhamnosus K4 i przechowywanego w temperaturze 15°C przez 18 dni (metoda QDA).

Fig. 6. Average sensory notes of fermented beet root juice with the addition of 7% saccharose, vaccinated Lb. rhamnosus K4 and stored at 15°C for 18 days (QDA method).

Źródło: Badania własne

Source: The own study

CONCLUSIONS

As a result of the selection of probiotic and potentially probiotic bacteria strains, the *Lactobacillus rhamnosus* K4 was selected for fermentation of beet root juice. The juice fermented with this strain had appropriate amount of bacteria cells and achieved high sensory notes. The short time conditions of fermentation (10 hours at 37°C) applied for beet root juice resulted in high number of lactic acid bacteria (above 6 log cfu / ml). The final product was of satisfactory sensory quality. Juice stored at 4°C was characterized by greater stability of taste and better overall quality than juice stored at 15°C. The research showed that there is the possibility of producing probiotic beet root juice with an adequate number of bacterial cells of the potentially probiotic strain *Lactobacillus rhamnosus* K4 and acceptable flavor characteristics.

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MYCOTOXINS IN BEER®

Mykotoksyny w piwie®

Beer is currently the most popular alcoholic beverage in the world. Due to the scale of consumption, ensuring maximum health safety of it is extremely important issue. One of it's safety risks is the possibility of mycotoxin occurrence. These compounds were first discovered in the 1960s, but new information about their properties is being discovered to this day. Mycotoxins are metabolites of cereal attacking mold fungi which can contribute to a wide range of conditions, from foodborne illnesses to various types of cancer. As contamination may occur at various leading to the production of a finished product,, manufacturer's awareness of this type of hazard is an important issue. The article discusses the most common groups of mycotoxins found in beer, brings up the issue of their origin and impact on the sensory characteristics of beer. In addition, article presents data on the occurrence of these compounds in beverages available on the market, as well as methods that can reduce their content.

Key words: fungi, mycotoxins, aflatoxin, *Fusarium*, beer.

Piwo jest obecnie najpopularniejszym napojem alkoholowym na świecie. Ze względu na skalę konsumpcji, bardzo ważną kwestią jest zapewnienie maksymalnego bezpieczeństwa zdrowotnego tego produktu. Jednym z zagrożeń jest możliwość występowania mykotoksyn. Związki z tej grupy zostały po raz pierwszy odkryte w latach 60 ubiegłego wieku, a nowe informacje dotyczące ich właściwości pojawiają się po dziś dzień. Są one metabolitami grzybów pleśniowych atakujących zboża i mogą przyczyniać się do występowania szerokiej gamy schorzeń, od zatruć pokarmowych aż do różnego rodzaju nowotworów. Skażenie może wystąpić na różnych etapach prowadzących do otrzymania gotowego produktu, stąd istotną kwestią jest świadomość producentów dotycząca zagrożenia. Artykuł omawia najczęściej występujące grupy mykotoksyn w piwie, porusza kwestię ich pochodzenia i wpływu na cechy sensoryczne produktu. Dodatkowo przedstawione zostały dane dotyczące występowania tych związków w piwach dostępnych na rynku, jak i metody mogące zmniejszyć ich zawartość.

Słowa kluczowe: grzyby, mykotoksyny, aflatoksyna, *Fusarium*, piwo.

INTRODUCTION

For years, beer has been widely appreciated among consumers. According to WHO [25] it is the most popular alcoholic beverage in Europe, with an average annual *per capita* consumption in the year 2018 ranging from 33 to 141 L, depending on country. For many years the highest consumption is observed in Czechia, where in 2018 the average annual consumption was 141 L. Subsequent countries in terms of consumption are Austria, Germany and Poland, respectively 107, 102 and 100 L *per capita* [23,25]. The size of this market can be exhibited by production volume, which only for European countries, reached 406 050 hL in 2018 alone.

Due to consumption volume, ensuring proper quality and health safety of the product is an extremely important issue. In case of toxic contamination, considerable and regular consumption which is observed in European countries, can bring health hazard to consumers. Toxic agents that may be present in beer include those presented in Table 1. In recent years, special attention began to be paid to mycotoxin occurrence in food products [13].

The aim of this article is to discuss issues regarding mycotoxin occurrence in beers. The article provides information on origination of these compounds in a product, their influence on sensory characteristics of beer and shows methods of decreasing their levels in a product.

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Table 1. Main toxic factors occurring in beer

Tabela 1. Główne czynniki toksyczne występujące w piwie

Factor	Origin
Chlorinated aliphatic hydrocarbons	Groundwater, created during water treatment in brewery
Biogenic Amines	Microbial infections in brewery
Nitrates	Raw materials, mainly water and hops
Phthalates	Raw materials; product contact with plastic
Nitrosamines	Created during heat treatment, reactions of amines naturally occurring in materials, by microbial infections or pesticide contamination
Polycyclic aromatic hydrocarbons	Widely distributed in the environment
Polychlorinated biphenyls	Widely distributed in the environment despite usage ban since 1970s
Metals	Raw materials, brewery equipment
Pesticides	Raw materials
Coliforms	Not maintaining proper hygiene levels on final steps of production
Mycotoxins	Raw materials

Source: [13]

Źródło: [13]

FUNGI AS MYCOTOXIN PRODUCERS

The word ”mycotoxin” descends from a combination of Greek word *mykes* (fungus) and a Latin term for toxin, *toxicum*. This term refers to one of the groups of natural secondary metabolites, characterized by low molecular weight (usually below 1 kDa) produced by some mold fungi [27]. Vertebral organisms can be exposed to them by consumption of contaminated food, by inhalation or by skin contact [10]. They exhibit a wide range of activities, such as carcinogenic, mutagenic, teratogenic, cytotoxic, neurotoxic, nephrotoxic, neurotoxic, immunosuppressive and estrogenic [27]. Their toxicity is dependent on the type of the toxin itself, dose, time of exposition and additional synergistic reactions between other mycotoxins, which may be present in the product [27]. Exposure to high concentrations can have fatal effects, which event that took place in 1944 is an example of. In that year, in the Orenburg region of Russia cereal grains were contaminated with toxigenic species of *Fusarium* (producing T-2 toxin and Trichothecenes A). 10% of the region’s population were affected, among whom mortality rate was nearly 60%. Leukemia, bleeding from nose, throat, and gums, necrotic angina, sepsis, rash and fever were observed in the victims. Nowadays however, such contamination in the brewing industry is improbable. The much more worrisome issue is chronic exposure to low doses of mycotoxin, which effects are still vague. Long term intake of aflatoxins, one of the groups of mycotoxins may serve as an example. It is suspected that such an exposure can cause hepatocellular carcinomas, reduction of male fertility, lowering the body’s immunity and pulmonary fibrosis [10, 26]. There have been reports stating their contribution to the onset of Ray and Kwashiorkor syndromes in children.

Intensive research into understanding mycotoxins were initiated by accident that took place in 1960, when 100,000 farm birds have died as a result of contamination of the feed by *Aspergillus flavus* [15]. It is currently rated that nearly 350 species of mold have the capacity to produce mycotoxins, whose number is estimated at over 400 [15]. They are formed as a result of significant precursor accumulation required in primary metabolism performance such as amino acids, acetates and pyruvates. The main reason for their synthesis is believed to be cells tendency to reduce the amount of precursors present within them [15].

Mycotoxins are characterized by a high resistance to the effects of environmental factors, thus they can survive the whole production process, during which conditions are not sufficient to render them harmless – so they find the way to the finished product. The most common and also the most dangerous mycotoxins that can be present in beer are:

- Aflatoxins, in particular Aflatoxin B1 (B1) which is believed to have the highest carcinogenic activity among natural toxins. AFB1 is produced by members of *Aspergillus* section *flavi*, especially *Aspergillus flavus*, which are commonly found on aerial parts of plants. These mycotoxins are very stable, as they retain their properties for a long time, even when subjected to processes such as cooking, baking, roasting or extrusion, although alkaline environment tends to reduce their toxicity. Aflatoxins have been recognized by the International Agency for Research on Cancer (IARC) as carcinogenic factors belonging to group 1. AFB1 has hepatotoxic, mutagenic, carcinogenic and immunotoxic activities. They don’t have a fixed Tolerable Daily Intake (TDI) value [4,10,15].
- Trichothecenes, including Deoxynivalenol (DON - also known as Vomitoxin), Nivalenol (NIV), T-2 toxin (T-2) and HT-2. *Fusarium sporotrichioides*, *F. langsethiae*, *F. poae* are the most important producers of T-2 and HT-2 toxins. The jointly Tolerable Daily Intake for both T-2 and HT-2 toxin is 1 μg / 1 kg body weight per day. They act as immunotoxic and hepatotoxic agents [4]. DON is mainly synthesized by *F. graminearum*, *F. Culmorum* and *F. cerealis*. It has a TDI of 1 μg / 1 kg bw. per day. It is held responsible for diarrhea, vomiting and immunotoxic activity [4, 5].
- Ochratoxin A (OTA), produced mainly by *Aspergillus* section *Circumadati*, *Aspergillus* section *Nigiri*, *Penicillium verrucosum* and *Penicillium nordicum*. Reduction of its content in a raw material takes place when material is treated with temperatures of 250°C for several minutes [7, 10]. OTA is classified by IARC as a possible carcinogen to humans, with it’s TDI set to 1 μg / 1 kg bw. per day.
- Fumonisins (FMB1, FMB2, FMB3), mainly produced by molds of the *Fusarium* genus, especially those originating from section *Liseola*. *Fusarium verticillioides* and *F. proliferatum* are considered the most important producers of these mycotoxins. In order to reduce their amount, raw materials should be treated with temperatures of at least 150°C. The Provisional Maximum Tolerable Daily Intake (PMTDI) for the most common toxin from this group, FMB1 is 2 μg / 1 kg bw. per day. It is considered as carcinogen and nephrotoxic agent [4].

- Zearalenone (ZEN), synthetized by molds of the *Fusarium* genus, mainly *F. graminearum*, *F. culmorum*, *F. cerealis*, *F. equiseti*, *F. verticillioides* and *F. incarnatum*. Similarly to FMB1, thermal decomposition of ZEN takes place in an environment with temperatures above 150°C [10]. It hasn't been classified by IARC, but TDI for this mycotoxin is 0,25 μg / bw. per day. ZEN shows estrogenic and reprotoxic activities [4].

MYCOTOXIN ORIGIN IN BEER

Traditionally beer is made from 4 main ingredients: water, malt, yeasts and hops. Contrary to the popular belief about strong antiseptic properties of hops, this raw material might also be a source of mycotoxins [21]. However, due to the amount of hops used in the brewing process, and very low quantities of mycotoxin found in the material itself, its influence may be neglected. The main source of those compounds in beer is clearly the brewer's malt. According to FAO, nearly 25% of all cereals grown in the world can be contaminated with mycotoxins, although newer research indicates that the number of infected cereals can actually reach up to 72% [3]. Cereal contamination can take place at various stages of the production process. Incorrect drying, storage and packaging conditions, as well as improper agricultural practices may promote mold fungi growth. Other factors, such as using fungicides in insufficient doses can promote the growth of strains which are able to produce mycotoxins at higher rate [24]. Even if grain has not been contaminated with mycotoxin, due to the ubiquity of spores in the environment, it probably contains fungal spores. Fungal molds found on cereal grains can be divided into two major categories: those infecting plants before the harvest and fungi developing during storage of the grain. The most commonly found organisms of the first group are: *Alternaria*, *Aureobasidium*, *Cladosporium*, *Epicoccum*, *Fusarium* and *Helminthosporium*. Organisms in this group are parasites or saprophytes, that contribute to significant crop losses. The growth of these specific microorganisms is highly dependent on climatic conditions, varieties of cultivated cereals and agricultural practices. Fungi belonging to the second group are absent or identified only in small quantities in fresh raw material, and their quantity increases over storage time. The most common microorganisms in the second group are those of *Aspergillus* genus, and to a lesser degree, *Penicillium*. Storing grain with an increased moisture content may lead to development of the molds from *Absidia*, *Rhizopus* and *Mucor* genus [6]. These microorganisms possess a threat to all cultivated cereals, but because the most commonly used cereal in the brewing industry is barley, the remainder of the paragraph will focus on this cereal. The main threat to brewer's barley quality is the growth of filamentous fungi of *Fusarium* genus.

In order to obtain from the grain the material required for the production of beer, grains are subjected to the process known as malting. The purpose of this treatment is to change the physical structure and chemical composition of the grain through stimulation of the natural process of germination, and terminating it at the right moment. First problem arising at this stage is reduced germination capacity of contaminated grains. Actions taken during the malting process, create favorable conditions for the growth and production of mycotoxins by mold fungi. Wide availability of nutrients, water immersion of grains combined with aeration, low temperatures during steeping and germination and high relative humidity (~90%) stimulate growth of the fungal spores that might be present in the raw material. Microbial growth during this process highly depends on initial contamination of the grain, possible interactions between different microorganisms present in the environment, nutrient availability and the applied conditions of the malting process, such as temperature, humidity and rate of aeration. Additional contamination might come from endogenous microflora of a malthouse [22]. Fungal growth and as a result mycotoxin synthesis takes place during the whole malting process, until freshly obtained malt is dried to a water content of 4–5% [10,24]. Proper conduct of the malting process can lead to significant reduction of water-soluble toxins such as DON and ZEN. According to Piacentini et. all [17], provided there is no secondary growth of mycelium, malting can reduce the ZEN and DON levels by 69 and 71% respectively, compared to raw materials. Content of other toxins, such as T-2 and HT-2 is also reduced during the process [10]. Grains tested immediately after kilning are characterized by the lowest amounts of those compounds, which rises on the next steps of the malting process. In case of severe grains contamination, the final concentration of these toxins in malt can be even twice as high as in the raw material [10, 17]. It is noteworthy that the reduction of some mycotoxin content might be ostensible due to so-called modified mycotoxins. These toxins are conjugated to more polar compounds, such as sugars, and they are thought to be less toxic to the living organisms. As for now, the detailed information regarding their toxicity is still unknown, but it has been documented that the bonds with polar compounds and the toxin itself can be broken down inside digestive tract by the activity of lactic acid bacteria, which naturally inhabits mammal gastrointestinal tract, freeing toxins in the process [3]. Research suggests up to 50% of DON present in barley grains can be biotransformed to DON-3-Glc conjugate, thanks to activity of enzymes activated during malting [17]. Similar mechanism also occurs in cereal grains before harvest, probably as a specific way of "detoxifying" plants from fungal metabolites. It is considered that other mycotoxins produced by *Fusarium*, such as ZEN, FMB1, T-2, HT-2 and NIV can also undergo bonding with polar compounds [3]. As modified mycotoxins are more water soluble, there is a risk they can pass in larger quantities into the wort during the mashing process than original compounds.

According to research conducted by Gonzalez Pereyra et. all [6], the most common microorganisms found in malt are mold fungi from *Fusarium*, *Geotrichum* and *Aspergillus* genus. *Penicillium*, *Cladosporium* and *Alternaria* were also found, but less frequently. The most common representatives of *Fusarium* genus were *F. verticilloidies* and *F. proliferatum*. All of the malts tested in this research contained 104–145 μg/kg FMB1. AFB1 was detected in 18% of samples, at 19–44, 52 μg/kg. Malt contamination with AFB1 is relatively rare in European cultivations, since mold fungi producing them prefer a warmer climate [22]. As mentioned earlier, nearly all of the cereal is contaminated by mycotoxins to some degree, so the exact amount of compounds which passes from malt to a finished product is an important issue. Results obtained by Piacentini et. all [17] shows that on average, about 91% of DON contained in malt grains goes to the wort, and 89,9%

into the finished products. For ZEN first value is 6,3%, and in the finished product it's content is below detection level.

MYCOTOXIN INFLUENCE ON BEER SENSORY CHARACTERISTICS AND PRODUCTION PROCESS

The fungal metabolites load of the malt influences the fermentation process of the wort and the sensory characteristics of the finished beer. The main problem associated with usage of contaminated grains is a phenomenon known as gushing. It manifests itself in a violent and intensive foam formation after opening a beverage, resulting in a significant loss of the product. Contamination of the malt with a peptide metabolites of fungi, known as hydrophobins is indicated as the main cause of this defect. Other possible sources of this flaw are: bottle contamination, cleaning agent residues, excessive carbonation and occurence of metal ions or oxalates in the finished product [24]. Hydrophobins probably stabilize carbon dioxide bubbles in the drink by forming a protective layer around them, preventing them from collapsing, which leads to the creation of excessive amounts of foam [20]. The species responsible for this phenomenon are primarily those from *Fusarium* genus, however research suggests this defect may also be caused through development of *Aspergillus*, *Penicillium*, *Nigrospora* and *Stemphylium* [20,24]. It is believed that unlike mycotoxins, all mold fungi species can synthetize hydrophobins, so the content of the former can't be a direct determinant of the possibility of this defect appearing. It is also worth noting that fungi can also produce compounds counteracting gushing, such as lipids, therefore the resultant effect of such contamination is difficult to determine [20].

Fungal metabolites may affect wort quality parameters (such as Free Amino Acid content – FAN, pH, color), course of fermentation and parameters of finished product (FAN, color, flavor and aroma) [22]. Contaminated malt can be a source of thermostable proteases that, acting with endogenous malt enzymes will break down bonds inside malt proteins to a higher degree than endogenous enzymes themselves. This may cause changes to beer color, texture, aroma, flavour and foaming. Increased protease activity of the mash can accelerate fermentation rate thanks to higher FAN content in wort. However, the presence of T-2, DON and ZEN is known to reduce the rate of fermentation [22, 24]. The growth of fungi can also increase the amount of β-glucanases and pentosanases in malt. Additional activities from these enzymes could increase the efficiency and speed of wort filtration [22].

It has long been known that the growth of *Fusarium* is related to formation of undesirable aromas in beer [22]. In the research conducted by Oliveira et. all [12] beers brewed with highly contaminated malts contained higher content of volatile compounds, respectively: 10% more higher alcohols, 10% esters, 40% fatty acids, 75% ketones, 100% dimethyl sulfide and 1300% acetaldehyde, compared to the control sample. The authors suggest that an increase of higher alcohols, esters and ketones content is associated with a higher concentration of FAN in the wort obtained from contaminated malt. A significant increase in acetaldehyde concentration indicates a deficiency of active yeast cells in the final stages of fermentation. It indicates a decrease in yeast viability and premature flocculation. Additionally, quality parameters of obtained beer indicate it might be more susceptible to aging processes [12].

DECREASING MYCOTOXIN CONTENT USING TECHNOLOGICAL PROCESSES

The most beneficial solution in terms of beer quality and consumer health would be to completely stop using grain suspected of developing mold. However, in some years avoiding microbial infection is nearly impossible, due to the atmospheric conditions. Crop cultivations in some countries are especially prone to infections, as warm and humid climate promote them. Even healthy grains can be contaminated as a result of improper storage conditions or mistakes during malting. European Commission regulations sets the legal limits for maximum admissible content of mycotoxins in grains, namely: 2 μg/kg grain for AFB and 4 μg/kg for the sum of all aflatoxins, 100 μg/kg for ZEN, 1250 μg/kg for DON and 2000 μg/kg for sum of FMB1 and FMB2 [14]. But these values may be exceeded during the malting process. Malthouses should make every effort in order to ensure proper quality and health safety of their products. Proper malting conditions, such as steeping with restricted aeration, water change during aeration breaks, strict control of temperature during germination as well as general care for the equipment cleanliness can significantly reduce mold growth [22]. Since the temperatures used in the brewing process are not high enough to destroy toxins, another solution is needed. The most beneficial solution counteracting this problem in terms of economy and consumer health is decontamination. It's purpose is to reduce the amount of fungal spores present in the raw material along with reducing their growth during the process. Decontamination methods include:

- Ozonation – using 5 minute ozone treatment under certain conditions allows to deactivate 96% of mold spores, without decrease in grain's germination capacity (fungal cells are less resistant to ozone than seed embryos) and without leaving any residue [14];
- Washing the grains with hot water before malting – treatment with water at 45°C can reduce the amount of water soluble toxins such as DON in finished malt by 79–93% [14],
- Steeping using chlorinated water, water enriched with addition of hydrogen peroxide or alkaline waters – those methods allow to reduce the spore load of raw material, although they are cost-ineffective. Furthermore, using too high concentrations of this chemicals may decrease germination capacity or cause adverse sensory characteristics of malt [22];
- Addition of selected strains of lactic acid bacteria (LAB) – mainly those from *Lactobacillus* or *Pediococcus* genus have the ability to inhibits growth of *Fusarium* up to 23%, which may lead to 83% decrease in DON levels in brewer's malt. Production of lactic acid by these organisms, resulting in lowering of pH may increase enzymatic activity during malting and mashing [14];
- Addition of selected *Geotrichum candidum* cultures – growth of this microorganism confines the growth

of undesirable molds from *Fusarium*, *Penicillium* and *Aspergillus* genus, inhibits their ability to produce metabolites and stimulates growth of lactic acid bacteria. LAB further inhibits fungi growth by lowering the pH of the environment. Brewer's malt obtained in this way has superior quality parameters such as more effective filtration, inhibition of polysaccharide producing microflora and reduced fatty acids content [22];

- Radiation method – electron beam irradiation can reduce brewer's malt DON content by 60-100% with minimal impact on quality parameters of the product, leaving no residue [14]. This method relies heavily on using the right amount of radiation energy. Too low energy might not be sufficient to dispose of all of the fungal spores, and remaining microorganisms may have increased ability to produce secondary metabolites, as it is seen with *Aspergillus flavus* and *A. parasiticus*. On the other hand, too high energy significantly reduces germination capacity and changes the malt quality parameters [14,22].

Reduction of mycotoxin levels also takes place during the beer production stage. This can occur by removing them from the product or by transformation into less toxic forms. Removal of mycotoxins from the product can occur by binding them in sludge, which is separated from the product. Although not tested, it is believed there is a possibility of binding them with clarifying agents [14]. It is known that removal of OTA, ZEN and AFB1 occurs naturally by binding these compounds to β-glucans present in the cellular wall of the *Saccharomyces cerevisiae*. This phenomenon might allow to reduce wort ZEN levels up to 75,1 % [17]. Dead yeast cells have a higher binding capacity than live cells [14]. In current brewing technology, yeast sludge as well as live cells suspended in beer, are filtered out before bottling, which combined with mentioned phenomenon allows to obtain a product partly deprived of mycotoxins. Some of the microorganisms are known for their ability of their biotransformation into less harmful compounds. Certain *S. cerevisiae* strains are able to breakdown ZEN, FMB1 and FMB2, although it is a relatively slow process. Non-*Saccharomyces* yeasts, such as *Candida tropicalis*, *Torulaspora delbrueckii* and *Zygosaccharomyces rouxii* can transform ZEN into less dangerous β-ZEN [22].

MYCOTOXIN OCCURRENCE IN BEERS ON EUROPEAN MARKET

Currently, European Union legislation regulates the occurrence of 13 mycotoxins in food products (Commission Regulation 1881/ 2006 and 2013/165/EU Recommendation). Beer belongs to the category of cereal-based products, for which the limits are: 2 µg/kg for AF1, 750 µg/kg for DON, 75 µg/kg for ZEN, 400 µg/kg for the sum of FMB1 and FMB2, 5 µg/kg for OTA [14]. The data in Table 2 shows that the most common mycotoxin in beers on European market is DON. Depending on the source, its presence was found in 40,6-100% of tested beers. Kuzdraliński et al. [9] reports an average DON content range found in beers of 6,0-70,2 µg/l. Additionally DON was found in all of 57 samples originating from Poland. In studies conducted by Bryła et. al. [2] on the domestic market, the average DON concentration was 9,0±12,7 µg/l. The authors also investigated occurence of modified form of DON, DON-3-Glc. It's concentration was on average 9,2±7,5 µg/l. In a five-year study conducted by Olšovská et al. [13] ZEN was detected in only one sample from a pool of 157. When ZEN contamination occurs, its average content is in the range of 0,259-0,546 µg/l [9]. T-2 and HT-2 are relatively rarely found in beer. In samples they were present, their total level was in the range of 0,3-0,85 µg/l [13]. Despite nearly 70% contamination of beers with OTA, according to Bertuzzi et al. [1], the average content of this toxin is relatively low (0,019±0,029 µg/l). Similar results were found by Olšovská et al. [13]. As molds from *Fusarium* genus are the most common fungal microorganism found on cereal grains, significant beer contamination with FMB1 and FMB2 is not surprising. Average amounts of these mycotoxins found by Bertuzzi et. all was 5,8±7,4 µg/l for FMB1 and 0,6±1,0 µg/l for FMB2. The average NIV content in beers containing them is 2,4±1,9 µg/l, as reported by Bryła et al. [2].

Studies also show significant differences in the mycotoxin levels depending on beer style, raw materials used for its production, fermentation method and its alcohol content. Results obtained by Peters et al. [16] indicate higher DON and DON-3-GLC amounts in beers belonging to Imperial Bock and Eisbock styles. Contaminations were also found more frequently in beverages from those styles. On the contrary,

Table 2. Prevalence of mycotoxin contamination in beer. The results refer to beers available on the European market. Individual columns present the contribution of samples in which mycotoxins were found

Tabela 2. Częstość występowania skażenia mykotoksynami w piwie. Wyniki dotyczą piw dostępnych na rynku europejskim. Poszczególne kolumny przedstawiają udział prób w których stwierdzono obecność mykotoksyn

Mycotoxin content in beers on European market										
Autor	**DON**	**DON-3-Glc**	**ZEN**	**T-2**	**HT-2**	**OTA**	**FMB_1**	**FMB_2**	**NIV**	**AF**
Olšovskái in. [13]	29/50	-	0/30	7/29		45/49	-	-	-	0/35
Rodríguez i in. [19]	92/154	-	-	-	14/154	-	-	-	-	-
Bertuzzii in. [1]	70/106	-	-	-	-	72/106	32/33	19/33	-	-
Bryłai in. [2]	83/100	67/100	-	-	-	-	-	-	56/100	-
Kuzdralinskii in. [9]	91/91	-	10/91	-	-	-	-	-	-	-

Source: [1, 2, 9, 11, 13, 19]

Źródło: [1, 2, 9, 11, 13, 19]

lowest mycotoxin levels were found in Saison, Pale lager and other styles with low alcohol content. As the alcohol concentration in beer increases, an exponential increase in DON concentration is observed [8]. The probable explanation for this phenomenon is the characteristics of a strong beer production process – along with higher quantities of malt required to reach assumed alcohol levels, larger amounts of mycotoxins are supplied into the wort [8,18]. Many researchers observed higher concentrations of DON and HT-2 in wheat beers. This is probably due to the more frequent occurrence of these mycotoxin producers on wheat grains than on barley, hence all styles based on wheat malt are more exposed to increased HT-2 and DON levels [1]. A slightly higher DON contamination is reported in top fermented and dark beers, regardless of the alcohol content [9].

Despite the widespread occurrence of fungal metabolites in beverages, their content in most cases does not exceed the prescribed standards. According to Rodríguez-Carrasco et al. [19], the average DON and HT-2 content is 24,5-47,7 µg/l and 24,2-38,2 µg/l respectively. Considering average *per capita* consumption in Europe of 70,1 l/year, and assuming a body weight of 70 kg (standard average body weight established by European Food Safety Authority), the statistical consumer drinks 0,192 l of beer per day, thus providing this way 5% PMTDI of DON and 7-12% TDI of HT-2. In countries where consumption is higher, such as the Czech Republic, these values are 9 and 14-24% TDI respectively. The situation of people who consume excessive amounts of alcohol can raise concerns. Assuming consumption of 1 l of beer, the consumer can deliver in this way 25% PMTDI of DON and 37-64% TDI HT-2 [1]. It should also be noted that there are particularly contaminated beers on the market. Peters et al. [16] found beers samples in which the DON content ranged from 225 µg/l to 1031 µg/l. In this case, consumption of only 0,33 l such beer can significantly exceed TDI.

CONCLUSION

Despite the frequent occurrence of mycotoxins in beers on the European market, with some exceptions, the level of contamination of these products is relatively low. Particularly noteworthy are strong beers, especially Imperial Stout, which are characterized by a much higher occurrence of fungal mycotoxins than beers with a standard alcohol content. Beers of these styles are usually not produced by large concerns, which is why, with the development of the craft beer industry, more and more beverages with a significant alcohol content appear on the market. Their producers and malt suppliers should pay particular attention to the mycotoxin occurrence in the finished product and, if required, take measures to reduce their content. Good hygiene and production practices, from raw material to finished product, are necessary to maintain high product quality.

PODSUMOWANIE

Mimo częstego występowania mykotoksyn w piwach na rynku europejskim, za pewnymi wyjątkami, poziom skażenia tych produktów jest stosunkowo niski. Szczególną uwagę zwracają piwa mocne, a w szczególności Imperial Stout, charakteryzujące się znacznie wyższą zawartością toksyn grzybowych, niż piwa o standardowej zawartości alkoholu. Piwa w tym stylu nie są zazwyczaj produkowane przez duże koncerny, dlatego też wraz z rozwojem branży piw kraftowych, na rynku pojawiać się może coraz więcej napojów o znacznej zawartości alkoholu. Ich producenci oraz dostawcy słodu powinni zwrócić szczególną uwagę na zawartość mykotoksyn w gotowym produkcie i jeżeli to wymagane, podjąć działania mające na celu obniżenie ich zawartości. Dobre praktyki higieniczne i produkcyjne, od surowca, aż do produktu gotowego, są niezbędne do utrzymania wysokiej jakości wyrobu.

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THE ROLE OF INGREDIENTS CONTAINED IN FISH AND FISH PRODUCTS IN HASHIMOTO DISEASE®

Rola składników zawartych w rybach i produktach rybnych w chorobie Hashimoto®

Research financed by Polish Ministry of Science and Higher Education within founds of Institute of Human Nutrition Sciences, Warsaw University of Life Sciences (WULS), for scientific research

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Hashimoto disease is one of the most commonly recognized autoimmune and endocrine diseases. The development and the course of the ailment depends on a variety of factors, nutritional among other things. Fish and fish-based products contain nutrients regulating the homeostasis of thyroid hormones and the immune system functions. The paper provides up-to-date knowledge on the mechanisms of effects exerted by nutrients contained in fish on the thyroid functions and thyroid-released hormones, and on the course of inflammation in this gland. Familiarity with these issues is necessary for a proper planning of nutrition in Hashimoto-affected patients.

Key words: fish, thyroid, autoimmunity.

Choroba Hashimoto jest jedną z najczęściej rozpoznawanych chorób autoimmunologicznych i endokrynnych. Rozwój i przebieg schorzenia zależy od wielu czynników, w tym żywieniowych. Ryby i ich przetwory są produktami zawierającymi składniki regulujące homeostazę hormonów tarczycy i funkcjonowanie układu odpornościowego. W artykule scharakteryzowano aktualną wiedzę na temat mechanizmów wpływu składników zawartych w rybach na działanie tarczycy i wydzielanych przez nią hormonów oraz przebieg procesu zapalnego w gruczole. Ich znajomość jest niezbędna do prawidłowego planowania żywienia dla osób z chorobą Hashimoto.

Słowa kluczowe: ryby, tarczyca, autoimmunizacja.

INTRODUCTION

An autoimmune (lymphocytic) thyroid inflammation of Hashimoto type, commonly known as Hashimoto disease or Hashimoto thyroiditis, is a chronic disease derived from the immune system's abnormal stimulation and response. The disease most commonly affects people, predominantly women, aged between 45 and 65 years, however populations all around the world are concerned with the problem [12,23]. The effect of the disease is a progressive destruction of thyroid cells, leading to hypothyroidism that interferes with metabolic processes in almost every cell of the body. Both genetic and environmental factors are considered the triggers or enhancers of the disease. The latter cover nutritional agents such as an excessive iodine supply or an insufficient intake of selenium and vitamin D [15,32]. On the other hand, it is obvious that nutrients influence on the course of inflammation, modulate functions of the thyroid and its hormones, and affect the assimilation of drugs used in hypothyroid patients' pharmacotherapy. Given that, the food components play an essential, however often underestimated, role in the management of Hashimoto disease [30,63]. In this respect, a special role should be attributed to fish, which provide a proven health-improving effects by containing nutrients, bioactive compounds and other components regulating thyroid hormone metabolism and the immune system functions. Therefore, it seems justifiable to characterise their role in the development and treatment assistance of Hashimoto disease.

HASHIMOTO DISEASE CHARACTERISTICS

A mode of development of Hashimoto thyroiditis is not fully clear. Nevertheless, it is known as complex and multifactor-dependent. In the disease, proportions among various cell types of the autoimmune system change over time.

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Their activity is different than in healthy individuals as well. The alterations are manifested in the enhancement of the pro-inflammatory cell activity, more specifically type I T helper lymphocytes (Th1) and cytotoxic lymphocytes (Tc), and in the reduction of the anti-inflammatory cell activity – type II T helper lymphocytes (Th2) and regulatory lymphocytes (Treg). Moreover, the accumulation of B lymphocytes and macrophages in the thyroid parenchyma takes place [45].

The pathogenic process starts from an excessive inflow and thyroid-specific accumulation of the circulatory immunocompetent cells that produce and release greater quantities of proinflammatory compounds, i.e. mainly proinflammatory cytokines, e.g. interferon-gamma (INF-γ), tumour necrosis factor α (TNF-α) and interleukin 12 (IL-12), and anti-thyroid protein antibodies. Thyroid peroxidase (TPO) and thyroglobulin (TG), i.e. thyroid proteins providing a normal synthesis and accumulation of thyroid hormones, are antigens taking part in the autoagression. The effect of anti-TPO and anti-TG autoantibodies on the thyroid gland leads to the destruction of its follicular cells (thyrocytes), which synthesize and release smaller and smaller amounts of hormones into the blood. Besides, an enhancement of oxidative stress, an excessive stimulation of processes based on the programmable cell death (apoptosis) and thyroid fibrosis appear in the thyroid gland. This accelerates the destruction of thyrocytes and leads to hypothyroidism. In Hashimoto disease thyrocytes are exposed to an intensive activation of apoptosis by synergistic impact of proinflammatory cytokines on numerous genes involved in the signalling pathway of the process. On the other hand, those regulatory mechanisms are weakened that would cope with the blockage of an initiated cascade leading to autodestruction, e.g. by the triggering of apoptosis within the intrathyroid lymphocytes, which is inhibited in the Hashimoto thyroiditis [2, 12, 17, 32, 34, 35].

Among factors inducing the autoimmune process in the thyroid the first place is mentioned to be taken by genetic factors associated with histocompatibility antigens, like HLA-DR3 and HLA-DR5, and with the polymorphism of a gene encoding for cytotoxic T cell antigen 4 (CTLA-4) protein and of other genes connected to cytokines and thyroid proteins [12, 34]. Both environmental and internal (e.g. hormones) agents can trigger or enhance the disease development in individuals with genetic predispositions. The former cover the following: tobacco smoking, infections, stress, alcohol, some drugs, chemical contaminations, alimentary allergens, an excessive iodine supply and an insufficient intake of selenium and vitamin D [10, 35]. Furthermore, Hashimoto disease frequently co-exist with other autoimmune diseases, i.e. type I diabetes, celiac disease, unspecific inflammatory conditions of the intestines, pernicious anaemia, rheumatoid arthritis and multiple sclerosis, among other things, with hypofunction of other glands (the adrenal glands, gonads and parathyroid glands) and with chromosomal diseases including Down and Turner syndromes, and it may bring to light in pregnant women [40, 57].

A compromised thyroid function stems mainly from intrinsic morphological changes due to an inflammatory process and a reduction in TPO activity, a key enzyme in the regulation of all stages of thyroid hormone biosynthesis, i.e. the oxidation of iodine ions, the iodination of TG thyrosil residues with the formation of iodothyrosines and their fusion to triiodothyronine (T3) and thyroxine (T4). A consequence of a diminished T3 and T4 synthesis is manifested in a drop in blood hormone levels. Based on a phenomenon of feedback, this, in turn, stimulates the upper levels of the hypothalamic-pituitary-thyroid (HPT) axis, thyroid axis for short, for the synthesis and release of thyreoliberin (TRH) and thyreotropin (TSH). However, this does not reflect in the production of sufficient amounts of thyroid hormones (TH). As a consequence, a gradual TSH blood level increase can be observed, with a concomitant reduced level of free thyroid hormone forms (fT4 and/or fT3) after some time [12, 27, 30, 58]. The levels of TSH, fT4 and fT3 correspond to the thyroid functions, however they cannot serve making Hashimoto disease diagnosis but its consequences manifested in primary hypothyroidism – occult (subclinical) or clinically overt. In fact, the disease is diagnosed based on an elevated anti-TPO and/or anti-TG antibody titre and an abnormal image of the thyroid gland in ultrasound (USG) examination [12, 57, 58].

Because of the fact that thyroid hormones are responsible for baseline metabolization and the regulation of metabolic processes in almost every cell of the human body [18], in the event of their deficiency the rate of metabolization and tissue susceptibility to insulin (insulin resistance) drop, and carbohydrate and lipid changes become disturbed. As a result, type 2 diabetes and cardiovascular diseases may develop [23, 40, 59].

Hashimoto thyroiditis develops slowly and, initially, may not be symptomatic. Laboratory test and imaging examination results may also be normal. Most frequently, complaints in patients only appear after considerable thyroid destruction and its hypoactivity have taken place. The list of complaints usually encompasses the following: weakening, chronic fatigue, sleeping problems, emotional changes, excessive sweating, hand tremors, oedemas of the face, palms and feet, the feeling of cold with body mass gain, constipations and hypermenorhoea in women. Apart from that, skin dryness and roughness, nail fragility and hair loss are reported [12, 35, 57]. In children the first clinical sign of Hashimoto-triggered hypothyroidism is a retarded rate of growth and learning difficulties [4].

Hashimoto disease is incurable and its course can only be retarded. Nevertheless, Hashimoto-induced hypothyroidism is subject to pharmacotherapy. It is based on the administration of a levorotatory thyroxine synthetic analogue (L-thyroxine), usually fasting 30-60 minutes prior to breakfast in the morning. In the case of one of Hashimoto disease varieties, a so-called IgG4-dependent variant, a short-lasting glucocorticosteroid therapy is instituted as well [12, 32, 45].

AIM AND GENERAL DIETARY MANAGEMENT RULES IN HASHIMOTO DISEASE

The aim of dietary management in Hashimoto disease is the retardation of processes leading to thyroid destruction, the elongation of normal thyroid function time-period, and the provision of optimum action of hormones, both still released by the gland and delivered in a drug form. Moreover, it is aimed at retarding metabolic disorder development and resulting diseases [30,51,63]. Normal physiological action of

the thyroid hormones are provided by processes at a variety of levels – from the functions of the thyroid axis, through thyroid hormone blood transport, their uptake by tissues and intracellular transformations, up to triiodothyronine binding with its receptor. Nutritional factors play an essential part at every level of the thyroid hormone metabolization [30].

There is no need to use sophisticated diets, widely propagated in the Internet, among other things. Hashimoto disease diet should not be an elimination diet provided there are no specific medical contraindications. It should be based on feeding rules designated for healthy people and take into consideration individual needs related to age, sex, physiological condition and possible concomitant metabolic disorders and other diseases [17, 30, 47].

In nutritional scheduling it is important that the food products would contain adequate quantities of macro- and micronutrients, as required, and compensate possible deficiencies. Components whose deficiency is popular in Hashimoto-affected patients are aforementioned vitamin D and selenium, but also polyunsaturated fatty acids from n-3 (n-3 PUFA) family, vitamins A, E and C and mineral elements, i.e. iron, zinc and iodine. Due to the use of restrictive diets without any consultation with a dietician, patients are additionally exposed to protein-energy deficiencies [23, 38, 42, 44, 51].

The significance of food products in the diet therapy of Hashimoto-induced hypothyroidism is originated from the effect of the above-mentioned nutrients on thyroid functions and its hormones released. It deserves noting that dietary substitutes are not able to provide the same physiological effect as nutrients occurring in natural products do. Nonetheless, in order to understand the importance of food products in Hashimoto disease and to skilfully use them in the disease-related dietary management, one should be familiar with the modes of action of nutrients contained in them. To sum up, a final physiological effect will be the resultant of action of all products and their components taken into account in all-day alimentary rations. Health-improving products abundant in components relevant in Hashimoto disease are fish and fish products, among other things, whose relevance is characterised below.

FISH AND FISH PRODUCTS VS. HASHIMOTO DISEASE

A positive effect of fish on human health has been confirmed in many clinical trials. It is mainly attributed to fish-contained polyunsaturated fatty acids, especially from the n-3 family, i.e. eicosanopentaenoic (EPA) and docosahexaenoic (DHA) acids, and to a full-value protein, fat-soluble vitamins, and macro- and microelements such as calcium, phosphorus, selenium, fluorine and iodine [64]. The content of the above-mentioned compounds is differentiated and characteristic of a particular fish species, its age, size, physiological condition, type of ingested food, site of feeding, type of pisciculture and fishing time. Besides, a health-improving effect of fish and fish products is due to their quantities in a daily diet, their quality and an extent of processing [13, 21, 65]. The consumption of fish and fish products in Poland is above twice as low as in other EU countries, amounting to 12.5 kg *per capita* in 2017. A greater fish consumption is interfered with by a rise in their prices, the worsening of fish-slaughter animals and poultry price ratio and a reduction in the import of fresh-water fish like carp and trout [19].

The content of fat in the muscular tissue depends on the species. The highest levels of this macronutrient in salt water fishes (11–13%) were found in Atlantic and Baltic salmon, gilthead Sea bream and Atlantic horse mackerel, whereas the lowest (0.08%) in cod, which accumulates lipids mainly in the liver. The greatest fat content in fresh-water fishes (5-6%) has been reported in fish from *Cyprinidae* family (carp, grass carp, silver carp and goldfish), whereas the smallest (0.1-0.3%) – in predatory species like perch, pike and zander. In the muscular tissue of a number of salt- and fresh-water fish species polyunsaturated fatty acids (PUFA) predominate, and, similar to total fat content, they are more abundant in sea- vs. fresh-water fish meat, 23.5–67.4% and 17.7–50.6%, respectively. A high content of PUFA has been found in cod, zander, silver carp and rainbow trout. Sea fishes contain greater quantities of DHA and EPA compared to fresh-water fishes. The latter, in turn, contain more 18-carbon atom PUFA molecules, linoleic from n-6 family and α-linolenic from n-3 family. Apart from PUFA, fishes contain monounsaturated fatty acids (MUFA), especially abundant in the European eel and carp [21].

Fish rich in EPA and DHA, which should be recommended to patients with Hashimoto disease, is the Atlantic salmon. Other fishes rich in n-3 PUFA are: mackerel, tuna, Atlantic sturgeon, herring, anchovy, pilchard and rainbow trout [29]. There is a very beneficial n-3/n-6 PUFA ratio, amounting to 13–14, in the fat of the Atlantic salmon's and cod's muscular tissue. In the remaining marine fishes the parameter ranges from 5 in herring up to 10 in billfish. An exclusion in the group are so-called lagoon fishes from brackish waters like European Sea bass and gilthead, in whom the proportion between n-3 and n-6 PUFA is comparable to fresh-water fishes, where it is estimated to be 1 on average. Among fresh-water fishes the greatest value was recorded in rainbow trout (4.3), and values within the range of 2–3 were found in the fat of silver carp, bighead carp and grass carp, however below 2 and above 1 – in the fat of fishes from *Cyprinidae* family, i.e. carp, bream, tench and goldfish [21]. A beneficial n-3/n-6 PUFA ratio is also reflected in the fat of pikes and zanders [13].

The effect of **n-3 PUFA** is mainly based on risk reduction in cardiovascular incidents including fatal episodes. This is due to their hypolipaemic, hypotensive and antithrombotic effects. Moreover, n-3 PUFAs provide normal functions of the endothelium, an arterial wall internal layer. Besides, beneficial effects of n-3 PUFAs on the functions of the brain and the eyesight sense organ have been documented. Moreover, they have been found to alleviate rheumatoid disease-related symptoms, prevent from systemic lupus erythematosus, neoplastic diseases, type 2 diabetes and bronchial asthma [64].

Special attention should be paid to a regulatory effect of n-3 PUFAs on the immune system and their anti-inflammatory and antioxidative properties. This fact can be used in dietary management with Hashimoto patients in order to alleviate thyroid inflammation and retard the gland's autodestruction. The n-3 PUFAs exert an impact on the functions of macrophages, neutrophils, B and T lymphocytes and other immunocompetent cells like dendritic

cells, natural killers (NK), basophils, eosinophils and mast cells. Additionally, they change proportions among various T lymphocyte subpopulations [14]. The n-3 acids affect the immune system cells by the modification of mediator synthesis, e.g. eicosanoids, cytokines and nitrogen oxide (NO), which are responsible for intercellular communication. The immunomodulatory effect of n-3 PUFA is mainly based on an inhibition of excessive immune system response by reducing the expression and synthesis of agents involved in the pathophysiology of an inflammatory condition, i.e. interleukin 1 (IL-1), TNF-α, fibrinogen and C-reactive protein (CRP), and by enhancing monocyte-mediated synthesis of anti-inflammatory cytokines, i.e. interleukin 4, interleukin 10 (IL-4 and IL-10) and transforming growth factor beta (TGF-β) [8, 53]. Apart from that, EPA and DHA derivatives, produced in our bodies, like resolvins, maresins and protectins, take an active part in eliminating the inflammatory process at the site of its development, mainly by inducing anti-inflammatory factors [8, 43].

Many studies have also revealed a beneficial effect of n-3 PUFA on thyroid functions by enhancing the activity of Na^+-I^- symporter (NIS) and TPO, thereby improving iodine uptake by the thyroid and the gland's synthetic and secretory potentials. Apart from that, these acids increase an enzymatic activity of type 1 and 2 deiodinases (D1 and D2, respectively), which are responsible for T4 transformation, a prohormone, into a metabolically active T3 in the liver and in the peripheral tissues. They also condition a normal binding of T3 to its nuclear receptor [30].

Another element linking the action of fatty acids with Hashimoto disease is their competitiveness together with TH for binding with plasma transporting proteins. When the blood level of free fatty acids becomes increased, the elevation of free forms of thyroid hormones may take place. Those hormones provoke a feedback inhibition of TRH and TSH, thereby stimulating the thyroid gland. In human studies it has been documented that PUFAs decrease T4 binding with thyroxine-binding globulin (TBG). In other studies plasma fT4 level has positively correlated with the blood level of arachidonic acid from the n-6 family. In contrast, it has not correlated with either EPA or DHA levels [50].

Eicosapentaenoic acid exerts a protective effect on thyrocytes. This was confirmed by study results, in which the administration of ethyl ester EPA in animals subjected to the effect of methimazole, an anti-thyroid drug, prevented from thyroid destruction and diminution of blood T3 and T4 levels [36]. This mechanism may be mediated by one of the nuclear receptors, i.e. a *peroxisome proliferator-activated receptor gamma* (PPAR-γ). This is due to the fact that n-3 PUFAs and their derivatives synthesized in the body, e.g. prostaglandins, are PPAR-γ natural ligands. Most probably, this is the pathway by means of which n-3 PUFAs regulate the differentiation of thyroid cells and protect from the development of autoimmune thyroid diseases [50]. Using n-3 PUFA-deficient and saturated-acid-rich diets results in a decrease in the following: HPT axis activity, thyroid gland synthetic capacity, hepatic conversion of T4 to T3 and T3 binding with the nuclear receptor [30].

Apart from n-3 PUFA, an immunomodulatory effect is also exerted by **vitamin D**, which can be found in fish and fish products. Fatty fishes, like herring, rainbow trout, salmon, sardine, mackerel and carp, are its most abundant source. These fish species contain from 5 up to approximately 20 μg of vitamin D per 100 g of their eatable parts [29]. Vitamin D presents a series of beneficial functions. It regulates the homeostasis of calcium, phosphates and bone metabolization. It also influences on smooth muscle cells of the blood vessels and the cardiac muscle. It regulates insulin secretion by pancreatic B cells and conditions normal development of the nervous system. Moreover, it is a strong stimulator of the immune system [3,33]. Vitamin D deficiency is a common phenomenon both in Poland and abroad. A mean amount of vitamin D supplied with diet of a European is only 2.5-4 μg daily [8]. Not only is it associated with a greater incidence of rickets and osteoporosis, but also with disturbances regarding insulin secretion and carbohydrate metabolization, cardiovascular and autoimmune diseases including Hashimoto. A negative correlation between 25(OH)D blood level *vs.* anti-TPO and anti-TG antibody titres has been reported [3, 33].

The effect of vitamin D on the immune system stems from the presence of vitamin D receptors (VDR) in the cells of T and B lymphocytes, monocytes, macrophages and dendritic cells. Vitamin D reduces the activity of Th1 and Th2 cells. In contrast, it enhances the activity of Th2 and Treg cells. Hence, there is a transition in the cytokine production from Th1 towards Th2. As a result, the secretion of proinflammatory cytokines, e.g. INF-γ, is diminished, while the secretion of anti-inflammatory cytokines, e.g. IL4 and IL-10, becomes augmented. The effect of vitamin D on various subpopulations of T lymphocytes indicates that it plays an essential role in an inflammatory process fading. This protects from tissue damage caused by inflammatory cells. Additionally, vitamin D demonstrates an impact on B lymphocytes by stimulating their apoptosis and inhibiting their proliferation. This is reflected in a drop in immunoglobulin secretion. Moreover, it activates the proliferation of monocytes and their differentiation into macrophages, which present more effective phagocytic abilities. Vitamin D also weakens the maturation of dendritic cells and their capacity to present antigens, which proves its immunosuppressive properties. The maintenance of normal vitamin D blood level may therefore reduce the risk of Hashimoto disease and affect its course [25, 33, 41].

Vitamin D deficiency leads to an imbalance among T lymphocyte subpopulations, an enhancement of the inflammatory process in the thyroid and the elevation of anti-thyroid antibodies in the blood. Furthermore, an increase in TSH release by the pituitary gland and a decrease in the thyroid hormone blood levels occur. Yet, not all study results have confirmed the relationship between vitamin D blood level and anti-TPO antibody titre and/or TSH level. It is worth noting that vitamin D deficiency in the body may be either a cause or an effect of Hashimoto disease and other autoimmune diseases [26, 60].

Fatty fish, like herring, salmon, trout and mackerel, not only contain vitamin D but also considerable amounts of **vitamin A**. It is irreplaceable in the regulation of the following: vision process, cell division and differentiation, development, growth, reproduction and normal functions of the immune system. Vitamin A plays an important role in the maturation and differentiation of the immune system cells, e.g. lymphocytes, monocytes and neutrophils. To add more,

it affects lymphocyte T subpopulation and macrophagous phagocytic activity. Vitamin A deficit compromises the immune system functions by reducing macrophagous phagocytosis and disturbing Th1 to Th2 normal proportions to Th1's advantage [8].

The relevance of vitamin A in Hashimoto disease is also originated from its anti-inflammatory and antioxidative effects. This is important due to the fact that in the course of the disease a pronounced oxidative stress takes place in the thyroid gland. Both thyrocytes and immunocompetent cells are sensitive to the phenomenon. Therefore, normal supply of vitamin A can retard an auto-destructive process in the thyroid cells and exert a beneficial effect on TH synthesis [30, 56].

Moreover, vitamin A influences on HTP axis activity and the peripheral metabolization of thyroid hormones. In the event of hypovitaminosis A, a reduced iodine uptake by the thyroid and a lowered synthesis and secretion of thyroid hormones appear. This is accompanied by TSH level increase and thyroid hypertrophy, thereby the development of goitre. A synthesis of thyroid hormone transporting proteins, the level of T4 into T3 transformation in target tissues, TH uptake by the cells and T3 binding with the nuclear receptor become reduced, as well [56, 66].

Also, **carotenoids** belong to valuable compounds contained in fish. They can either play a role of provitamin A – mainly β-carotene, or not – astaxanthin, fucoxanthin, lutein, zeaksanthin and cantaxanthin [1]. All these substances display stronger antioxidative properties than vitamin A, which are based on the quenching of singleton oxygen and removing free radicals. Antioxidative properties of carotenoids also determine their anti-inflammatory potential. Furthermore, they regulate the functions of the immune system cells by taking synergistic actions with B and T lymphocytes, macrophages and other white blood cells. Astaxanthin gives red pigmentation to salmons, trouts and red breams. Importantly, it is a stronger antioxidant than other carotenoids and, definitely, more potent than α-tocopherol [1, 8, 16]. In clinical studies it has been demonstrated that astaxanthin reduces the level of oxidative stress and inflammation markers. Fucoxanthin is involved in the protection of cells against the oxidative stress, too. The significance of both these compounds in Hashimoto disease may also stem from the fact of their participation in the prevention of the development of Hashimoto-induced disorders and diseases. The two carotenoids directly or indirectly reduce the risk of cardiovascular diseases and improve plasma lipid profile. Furthermore, fucoxanthin decreases tissue insulin-resistance and glycaemia. It leads to the enhancement of thermogenesis and prevents from adipose tissue accumulation, especially within the abdominal cavity [1, 65].

A full-value piscine **protein** is a macronutrient whose activity may be used in the Hashimoto's diet therapy. Its quality is comparable to the quality of slaughter animals' and poultry's protein, and its digestibility exceeds 95%. Protein content in fish ranges from 13 up to 24%, from which the majority (95–97%) is the full-value protein of a beneficial amino acid content, outstripping a model protein content [19]. Fresh fishes, like halibut, sardine and tuna, feature the greatest protein content [29]. A considerable protein content (17–21%) and nutritional quality is also displayed by fishes originating from national cultures, like zander, pike, rainbow trout, perch and most species from the *Cyprinidae* family [54]. A good source of tyrosine and phenylalanine are the following: zander, roach, bream, perch, herring and salmon [49].

Protein significance in Hashimoto thyroiditis is derived from the amino acid participation in the synthesis of thyroid hormones and proteins relevant in the regulation of this process, i.e. TPO and TG. Tyrosine is a direct substrate for TH molecule synthesis, which is an iodinated derivative of the amino acid. Another amino acid indirectly participating in the thyroid hormone synthesis is phenylalanine, which is subject to conversion into tyrosine in the body [30].

An insufficient protein supply in a diet leads to HPT axis inhibition at all its levels and an impairment of its negative feedback mechanism. This is reflected in a reduced TSH release by the pituitary and its diminished stimulatory effect on TH secretion. Protein deficit also induces a stronger binding of T3 by transporting proteins in the blood, which results in fT3 level drop [46]. Besides, the protein role in Hashimoto disease is due to its participation in the regulation of food-induced thermogenesis and the acceleration of satiety feeling. Metabolic changes of proteins require a greater load of energy than of the remaining macronutrients, which makes proteins the least efficient energetic substrate. This conditions the acceleration of metabolization, which is important for hypothyroid patients, in whom the metabolization rate is slowed down [61]. Furthermore, eating the full-value protein inhibits hair loss, a phenomenon frequently observed in Hashimoto thyroiditis patients [63].

Proteins of a number of fishes, like mackerel, scad, silver hake, tuna, salmon, herring, carp, tilapia, silver carp, grass carp, fish species from the Siluriformes order, yellowstripe scad, sardinella, capelin, southern blue whiting, coho, round scad, Conger eel, yellowfin sole, flounder, Pacific hake and Atlantic cod are also the source of bio-peptides, released into the alimentary tract as a response to proteolytic enzymes. The bio-peptides can exert antioxidative and cardioprotective effects [7].

Apart from unsaturated fat, protein, vitamin D, vitamin A and carotenoids, the health-improving properties of the fish, mainly marine fish, is reflected in the presence of iodine and selenium in them. The best source of iodine are cod, mackerel, pollock and salmon. In turn, the best source of selenium are herring, cod, tuna, sardines, carp and eel [29, 39, 48].

Apart from tyrosine, **iodine** is the second substrate for HT synthesis. A deficit of this microelement is the cause of goitre development and the thyroid gland's hypoactivity. An excessive stimulation of HPT axis in response to a drop in thyroid hormone level makes its contribution. As a consequence, blood TSH elevation occurs. In turn, an increased level of thyreotropin in the event of iodine deficiency leads to an excessive production of hydrogen peroxide and other reactive oxygen species (ROS) in the thyroid. Hydrogen peroxide has a cytotoxic effect on the thyroid, which initiates or deepens its fibrosis and destruction [15, 39].

On the other hand, an excessive iodine supply is considered a risk factor of Hashimoto disease due to its detrimental effect on the immune system cells, enhancement of apoptotic changes in thyrocytes and inhibition of thyroid hormone

production [22]. Nonetheless, the amount of iodine delivered to the body with fish does not bring any risk of the iodine excessive supply.

Thyroid contains not only large quantities of iodine but also of **selenium**, which source are fish and fish products. Selenium plays a pivotal part in maintaining the homeostasis of the whole body. This pertains to the thyroid and the immune system, in particular. A daily consumption of this trace element in Poland is 20–59 μg. Selenium deficiency has been reported in many countries. It may refer to as many as milliard people all around the world [55].

Selenium action is based on the maintaining of thyroid hormone homeostasis at the level of HPT axis, liver and other target tissues. Its direct or indirect participation in TH synthesis regulation in the thyroid and other organs is conditioned by its presence in the active centre of deiodinases and antioxidative enzymes. In the former case selenium regulates thyroid hormone transformations mainly in target tissues, however also in the thyroid and the glands of higher HPT axis levels – the hypothalamus and the pituitary. In turn, antioxidative enzymes, i.e. glutathione peroxidases 1, 3 and 4 (GPx1, GPx3 and GPx4) and isoform 1 of thioredoxin reductase (TrxR1) protect from the oxidative stress, whose intensification is inseparably associated with thyroid hormone synthesis. GPx3 level is a factor deciding on the thyroid concentration of hydrogen peroxide – a TPO cofactor. Given that, selenium is a micro-component protecting the thyroid against toxic effects of hydrogen peroxide. This is directly reflected in TH synthesis level. Moreover, this prevents from an excessive thyroid stimulation [15, 39, 60].

Furthermore, selenium is a component of selenoproteins (SELENOs), which regulate the immune system functions. This is based on the inhibition of proinflammatory cytokines and on the enhancement of Th2 and Treg cell activity. In turn, Th2 and Treg cells reduce the oversensitivity and over-reactivity of the body's own antigens, thereby protecting the thyroid gland from autoagression that might lead to self-destruction [52].

Selenium deficit in a diet causes a reduced activity and impairment of selenoenzyme functions, which disturbs hepatic conversion of T4 into T3, potentiates thyroid oxidative stress, the apoptosis of thyrocytes and thyroid tissue fibrosis. Mechanisms leading to thyroid damage are not only mediated by oxidative stress but also by a high TSH level. This may initiate the development of Hashimoto disease or accelerate its progression and intensify symptoms. In the event of selenium deficit, iodine metabolization also becomes compromised, which leads to TH synthesis disturbance. The thyroid destruction has a more rapid and more intense course if selenium deficiency co-exists with iodine deficit. On the other hand, a normal supply of selenium may compensate the consequences of the iodine excess and prevent from destructive and inflammatory lesions [31, 55].

Selenium modulates the immune system functions not only by its protection against the oxidative stress and the regulation of SELENOs synthesis and activity, but also by its effect on B lymphocyte-mediated antibody production and on the activation of T lymphocytes and macrophages. Additionally, the beneficial impact of selenium in Hashimoto disease can also be accounted for by its potential for reducing the expression levels of HLA-DR antigens on the surface of thyrocytes, for diminishing anti-thyroid antibody levels and for inhibiting proinflammatory cytokine synthesis and other proinflammatory mediators, like prostaglandins and leukotrienes [55].

Selenium demonstrates a beneficial effect on the body only in a narrow range and its overconsumption leads to the appearance of undesirable effects. A consequence of selenium excess is reflected in thyroid hormone synthesis disturbance and the enhancement of thyroid oxidative stress and inflammation. Daily consumption of selenium exceeding 400–700 μg may have a toxic effect [55]. Fortunately, eating recommended amounts of fish will not contribute to an excessive supply of this micro-nutrient with diet.

Some fishes, such as herring, eel and smoked sprat are a good source of **zinc** [19]. A correlation of this micronutrient with Hashimoto disease stems from its anti-inflammatory and antioxidative properties. Zinc regulates the functions of the higher levels of HPT axis, TH synthesis and extrathyroid metabolization by means of D2 activity increase. It is the component of nuclear receptors specific for the activation of T3. Zinc deficiency is one of subclinical causes of the hypothyroidism. Moreover, such a condition impairs the secretion of TRH and TSH, the conversion of T4 into T3 and T3 binding with its nuclear receptor. Zinc plasma level in Hashimoto disease-affected patients is usually smaller compared to healthy individuals. It demonstrates a negative correlation with the level of anti-thyroid antibodies [11, 23, 24, 39].

EPA and DHA, vitamin D and vitamin A, carotenoids, iodine, selenium and zinc are the components of fish and fish products that exert a beneficial effect on thyroid functions and its hormones secreted. Moreover, they retard the gland's autodestruction. Due to that, fish-containing meals – of mainly marine, but also of fresh-water fish – should be scheduled in the nutrition of Hashimoto disease patients in the amount of two portions per week, including a fatty fish as one of them [20]. It is recommended to eat fresh and frozen fish. In the case of tinned fish, consumers should first choose fish in its own sauce or tomato sauce. On the other hand, in the case of fish in oil, consumers should remove the oil. The best ways of preparing fish are stewing, baking, steam-boiling and grilling with the use of an electric grill. Contrary to that, it is contraindicated to fry fish, especially in deep fat, and to coat it in bread crumbs and egg [64].

Concerns arise when it comes to the content of harmful compounds in fish and fish products, namely heavy metals (mercury, lead, cadmium, arsenic), dioxins and polychlorinated biphenyls (PCBs), which can contribute to their supply reduction in a diet of Hashimoto disease-affected patients. Fishes taking their places on the top of food-chain, e.g. pike, shark, tuna and swordfish, may accumulate the greatest quantities of mercury. Its absorption in the form of methylmercury rises along with the temperatures of seas and oceans. The least amounts of harmful substances are contained in fishes from the Pacific Ocean, the Atlantic Ocean and the North Sea [28].

Methylmercury and other heavy metals, as so-called endocrine disruptors, impair thyroid hormone metabolization at a variety of levels. Methylmercury inhibits the beneficial

effect of selenium on the thyroid and the transformations of thyroid hormones because of the fact that it is a specific and irreversible inhibitor of selenoenzymes. A considerable affinity of methylmercury to selenium makes it easily forms stable and insoluble complexes with this chemical element. Moreover, it links to the active centre of enzymes, thereby inhibiting their synthesis and activity. Selenium bound with mercury is not absorbable by the human body. This is an inactive connection but, at the same time, non-toxic. Furthermore, selenoenzymes affect methylmercury metabolization, by means of which reduce its toxicity [37]. Also, mercury impairs the immune system functions by demonstrating an immunotoxic effect on T and B lymphocytes, by disturbing the secretion of cytokines and by inhibiting the activity of T lymphocyte subpopulation, which ends up with autoimmune disorders [28].

Besides mercury, an excess of cadmium and lead contributes to structural and functional changes in the thyroid gland. Both those heavy metals tend to easily accumulate in the thyroid and other organs essential in TH metabolization, in the liver and in the kidneys, among other things. Furthermore, they impair the synthesis and secretion of TRH, TSH and TH, the conversion of T4 into T3, change lymphocytic functions and initiate the autoimmune process. In addition, cadmium induces functional changes in TG and the elevation of apoptosis and oxidative stress markers, whereas lead interferes with glucose metabolization [5, 6, 62].

Due to documented adverse effects of harmful substances present in fish and fish products on the thyroid and TH homeostasis, it is recommended to eat fishes with a short lifespan and situated as low in the food-chain as possible. Patients with Hashimoto disease, children, pregnant or breast-feeding women should not be advised to consume predatory fish species such as shark, swordfish, cero and golden tile. Instead, they should choose from fishes containing inconsiderable amounts of mercury and large amounts of n-3 PUFA and selenium, e.g. sardines, mackerel, anchovy and salmon [20,37]. Such an approach guarantees the achievement of expected medicinal effects, particularly with regard to a diet-assisted prophylaxis and Hashimoto disease diet therapy. Indeed, scientific evidence indicates the advantage of health-improving benefits resulting from fish consumption over risks connected to the avoidance of the fish-based food [9].

SUMMARY AND CONCLUSIONS

Components contained in fish and fish products exert a complex and multidirectional effect on all the levels of HPT-target tissue axis and on the course of inflammation in the thyroid. That action is predominantly of a beneficial nature, although some components consumed in excess or regarded as endocrine disruptors may compromise the synthesis of thyroid hormones and enhance pro-oxidative and proinflammatory processes in the thyroid gland. Due to the presence of harmful substances, the use of some fishes in the Hashimoto disease dietary management is limited. A summary of the relationship between fish components and Hashimoto disease has been illustrated in table (tab.1).

Table 1. Fish ingredients and Hashimoto thyroiditis
Tabela 1. Składniki ryb a choroba Hashimoto

Fish ingredients	Thyroid and TH action					Preventing thyroid destruction			
	A	B	C	D	E	F	G	H	I
Protein (amino acids)	V	V	V						V
Protein (biopeptides)						V			V
n-3 PUFA	V	V	V	V	V	V	V	V	V
Vitamin D		V					V	V	V
Vitamin A	V	V	V	V	V	V*	V	V	
Iodine	V	V						X**	
Selenium	V	V		V	V	V*	V*	V	V
Zinc	V	V		V	V	V	V		
Carotenoids		V			V	V	V	V	V
Mercury	X	X		X		X	X	X	X
Lead	X	X		X				X	X
Cadmium	X	X		X		X		X	X

A – thyroid hormone synthesis
B – regulation of thyroid hormone synthesis within the hypothalamic-pituitary-thyroid axis
C – thyroid hormone transport
D – conversion of thyroxine to triiodothyronine
E – receptor binding of triiodothyronine
F – antioxidant effect
G – anti-inflammatory effect
H – immunomodulatory effect
I – prevention of metabolic disorders and diseases caused by hypothyroidism

V – beneficial effect; X – adverse effect; * – pro-oxidative and/or pro-inflammatory effect at excess; ** - with excess

Source: Own study

Źródło: Opracowanie własne

TH synthesis and secretion and the mechanisms regulating these processes within the thyroid axis are stimulated by the following compounds contained in fish: n-3 PUFA, full-value protein, iodine, selenium and zinc. In order to retard the thyroid autodestruction, immunomodulatory, anti-inflammatory and antioxidative effects of n-3 PUFA, vitamin D, vitamin A, carotenoids, selenium and zinc should be taken into account in scheduling nutrition programmes for Hashimoto disease-affected patients. Normal uptake of thyroid hormones by the cells, either naturally produced in the thyroid or administered as synthetic drugs, thyroid hormone activation and functions at the cellular level are to the greatest extent conditioned by selenium, zinc, vitamin A and n-3 PUFA. Thyroid degradation may be accelerated as a response to an insufficient consumption of n-3 PUFA, protein, vitamin D, vitamin A, iodine, selenium and zinc [30]. The consumption of recommended fish rations does not bring the risk of excessive supply of the aforementioned micronutrients and harmful chemical compounds, which might impair the thyroid hormone homeostasis and the immune system functions. Yet, it is advised to include other sources of the discussed substances in a daily diet including dietary supplements.

Moreover, nutrients present in fish play a crucial role in preventing or retarding the development of disorders and diseases resulting from the hypothyroidism, i.e. obesity, metabolic syndrome, type 2 diabetes and cardiovascular diseases.

From a review of the literature made it is clear that fish is products, which – apart from well-known and widely described health-improving features – demonstrate the influence on the thyroid gland and mechanisms regulating the homeostasis of thyroid hormones. Furthermore, fish can contribute to reducing the risk of Hashimoto disease and to alleviating its course.

PODSUMOWANIE I WNIOSKI

Składniki obecne w rybach i przetworach rybnych wywierają złożony i wielokierunkowy wpływ na wszystkie piętra osi HPT-tkanki docelowe oraz na przebieg procesu zapalnego w tarczycy. Działanie to ma głównie charakter korzystny, ale niektóre składniki spożywane w nadmiarze lub zaliczane do dysruptorów endokrynnych mogą upośledzać syntezę hormonów tarczycy oraz nasilać procesy prooksydacyjne i prozapalne w gruczole. Ze względu na obecność substancji szkodliwych, wykorzystanie niektórych ryb w postępowaniu dietetycznym w chorobie Hashimoto jest ograniczone.

Syntezę i wydzielenie TH oraz mechanizmy regulujące te procesy w obrębie osi tarczycowej pobudzają występujące w rybach: n-3 PUFA, pełnowartościowe białko, jod, selen, i cynk. W celu spowolnienia autodestrukcji tarczycy w planowaniu żywienia osób z chorobą Hashimoto należy uwzględnić immunomodulacyjne, przeciwzapalne i antyoksydacyjne działanie n-3 PUFA, witaminy D i A, cynku, selenu i karotenoidów. Prawidłowy wychwyt przez komórki i aktywację hormonów tarczycy (zarówno powstających w tarczycy, jak i dostarczanych w postaci leku) i ich działanie na poziomie komórkowym w największym stopniu warunkują selen, cynk, witamina A i n-3 PUFA. Niszczenie tarczycy może ulec przyspieszeniu w sytuacji niedostatecznego spożycia n-3 PUFA, białka, witamin D i A, jodu, selenu i cynku [30]. Spożywanie zalecanej porcji ryb nie stanowi ryzyka nadmiernej podaży wymienionych mikroskładników, co mogłoby zaburzać homeostazę hormonów tarczycy i funkcjonowanie układu odpornościowego. Należy jednak uwzględnić inne ich źródła w całodziennej racji pokarmowej, w tym suplementy diety.

Składniki obecne w rybach mają również istotne znaczenie w zapobieganiu lub opóźnianiu rozwoju zaburzeń i schorzeń będących konsekwencją niedoczynności tarczycy tj. otyłość, zespół metaboliczny, cukrzyca typu 2 i choroby sercowo-naczyniowe.

Z dokonanego przeglądu piśmiennictwa wynika, że ryby są produktami, które poza dobrze znanymi i opisanymi właściwościami prozdrowotnymi wykazują wpływ na tarczycę i mechanizmy regulujące homeostazę hormonów tarczycy oraz mogą przyczynić się do zmniejszenia ryzyka choroby Hashimoto i złagodzenia jej przebiegu.

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CREATIVE ELEMENT OF THE SYSTEM CIVILIZATION DEVELOPMENT STRUCTURE®

Pierwiastek twórczy w systemowej strukturze rozwoju cywilizacyjnego®

The article presents the concept of „creative element" in the process of civilization development, showing the relationships between development and system elements of the inventive triad. The author's attempt to interpret its essence in the process of solving inventive problems is illustrated on the example of an innovative solution in the field of fish processing machinery.

Key words: creative, system approach, innovation, development.

W artykule przedstawiono pojęcie „pierwiastek twórczy" w procesie rozwoju cywilizacyjnego, ukazując związki między rozwojem i elementami systemowymi triady wynalazczej. Autorską próbę interpretacji jego istoty, w procesie rozwiązywania problemów wynalazczych zobrazowano na przykładzie innowacyjnego rozwiązania w zakresie maszyn przetwórstwa rybnego.

Słowa kluczowe: pierwiastek twórczy, ujęcie systemowe, innowacje, rozwój.

INTRODUCTION

Civilizations arise and develop thanks to many people who have a stronger creative element. This applies in particular to two groups of people: social activists who create new ideas and engineers who create the material basis of every civilization with a long and arduous harnessing of natural forces to work for man. As L. Sprague de Camp writes in his beautiful book "Great and Small Artists of Civilization": sometimes they were inventors, and sometimes entrepreneurs, but the fact that they were able to create new concepts and put them into practice is important. They also had enough courage, stubbornness and energy to improve their inventions, bringing them to practical form and propagate them until they convince others of their usefulness [10]. These processes have been the basic imperative of human activity and work encoded in the human brain since the beginning, the goal of which was not always the conscious realization of everything.

The general truth is also the fact that the world is constantly evolving, that the place of simple activities is increasingly taken by complex, automated activities that require professional preparation. There are more and more predictions that the world will have knowledge, innovation and creativity at its core. Hence, we are observing a steady increase in demand for creative units. Around 1900, this demand was 1% of the population, in 2000 – 7.5%, and now – 10% of the population [7].

We shape our innovativeness within a specific situation and our level of agency in this area is largely determined by this situation. The relationship of the thinking process as a causative element in human activity is reflected in the oldest record and the word has become a body, which we also find in the Bible, similarly to other books of wisdom. The "word" is a product of thought, or an idea (from Greek) that inspires and shapes the emergence of abstract and consequently material beings. In solving inventive and broadly innovative problems, this creative thinking formulates the needs (goals) as well as the ways of achieving them (abstract beings), as well as the material structures of their implementation in the form of machines and devices. The purpose of the article, expressed in the title, falls under the above-mentioned problems, in which the most important role in solving the problems of civilization development of the world is assigned to the creative element. An important feature of the conducted considerations is the systemic approach to the conducted analyzes.

The contribution of the presented considerations consists primarily in the location of the creative element in an innovative system with the development of civilization and an indication that it gives direction to changes considered as progress. The conducted considerations were illustrated on the example of the author's solving of an innovative problem in the field of food processing equipment. The information provided can be used in knowledge management.

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SYSTEM INTERPRETATION OF THE CREATIVE ELEMENT

The term "creative element" (in the sense of the concept taken very broadly) was introduced into the circulation of the Austrian economist J. A. Schumpeter in 1912. Like the concept of innovation and destruction, he was associated with the concepts of the processes of formation of scientific discoveries, innovations and more broadly development, in the connotations of the element of novelty [9]. This concept is still a central problem in the area of knowledge called heuristics [2]. The roots of knowledge about inventiveness go back to the complex problems of analyzing the interrelationship of matter, energy and information. They are stuck in the attempts to identify the ways in which inventions arise in the processes of their creation, because they cannot arise in a different way when a system is created to look for the answer to the question how?

From antiquity to our time, the "creative element" is identified with the basic determinant of creativity, and its pedigree, essence and causative role (according to J. A. Schumpeter) lies in the unity of opposites [9]. The creative element enters all fields and is increasingly connecting with enterprises and business [2]. A creative act is a new activity, more efficient than the ones that perform the same or similar purpose. An intentional creative act is an intentional mental action towards increasing the understanding of the essence of things, increasing the chance of finding another creative problem. Innovation is a job that requires knowledge, often great ingenuity, appropriate predispositions, but above all it means hard purposeful work [3].

Nowadays, creativity has ceased to be reserved only for artistically talented people. Creativity does not mean that man must create painting, literary or musical works, although he can devote himself to these classes. Creativity can concern every area of human life. Currently, creativity appears as a need to change the world, hence the creative element is treated as a kind of inspiration that affects our mood, fulfillment and everyday life. This inspiration stimulates us to exceptional behavior in all areas of our lives [6].

Creativity is an element that underlies all innovative activities and we owe it to civilization and technical condemnation [1]. The main factor in this activity is that everything that exists−ages. In innovations, there is no direct relationship between cause and effect, there are many causes and many effects that are difficult to separate, and therefore requires a systemic approach. The borderline beyond which the systemic approach becomes closer to us than the domain-specific approach is the moment when we realize that instead of perceiving only the cause-and-effect relationship between the state of affairs and its consequences (or cause), we create such a relationship as a mental being and it's a "creative element".

In the system of innovative activities, the concept of "creative element" can and should be located as a bond connecting the three basic elements (scientific discoveries, inventions, innovations) that make up the inventive triad. It should be recalled here that in general the system (Greek systema) means a static, organized structure (minimum three elements) or a structured set of ideas, assumptions (goals) of concepts, methods and principles of generalization, classification, activities between which there are various types of mutual relations dependencies and relationships. Each of these elements of the system created here responds to specific needs −Fig. 1.

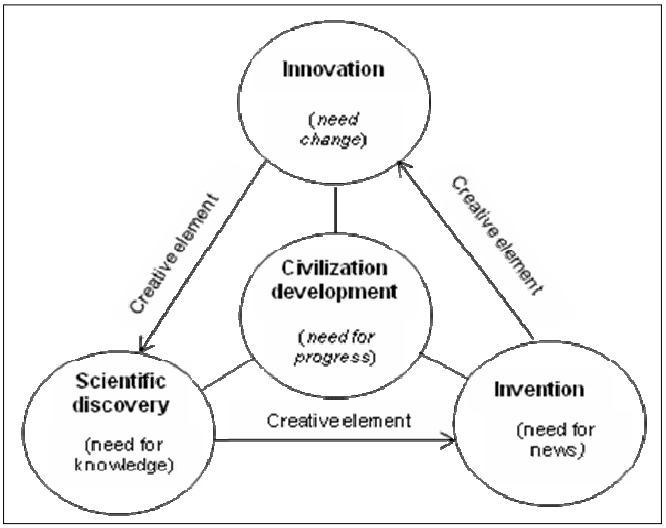

Fig. 1. The creative element as a bond forming the innovative system.

Rys. 1. Pierwiastek twórczy jako więź tworząca system innowacyjny.

Source: Own study

Źródło: Opracowanie własne

Scientific discoveries, innovations and development are treated here as collective names of „basic processes", dividing into three groups of the set of all unit processes that form them as a result of a kind of task integration. Scientific discoveries are the objective results of cognitive scientific cognition. Their use is the basis for creating inventions and innovations. Inventions and nowadays also innovations treated as synonyms are only a derivative of the occurrence of: a need, a mistake, or an accident (the phenomenon of an unexpected serendipity event) and their source is human thinking. The conceptual scope of inventions and innovations is different. Together, they fall into a group of 176 synonyms, referred to as „innovation," which means introducing something new. The transition from one element to another in each case requires mental activities of a creative nature, described in the above model with the term „creative element". There is a statement according to which the mere perception of the need and treating it as an inventive problem often carries the element of creativity, as well as its very solution, which is considered to create an unknown way of realizing the need (goal) that creates the process (abstract being) and consequently some material existence.

In the innovative context, the concept of „creative element" defined by J.A. Schumpeter as „the result of the struggle of opposites" („creativity and destruction are two faces of the same coin" [9]. In his arguments he was based on the basic laws of dialectics (And the law of dialectics according to Hegel). This is a principle for the very existence of any phenomenon. Dialectic in the earliest period of its development (from Heraclitus recognized as its precursor) is associated with the concept of contradiction. The dividing of what is one and learning about its contradictory parts is

included in the basics of dialectics, which does not seem to be easy to understand. Without the clarity of the goal (development), doing something just because it is good (e.g. invention) is not enough to achieve a high level of usability of the entire system. but they are so general that they are almost completely ignored. Clear sfo formulating intentions (what?) to be done allows to significantly improve actions on how to proceed (how?). The intention expressed with the question what? Does not have to be formulated in an elegant language and too detailed. In this way, you can get stuck in a maze of words and lose the context of the goal.

Two basic (observable in history) concepts of development (evolution of the world) are [8]:

a) development – as decreasing and increasing as repetition,
b) development – as a unity of opposites (a split) of what is one, on mutually exclusive opposites and mutual relations between them.

The authors in this article are in favor of this first concept of development.

In general (according to the dictionary definition) the term „development" means any long-term process of directional changes in which one can correctly distinguish the following stages of transformation (development phases) of a given object (system), showing a definite differentiation of that object in a given respect. The process of positive changes (progress) can be accepted as civilization development. An innovative system, the source of which is development, cannot be described by a static structure (triad or even cycle), because changes occur not only repetitive but also progressive. The correct model of such a (action) system is a spiral spinning upwards as a picture of the intensification of progress. This spiral is a picture of directional changes that are a derivative of the creative element's involvement in activities related to the improvement of our material reality.

In the most general terms, all human activities of a creative nature, leading to the replacement of the old with new, is nothing but the implementation of processes occurring in social life and production. All phenomena in nature are also processes. Everything that exists now and arising in the future has a procedural nature, because it could not arise otherwise than as a result of the implementation of processes. The basic definition of the process defines it as the ordered operation of interrelated activities that achieve the intended goals. The process can also be defined as work done as a result of the flow of matter, energy and information.

The process of creating development, which was visualized in the form of an action system in Fig. 2, determines its duration and the gradual expansion of progressive changes. It defines the concept of the act of inventing how mass, energy or information flows to achieve a specific purpose. To this was added the nature of the growth spiral, emphasizing that it is developmental (progressive). It reveals the purpose, directions of impacts and sequences of its factors, science and innovation in its widest range. Development is always the sum of the results of partial processes.

Development and its factors are continuous, just like the existence of a human being but the speed of this process is variable. The first and most basic feature of the applicability of the presented analysis is understanding the concept of development as an action system, i.e. a dynamic process consisting of three total elements: scientific discoveries, inventions and their implementations in the form of innovation.

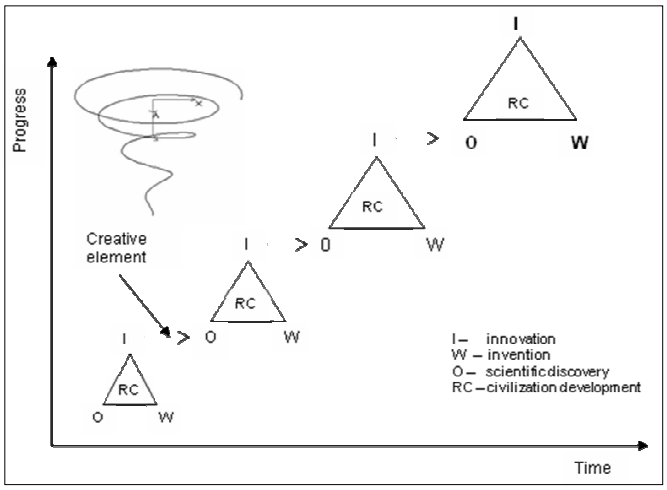

Fig. 2. Innovative system in terms of process.
Rys. 2. System innowacyjny w ujęciu procesowym.
Source: Own study
Źródło: Opracowanie własne

Relations between increasingly developed systems, depicted by arrows, express the existence of so-called the element of creativity, without which no flow of matter, energy and information can arise. The consequence is the existence of a dynamic state of innovation system. The same must occur in lower-level innovation processes that create the summary concept of innovation. Innovation and inventiveness are derived from three types of successes: scientific, intellectual and market and they can reflect positive changes referred to as development. Its lack is defined by the concept of regression, which in earlier definitions was the concept of regressive development, marked with a minus sign. A scientific discovery, a beginner's triad of development, is usually a kind of achievement in achieving a cognitive goal, less often an application one. Its use in order to use the progressive idea: to live better, to create an invention / innovation, requires another two successes: intellectual, consisting in inventing something new – invention (derivative of developmental research) and further market, consisting in spreading this novelty in broad social practice, including development in food processing.

System thinking goes beyond individual events, it brings together events that appear to be distant and independent of each other. Systemicity is a method of both ordering and solving a problem, or designating procedures in which things and phenomena are treated comprehensively in their cause-and-effect relationships. In the system approach, new knowledge is the result of processing existing knowledge as an expression of a rational view of the situation. An important element of the system approach is the ability to present thoughts and relationships using diagrams and graphic models. Psychology of knowing this kind of information message considers the most effective way to understand phenomena and to find links between them as a way to create an invention. The following example contains elements that demonstrate the use of systematic skills to master the basics of the ability to apply the thinking of the inventor in practice (here in relation to food processing).

EXAMPLE OF USING A CREATIVE ELEMENT IN A SYSTEMIC APPROACH TO SOLVING AN INNOVATIVE PROBLEM

In the field literature in the field of food production engineering, there are few systemic approaches in presenting knowledge about methods to support inventiveness, especially based on real examples of its application. This is due to the fact that this approach, already widely used in practice, in science, the economy and social life, has a general, universal character, which allows the use of human action in every field, which requires adequate knowledge and considerable effort. Over the past few years, most articles on this issue have been found in this journal. In these textbooks and publications, the knowledge about the adaptation of systems theory to knowledge about inventiveness is not properly reflected. For many reasons, the development of the skills of their practical application, or the applicability of this knowledge, is definitely lagging behind the great advances in the theory of inventiveness (in its cognitive sense) [4]. As a result, in social consciousness, in which there is already an understanding of the value of skills and competences, we encounter the opposition of theory of practice. To the question of what separates already existing theories from their application in practice, there is an answer – an unusual difficulty in acquiring the skills to use them, which is due to the complexity and insufficient knowledge of the act itself of the creative process as a process of creating something new in the field of science and technology.

Therefore, this method can be used to shape and consolidate the ability to identify stages, select system elements of structures and the cause-effect relationships that connect them, but it does not always lead to the final goal – which is the invention. This is because newness cannot be determined before it is created, and the very process of its creation can be both spontaneous (the "Eureka" effect) and determined by the systematic approach. An example of such a system approach is the diagram shown in Fig. 3, specifying the procedural triad of innovative activities.

The procedural triad presented here is a general scheme that organizes inventive and innovative thinking, which leads to the answer to problem questions:

1. What?, Or for what? – resulting from the function definition.
2. How? – resulting from the adoption of a process or unit operation,
3. What? – the resulting determination of the material structure of the working body or a reaction chamber, carrying out a process or unit operation.

To achieve the goal of the existence of a technological device that performs a given function, solutions in these three subsystems should be found, and this requires the development of a total of 9 system components, located in two-way cause-and-effect relationships, through analysis, synthesis and inference processes. These subsystems, treated as autonomous systems, require an indication of their components selected so that there are causal relations between them. Following the model of the main system (Fig. 3), they can be presented in the form of material and formal system structures created to find a solution to the problem contained in each of the three questions defining them. The synthesis of the three subsystems presented, two of which reflect thought processes and the third real process, creates nine defined concepts of elements of these subsystem structures, and the arrows indicate the order of actions from general to detail, which is both a feature of the mental analysis process, but also of systematic.

An example (correspondingly (indirectly) of what constitutes the concept of a creative element in the solution of an inventive problem, in other words the way in which the concept is created, i.e. the emergence of a new way of operating the device used in food processing according to the invention, was the use of the scientific discovery presented in [4]. It was known about the differences in cutting force values depending on the type of fish body structure cut: skin, meat tissue and bones with the help of rotary disc knives. This was used to develop a new, innovative, machine-separated method of separating bone and skin from fish tissue, extended to raw materials from warm-blooded animals, causing revolutionary changes in their processing. The essence of this scientific discovery is shown in Fig. 4 in the form of a graph of changes in the value of these forces (occurrence of differences in cutting forces - emphasis of the authors), without which the method used (the essence of the invention) could not exist [5].

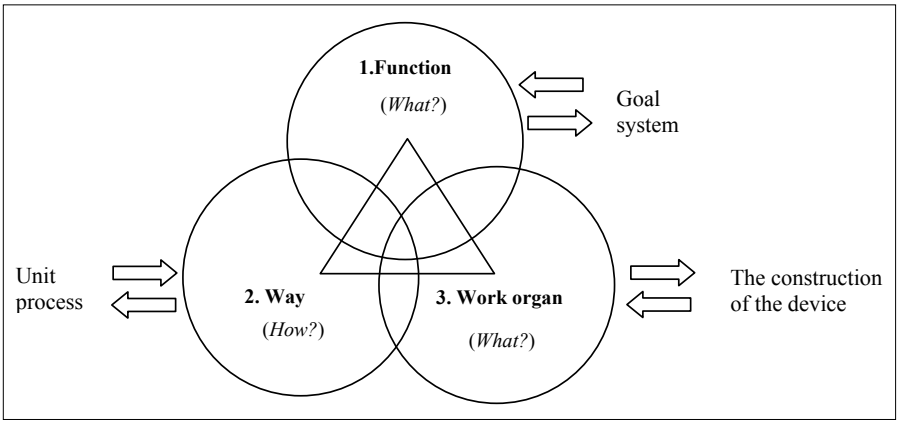

Fig. 3. Procedural triad of system approach in creating solutions regarding construction of working organs of technological devices (machines or apparatuses).

Rys. 3. Triada proceduralna podejścia systemowego w tworzeniu rozwiązań dotyczących konstrukcji organów roboczych urządzeń technologicznych (maszyn lub aparatów).

Source: Own study

Źródło: Opracowanie własne

The example shows the use of the discovery (maybe small, but still) to create the invention of the method and device for its implementation. What do we find at its base?–information about the fact of differences between the cutting forces of the constituent parts of the fish. The body of the fish has a structure

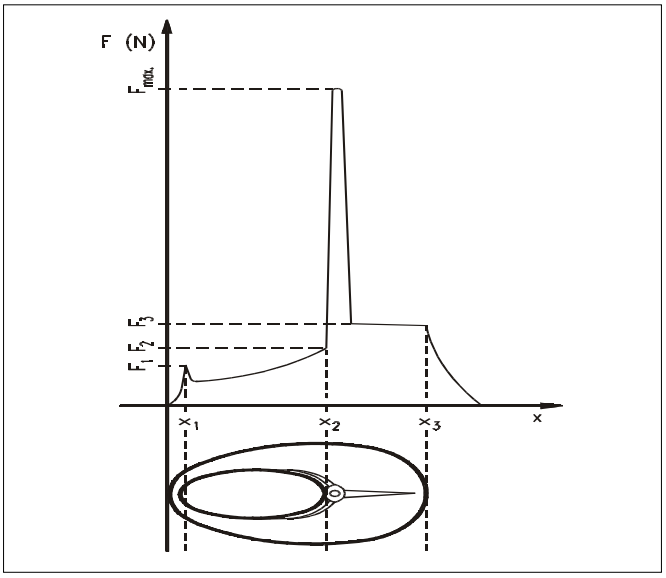

Fig. 4. Changes in the cutting forces on the head removing fish as the circular knife passes from the cut, skin, muscle tissue to the bones.

Rys. 4. Zmiany sił cięcia odgławiającego ryb w miarę przechodzenia noża tarczowego od cięcia, skóry, tkanki mięśniowej do kości.

Source: [Majewski, 2005]

Źródło: [Majewski, 2005]

composed of tissues of varying strength, which affects the amount of forces acting on the blade during cutting operations. Initially, the head removal operation showed a strong increase in cutting resistance due to the knife's impact on the tissue and its deformation. The cutting resistance reached the local maximum at point x1 under the stress associated with cutting the skin. After cutting the skin there was a rapid decrease in resistance, and after crossing point x2 there was a very strong increase in resistance, which was associated with cutting the spine (bone tissue). After cutting it, the cutting resistance did not return to the F2 value, but it set at a higher F3 level, which should be explained by the increased friction force. The largest increase in real cutting forces (from 6.3 to 139.7 N) occurred when cutting the spine. Such a strong (more than twenty-fold) increase in the forces acting on the blade was used to create a new way of working the demisting machine-previously not used type of cutting called "shaped", because it runs along the upper part of the fish gill cover.

The benefits of using it (compared to previously used head cutting with a flat cut perpendicular to the line of the spine) results from the recovery of meat behind the upper part of the gill cover. A clear difference in cutting forces when cutting the spine and other tissues is a key condition for the possibility of using contouring (the invented "disc" knife). This knife, together with the new design solution for transporting fish during the head removal operation, constitutes the working organ of the machine.

He inventive solution shown presents both a new way of working the machine and its working body (a new type of knife), but also a previously unused solution of the way of transporting fish during the heading operation and the structure for its implementation. The material expression of this structure are symmetrically pivoted rotating rollers, two on each side of the fish side, with movable pads from the action of the longitudinal force component, derived from the fish transferred in an oblique direction (along the cone forming the knife) and after the cessation of this returning force to the starting position under the action of the sector guide located on the non-working side of the rollers.

An example of the use of known differences in the size of unit cutting forces of various components of raw materials to create inventive solutions, shows the role of "differences" in the properties of raw materials as information from scientific discoveries in their creation, when we are able to combine and use their cause-effect relationships with phenomena enabling energy flow in the process transformation of agricultural raw materials.

SUMMARY

The above description of the elements present, the concepts used and, what is important, showing the sources, which turned out to be differences in the properties of fish, was only a practical example of illustrating the stages of inventive solutions. The synthesis of the concept of inventiveness is the ability to find the not always obvious cause and effect relationships: things, living and dead matter and energetic phenomena of nature, which are the subject of research in increasingly divided fields of science. In relation to inventiveness in the field of food production, the article of the authors in this magazine in issue 1 from 2019 is devoted. This article became the basis for reflection on the essence of the creative process in the context of dialectical development of the world?

Using the dialectical phenomenology method, it can be stated that the scientific thesis and proven by research (there is a difference in cutting forces) and its antithesis gave the answer to the questions: „what"?, „How" and „what"? And this (as a result of creative synthesis) led to implications in the form of the invention. From a methodological point of view, „creative element" is therefore a synthesis.

It is in inventing, perceiving and inventing a new way of energy flow to do the work of cutting processed animal raw materials. The idea of the invention of the method of implementation arose in the human mind by noticing the non-obvious causal relationship of the properties of the raw material, more precisely the differences just mentioned, energy and need (purpose), treated as necessary three elements in the systemic approach, which is also a kind of triad as the development triad discussed earlier where the development element is the equivalent of a need (goal). If this relationship did not lead to an inventive thought – a method of machine cutting with separation of meat from bones – this process would still be carried out manually. The beginning of the inventive process of inventing a new, machine-based method did not appear until after a scientific discovery, seemingly small, but important for many processes in the food processing industry. In this example, it can be traced that the process of development of anything originates from the processes of cognition, science that creates knowledge and scientific discoveries, but the intermediate link without which no development could occur is inventiveness, a concept currently

dominated by innovation. Regardless of what it will be called, the root of these concepts lies the element of creativity. Each of us possesses it to a greater or lesser extent, the point is to want to use it to create social and technical progress.

PODSUMOWANIE

Przedstawiony wyżej opis występujących elementów, wykorzystywanych pojęć i co istotne, ukazania źródeł, jakimi okazały się różnice właściwości ryby, był tylko wziętym z praktyki przykładem zobrazowania etapów powstawania rozwiązań wynalazczych. Syntezę pojęcia wynalazczości stanowi bowiem umiejętność doszukiwania się nie zawsze oczywistych przyczynowo-skutkowych związków: rzeczy, materii ożywionej i martwej oraz energetycznych zjawisk przyrody, stanowiących przedmiot badań coraz bardziej dzielonych dziedzin nauki. W odniesieniu do wynalazczości w dziedzinie produkcji żywności poświęcono artykuł autorów w tymże czasopiśmie w numerze 1 z roku 2019. Artykuł ten stał się podstawą rozważań nad istotą procesu twórczego w kontekście dialektycznego rozwoju świata?

Stosując metodę fenomenologii dialektycznej można stwierdzić, że postawiona i udowodniona badaniami teza naukowa (jest różnica sił cięcia) i jej antyteza, dały odpowiedź na pytania: „co" ?„jak" i „czym"?, a to (w wyniku wystąpienia twórczej syntezy) doprowadziło do implikacji w postaci wynalazku. Z metodologicznego punktu widzenia „pierwiastek twórczy" jest więc syntezą.

Tkwi on w wymyśleniu, dostrzeżeniu, wynalezieniu nowego sposobu przepływu energii dla wykonania pracy cięcia obrabianych surowców pochodzenia zwierzęcego. Idea wynalazku sposobu realizacji powstała w ludzkim umyśle przez dostrzeżenie wcale nieoczywistego związku przyczynowo-skutkowego właściwości surowca, ściślej właśnie wymienionych różnic, energii i potrzeby (celu), traktowanych jako niezbędne trzy elementy w ujęciu systemowym, stanowiące również swego rodzaju triadę jak omawiana wcześniej triada rozwoju, gdzie element rozwoju jest odpowiednikiem potrzeby (celu). Jeśliby ten związek nie doprowadził do powstania myśli wynalazczej – sposobu maszynowego przecinania z rozdzieleniem mięsa od kości – to nadal ten proces wykonywany byłby ręcznie. Początek wynalazczego procesu wymyślania nowego, maszynowego sposobu zaistniał dopiero po dokonaniu odkrycia naukowego, wydawałoby się drobnego, ale istotnego dla wielu procesów w przemyśle przetwórstwa spożywczego. Na tym przykładzie można prześledzić, że proces rozwoju czegokolwiek bierze swój początek z procesów poznania, nauki, która tworzy wiedzę i odkrycia naukowe, ale pośrednim ogniwem bez którego żaden rozwój nie mógłby zaistnieć, jest wynalazczość, pojęcie zdominowane obecnie przez innowacyjność. Niezależnie jakkolwiek będzie to nazywane, u podstaw tych pojęć leży pierwiastek twórczości. Każdy z nas go posiada w większym lub mniejszym stopniu, chodzi o to, aby chcieć go wykorzystać tworząc postęp społeczny i techniczny.

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Praca finansowana przez Ministerstwo Nauki i Szkolnictwa Wyższego w ramach środków na utrzymanie potencjału badawczego Instytutu Nauk o Żywieniu Człowieka, SGGW w Warszawie

Infertility is one of the most serious medical issues and its prevalence has dramatically increased worldwide, especially in the past few decades. Recent studies have demonstrated that nutrition and lifestyle play crucial roles in the normal functioning of the reproductive system, as well as in prevention and in supportive treatment of infertility. Fruits and vegetables are a special group of foods that provide many nutrients necessary for female and male reproductive health. The paper presents current knowledge about the effects of nutrients contained in fruits and vegetables on male reproductive functions and their use in the supportive treatment of infertility. Understanding these issues can help in designing a proper diet for men of reproductive age planning parenthood, and/or those who have been diagnosed with infertility.

Key words: male, fertility, antioxidants, pro-healthy food, fruits, vegetables, nuts.

Niepłodność jest jednym z najpoważniejszych problemów medycznych, a jej rozpowszechnienie dramatycznie wzrosło na całym świecie, szczególnie w ciągu ostatnich kilku dekad. Ostatnie badania wykazały, że odżywianie i styl życia odgrywają kluczową rolę w prawidłowym funkcjonowaniu układu rozrodczego, a także w zapobieganiu i wspomaganiu leczenia niepłodności. Owoce, warzywa i orzechy to grupa żywności, która dostarcza wiele składników odżywczych niezbędnych dla zdrowia reprodukcyjnego kobiet i mężczyzn. W niniejszej pracy przedstawiono aktualną wiedzę na temat wpływu składników odżywczych zawartych w owocach, warzywach i orzechach na męskie funkcje rozrodcze i ich zastosowanie we wspomaganiu leczenia niepłodności. Zrozumienie tych problemów może pomóc w opracowaniu odpowiedniej diety dla mężczyzn w wieku rozrodczym planujących rodzicielstwo i / lub tych, u których zdiagnozowano niepłodność.

Słowa kluczowe: mężczyźni, funkcje rozrodcze, przeciwutleniacze, żywność prozdrowotna, owoce, warzywa, orzechy.

INTRODUCTION

According to the World Health Organization's (WHO) definition, infertility is the failure to achieve a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse. The prevalence of this problem is increasing. Globally, about 60–80 million couples are affected by infertility, persistently or periodically; this problem concerns 10–20% of couples in the developed countries, and 15–20% of couples of reproductive age, as reported by the Polish Society of Gynaecologists and Obstetricians. Infertility has been recognized as a lifestyle disease, and was included in the International Statistical Classification of Diseases and Related Health Problems. WHO devotes a lot of attention and makes considerable efforts to promote activities aimed at the broadly understood prevention and treatment of infertility in people of reproductive age. This is a strongly justified approach, because the inability to have biological children has serious consequences for the overall mental health of individuals affected by infertility [25].

It is well known that prevention is the most effective way to reduce the incidence of many diseases. There are reliable scientific data confirming the impact of lifestyle, including diet, the use of stimulants, or physical activity, on health, including reproductive capacity. There are many nutrition-related diseases which largely result from 'wrong' irrational and unbalanced diets [9].

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A similar problem concerns infertility: more and more attention is paid to the prevention of this disease, also by means of nutritional management, and to aid its treatment with the use of foods that have a positive effect on human reproductive functions.

Reproductive capacity mainly depends on the normal functioning of glands that produce hormones regulating reproductive processes (hypothalamus, pituitary gland and gonads) and the production of gametes (spermatozoa in the testes and oocytes in the ovaries) able to survive and perform their biological role. Other hormones regulating the functions of the entire reproductive system (insulin, growth hormone, prolactin, cortisol, thyroid hormones) also play a vital role, and the ability to conceive, maintain the pregnancy and give birth to a healthy, viable child depends on the general fitness and health of both the woman and man [14].

Currently, a very positive trend is being observed: people are more aware of health issues, they understand how food and diet directly or indirectly influence health, and they perceive food not only as something satisfying physiological needs, but also as a way to prevent and treat many diseases. The positive effects of food on health seem to be a feature that, along with sensory qualities and price, has the strongest impact on consumer purchasing behaviour in developed countries. Health-promoting foods include natural products of plant and animal origin with positive effects on health due to their content of certain substances, foods fortified with certain nutrients, and foods with a reduced content of undesirable components. Many recent studies have described in detail and documented the positive effects of fruits and vegetables on health. This is a group of foods characterised by a huge diversity in terms of composition. Fruits and vegetables contain nutrients and bioactive compounds that have a significant effect on the reproductive function. Therefore, it is important to characterize their role in ensuring reproductive health and supportive treatment of infertility [19, 22, 26].

MALE REPRODUCTIVE FUNCTION. THE ROLE OF ANTIOXIDANTS AND OXIDATIVE STRESS

The reproductive capacity of men depends primarily on the quality and quantity of sperm, and blood testosterone levels. Disorders in these parameters contribute to the development of male infertility. Males solely account for 20–30% of infertility cases and are responsible for 50% of all infertility cases. Semen quality and male fertility have been declining over the past few decades. One of the most common causes of male infertility is sperm dysfunction caused by many factors leading to defective spermatogenesis, like varicocele, obstructive lesions, infections, environmental factors, and deficiency of vitamins and trace elements, especially zinc and selenium [10, 39].

Free radicals, including reactive oxygen species, are necessary for normal sperm function at the stage of sperm production and maturation, and in the fertilization process. In physiological concentrations they play a vital role in maintaining the normal functioning of the cell membrane, which is associated with sperm motility, during spermatogenesis, and reactions preceding the process of fertilization and necessary for its correct course – capacitation, hyperactivation, acrosomal reaction and, finally, the fusion of reproductive cells.

Under normal conditions the main source of free radicals in the semen are leukocytes and abnormal and/or immature gametes. Free radicals are also a by-product of oxygen metabolism in cell membranes, mitochondria, peroxisomes, or in the endoplasmic reticulum [46].

The physiological level of free radicals is regulated by enzymatic and non-enzymatic antioxidants. Antioxidants are characterized by strong reducing properties. They react with free radicals and reduce their concentration, and prevent oxidant/antioxidant imbalance and the onset of oxidative stress. The cytoplasm of spermatozoa and semen contains high levels of enzymatic antioxidants: superoxide dismutase (SOD), glutathione peroxidase (GPX) and catalase (CAT), as well as non-enzymatic antioxidants, e.g. glutathione, ascorbic acid (vitamin C), alpha-tocopherol, carotenoids and ubiquinol (the reduced form of coenzyme Q10). Oxidative stress can develop when the level of free radicals is higher than the concentration and activity of antioxidants, and this has a negative effect on fertility through many mechanisms. Antioxidants neutralize free radicals by donating one of their own electrons, ending the electron-stealing reaction. The antioxidants do not themselves become free radicals by donating electrons because they are stable in either form. These act as scavengers and play the housekeeper's role by mopping up free radicals before they get a chance to create havoc in a body. Thus, they may well be defined as substances that are capable of quenching or stabilizing free radicals. These antioxidants decrease the levels of markers of oxidative stress, decrease DNA damage, prevent lipid peroxidation, and thus are associated with normal spermatogenesis, sperm maturation, and sperm motility and overall functioning [3, 46]. Selenium and zinc supplied with food are necessary for the proper functioning of enzyme-dependent antioxidative systems. Selenium is a component of glutathione peroxidase, a key enzyme that prevents oxidative stress by catalyzing the reduction of free radicals and thereby interrupting free radical reactions. Selenium has been shown to have a protective role in relation to differentiating and maturing male reproductive cells by preventing damage to genetic material (DNA) and thus ensuring the stability and motility of spermatozoa. Selenium is also an element necessary for the proper synthesis of testosterone in the testes. Moreover, a positive correlation between the plasma concentration of selenium and testosterone has been reported [34]. The importance of zinc for the normal reproductive function in men is evidenced by the high concentration of this element in all organs of the reproductive system, in semen and in spermatozoa. Moreover, zinc plays a key role in the anatomical development and maturation of the reproductive system. Studies have demonstrated that zinc is an essential element for normal testosterone synthesis and for the differentiation and maturation of spermatozoa in the testicles and in the epididymis. The concentration of zinc is decisive for the normal morphology and motility of spermatozoa, especially progressive sperm motility [27].

Oxidant/antioxidant imbalance can be caused by many very complex mechanisms and factors, among which the most frequently reported are environmental pollution and lifestyle-related factors, including alcohol consumption, addiction to

tobacco and food-related factors. It should be emphasized that many disorders and diseases, such as diabetes or obesity, may also lead to oxidative stress [14].

Studies conducted in various populations of healthy and infertile men have revealed that the levels of markers of oxidative stress in semen, i.e. malonyldialdehyde (MDA, product of the reaction between free radicals and polyunsaturated fatty acids, i.e. lipid peroxidation) and total antioxidant capacity (TCA), are correlated with semen parameters. There was a negative correlation between motility, morphology and sperm count, and MDA level, and a positive correlation between these parameters and TCA. In addition, men with idiopathic infertility (of unknown causes) had higher MDA levels and lower TCA in semen compared to men without infertility [4, 18].

Oxidative stress resulting in the excessive synthesis of free radicals can cause damage to DNA in reproductive cells and thus reduce not only the quality of semen (fertilization capacity), but also cause complications during pregnancy. Excessive concentration of free radicals also has a negative effect on sperm motility. The cell membrane of spermatozoa responsible for motility contains large amounts of polyunsaturated fatty acids, and their oxidative damage (lipid peroxidation) deteriorates sperm motility and thus decreases sperm quality [4, 10].

Studies also revealed that oxidative stress has a direct negative effect on male fertility by affecting sperm quality, but also an indirect effect because it influences the endocrine function of the hypothalamic-pituitary-gonadal axis. Studies investigating various factors stimulating the excessive synthesis of free radicals and thus the onset of oxidative stress have demonstrated negative effects at various levels of this axis. For example, free radicals inhibit the synthesis and release of GnRH (gonadotropin-releasing hormone) from the hypothalamus, and LH (luteinizing hormone) and FSH (*follicle-stimulating hormone*) from the pituitary gland, which is associated with the abnormal stimulation of testosterone production in gonads. Free radicals also inhibit testosterone production in the testes, mainly by decreasing the activity of the key protein StAR (Steroidogenic Acute Regulatory Protein) and finally disturb the function of Leydig cells (which produce testosterone), and Sertoli cells (sustentacular cells for spermatozoa). As a result, the blood concentration of testosterone is decreased and the negative feedback mechanism that optimizes the axis function is dysregulated [14].

Other studies revealed that the supplementation of exogenous antioxidants can minimize or even prevent oxidative damage caused by free radicals and even the onset of oxidative stress, thereby improving the quality of semen in infertile men. Supplementation of antioxidants (including alpha-tocopherol, ascorbic acid, carotenoids, e.g. lycopene, as well as selenium and zinc - components of enzymatic antioxidants) reduces the DNA damage and DNA fragmentation in reproductive cells and thus improves sperm morphology, but also lowers the peroxidation of lipids and thus counteracts the reduction of sperm motility. Therefore, it seems that the supplementation of antioxidants may be effective in the prevention and/or treatment of functional disorders of semen associated with oxidative stress [1, 3].

However, various studies have not provided conclusive evidence on the beneficial effects of antioxidant supplementation and relevant recommendations. The problem is in the huge and unlimited availability of food supplements, most often multi-component, which can easily be overdosed. Moreover, uncontrolled supplementation can be counterproductive. For example, the antioxidant paradox was described, and this problem concerns the negative effect of antioxidants taken in an uncontrolled way and in excessive doses: this supplementation strategy has no positive effects and instead stimulates the synthesis of free radicals. On the other hand, as previously mentioned, free radicals at physiological concentrations are necessary to maintain the normal function of the male reproductive system, and therefore the oversupplementation of antioxidants could unnecessarily inhibit their synthesis and lead to serious disorders. It has also been pointed out that the supplementation of antioxidants should be preceded by laboratory tests to measure the markers of the oxidant/antioxidant status in both blood and semen, and to identify individuals who would really benefit from this supplementation and improve their fertility [2, 46].

It seems more reasonable and safer to provide antioxidants with food, because the human body has mechanisms that regulate the absorption of food components as needed. Thus, the diet, as a modifiable aspect of lifestyle, can be used to both prevent and treat infertility.

FRUITS AND VEGETABLES VERSUS MALE FERTILITY

Epidemiological studies have clearly indicated that foods rich in antioxidants play an important role in the prevention of many disorders and diseases, including cardiovascular diseases, cancer and degenerative diseases, and also have a significant anti-ageing effect. This is possible due to the fact that food can provide optimal amounts of various types of nutrients with beneficial effects on the body. Plant products, mainly fruits and vegetables, are a natural rich source of antioxidants in the everyday human diet. Fruits and vegetables contain a range of antioxidants: polyphenols (a complex group of compounds including phenolic acids, flavonoids and other compounds such as lignans, stilbenes, tannins, coumarins, and lignins), vitamins and C and E (tocopherols and tocotrienols), carotenoids (carotenes and xanthophylls), organic acids, selenium, zinc, glutathione, indoles, phytates, thiocyanates and others [24, 30]. The benefits of antioxidants have not been investigated and documented for all the above-mentioned compounds. Moreover, their mere presence in a food product, even in large quantities, is not enough to produce a positive effect. Antioxidants, like any other food components, are metabolised and modified in the human gastrointestinal tract by digestive juices, secretions (bile), as well as microorganisms forming the human microbiome. Most of these modifications do not affect the antioxidant capacity of these compounds, although in some cases can reduce it (e.g. flavonoids, including quercitin, undergo microbial degradation in the gut). In addition, antioxidants, like any other food components, undergo similar changes during processing and storage. Already at the early stage of processing, i.e. peeling, cleaning or chopping, the enzymatic decomposition of antioxidants and other compounds is activated. The most destructive processes

include oxidation, exposure to light, thermal decomposition and extraction. In order to minimize the loss of antioxidants, it is recommended that food products undergo very limited pre-treatment and further processing, and storage should be as short as possible [45].

Fruits and vegetables are a very diverse group of produce both in terms of nutrient content and in terms of organoleptic properties, cooking techniques and methods of their processing. Even with a small range of plant species and varieties, a balanced and diversified diet can be created which will provide all the necessary nutrients and bioactive ingredients. Studies have provided conclusive evidence that a large share of fruits and vegetables and their products in the diet plays a key role in preventing chronic diseases, including those related to lifestyle [24, 30, 43].

Most fruits and vegetables are rich in antioxidants. However, the actual antioxidant activity in the human body has not been documented for all of them. The concentration and type of specific antioxidants differ depending on the fruit and vegetable species and variety. Their concentration and antioxidant activity also depends on the degree of ripeness and duration of storage after harvesting [24, 46].

Particularly strong antioxidant activity resulting from high content of polyphenols has been found for soft fruits, mainly black chokeberry, bilberry, elderberry, raspberry, cranberries, black currants, gooseberries and grapes. High levels of polyphenols are also found in stone fruits, such as apples, cherries, plums, peaches, apricots, and citrus fruits. Vegetables rich in polyphenols include broccoli, cauliflower, Brussels sprouts, kale, garlic, spinach, white cabbage, beetroot and legume seeds, such as beans, soybeans, lentils, broad beans, faba beans and peas. Processing technology has a significant effect on the content of polyphenols and their antioxidant properties. Processes with the strongest negative effect are thawing, aerobic drying and rehydration, while short-term heat-treatment, blanching, freezing, and alcohol fermentation are the least destructive. Importantly, the effect of processing technology on the antioxidant activity of polyphenols contained in plant raw materials strictly depends on the type of plant material used [8, 20, 33, 46].

Among the carotenoids with a proven antioxidant effect on the human body, beta-carotene and lycopene have been the most extensively investigated. The richest source of lycopene are tomatoes, but also fruits: peach, melon, watermelon, red grapefruit, papaya and apricots. The content of lycopene in these fruits and tomatoes is higher the darker their red colour is. The highest concentration of lycopene is found in tomatoes ripening in the sun, not those from a greenhouse. Lycopene is found mainly under the skin of tomatoes, and is released during the disintegration and cooking of tomatoes. Therefore, lycopene from processed tomato products (e.g. sauce, puree or a concentrate) is much better absorbed than that from fresh tomatoes. Heating causes the chemical transformation of lycopene into *trans*-lycopene, which is better absorbed in the digestive tract [8, 20, 33, 46].

The content of beta-carotene also depends on the colour of fruits or vegetables. The richest sources of beta-carotene are apricots, peaches, watermelon, pumpkin, papaya, carrots, sweet potatoes, red peppers, tomatoes, lettuce, spinach and kale. Processing affects both the content and activity of beta-carotene. The degradation of cell walls during heat-treatment or enzymatic hydrolysis increases the bioavailability of beta-carotene. High-temperature processing (boiling, sterilization) does not cause a significant loss of beta-carotene and thus it does not reduce its antioxidant activity [8, 20, 33, 46].

Wholemeal bread, cereal products, cocoa, nuts, pumpkin seeds and legume seeds are the richest plant sources of zinc and selenium in the diet. Importantly, the bioavailability of selenium is reduced when the diet contains high levels of zinc, but increases when vitamins A, E and C are present. The bioavailability of zinc is reduced by phytic acid, oxalic acid, and dietary fibre, as well as excess intake of calcium and copper, while vitamins A, E and C, as well as magnesium, phosphorus and selenium have the opposite effect [8, 20, 33, 46].

Plant sources of vitamin E include nuts, sunflower seeds, green leafy vegetables, such as spinach and lettuce, and black currant and cranberries. Tocopherols and tocotrienols are stable even at temperatures of up to 200°C. However, they degrade during freezing, long-term storage and exposure to sunlight (particularly UVA and UVB) [8, 20, 33, 46].

The richest sources of vitamin C are blackcurrant, citrus fruits, various types of peppers, broccoli, Brussels sprouts, kale, cabbage, white cauliflower and spinach, chives and beet leaves (chard). Unfortunately, vitamin C is unstable in food products exposed to daylight and in contact with air. However, it is resistant to freezing, and thus frozen fruit and vegetables are an excellent source of this compound [8, 20, 33, 46].

It has been reported that the intake of antioxidants is associated with semen quality. Studies have shown a positive correlation between the dietary intake of several antioxidant nutrients (assessed using a semi-quantitative food frequency questionnaire (FFQ)) and selected semen parameters, like total motile sperm count, sperm concentration and morphology. Moreover, males with sperm abnormalities, or infertile subjects, had a significantly lower intake of selected antioxidants, like selenium, vitamin C and E, lycopene and beta-carotene, compared to control subjects. These antioxidants originated mainly from vegetables and fruits, and all of them have a pivotal role in improving semen quality, mainly through reduction in oxidation damage and lipid peroxidation potential [5, 17, 28, 29, 35, 36].

It is worth mentioning that nutrition is considered as a whole dietary pattern. People of reproductive age have been affected by the spread of unhealthy eating behaviours and rapid negative changes in dietary patterns, such as high intakes of saturated fatty acids, *trans* fatty acids and sodium, and low intakes of vegetables and fruits. Such unhealthy dietary patterns influence the health of the reproductive system. They also contribute to many disorders, like overweight and obesity, insulin resistance, diabetes mellitus, and dyslipidaemia, which also impairs fertility. Luckily, the negative effects of unhealthy dietary patterns may be reversible. A healthy diet for men of reproductive age includes foods which are rich in specific nutrients necessary for endocrine function, production and balance, foetal development, egg health, sperm health and much more. Several recent studies have concluded that, compared to subjects with the strongest adherence to a healthy diet, those in the lowest category of adherence had significantly poorer sperm quality. Studying dietary patterns

is a useful approach for describing the overall diet, including potential synergetic effects of food or nutrients, which are crucial determinants of nutritional status linked with normal reproductive functioning. Dietary patterns are identified by principal component analysis or factor analysis. This approach uses collinearity between nutrients or food, examining the interrelation between the diet and its health effects [13].

In general, dietary patterns are categorized as the Western-style dietary pattern and the health-promoting dietary pattern. The Western-style dietary pattern is characterized by low consumption of vegetables and fruits, frequent consumption of sweets and snacks, red and/or processed meat, animal fat, refined grain products, red meat, potatoes, high-fat dairy products, coffee, alcohol, and sugar-sweetened beverages, and is associated with lower semen quality, i.e. abnormal sperm progressive motility, count and morphology of semen. These negative effects of the Western-style dietary pattern are attributed to the high content of saturated fatty acids, natural *trans* fatty acids, and carbohydrates. This diet is low in antioxidants, which is associated with increased risk of anatomical and functional anomalies of semen.

The healthy dietary pattern is characterized by frequent consumption of fish, fruits, vegetables, legumes, soups, mixed dishes, whole-grain products, juices and nuts rich in antioxidants (beta-carotene, vitamin E and vitamin C and polyphenols), fibre, folate, vitamin B6, and omega-3 fatty acids, which play an important role in ensuring the quality of semen. It has been suggested that the possible effect of antioxidants may consist in reducing oxidative stress and chronic inflammation while improving the function of semen, reducing the amount of damaged DNA, participating in steroid hormone synthesis, inhibiting sperm agglutination, and most probably protecting against the toxic effect of heavy metals. A healthy diet, according to specific components, is also divided into the following patterns: health-conscious (fruits, vegetables, fish, legumes and whole grains are the main foods consumed in this pattern), prudent (fruits, vegetables, legumes, poultry and whole grains are the main foods consumed in this pattern), and Mediterranean (high consumption of olive oil, nuts, fruits, vegetables, legumes and whole cereals, and fish, poultry and wine consumed in moderate amounts) [7, 13, 16, 40].

The Mediterranean diet is well known for its positive effects on longevity by preventing cardiovascular disease. Studies have also demonstrated its beneficial effects on preventing lifestyle diseases, such as diabetes, obesity, cancer, infertility, and neurodegenerative and autoimmune disorders. The positive effect of this diet is most likely due to the high content of monounsaturated and polyunsaturated fatty acids from the omega-3 group, and antioxidants such as vitamin C, E, carotenoids and flavonoids [12].

In addition to antioxidants, vegetables and fruits also contain other compounds important for male fertility. Particularly noteworthy is dietary fibre, whose content in fruit and vegetables is significant, and in fact they are its main source in the human diet. A diet rich in fibre is recommended, for example, to prevent overweight and obesity, and carbohydrate metabolism disorders such as hyperinsulinaemia, insulin resistance and diabetes. These medical conditions have a strong negative effect on male fertility. Excess of body fat disturbs the hormonal axis regulating gonadal function, which leads to abnormal testosterone synthesis and the differentiation and maturation of spermatozoa. In addition, overweight and obesity significantly disrupt the secretion of leptin, resistin and adiponectin, which are also hormones essential for normal gonadal function. Consequently, the quality of sperm and its fertilization capacity are reduced. It has been demonstrated that obese men have a decreased count of spermatozoa with normal morphology and their concentration in ejaculate, and are at very high risk of oligozoospermia and azoospermia. Hyperinsulinaemia, usually associated with states of overweight and obesity, affects the conversion of testosterone to oestrogen in adipose tissue, thus leading to abnormal testosterone to oestrogen ratios. In addition, it is associated with the inhibited hepatic synthesis of SHBG (sex hormone binding globulin), a protein that also binds testosterone. This increases the risk of developing hypogonadism, which is a direct cause of male infertility. Thus, a higher intake of fruits and vegetables in the diet, especially those rich in fibre, helps to prevent infertility and supports its treatment [9, 15, 44].

Legume seeds, including soybeans, are particularly noteworthy in terms of their impact on male reproductive capacity. Legume seeds are rich in nutrients, including dietary fibre and antioxidants, mainly represented by isoflavones. Soy isoflavones have strong antioxidant properties with documented positive effects on the human body [45]. However, their oestrogenic and anti-oestrogenic properties in the aspect of male fertility raise considerable concerns. Isoflavones, such as genistein, daidzein and glycitin, contained in soy and soy products, can bind to oestrogen receptors and thus influence hormonal metabolism. It should be emphasized that studies on humans and animals have not provided conclusive evidence on the negative effects of soy and soy products consumption on male hormonal balance, testicular mass or sperm properties, and thus on fertility. The richness of nutrients and bioactive ingredients in soy should be considered, as well as the basic principle of proper diet, which is moderation, to balance potential negative effects [21, 31, 39, 47].

Fruits and vegetables are recommended as the basic components of a healthy diet promoting both general and reproductive human health. However, the presence of pesticide residues in these products is of concern. In fact, fruits and vegetables are the main source of exposure to pesticides in the human diet. Considering this, it is important to distinguish between fruits and vegetables that accumulate small to medium amounts of pesticide residues and those that accumulate large amounts. The lowest levels of these residues are found, for example, in avocado, sweet corn, pineapple, cabbage, sugar peas, onion, asparagus, mango, papaya, kiwi, eggplant and cauliflower. The highest levels of pesticide residues are accumulated in strawberries, apples, celery, grapes, cherries, spinach, tomatoes, red peppers, cucumber and lettuce [32, 48]. It has been demonstrated that the consumption of fruits and vegetables containing small to medium amounts of pesticide residues is associated with better sperm parameters in young men, i.e. the count and morphology of spermatozoa, compared to men consuming fruits and vegetables containing large amounts of residues. This implies that the content of pesticide residues can modify the beneficial effects of fruits and vegetables on male fertility [11, 31]. Therefore, it is important to make conscious choices of individual types of vegetables and fruit available on the market.

Another healthy food that plays an important role in human nutrition and health due to their nutrient profile and bioactivities are nuts. Nuts (tree nuts and peanuts) are nutrient-rich foods that contain plenty of compounds such as: unsaturated fatty acids, B-vitamins, fibre, microelements (copper, magnesium, potassium, zinc, selenium, calcium), nutrient and non-nutrient antioxidants (e.g. phenolic compounds and tocopherols), and numerous bioactive components which have beneficial effects on human health. These components can be acquired provided that nuts are not roasted. Different kinds of nuts have characteristic compositions, thanks to which they influence particular diseases, such as cardiovascular diseases, atherosclerosis, obesity, and inflammatory disorders. They also have neuroprotective activity and reduce stress. The most popular edible tree nuts are almonds, hazelnuts, walnuts and pistachios. Other common edible nuts are pine nuts, cashews, pecans, macadamias and Brazil nuts [6, 38, 49]. Many studies have aimed to investigate the role of different nuts in human fertility, especially in male fertility. Nut supplementation improves semen quality and functioning in healthy men and in animal studies. A hazelnut supplemented diet improves plasma testosterone levels, plasma and testicular oxidant-antioxidant status, and semen quality markers [23]. Moreover, the inclusion of a mixture of nuts in the Western-style diet significantly improves the total sperm count and the viability, motility, and morphology of sperm. These findings could be partly explained by a reduction in sperm DNA fragmentation, and this beneficial effect is probably attributed to the nuts' components, i.e. microelements – zinc, selenium and other antioxidants [37, 41]. Additionally, compliance with a healthy diet supplemented with mixed nuts may help to improve erectile function and sexual drive in healthy males [42].

In conclusion, nuts, beyond their basic nutritional functions, offer an excellent choice as a reproductive-healthy snack food and food additive. Nuts should be consumed with their skin (pellicles) whenever possible, because of their high phytochemical content as well as antioxidant activity.

CONCLUSIONS

Human infertility could be induced by free radicals through occupational activities and the uncontrolled growth of industrialization, civilization and malnutrition. However, dietary supplementation with functional food components can prevent this abnormality. Therefore, the consumption of functional foods to ensure reproductive health and capacity should be advocated for the proper management of infertility among concerned couples.

Vegetables, fruits and nuts rich in unique nutrients, sometimes referred to as superfoods, should be basic components of the diversified and balanced diet of men of reproductive age planning parenthood and those treated for infertility.

PODSUMOWANIE

Niepłodność u mężczyzn może być skutkiem uszkadzającego działania wolnych rodników związanego z narażeniem zawodowym, industrializacją, rozwojem cywilizacji i niewłaściwym sposobem żywienia. Uzupełnienie diety w produkty żywnościowe korzystnie wpływające na męskie funkcje rozrodcze może temu zapobiec. Dlatego zbilansowana dieta bogata w produkty prozdrowotne powinna być zalecana w postępowaniu w przypadku niepłodności.

Warzywa i owoce oraz orzechy, ze względu na bogactwo i unikatowość składu, określane jako produkty prozdrowotne o wysokiej wartości odżywczej, powinny stanowić podstawowy element zróżnicowanej i zbilansowanej diety dla mężczyzn w wieku reprodukcyjnym zarówno planujących rodzicielstwo, jak i leczonych z powodu niepłodności.

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ANALIZA STOSOWANIA SUBSTANCJI DODATKOWYCH W PRZETWORZONYCH PRODUKTACH EKOLOGICZNYCH®

Analysis of application of food additives in processed organic products®

W artykule zaprezentowano uzyskane wyniki badań dotyczące przeprowadzonej analizy stosowania substancji dodatkowych w przetwarzaniu żywności ekologicznej. Materiałem do badań były informacje zawarte na etykietach przetworzonych produktów ekologicznych, oferowanych przez różnych producentów i dostępnych w popularnych supermarketach zlokalizowanych na terenie woj. podlaskiego. Łącznie przeanalizowano 175 przetworzonych produktów ekologicznych należących do różnych grup asortymentowych i różnych kategorii żywności. Wg deklaracji producentów, obecność substancji dodatkowych stwierdzono w 17% ogólnej liczby produktów. W składzie produktów deklarowanych jako ekologiczne stosowano z różną częstotliwością (36 razy w 30 produktach) jedynie jedenaście różnych substancji dodatkowych przyporządkowanych do ośmiu grup dodatków technologicznych. Najczęściej stosowano kwas askorbinowy jako przeciwutleniacz (38% wszystkich dodatków), a następnie mączkę chleba świętojańskiego (21%) stosowaną jako środek zagęszczający i stabilizujący, regulatory kwasowości (14% wszystkich dodatków), emulgatory (10%), pektynę jako substancję żelującą (10%), kwasy (6%) oraz substancje spulchniające (3% wszystkich dodatków).

Słowa kluczowe: kategorie żywności, żywność ekologiczna, dodatki do żywności, substancje dodatkowe.

What has been done, was the analysis of application by producers of food additives in processed organic products. As the material of investigation was used the information published on the label of processed organic products, offered by different producers, available in Podlasie region, Poland. 175 different ecological processed products were analysed in total. These products originated from their various range and belonged to different food categories. It was stated according to declarations of producers provided on the products that food additives were used in 17% of analysed products. Eleven additives belonging to eight different technological groups of additives were used by producers with different frequency (36 times in 30 products), in the food products, which were declared as organic. Mostly the ascorbic acid was used as an antioxidant (in 38% of total amount of additives), then locust bean gum was used (in 21% of total additives) as thickening and stabilizing agent, acidity regulators (14% of the total additives), emulgators (10%), pectin as a gelation agent (10%), acids (6%) and raising agents (3 % of the total additives).

Key words: food categories, organic food, food additives, additive compounds.

WSTĘP

W ostatnich latach na rynku żywności zauważalnie wzrosła liczba asortymentu produktów ekologicznych. Do niedawna można było nabyć głównie surowce, a produkty przetworzone stanowiły rzadkość. Obecnie, w krótkim czasie, dynamicznie, sytuacja ta uległa zmianie. Niemalże wszystkie sieci sklepów oferują przetworzoną żywność ekologiczną, o czym informują często emitowane reklamy medialne. Tendencja taka jest bardzo korzystna biorąc pod uwagę zachowanie równowagi środowiska i odnawialność gatunków o czym pisze się w literaturze fachowej [1, 2, 3, 4, 5, 9, 12, 19].

Produkcję żywności ekologicznej regulują przepisy prawa, wśród których podstawowym jest Rozporządzenie Rady (WE) nr 834/2007 z dnia 28 czerwca 2007 r. w sprawie produkcji ekologicznej i znakowania produktów ekologicznych i uchylające rozporządzenie (EWG) nr 2092/91 [17]. Rozporządzenie to wskazuje, że „ekologiczny" oznacza pochodzący z produkcji ekologicznej lub z nią związany. Dotyczy to zarówno surowców, jak i produktów przetworzonych. W praktyce – produkt przetworzony może być uznany za ekologiczny tylko wówczas, jeżeli wszystkie lub niemal wszystkie składniki pochodzenia rolnego, z których się on składa, są ekologiczne. Przyjęto, że co najmniej 95 % masy składników pochodzenia rolniczego wchodzące w skład wytworzonego produktu muszą stanowić składniki ekologiczne.

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Dodatkowo ekologiczne produkty przetworzone powinny być produkowane przy użyciu takich metod, które gwarantują przestrzeganie zasad produkcji ekologicznej i utrzymanie zasadniczych cech produktu na wszystkich etapach produkcji. To znaczy, że żywność ekologiczną można produkować przy użyciu tych samych linii technologicznych co produkty nieekologiczne, ale produkcja jednych i drugich powinna być rozdzielona w czasie. Przed produkcją żywności ekologicznej, w przypadku, gdy wcześniej był produkowany produkt nieekologiczny, urządzania produkcyjne powinny zostać dokładnie oczyszczone [14]. Najlepiej jednak, gdyby produkcja odbywała się na oddzielnych liniach technologicznych i w oddzielnych pomieszczeniach.

Dostosowanie się do wymagań prawa powoduje, że przetworzona żywność ekologiczna jest droższa od analogicznej konwencjonalnej. Nabywając takie produkty za wyższą cenę konsumenci mają prawo oczekiwać, że otrzymają produkt o wysokiej jakości, który w potocznym rozumieniu zazwyczaj kojarzy się z wyrobem „bez konserwantów". W rzeczywistości może być jednak inaczej. Do wytwarzania produktów ekologicznych dopuszczone jest stosowanie nieekologicznych składników, w tym dodatków funkcjonalnych, jeżeli dany składnik nie jest dostępny na rynku w postaci ekologicznej. Należy jednak wiedzieć, że różne dodatki do żywności oraz składniki nieekologiczne, powinny być wykorzystywane w minimalnym zakresie i tylko w sytuacji istotnej potrzeby technologicznej lub w celu uzyskania szczególnych celów żywieniowych (np. w produkcji żywności przeznaczonej dla niemowląt i dzieci). Wykaz dodatków dozwolonych do stosowania w produkcji żywności ekologicznej jest opublikowany w Załączniku VIII Rozporządzenia Komisji (WE) nr 889/2008 [13, 14, 16, 20].

Celem artykułu jest przedstawienie analizy składu surowcowego produktów ekologicznych, zadeklarowanego w wykazie składników na etykietach opakowań jednostkowych ekologicznych produktów dostępnych w supermarketach woj. podlaskiego.

MATERIAŁ I METODY BADAWCZE

Materiałem do badań były przetworzone produkty ekologiczne, które znajdowały się w ofercie wybranych sklepów zlokalizowanych na terenie województwa podlaskiego. Fotografowano etykiety wszystkich produktów przetworzonych znajdujących się w wymienionych sklepach, a następnie poddawano analizie ich skład surowcowy zamieszczony na opakowaniach. Produkty pogrupowano według kategorii żywności.

Omawiane produkty ekologiczne pochodziły z dwudziestu jeden różnych państw. Najwięcej było produktów polskich (89 szt. co stanowiło 51% wszystkich produktów ekologicznych) oraz niemieckich (50). Ponadto produkty pochodziły ze Sri Lanki (6/175), po cztery (4/175) z Belgii, Hiszpanii i Włoch, po dwa produkty (2/175) z Bułgarii, Indonezji i Meksyku oraz po jednym (1/175) z Austrii, Brazylii, Francji, Grecji, Holandii, Kanady, Łotwy, Nigerii, Norwegii, Pakistanu, Paragwaju i Ukrainy.

WYNIKI BADAŃ I ICH OMÓWIENIE

Analizie stosowania dodatków do żywności poddano łącznie 175 produktów deklarowanych jako ekologiczne. Produkty te zakwalifikowano do dwunastu różnych kategorii żywności (tab. 1) spośród 18 wymienionych w załączniku II do Rozporządzenia Komisji (UE) nr 1129/2011 [13] oraz z Rozporządzenia Parlamentu Europejskiego i Rady (UE) nr 609/2013 [15].

Największą grupę przetworzonych produktów ekologicznych stanowiły napoje (21,7% wszystkich produktów), a następnie produkty zaliczane do żywności specjalnego przeznaczenia (zgodna z Rozporządzeniem 609/2013) (34/175). Dość liczną grupę stanowiły również przetworzone warzywa i owoce (13,1%) oraz produkty mleczne i ich analogi (13,1%) – tab. 1.

Produkty z kategorii zboża i produkty zbożowe oraz sole, przyprawy, zupy, sosy, sałatki i produkty białkowe stanowiły po 8,6% ogólnej liczby analizowanych produktów. Wśród analizowanych kategorii wyroby piekarskie oraz ryby i produkty rybołówstwa, stanowiły po 0,6% ogólnej liczby produktów. Substancji dodatkowych ani żadnych innych dodatków nie stwierdzono w produktach ekologicznych z kategorii: tłuszcze i oleje, emulsje tłuszczowe i olejowe, ryby i produkty rybołówstwa, cukry, syropy, miód i słodziki stołowe oraz sole, przyprawy, zupy, sosy, sałatki i produkty białkowe (tab. 1).

Tabela 1. Przyporządkowanie analizowanych produktów ekologicznych do poszczególnych kategorii żywności

Table 1. Classification of the analized organic products into particular food categories

Kategorie żywności	Liczba wszystkich analizowanych produktów w danej kategorii żywności	Liczba produktów w danej kategorii żywności z dodatkami technologicznymi
Produkty mleczne i ich analogi	23 (13,1%)	5
Tłuszcze i oleje, emulsje tłuszczowe i olejowe	7 (4%)	0
Warzywa i owoce	23 (13,1%)	6
Wyroby piekarskie	1 (0,6%)	1
Wyroby cukiernicze	3 (1,7%)	1
Zboża i produkty zbożowe	15 (8,6%)	1
Ryby i produkty rybołówstwa	1 (0,6%)	0
Cukry, syropy, miód i słodziki stołowe	9 (5,1%)	0
Sole, przyprawy, zupy, sosy, sałatki i produkty białkowe	15 (8,6%)	0
Żywność specjalnego przeznaczenia	34 (19,4%)	13
Napoje	38 (21,7%)	2
Przekąski gotowe do spożycia	6 (3,4%)	1
Łącznie analizowane produkty	175 (100%)	30

*/ *W nawiasie podano procentowy udział danej kategorii żywności w ogólnej puli analizowanych produktów*

Źródło: Badania własne

Source: Own study

Na rys. 1 przedstawiono procentowy udział produktów ekologicznych z dodatkami technologicznymi w poszczególnych grupach asortymentowych. Substancje dodatkowe stwierdzono łącznie w 30 wyrobach, tj. w 17,1% wszystkich analizowanych produktów ekologicznych.

Największą grupę wyrobów z dodatkami technologicznymi stanowi żywność specjalnego przeznaczenia (wg Rozporządzenia 609/2013) (38,2% wszystkich produktów z tej grupy), wyroby cukiernicze (33% puli wyrobów w tej grupie) oraz owoce i warzywa (26,2% puli wyrobów z tej kategorii). Wyroby piekarskie w 100% zawierały dodatki do żywności, ale należy zważyć na fakt, że znaleziono i analizowano tylko jeden produkt.

Rozpatrując liczbę konkretnych produktów z dodatkiem substancji dodatkowych, stwierdzono, że najwięcej tych substancji jest w przetworach owocowych i mlecznych dla dzieci (11 różnych produktów) (rys. 2).

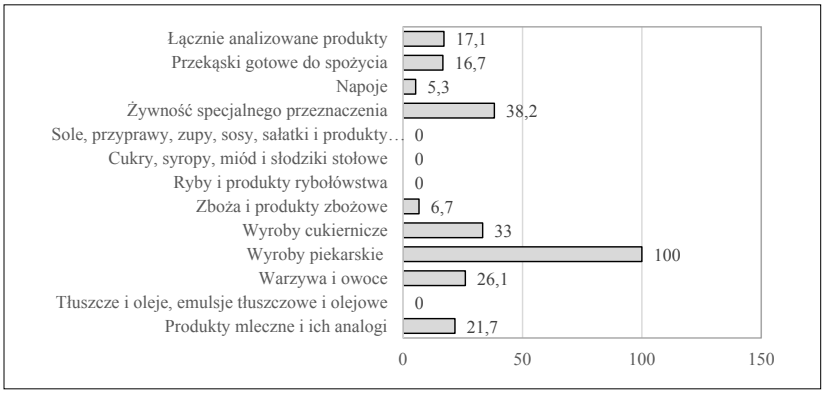
Dodatki deklarowano także w trzech rodzajach serków homogenizowanych i trzech rodzajach dżemów, dwóch rodzajach jogurtów, dwóch surówkach, mleku dla dzieci i napojach; w jednego rodzaju pomidorach krojonych, czekoladzie, ciastkach, musli i słonych paluszkach (rys. 2).

Wszystkie substancje dodatkowe deklarowane w produktach ekologicznych należały do ośmiu różnych grup dodatków (rys. 3). Były to: stabilizatory, emulgatory, regulatory kwasowości, środki wiążące, kwasy, przeciwutleniacze, środki zagęszczające, substancje żelujące oraz substancje spulchniające.

W największym stopniu stosowano przeciwutleniacze (33,3% wszystkich stwierdzonych substancji dodatkowych), a następnie środki zagęszczające (18,2% puli substancji dodatkowych stwierdzonych we wszystkich produktach) i regulatory kwasowości (12,1% stwierdzonych w wyrobach substancji dodatkowych). Przeciwutleniacze deklarowano w ponad 6% analizowanych wyrobów ekologicznych, środki zagęszczające w 3,5% produktów, a regulatory kwasowości w ok. 2% wszystkich wyrobów. Stabilizatory, emulgatory i substancje żelujące deklarowano również w ok. 2% wyrobów, a stanowiły one po 9,1% wszystkich dodatków zadeklarowanych w wyrobach.

Należy stwierdzić, że łącznie zastosowano jedynie jedenaście różnych substancji dodatkowych, które stosowano z różną częstotliwością (36 razy) w różnych grupach produktach spożywczych (rys. 4).

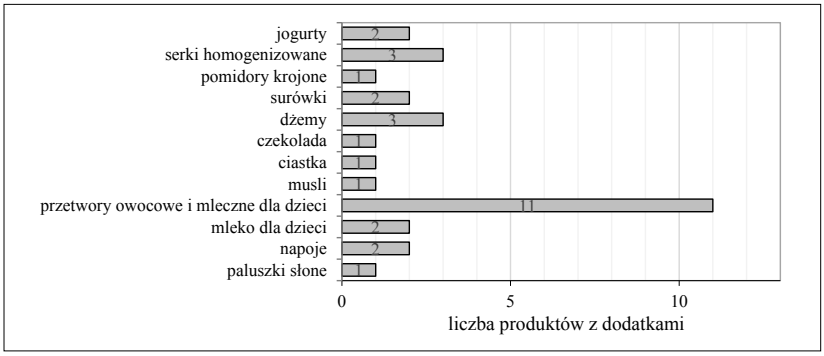
Kwas askorbinowy deklarowany jako przeciwutleniacz był najczęściej stosowany w produktach zaliczanych do kategorii żywności zgodnej z Rozporządzeniem 609/2013 (w przetworach owocowych i mlecznych dla dzieci, np.



Rys. 1. Procentowy udział rynkowych produktów ekologicznych zawierających substancje dodatkowe w poszczególnych kategoriach żywności.

Fig. 1. Percentage share of commercial organic products containing additives in particular food categories.

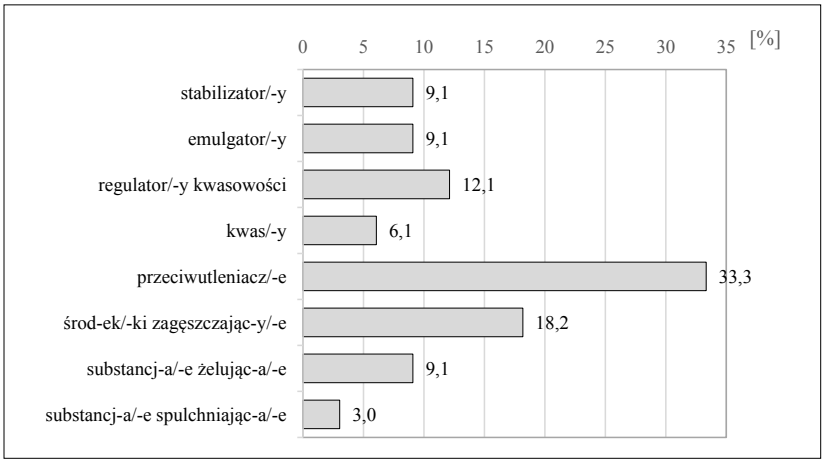
Źródło: Badania własne
Source: Own study



Rys. 2. Asortyment produktów ekologicznych, w których deklarowano stosowanie dodatków do żywności.

Fig. 2. Range of organic products, in which were used the additives declared by producers.

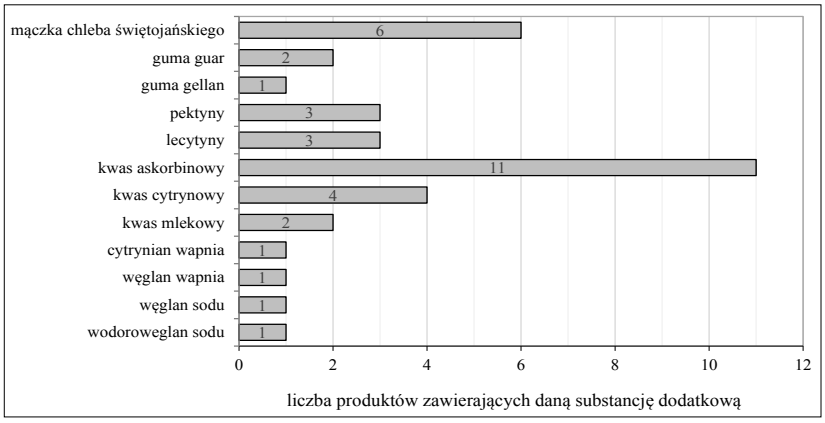
Źródło: Badania własne
Source: Own study



Rys. 3. Grupy substancji dodatkowych oraz ich procentowy udział w ogólnej puli dodatków zadeklarowanych w składzie analizowanych wyrobów ekologicznych.

Fig. 3. Groups of additives and its percentage share in the total pool of additives, declared by producers among ingredients of analyzed organic products.

Źródło: Badania własne
Source: Own study



Rys. 4. Rodzaje substancji dodatkowych deklarowanych w analizowanych wyrobach ekologicznych i częstotliwość ich stosowania.

Fig. 4. The kinds of additives declared by producers among ingredients of analyzed organic products and the frequency of its application.

Źródło: Badania własne
Source: Own study

„Bio Banany z jabłkami", BIO-jogurty z owocami oraz BIO-kaszki mleczne). Innym dość często stosowanym dodatkiem była mączka chleba świętojańskiego (w pięciu przypadkach była to żywność z kategorii produkty mleczne i ich analogi, a w jednym – napoje). Mączka chleba świętojańskiego stanowiła „zagęstnik" w trzech serkach homogenizowanych oraz w dwóch jogurtach pitnych. Jako stabilizator była użyta w napoju migdałowym.

W czterech produktach ekologicznych zastosowano kwas cytrynowy deklarowany jako regulator kwasowości w żywności zaliczonej do kategorii warzywa i owoce (np. krojone pomidory, dżemy).

Jako substancje żelujące stosowano pektyny (w przypadku dżemów, kategoria warzywa i owoce). Lecytynę stosowano jako emulgator w wyrobach cukierniczych (czekolada mleczna, ciastka z czekoladą) oraz w wyrobach z kategorii zboża i produkty zbożowe (musli owocowe). Guma guar deklarowana była jako substancja stabilizująca oraz zagęszczająca w dwóch różnych surówkach (kategoria: warzywa i owoce). Kwas mlekowy zastosowano jako stabilizator pH (kwas) w mleku dla dzieci początkowym i następnym z kategorii żywności zgodnej z Rozporządzeniem 609/2013.

Guma gellan (substancja stabilizująca), cytrynian wapnia, węglan wapnia, węglan sodu i wodorowęglan sodu występowały w pojedynczych przypadkach. Cytrynian wapnia wykorzystano jako regulator kwasowości w twarożku z owocami dla dzieci. Węglan wapnia był wskazany jako regulator kwasowości tylko w jednym produkcie z kategorii żywności zgodnej z Rozporządzeniem 609/2013 (w owocach z jogurtem dla dzieci). Węglan sodu był użyty jako substancja spulchniająca w ciastkach owsianych z czekoladą (z kategorii żywności wyroby cukiernicze). Wodorowęglan sodu był natomiast dodany w celach regulacji kwasowości w pełno-zbożowych paluszkach orkiszowych z kategorii żywności przekąski gotowe do spożycia.

DYSKUSJA

Zgodnie z definicją, dodatki do żywności są to substancje, które w normalnych warunkach nie mogą być spożywane samodzielnie jako żywność oraz nie mogą być stosowane jako specyficzny składnik żywności pomimo potencjalnych wartości odżywczych [13]. Równocześnie biorąc pod uwagę wymagania dla produkcji żywności ekologicznej [17] oraz oczekiwania konsumentów, do żywności tej w zasadzie nie powinno stosować się substancji dodatkowych [4, 7].

W niniejszej pracy stwierdzono jednak, że nawet w żywności ekologicznej można znaleźć substancje dodatkowe, takie jak np. stabilizatory, emulgatory, regulatory kwasowości, środki wiążące, kwasy, przeciwutleniacze, środki zagęszczające, substancje żelujące czy substancje spulchniające. Są to substancje o właściwościach technologicznych warunkujących oczekiwaną przez konsumentów jakość produktu, a co istotne podnoszą także ważną dla producentów efektywność przetwórstwa żywności i handlu [6].

Niektóre dane literaturowe wskazują, że w Polsce zbyt liberalnie podchodzi się do praktyki nadmiernego, niepotrzebnego stosowania w technologii przetwarzania żywności różnych substancji dodatkowych, pomimo, że znajdują się one na tzw. liście pozytywnej [10, 11].

Obserwuje się wzrost udziału wyrobów spożywczych „ekologicznych" w obrocie rynku żywnościowego, który na chwilę obecną szacowany jest na ponad 10% rynku europejskiego i ok. 1% rynku polskiego [6]. Poszukiwanie takiej żywności wzrasta wraz ze wzrostem świadomości konsumentów o wpływie rodzaju spożywanej żywności na ich zdrowie. Wciąż jednak uważa się, że w Polsce świadomość na temat stosowania dodatków do żywności jest zbyt niska [7].

Ważnym aspektem jest fakt, że substancje dodatkowe stosowane w produkcji żywności ekologicznej uznawane są przez konsumentów jako „mniej" szkodliwe i są one zwykle polecane jako „pochodzenia ekologicznego". Ponadto, w żywności ekologicznej lista takich dodatków jest mocno ograniczona [13, 14].

Należy podkreślić, że wszystkie deklarowane substancje dodatkowe w analizowanych produktach dodawane były zgodnie z wymaganiami Rozporządzenia Komisji (WE) nr 889/2008 [14] dotyczącego żywności ekologicznej. Niektóre ze stosowanych dodatków były także pochodzenia ekologicznego, np. była mączka chleba świętojańskiego, którą dodawano do wszystkich analizowanych serków homogenizowanych oraz do jednego jogurtu. Jako dodatek pochodzenia ekologicznego deklarowano również gumę guar stosowaną w produkcji surówek oraz lecytynę stosowaną w produkcji czekolady mlecznej i ciastek owsianych z czekoladą.

Z punktu widzenia żywieniowego guma guar czy pektyny mogą pełnić funkcje błonnika pokarmowego [18], zaś lecytyna jest cennym składnikiem korzystnie wpływającym na naszą pamięć i układ nerwowy. Jej właściwości technologiczne wynikają z właściwości powierzchniowo czynnych, które poprawiają stabilność emulsji (emulgator), ale także modyfikują właściwości reologiczne (substancja poprawiająca konsystencję emulsji) [8].

PODSUMOWANIE

1. Łączna liczba produktów ekologicznych zawierających dodatki technologiczne (substancje dodatkowe) była niewielka w porównaniu z całą ofertą produktów ekologicznych znajdujących się na rynku podlaskim. Spośród 175. analizowanych produktów ekologicznych, tylko 30 z nich (17,1% ogólnej puli wyrobów) zawierało substancje dodatkowe pełniące funkcje technologiczne.
2. W składzie produktów deklarowanych jako ekologiczne stosowano z różną częstotliwością (36 razy w 30 produktach) jedynie jedenaście różnych substancji dodatkowych przyporządkowanych do ośmiu grup dodatków technologicznych.
3. W produkcji wyrobów ekologicznych najczęściej stosowano przeciwutleniacze (głównie kwas askorbinowy), środki zagęszczające (mączka chleba świętojańskiego, pektyny, guma guar) i regulatory kwasowości (kwas cytrynowy, węgla wapnia i cytrynian wapnia).
4. Substancje dodatkowe najczęściej stosowano w produkcji przetworów owocowych i mlecznych dla dzieci, należących do żywności specjalnego przeznaczenia (wg Rozporządzenia 609/2013), produktów mlecznych i ich analogów oraz wyrobów cukierniczych.

SUMMARY

1. The total number of organic products containing technological food additves was low in comperison with the whole offer of organic products available in Podlachia region. Only 30 out of 175 analysed organic products (it was 17,1% of the total pool of analysed products) contained functional, technological additives.
2. Among ingredients of analysed organic products there were applied only eleven different food additives that belong to eight different technological groups, with various range (36 times in 30 products).
3. In the production of organic food, there were mostly used the antioxidative substances (usually ascorbic acid), then thickener agents (locust bean gum, pectins, guar gum) and the acid regulators (citric acid, calcium carbonate and calcium citrace).
4. The additives were mostly used in production of fruit and milk products for children that belong to category of special food customer (according to Decree 609/2013), also to category of dairy products and their analogues, as well as to confectionery.

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CHARACTERISTIC OF PHENOLIC COMPOUNDS OF BEER AND THE INFLUENCE OF PRODUCTION PROCESS ON ANTIOXIDANT PROPERTIES®

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Beer is one of the most consumed types of alcoholic beverage in the world. Beer is brewed using the following ingredients: water, barley, hops and yeast, but the selection of the raw materials and brewing processes determines the nutritional value and content of phenolic compounds in the final product. The aim of this article is to characterize the phenolic compounds of beer, as well as presenting the impact of the beer production process on its antioxidant properties.

Key words: beer, phenolic compounds, antioxidant properties.

Piwo jest jednym z najpowszechniej spożywanych napojów alkoholowych na świecie. Podstawowymi składnikami wykorzystywanymi do produkcji piwa jest woda, jęczmień, chmiel i drożdże, a dobór surowców i procesów warzenia determinuje wartość odżywczą i zawartość związków fenolowych w finalnym produkcie. Celem artykułu jest charakterystyka obecnych w piwie związków fenolowych, a także przedstawienie wpływu poszczególnych procesów produkcji piwa na zawartość fenoli, jak również na jego właściwości antyoksydacyjne.

Słowa kluczowe: piwo, związki fenolowe, właściwości antyoksydacyjne.

INTRODUCTION

Alcoholic beverages are the most commonly used stimulant in society in many countries. According to the World Health Organization, beer is one of the most consumed types of alcoholic beverage in the world [69]. In Europe, the countries with the highest beer consumption are the Czech Republic, Austria, Germany and Poland [32].

Beer is brewed using the following ingredients: water, barley, hops and yeast, but due to the selection of the raw materials and brewing processes the resulting product is chemically complex, which is why many types of beer are distinguished [70]. Currently, beers are mainly classified according to the fermentation process, as bottom or top fermentation. The most commonly consumed type of beer is light beer (lager type), which uses bottom-fermenting yeast for its production, and the fermentation is carried out at a temperature between 6 and 15 °C, while ale type beers are produced using top-fermenting yeast occurring at a temperature between 16 and 24 °C. Depending on the raw materials, recipes and production techniques used, different beers such as Pilsen, bock, pale and many others are distinguished [4], characterized by a different nutritional value and content of phenolic compounds. The results of numerous studies confirm the health-promoting effects of the phenolic compounds present in beer, which are characterized by their antioxidant [45], anti-inflammatory [31], anticancer [24] and hepatoprotective properties [64]. It is suggested that low or moderate consumption of beer may have beneficial effects on health by reducing the risk of cardiovascular diseases, Osorio-Paz et al. [47], osteoporosis [13] or Alzheimer's disease, and other neurodegenerative diseases [53], but also the stimulation of the immune system [56]. The benefits of moderate alcohol consumption should be carefully cautioned so that consumers do not interpret this as permission to drink excessively [17]. It should be noted that excessive drinking of beer promotes gout, obesity, allergies, dementia, and cancer [56], as well as being associated with serious social problems such as addiction, violence or crime [16].

The aim of this article is to characterize the phenolic compounds of beer, as well as presenting the impact of the beer production process on its antioxidant properties.

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ENERGY AND NUTRITIONAL VALUE OF BEER

Beer can be defined as a complex beverage of ingredients that differ significantly in structure and quantity, thus the beer contains various chemical components that can react and interact at all the stages of the brewing process [15]. In the beer's production method, barley and hop cultivars determine the nutritional value of the beer [27], which contains over 3 000 different compounds [1]. About 90% of the beer's volume is water, the composition of which according to Cetó et al. [9], is a key parameter. Many different water parameters, among them pH, alkalinity or the concentration of metal ions, can affect the taste of beer. The water used in the brewing process must be pre-treated as well as pre-cooked to remove its hardness, it should also be characterized by the appropriate alkalinity, because, if the alkalinity of the water is too high, it causes the pH of the wort and beer to increase in the final product, which may negatively affect its taste profile. Some beers have a characteristic taste due to the water from the region, e.g. Pilsner Urquell, which is made from soft water from Pilsen in the Czech Republic [1]. During fermentation, ethanol and volatile compounds belonging to various chemical groups are produced, including aliphatic and aromatic alcohols, esters, acids, aldehydes, carbonyl compounds and terpene substances.

Volatile compounds create the aroma and taste of beer, which is why analysing the composition of beer can help in choosing the best raw materials and yeast strains, and in quality control [5, 15]. Beer contains ethyl alcohol in an average amount of 3–6% [5], while providing information on the ethanol content on the label is mandatory, there is no requirement to provide the energy or nutritional value of beer [69]. In the Table 1 are presented energy and nutritional value of light beer.

The energy value of beer is shaped by the ethanol content (1 g of ethanol provides 7 kcal), but also the content of protein and carbohydrates, and in beers fermented in a traditional way, the content of partially degraded starch can be about 25%, which will affect the higher caloric value. Whereas the light beers usually contain smaller amounts of carbohydrates. It is generally stated that the energy value of 1 litre of beer is about 150 to 1 100 kcal [3]. Carbohydrates mainly come from malted barley, which are about 70–85% [35]. On average, beer contains about 4% carbohydrates, of which about 70% are dextrins, 25% monosaccharides and oligosaccharides, and about 6% are pentosans. However, after the fermentation process, beer contains amounts of disaccharides (maltose and sucrose) and monosaccharides (including glucose and fructose), which give the beer a sweet taste [11]. During the mashing process, oligosaccharides and/or monosaccharides are formed from the starch under the influence of enzymes and heat, but the largest amounts of decomposed starch are used in the fermentation process. There are also soluble and insoluble polysaccharides in grain and hops, which can have a significant impact on the brewing process, while polysaccharides persist and are also present in the finished product [5, 23].

Nitrogen compounds, i.e. amino acids, peptides, polypeptides, proteins, nucleic acids, as well as their degradation products are of key importance in determining the quality and stability of beer [25]. The content of nitrogen compounds in beer depends on the raw materials used and the enzymatic reactions used in the beer production process [18], mainly they come from malted barley, in which they are present in an amount of about 10–15% [35]. During the malting process, the reserve proteins are broken down into amino acids and other peptides. Then, in the fermentation process, the amino acids from the wort are used by the yeast, which affects the quality of the finished product [25]. Test results of Devolli et al. [18], indicate that in the brewing process the amount of protein decreases significantly, but its content in the final product is very important because it determines stability and the formation of haze. Beers containing large amounts of protein are characterized by a high level and tendency to create haze [18]. In addition, nitrogen compounds can also affect foam quality and stability [25].

Beer contains not only macronutrients, but also B vitamins and many minerals, namely calcium, magnesium, potassium and a small amount of sodium, as well as iron, copper, zinc

Table 1. Energy and nutritional value of light beer [34]

Tabela 1. Wartość energetyczna i odżywcza piwa jasnego [34]

Parameters	Beer (100 ml)
Energy (kcal)	49
Water (g)	91
Carbohydrates (g)	3,8
Protein (g)	0,5
Potassium (mg)	26
Phosphorus (mg)	26
Magnesium (mg)	9
Calcium (mg)	6
Sodium (mg)	3
Iron (mg)	0,1
Manganese (mg)	0,03
Folate (µg)	6
Niacin (mg)	1,30
Vitamin B6 (mg)	0,02
Vitamin B2 (mg)	0,018
Vitamin B1 (mg)	0,004
Amino acids	
Glutamic acid (mg)	101
Proline (mg)	94
Aspartic acid (mg)	37
Glycine (mg)	30
Alanine [mg]	31
Valine (mg)	26
Serine (mg)	20
Arginine (mg)	19
Cystine (mg)	19
Lysine (mg)	19

and manganese, so it can be assumed that beer is characterized by a better nutritional value compared to other alcoholic beverages [3, 5, 65]. Minerals in beer come mainly from grain (75% malt) and water (the remaining 25%), while hops contribute insignificant amounts of minerals due to their low addition in the production process. It should be added that in the beer brewing process the amount of minerals that precipitate decreases [42]. According to research, beer can be a good source of calcium, because 500 ml of beer contributes up to 12% of the daily norm for this component in accordance with the Polish reference value and up to 15.5% in relation to US norms, while in the case of potassium the same amount of beer contributes up to 3% of the daily need [59]. In beer there are also phenolic compounds that can be assigned to several structural groups characterized by different biological activity, but determining the antioxidant properties of beer [28].

CHARACTERISTICS OF PHENOLIC COMPOUNDS IN BEER

Most of the phenolic compounds of beer, about 70-80%, come from malt, and about 20-30% from hops, while the final content and profile largely depends on the type of beer and are associated with the raw materials used and the method of brewing beer [72]. The growing sites of the barley cultivars have an impact on the content of phenolic compounds in barley [76]. Research by Šimić et al. [63], showed that the type of barley affects not only the total phenol content and antioxidant activity, but also the barley malt yield. According to Maillard et al. [41], although the cultivars of barley have a significant impact on the total content of phenolic compounds in the barley, the share of individual groups of phenols does not change. Phenolic compounds found in barley are mainly derivatives of benzoic and cinnamic acids, flavonoids, chalcones, quinines and amino phenols [22]. Despite the fact that the addition of hops to beer is small, because only 200 mg of hops is used to produce about 100 litres of beer [42] it is a valuable source of polyphenolic compounds. Dried hop cones contain about 14.4% phenolic compounds [66]. Some phenolic compounds present in beer are formed during the mashing and brewing process of grain and hops. While some of these compounds have no effect, others may have a positive or negative effect on the sensory characteristics of beer [37]. An example is xanthohumol, isoxanthohumol and 8-prenylnaringenin formed during brewing, which is formed during the drying, storage and extraction of hops [58]. Generally, phenolic compounds determine the smell, colour, aroma and quality of the beer, and reactions that occur during storage (e.g. reactions of polyphenols with proteins) cause haze, which adversely affects the sensory values and overall quality [7, 2, 55]. The antioxidant effect of beer polyphenolic compounds is to remove free radicals, chelate metals, as well as inhibit lipoprotein oxidation [2], and inhibit oxidation of ascorbic acid and unsaturated fatty acids [75].

Phenolic compounds of beer constitute a structurally diverse group of compounds belonging to simple phenols, benzoic-and cinnamic acid derivatives, coumarins, catechins, proanthocyanidins, chalcones and flavonoids (flavan-3-ols: catechin, epicatechin, gallocatechin), flavonols (kaempferol, myricetin, quercetin), as well as alpha acids and iso-alpha acids [6, 75].

The lowest content of polyphenolic compounds is found in dark and lager beers and white wine, while the highest in red wines [40]. However, beer flavonoids derived from barley and hops are different from those used in wine-making grapes [17]. The difference in phenolic compounds in alcoholic beverages means that beer is considered a drink with a higher antioxidant potential than white wine [28]. According to Pagang et al. [48], the antioxidant activity of one glass of red wine is equivalent to two glasses of beer and as many as twelve glasses of white wine. Interestingly, another study showed that the assessment of the antioxidant potential in beer and wine may depend on the test used, because although red wine had a much higher antioxidant potential than other beverages, beer had a greater ability to prevent lipid oxidation [52]. There are a lot of different tests used to determine the antioxidant potential, among them are gallic acid equivalent, iron antioxidant reduction test (FRAP), oxygen radical absorption capacity (ORAC) or 1,1-diphenyl-2-picrylhydrazyl (DPPH (·)) test. In addition, some authors point to the possibility of determining the antioxidant capacity of beer based on data on the content and density of ethanol, bitterness and refractive index [43]. Depending on the type of beer and the test used, the total polyphenol content varies significantly. In the study of Piazzon et al. [51], it was found that in various types of beer the polyphenol content is from 366 μg /ml gallic acid equivalent in non-alcoholic beer to 875 μg /ml gallic acid equivalent in bock strong beers and top fermented beers (ale type). Similarly, the antioxidant activity measured using the Iron Antioxidant Reduction Test (FRAP) is different depending on the type of beer, with the highest amounts recorded for bock, abbey and ale (4 663 μM for type bock) and the lowest for non-alcoholic beer (1 525 μM) [51]. Similarly, Vinson et al. [73], noted that the highest content of phenolic compounds is in ale, then lager beer, then in low-calorie beer, and the lowest in non-alcoholic beer, with the authors measuring the content of phenols colorimetrically using Folin-Ciocalteu reagent. However, Granato et al. [29], analysed the antioxidant activity of commercial Brazilian beers based on the ORAC and DPPH (·) tests and showed that ale-type brown beers were characterized by significantly higher antioxidant properties compared to lager type beers. Dabina-Bicka et al. [14], also showed that in the case of Latvian beers, the total content of phenols in dark beer is higher than in light beer. Moreover, Nino-Medina et al. [46], noted a higher content of phenolic compounds and the antioxidant capacity of Mexican lager beers compared to most literature data available on beers from different geographical regions. Also, the content of individual phenolic compounds in beers depending on the geographical region may be different, for example Brazilian beers in comparison with European beers are characterized by a higher content of gallic acid and lower content of ferulic acid [43].

THE IMPACT OF BEER PRODUCTION PROCESSES ON ITS ANTIOXIDANT PROPERTIES

Phenolic beer compounds are endogenous antioxidants that can inhibit or prevent oxidation processes during brewing, which is why their importance in brewing is very high. Beer with high antioxidant activity, which can prevent

the formation of free radicals that are formed only after deactivating antioxidants in beer. Barley malt, the brewing process and storage conditions of the final product affect the phenol profile of beer, and thus also its antioxidant activity [74, 76].

The first stage of beer production is malting, which aims to transform barley into malt suitable for brewing. Malting involves soaking the purified grain, followed by germination, during which the enzymes break down storage proteins and sugars, and finally drying or roasting the malt, which aims to reduce the moisture content of green malt and achieve a state that ensures stability during transportation and storage [8, 68]. Depending on the time and temperature of kilning or roasting, this stage has a decisive influence on the final colour and taste of the beer [74]. The results of many studies confirm that the content of phenolic compounds in malt is definitely higher than in barley [39, 21, 63, 33]. According to Koren et al. [33], a significant increase in their content occurs already during the process of soaking raw barley, in which the amount of moisture increases from 11–12% to 40%, making phenols more susceptible to extraction. Barley cultivars with higher antioxidant capacity, still retain their antioxidant properties after malting [21]. These observations contradict the results obtained by Quan et al. [64], who noted a much lower content of free phenolic content in the grain after steeping compared to raw grains, which, according to the authors, may be due to the fact that some phenolic compounds have dissolved in water or formed insoluble complexes with proteins. Interestingly, the impact of subsequent stages is also different. Some authors noted an increase content of phenolic compounds at the end of steeping and early germination, followed by a decrease in their content, also during kilning [50, 33], and others inversely, first reducing the content during steeping and early stages of germination, and then a significant increase in later stages of germination and during kilning [39, 36]. Different results were probably caused by differences in the technological process and the devices used [33]. It is generally noted that malting allows for better release and/or extraction of phenolic compounds [36], and the phenolic compound profile is relatively constant [68].

According to Koren et al. [33], the antioxidant activity of beer is significantly affected by the composition of the malt, from which the wort is obtained. Darker beers have a higher antioxidant potential than light, which is associated with the use of special malts containing more melanoidins, dark-coloured compounds that are formed as a result of Maillard's reaction and have antioxidant properties [77]. Also, in the study of Ditrych et al. [19], it was demonstrated that dark beers have a higher antiradical potential and polyphenol content than in lager, wheat and non-alcoholic beers. Some malt can also be replaced by other cereals, for example corn or rice [42].

The next stage of beer production is mashing, but before that it is necessary to grind the dried malt, while it has been demonstrated that wet milling significantly reduces the total content of phenolic compounds [62]. During the mashing and brewing process, phenolic compounds are released into the wort from grains and hops and are thus present in the finished beer product [37]. Malt mashing takes place in two stages, first during mash production, the transformation of insoluble ingredients into soluble ones (fermenting sugars, dextrins, mineral substances, soluble proteins). To obtain wort with the right extract and clarity, mash filtration is carried out [57]. Important elements affecting the phenol content are the mashing method (infusion or decoction), mashing time, temperature, pH, as well as mash thickness, grain size and composition of the meal [71, 76, 68]. During mashing, the phenol content increases significantly, because under the influence of enzymes, bound phenols are released [76]. In the study of Pascoe et al. [49], it was demonstrated that the content of phenols such as catechins, ferulic, vanillic, chlorogenic and p-coumaric acids significantly increased during mashing. According to Schwarz et al. [54], the most optimal mashing temperature is 40–45 °C, with an increase in phenolic acid concentrations observed from the beginning of mashing to heating the wort to 62°C [71]. In addition, longer mashing times seem to be beneficial, since a higher concentration of phenolic acids in the wort was obtained [54] and the optimal pH is 5.8 [71]. In the second stage, after adding hops in the form of whole hops, granules or extracts, the wort is cooked [57]. Wort brewing causes a significant reduction in the total amount of polyphenolic compounds and their activity [36], with a loss of 50% [26].

Then the wort undergoes alcoholic fermentation during which carbohydrates are converted by yeast into alcohol, carbon dioxide and other by-products [76]. In several studies, a significantly lower phenol content in beer was observed compared to the wort [60, 61], although Pascoe et al. [49], noted increased antioxidant activity of beer after fermentation. According to Cortese et al. [12], the reduction of phenol content can be explained by the fact that most of them are absorbed by the yeast added during fermentation. It was observed that spent yeast contained a larger amount of phenolic compounds compared to the starting yeast, and in addition several phenolic compounds derived from hops were found in spent yeast but not present in starting yeast.

The last process is wort filtration, which aims to remove yeast and turbidity, which also causes a loss in the content of phenolic compounds, because they form complexes with proteins that cause beer turbidity [49, 60]. The type of filter used can also affect the amount of loss [26].

The stability of beer as the final product determines its microbiological and colloidal stability, as well as foam and taste stability, which can be influenced by the endogenous antioxidant activity of beer [75, 68]. On the other hand, phenolic compounds undergo changes during beer storage, which leads to a decrease in their total content mainly in the first month of beer storage [19,49,60,55], and other authors observed the largest decrease in phenol content for the first 3 months of beer storage [38]. Phenolic compounds, which are present in barley malt and hops, are therefore present in limited quantities in beer as the final product [12].

CONCLUSION

Beer production is a multi-stage process, during which there is undoubtedly significant losses in the amount of phenolic compounds that are present in barley malt and hops, but in beer as the final product they occur in limited quantities [12]. Although the results so far indicate a low content of

phenolic compounds in beers compared to wine, this product still has antioxidant properties. At the same time, scientists are attempting to use new technologies in brewing that can improve the antioxidant properties of beer, e.g. brewing method assisted by hydrodynamic cavitation, which can be used to produce larger amounts, including xanthohumol and related prenylflavonoids, which not only contribute to greater antioxidant activity, but also have a proven protective effect on the cardiovascular system, as well as a risk-reducing effect on neurodegenerative diseases and certain types of cancer [10]. Another direction of future research may be the analysis of the possibilities of increasing the antioxidant properties of beer by the addition of various plant materials that are a rich source of antioxidants. A promising functional additive that does not change the physicochemical parameters of beer and significantly increases its antioxidant activity is ethanol propolis extract [67], eggplant (*Solanum melongena L.*) peel extract [30], thyme, juniper and lemon balm [20], or the addition to beers at the stage of fermentation of various fruits, which significantly increased the antioxidant activity of beer and quantitatively and qualitatively improved its phenolic profile, especially in cherry and grape beer [44].

PODSUMOWANIE

Produkcja piwa jest procesem wieloetapowym, w trakcie którego niewątpliwie dochodzi do znacznych strat w ilości związków fenolowych, które są obecne w słodzie jęczmiennym i chmielu, ale w piwie jako finalnym produkcie występują w ograniczonych ilościach [12]. Choć dotychczasowe wyniki wskazują na niską zawartość związków fenolowych w piwach w porównaniu z winem, to nadal produkt ten charakteryzuje się właściwościami antyoksydacyjnymi. Jednocześnie naukowcy podejmują próby stosowania nowych technologii w browarnictwie, które mogą poprawić właściwości przeciwutleniające piwa np. metodę warzenia wspomaganą kawitacją hydrodynamiczną, dzięki której można wytworzyć większe ilości m.in. ksantohumolu i pokrewnych prenyloflawonoidów, które nie tylko przyczyniają się do większej aktywności przeciwutleniającej, ale także mają udowodnione działanie ochronne na układ sercowo-naczyniowy, a także działanie obniżające ryzyko chorób neurodegeneracyjnych oraz niektórych rodzajów raka [10]. Innym kierunkiem przyszłych badań może być analiza możliwości zwiększania właściwości antyoksydacyjnych piwa poprzez dodatek różnych surowców roślinnych będących bogatym źródłem antyoksydantów. Obiecującym dodatkiem funkcjonalnym nie zmieniającym parametrów fizykochemicznych piwa a istotnie zwiększającym jego aktywność przeciwutleniającą jest etanolowy ekstrakt propolisu [67], ekstrakt ze skórki bakłażana [30], tymianku, jałowca i melisy [20] czy dodatek do piw na etapie procesu fermentacji różnych owoców co znacznie zwiększyło aktywność przeciwutleniającą piwa oraz jakościowo i ilościowo poprawiło jego profil fenolowy, zwłaszcza w piwie wiśniowym oraz winogronowym [44].

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POTENTIAL NATURAL SOURCES OF TOCOPHEROLS AND TOCOTRIENOLS AND POSSIBILITIES THEIR USE IN THE FOOD INDUSTRY®

Potencjalne naturalne źródła tokoferoli i tokotrienoli oraz możliwości ich zastosowania w przemyśle spożywczym®

Tocopherols and tocotrienols are natural compounds found in oil plants. Their antioxidant properties make them interesting for food producers and consumers looking for healthy food. The aim of this study is to present the potential natural sources of tocopherols and tocotrienols, which as antioxidants are increasingly used as food additives to extend itheir durability, and additionally enrich the product with vitamin E. The work shows their chemical structure, methods of obtaining and legal regulations allowing tocopherols and tocotrienols for use in food processing. The current ways of using them in food production were discussed.

Key words: vitamin E, tocopherols, tocotrienols, antioxidant, food stability, food quality.

Abbreviations: α – alpha
β – beta
γ – gamma
δ – delta

Tokoferole i tokotrienole to naturalne związkami występujące w roślinach oleistych. Ich właściwości przeciwutleniające sprawiają, że są interesujące dla producentów żywności i konsumentów poszukujących zdrowej żywności. Celem artykułu jest omówienie potencjalnych naturalnych źródeł tokoferoli i tokotrienoli, które jako substancje przeciwutleniające są coraz częściej wykorzystywane jako dodatki do żywności w celu przedłużenia jej trwałości, a dodatkowo wzbogacają produkt w witaminę E. W artkule przedstawiono ich strukturę chemiczną, sposoby pozyskiwania oraz regulacje prawne dopuszczające tokoferole i tokotrienole do wykorzystania w przetwórstwie żywności. Omówiono dotychczasowe sposoby ich wykorzystania w produkcji żywności.

Słowa kluczowe: witamina E, tokoferole, tokotrienole, antyoksydant, stabilność, jakość.

INTRODUCTION

The content of bioactive ingredients with documented and beneficial effects on health as well as high quality and nutritional value of foods are now becoming the main determinant of the choice of food products [29]. Consumers are looking for foods, which can improve their health and prevent diseases. Food producers focus on research into, among others, new, natural substances, which increase the nutritional value of products, extend the shelf life of foods, including natural antioxidants, which effectiveness are comparable with synthetic counterparts [35]. Thermal processing of food raw materials, time and method of storage of raw materials or finished products, type of packaging determine the durability of the product and its final quality. One of the most important mechanisms leading to lowering the nutritional value and quality of foods, shortening the shelf life of products containing fat in their composition is the process of lipid oxidation, which causes undesirable changes in the final products. This process leads to the formation of an unpleasant taste and smell, a decrease in the nutritional quality and the safety of food products [20,22].The main initiators of lipid oxidation are free radicals, i.e., molecules having at least one unpaired electron on the outer shell, and therefore having a high affinity, e.g. to lipids. Prevention of oxidation depends primarily on eliminating free radicals as they form and inhibit the propagation process. One of the most effective and convenient strategies for delaying or preventing lipid oxidation is the addition of antioxidants, including vitamin E [43]. Vitamin E encompasses a group of eight fat-soluble compounds – four tocopherols (α, β, γ, δ) and four tocotrienols (α, β, γ, δ) (Fig. 1.), of which the highest biological activity is shown by α-tocopherol. Biochemically, α –tocopherol acts as an antioxidant by breaking chain reaction and interfering with reactive oxygen species formed by scavenging lipid peroxyl

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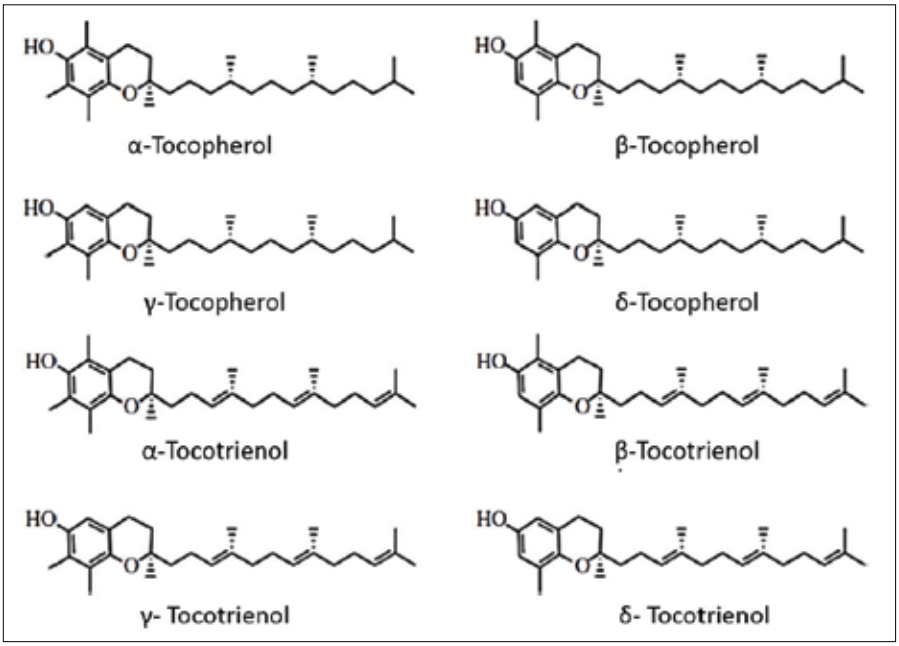

Fig. 1. Structural formulas of tocopherols and tocotrienols.
Rys.1. Wzory strukturalne tokoferoli i tokotrienoli.
Source: [37]
Źródło: [31]

radicals. During the chain-breaking reaction, α-tocopherol forms a free radical that can reacts quickly with another peroxide radical, thus ending two peroxidation chains [7].

VITAMIN E AS A CHEMICAL AND BIOACTIVE COMPOUND

Vitamin E was first described by Evans and Bishop in 1922, characterized as a dietary factor necessary for reproduction. Soon, vitamin E was identified as an antioxidant for polyunsaturated lipids. Subsequent studies have shown that tocochromanoles – a common name for tocopherols and tocotrienols, act as signal molecules which regulate gene expression, signal transduction and modulate cell function, regardless of antioxidant properties [14,33]. Tocopherols and tocotrienols are amphipathic molecules containing a 6-chromanol (6-hydroxychromanol) ring and a side chain made of 3 isoprene units. In tocopherols, it is linked to the phytyl chain and in the case of tocotrienols, it is linked to the isoprenoid chain [9]. They differ in the number and location of methyl groups in chemical structures and the presence of three trans double bonds at the 3', 7', and 11' positions in the side chain of tocotrienols, which is responsible for their unsaturated nature as compared with tocopherols. Structural interrelationships are presented in Table 1 [27, 33, 41].

Tocopherols and tocotrienols are homologs to each other. α-homologs contain three methyl groups, β- and γ-homologues are mutual isomers with two methyl groups, and α-tocopherols and δ-tocotrienols are monomethyl. Synthetic α-tocopherol (all-rac-α-T) is a racemic mixture of individual stereoisomers. Therefore, each of the tocopherols has eight optical isomers. For α-tocopherol, these are RRR-, RSR-, RRS-, RSS-, SRR-, SSR-, SRS-, SSS-. Only RRR-tocopherols occur in nature [41].

Vitamin E is an essential nutrient, it has antioxidant properties, hence it can play an important role in maintaining good health, reducing the risk of diseases in which reactive oxygen species participate in the pathogenesis [29,38]. Deficiencies of vitamin E can cause anemia, impaired immune response, retinopathy, and neuromuscular and neurological problems. Research also points to the numerous health benefits of taking tocochromanols, including the prevention of certain types of cancer, heart disease, and other conditions, and therefore it is suggested that daily vitamin E intake may be significantly higher than the presently established adequate daily intake [33].

Table 1. Structural relationship between tocopherols and tocotrienols
Tabela 1. Powiązania strukturalne między tokoferolami i tokotrienolami

Common name	Chemical name	Short	Position of the ring		
			R1	R2	R3
tocol	2-methyl-2-(4',8',12'-trimethyltridecyle)-chroman-6-ol	-	H	H	H
α-tocopherol	5,7,8-trimethyltocol	α-T	CH_3	CH_3	CH_3
β-tocopherol	5,8-dimethyltocol	β-T	CH_3	H	CH_3
γ-tocopherol	7,8-dimethyltocol	γ-T	H	CH_3	CH_3
δ-tocopherol	8-methyltocol	δ-T	H	H	CH_3
tocotrienol	2-methyl-2-(4',8',12'- trimethyltrideca-3',7',11'-trienyl) chroman-6-ol	-	H	H	H
α-tocotrienol	5,7,8-trimethyltocotrienol	α-T3	CH_3	CH_3	CH_3
β-tocotrienol	5,8-dimethyltocotrienol	β-T3	CH_3	H	CH_3
γ-tocotrienol	7,8-dimethyltocotrienol	γ-T3	H	CH_3	CH_3
δ-tocotrienol	8-methyltocotrienol	δ-T3	H	H	CH_3

Source: [41]
Źródło: [41]

Vitamin E is widely distributed in nature, but can only be synthesized by photosynthetic eukaryotes and other photosynthetic organisms such as cyanobacteria. Plants accumulate tocochromanols available in seeds, fruits or young tissues undergoing active cell division [2]. Due to their amphipathic properties, they join in the phospholipid bilayer of cell membranes, with a chromanol ring directed towards the water compartment, with a side chain embedded in non-polar space [6]. In this way, vitamin E protects membrane lipids, photosynthesis apparatus and plant seeds against oxidative stress [24]. Vitamin E in plant products occurs mainly in non-esterified form. Its content varies depending on the species, variety, stage of ripeness, season, time and method of harvesting as well as processing and storage time [31].

Tocopherols and tocotrienols occur naturally in vegetable oils, sprouts and cereals, nuts and almonds. Tocopherol is found in almond, walnut, sunflower, rapeseed, and olive oil. The best sources of tocotrienols are palm oil and rice bran oil; other sources are grape seed oil, hazelnuts, oats, corn, olive oil, sea buckthorn berries, rye, linseed, and sunflower oil (Tab. 2.). Research indicates that one of the best sources of both tocopherols and tocotrienols are palm fruits, rice grains and annatto seeds from the fruit of the Achiote tree (Bixa orellana) [29,33].

USE OF VITAMIN E IN THE FOOD INDUSTRY

Vitamin E in fortified foods, but also in dietary supplements, is often the esterified form of α-tocopherol, the most common esters being acetate and succinate. Esterified forms of vitamin E are more resistant to oxidation as they have a longer shelf life. A small number of studies focus on other esters, such as α-tocopheryl nicotinate, which is an ester of vitamin E and niacin and is not yet well understood [7]. Some studies suggest that the potency of antioxidants may vary between natural or synthetic sources of tocochromanols [2]. Due to their antioxidant activity, tocochromanols play a major role in protecting mono- and polyunsaturated fatty acids (PUFAs) from oxidation [33]. Natural tocopherols (E306) and synthetic α-, γ- and δ-tocopherols (E307, E308 and E309, respectively) are used as antioxidants in food to inhibit lipid peroxidation. They are used individually or in combination, according to Regulation (EC) No 1333/2008 on food additives and subsequent amendments according to Regulation (EU) 2018/1497. So far, no Acceptable Daily Intake (ADI) has been established, but the Upper Intake Level (UL) is set at 300 mg vitamin E per day according to EFSA or 1000 mg according to the Institute of Medicine. However, the ADI for α-tocopherol established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) was determined to be 0.15-2.0 mg α-tocopherol/kg body weight/day [9,12,32]. No oral toxicity was observed in tocopherols. Additionally, EFSA has approved the health claim for vitamin E. Food industry may use the "vitamin E sources" claim on their products when the food contains 1.8 mg of vitamin E per 100 g or 100 ml or a single serving of food or drink [22]. The Food and Drug Administration (FDA) in the United States has granted the status of tocopherols and tocotrienols generally recognized as safe (GRAS), with an approved dose of 40 mg tocopherol per 1 kg food [10]. The Supplements Working Group of Main Sanitary Inspectorate in Poland had established maximum acceptable level of vitamin E in supplements at 250 mg /day [17].

METHODS OF EXTRATIONS OF VITAMIN E

Initially, the main commercial sources of vitamin E used as a food additive were vegetable oils, however soybean oil and wheat germ oil contain too little of it. Soon, vitamin E extraction from fatty acid distillates from vegetable oils began, which proved to be cheaper and with higher content of vitamin E. Currently, almost all producers obtain vitamin E from distillates, although new raw materials appeared, from which they tried to obtain it – palm leaves, bananas, pineapples, sugar cane, rice, wheat, barley, corn, rye, rice bran [31].

Table 2. Total tocopherols (T) and tocotrienols (T3) content in selected food oils (mg/100g)

Tabela 2. Całkowita zawartość tokoferoli (T) i tokotrienoli (T3) w wybranych olejach spożywczych (mg / 100 g)

Products	α-T	β-T	γ-T	δ-T	α-T3	β-T3	γ-T3	δ-T3
Barley	14.2-20.1	0.6-1.9	3.5-15.1	0.9-4.6	46.5-76.1	nd-12.4	8.5-18.6	0.5-2.6
Coconut	0.2-1.8	tr-0.25	tr-0.12	nd-0.39	1.1-3.0	nd-0.17	0.33-0.64	nd-0.1
Corn	18.0-25.7	0.5-1.1	44.0-75.2	2.20-3.25	0.94-1.50	nd	1.30-2.00	nd-0.26
Cottonseed	30.5-57.3	0.04-0.30	10.5-31.7	tr	nr	nr	nr	nr
Olive	11.9-17.0	nd-0.27	0.89-1.34	nd-tr	nd-tr	nd	nd	nd-tr
Palm	6.05-42.0	nd-0.42	tr-0.02	nd-0.02	5.70-26.0	nr-0.82	11.3-36.0	3.33-8.00
Peanut	8.86-30.4	nd-0.38	3.50-19.2	0.85-3.10	nd	nd	nd	nd
Sunflower	32.7-59.0	tr–2.40	1.40-4.50	0.27-0.50	0.11	nd	tr	tr
Rapeseed	18.9-24.0	nd–tr	37.0-51.0	0.98-1.90	nd	nd	nd	nd
Soybean	9.53-12.0	1.00-1.31	61.0-69.9	23.9-26.0	nd	nd	nd	nd
Wheat germ	15.1-19.2	31.2-65.0	tr-52.3	nd-0.55	2.5-3.6	nd-8.2	nd-1.85	nd-0.24

nd: not detected; nr: not reported; tr: trace; T: tocopherols, T3: tocotrienols

Source: Own study based on [33]

Źródło: Opracowanie własne na podstawie [33]

The distillate is a mixture of acylglycerols, free fatty acids, tocopherols and stanols, hydrocarbons and other substances that affect the organoleptic characteristics of vegetable oils. It is produced as waste from the deodorization process, i.e. the removal of undesirable substances from the raw material. The content of vitamin E in distillates is dependent on oil, from which it has been produced; most content is observed, among others, in oil from corn, sunflower, peanuts, rapeseed and cottonseed [1, 31, 36].

Many researchers have developed various methods and techniques for extracting, analyzing, identifying, purifying and quantifying tocochromanols from various sources. However, scientists are still looking for a method of obtaining vitamin E which would be efficient, economical, and would lead to obtaining vitamin E concentrate, or individual isoforms, with the desired degree of purity and in the largest amount possible. Determination of tocochromanols in plant products combines classical techniques with physico-chemical methods and is based on such processes as esterification, saponification, liquid-liquid extraction, crystallization, distillation, enzymatic methods, ion exchange, chromatographic methods and their combinations (Fig. 2.) [7,25]. Due to the low concentration of vitamin E isoforms in food, an effective method of pre-treatment of samples is extremely important [25]. Sample preparation protocols vary at homogenization and extraction stages. Most methods include the saponification of samples [21]. However, studies have shown that the process of saponification of samples reduced the content of individual forms of vitamin E, which leads to a decrease in the content of overall vitamin E [7]. Similarly, the method of mechanical pressing, frequently used during extraction, have been shown to reduce the overall content of vitamin E in the tested samples compared to extraction with organic solvents [20]. Direct extraction methods are also widely used, differing in the choice of solvents, e.g. hexane, petroleum ether, pentane and in extraction procedures [29,31]. Other methods involve liquid-liquid extraction without saponification or solvent extraction after saponification. High-performance liquid chromatography (HPLC) is used in various combinations, using both the normal and reverse phases. HPLC uses UV (ultraviolet) diode, fluorescence, ELSD (evaporative light scattering detection), electrochemical and amperometric detection. In some studies [13], normal phase adsorption chromatography shows an advantage over other methods because they indicate that there is a complete separation of isomers. The use of fluorescence is described as more sensitive and selective than UV, and ELSD (evaporative light scattering detector) is used to analyze several compounds simultaneously [9,40]. Lu and Yang [25] proposed ultrasonic dispersion micro-extraction in the solid phase using multi-walled carbon nanotubes - the authors recommended the method as fast and simple, reproducible, and with lower usage of organic solvents. Rapid progress in vitamin E extraction and homologation separation technologies may lead to the development of the most cost-effective method for producing vitamin E of the highest quality and biological activity for producers, which will be used in food processing and other industries [31].

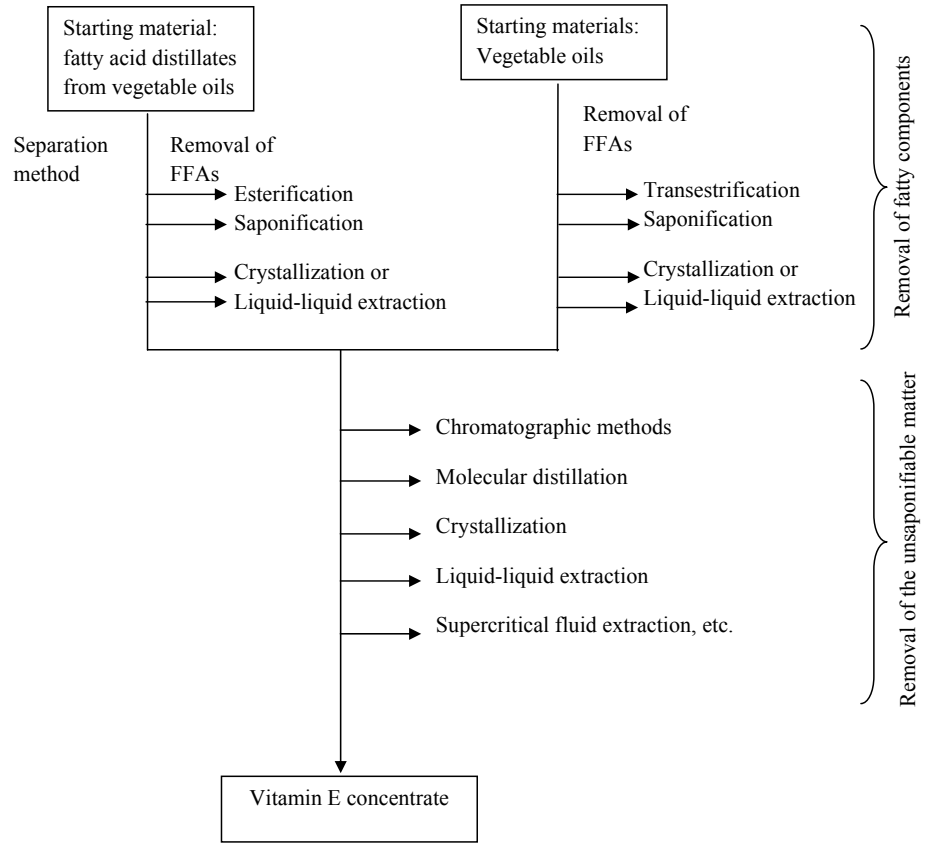

Fig. 2. Sample procedures for obtaining vitamin E.
Rys. 2. Przykładowe metody uzyskiwania witaminy E.
Source: [31]
Źródło: [31]

PRACTICAL USE OF VITAMIN E IN FOOD PROCESSING

The most common and easiest way to use vitamin E is to add it to food products as an antioxidant, in order to increase the stability of fatty acids, reduce food biochemical changes, e.g. a mixture of tocopherols obtained from soybean oil processing is often used to stabilize oxidation-sensitive lipid dietary supplements, such as fish oil. Also, oils rich in tocopherols, such as from oat, barley or wheat germ, can be mixed with other oils to stabilize them [42].

Tocopherols as antioxidants are also used to extend the shelf life of confectionery fat, lard, margarine, mixtures, drinks and infant formulas, which at the same time enriches these products with vitamin E [19, 39, 43]. Economos and co-workers [8] proposed fortifying orange juice with, among others, vitamin E, which could be a new source of fat-soluble vitamins in populations with insufficient consumption of this vitamin.

An example of a food which can be fortified with vitamin E is food consumed by the crew during missions on a spacecraft. Sirmons and co-workers [34] evaluated the stability and content of vitamins, sensory acceptance and color variation of fortified space food over the course of two years. It was noted that enriching food with antioxidant vitamins reduces the rate of color degradation of stored products. Vitamin E proved to be stable at different storage temperatures and did not affect the organoleptic quality.

Since tocochromanols have an antioxidant effect on lipid compounds, they are at the same time most frequently used in products which are most exposed to such reactions, i.e. in meat and meat products [16]. Bolger and his team [4] evaluated the effect of increasing the tocopherol content on physical and sensory quality in poultry sausages. They studied the stability of α-tocopherol during storage, cooking, frying, and grilling. α-tocopherol was added at a concentration of 200 mg/kg of product (the amount considered necessary to reduce lipid oxidation and exceeding the amount needed to meet the requirements of the EFSA health claim). It has been found that it is possible to produce sausages enriched with sufficient α-tocopherol to meet EFSA's nutritional and health requirements without adversely affecting the quality or shelf life of the sausages. During storage or thermal treatment of the product, no significant loss of α-tocopherol was observed. Similarly, the addition of tocopherols to fish, poultry, and red meat lowered the oxidation level of fat contained in meat [33].

It turns out that the stage of breeding is important for the content of vitamin E in a meat product. Research proves that the way animals are fed and the use of feed with higher vitamin E content affect later meat quality [23]. The meat of rabbits, which were fed with different contents of vitamin E during breeding was examined. The content of vitamin E in meat increased with the increase of vitamin addition in feeding. During storage, a slower meat lipid oxidation rate was noted. Additionally, lower cholesterol content was found in the meat of rabbits that received 100 mg of vitamin E / kg feed compared to animals fed with a lower content of vitamin E. The assessment of individual sensory quality characteristics of meat (smell, taste, juiciness, tenderness) varied depending on the amount of vitamin E administered in the feed [23].

In recent years, the antioxidant properties of tocopherols have also been used in the production of "active" food packaging. Antioxidant films, packaging made of several layers, i.e. high-density layers and low-density layers, containing α-tocopherol as a natural antioxidant, are becoming popular [30]. It was found that the addition of an industrial mixture of natural antioxidants containing the highest concentration of tocopherols (90.2%) to the packaging was the most effective in extending the shelf life of salmon and reduced the lipid oxidation in meat to 70%. This suggests that it is possible to use active antioxidant films to extend the shelf life of high-fat products [3,5,15]. The Otero-Pazos and co-workers' study [28] evaluated the possibility of using biodegradable films for coating food with the addition of α-tocopherol as an active antioxidant in food packaging. Those films maintained antioxidant activity for over 20 days. Similarly, biodegradable polyester-based films containing α-tocopherol showed antioxidant activity [26]. Other raw materials for producing "new" packaging are biopolymers - biodegradable, releasing natural α-tocopherol. In other studies, α-tocopherol was encapsulated in three different matrices (whey protein isolate WPI, soy protein isolate SPI and zein), which were then used as a food packaging on a thermoplastic wheat gluten film to form a double layer film. α-tocopherol was comparably stable in all films produced [11]. The new trend is called "active packaging" or "active package" [18].

SUMMARY

Tocopherols and tocotrienols are substances widely disseminated in nature. They exhibit antioxidant activity by eliminating free radicals. They can easily be obtained from available plant tissues and oil plants are their main source. Tocopherols and tocotrienols are generally recognized as safe and can be applied in food processing. Moreover, manufacturers can use health claims on the labels of products, which are vitamin E sources. Recently, food producers have become interested in new, natural ways to extend the shelf life of food products. As a result of this interest, many concepts arise for the use of vitamin E in animal breeding, in the processing of food raw materials, and in packaging materials used for food storage. These techniques are designed to preserve the flavor and odor sought by the consumer, adequate nutritional quality and food safety. Besides the use of natural vitamin E as a food additive, innovative packaging, called "active packaging" or biodegradable films for coating food products with the addition of antioxidants that release vitamin E into foods and prevent food quality changes, are created.

PODSUMOWANIE

Tokoferole i tokotrienole są substancjami szeroko rozpowszechnionymi w przyrodzie. Wykazują aktywność przeciwutleniającą poprzez eliminację wolnych rodników. Można je łatwo uzyskać z dostępnych tkanek roślinnych, a rośliny oleiste są ich głównym źródłem. Tokoferole i tokotrienole są ogólnie uznawane za bezpieczne i mogą być stosowane w przetwórstwie spożywczym. Ponadto producenci mogą stosować oświadczenia zdrowotne na etykietach produktów, które są źródłami witaminy E. Niedawno producenci żywności zainteresowali się nowymi, naturalnymi sposobami przedłużenia okresu przydatności produktów spożywczych. W wyniku tego zainteresowania powstaje wiele koncepcji zastosowania witaminy E w hodowli zwierząt, w przetwarzaniu surowców żywnościowych oraz w materiałach opakowaniowych używanych do przechowywania żywności. Techniki te zostały zaprojektowane w celu zachowania smaku i zapachu poszukiwanego przez konsumenta, odpowiedniej jakości odżywczej i bezpieczeństwa żywności. Oprócz zastosowania naturalnej witaminy E jako dodatku do żywności, powstają innowacyjne opakowania, zwane „aktywnymi opakowaniami" lub biodegradowalne folie do powlekania produktów spożywczych z dodatkiem przeciwutleniaczy, które uwalniają witaminę E do żywności i zapobiegają zmianom jakości żywności.

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TECHNOLOGICAL INGREDIENTS AND NUTRITIONAL VALUE OF GLUTEN FREE BREAD®

Składniki technologiczne i wartość odżywcza pieczywa bezglutenowego®

The basis of a gluten-free diet is the exclusion of all products containing gluten, which is obtained from wheat, rye, barley and oats and their derivatives. The quality of gluten-free bread is shaped by additives, including hydrocolloids, which affect its structure, improve palatability and affect the nutritional value. Gluten-free bread can be low in protein and contain more total fat and salt, compared to wheat bread. When choosing gluten-free bread, you should make a particularly careful selection of products and diversify dishes prepared with their use.

Key words: gluten-free bread, gluten-free cereals, hydrocolloids, nutritional value.

Podstawą diety bezglutenowej jest wykluczenie wszystkich produktów zawierających gluten, który otrzymywany jest z pszenicy, żyta, jęczmienia i owsa oraz z ich pochodnych. Jakość pieczywa bezglutenowego jest kształtowana przez dodatki m.in. hydrokoloidy, które wpływają na jego strukturę, poprawiają smakowitość oraz wpływają na wartość odżywczą. Pieczywo bezglutenowe może być ubogie w białko i zawierać więcej tłuszczu ogółem oraz soli, w porównaniu do pieczywa pszennego. Wybierając pieczywo bezglutenowe należy dokonywać szczególnie starannego doboru produktów i urozmaicania potraw przygotowywanych z ich udziałem.

Słowa kluczowe: pieczywo bezglutenowe, zboża bezglutenowe, hydrokoloidy, wartość odżywcza.

INTRODUCTION

Cereal products, including bread, are one of the basic ingredients of human diet. Choosing the right diet should be based on healthy and valuable products that will provide the body with all the essential nutrients needed for its development and life. It is equally important that the food consumed does not cause negative health effects on the body.

Celiac disease is a disease in which the use of an elimination diet is essential and necessary for the body of a sick person to function properly. The diet of people suffering from celiac disease is based on the exclusion of products containing gluten, which contribute to its development and aggravation of the symptoms of the disease. Gluten, which is toxic for people with celiac disease, occurs in cereal products and dishes made from wheat, rye or barley flour and oats, which itself does not contain toxic gluten, but can be contaminated during cultivation, harvesting and processing.

There are plants that do not contain gluten and can be used in the production of gluten-free food, while not reducing the nutritional and organoleptic value of the final product. By choosing the right technological ingredients, we can compose healthy and nutritious dishes. Thanks to the wide range and availability of gluten-free products, the diet of people with celiac disease can be varied and tasty.

There are many companies producing gluten-free food on the Polish market, thanks to which people on a diet have easier access to most gluten-free cereal products and get the opportunity to eat properly. Gluten substitutes used in these products improve the structure of the products, so they do not differ in quality from foods containing gluten.

The purpose of this article was to characterize technological ingredients and nutritional value of selected gluten-free breads intended for people with celiac disease.

GLUTEN – CHARACTERISTICS

Gluten proteins can be divided into two main fractions depending on their solubility in alcohol into soluble prolamines, i.e. gliadin from wheat, rye secalin, barley hordein and insoluble - glutenins.

Both fractions form a micellar network connected by non-covalent and disulfide bonds. Gluten protein is formed during the flour mixing and plays an essential role in forming the dough structure.

Gluten gives the dough cohesiveness, viscosity, elasticity, plasticity, extensibility and increases the ability to absorb water allowing the swollen starch granules and carbon dioxide bubbles, which comes from alcoholic fermentation, to remain in the new-created mesh [34, 25]. Under the influence of

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swelling gluten in the aquatic environment, a gluten mesh is formed, which traps carbon dioxide bubbles formed during fermentation. Swelling of gluten and its denaturation when baking bread results in the formation of a suitable porous and spongy structure appropriate for bread. Pure gluten is a springy, sticky mass that we get after washing out the starch and other flour ingredients from the dough obtained from the above-mentioned cereals. Gluten consists of amino acids and peptides [14]. The gluten content in flour is one of the basic parameters of its baking properties [35].

GLUTEN SUBSTITUTES

We can improve the quality of bread and gluten-free dough by adding the right amounts of starch [corn, potato, rice or wheat gluten-free], as well as hydrocolloids, which are thickening, gelling and stabilizing substances. Such an action is shown by, among others xanthan gum, guar gum, agar, acacia, modified starch, locust bean gum, carrageenan, gelatin, pectin, carboxymethyl cellulose and sodium caseinate. The quality of the dough can also be improved by adding substances that have a leavening effect and this group includes compounds such as lactone, gluten-free baking powder, sodium carbohydrate and gluconic acid.

During the production of dough, it is very important to maintain the right proportion of hydrocolloids in relation to the other ingredients, because too much thickening substance can cause buildup. Hydrocolloids, i.e. gluten substitutes, must be used in an amount of 0.1% to 1.2% of all the ingredients used. This proportion increases the water absorption of the dough, increases the bread volume, improves the crumb structure and extends the freshness of the bread [25].

Natural hydrocolloids and their derivatives are very often used in the food industry (Tab. 1). The main advantage of these substances is their increased possibility of water retention in various food products. Hydrocolloids are mainly used in manufacturing pastry, confectionery and food concentrates. We can also add them to traditional products or those that require reduced fat or sugar content as well as in the production of gluten-free products [11].

CHARACTERISTICS OF HYDROCOLLOIDS USED IN GLUTEN-FREE BREAD

Agar, E 406 – is a mixture of many polysaccharides, which we obtain as a result of extraction of marine algae. Agar is characterized by high swelling capacity; only dissolves in water above 90°C at pH 8.0–9.0. The gels it forms are thermo-reversible, clear and brittle. The addition of sugar will cause an increase in the hardness of agar gels and greater resistance to hydrolysis (Tab. 1) [1, 27].

Carboxymethylcellulose, E466 – is the incomplete sodium salt of cellulose carboxymethyl ester. Slightly hygroscopic, soluble in hot and cold water, where it forms non-Newtonian solutions. Its solubility increases with a decrease in sugar and Ca2 + content, and its viscosity decreases with increasing temperature (Tab. 1) [27].

Carrageenan, E 407 – a substance that can be obtained from seaweed. It is a mixture of different types [iota, kappa, lambda, mi, ni], but the most important are lambda, iota and kappa. Only iota and kappa types have the ability to form gels (Tab. 1) [1, 27].

Guar gum, E 412 – we obtain it from the seeds of guar trees, which grow mainly in India and Pakistan. It dissolves in cold water, even in low concentration it has the ability to create stable solutions characterized by high viscosity. Due to the large number of galactose groups that hinder the formation of a spatial grid, guar does not form a gel on its own. In food, it interacts quite well with other ingredients, especially with other rubbers. During the reaction with xanthan, the viscosity of the system increases. Guar also delays the crystallization process and prevents syneresis, causes better stabilization of suspensions and emulsions (Tab. 1) [13, 27].

Hydroxypropulomethylcellulose, E 464 – is obtained from cotton or wood pulp fibers by using reagents i.e. methyl chloride and propylene oxide. It dissolves in cold water to form sticky colloidal solutions, and in hot water it precipitates, but it dissolves again when cooled. Insoluble in organic solvents and in ethanol. This substance acts as a thickener, stabilizer and emulsifier. It supports the emulsification process and creates protective layers. It is used as a thickener in the cold. It stabilizes decorative foams, creams and emulsions [sauces]. Used in the baking industry for the production of concentrates (Tab. 1) [15, 27].

Karob, E 410 – we obtain it from dry fruit of trees, mainly from Spain, Greece, Turkey and Portugal. Carob creates highly viscous solutions in hot water above 80°C with pH 4.4–10.0. This substance does not have gelling properties, but it can affect the structure and elasticity of gels that have arisen from other hydrocolloids. Gels obtained as a result of combination with agar do not show syneresis, because carob has a high ability to bind water (Tab. 1) [27, 32].

Konjak gum, E 425 (i) – is a polysaccharide obtained from the tuber of a plant naturally occurring in Asia - the weirdo Riviera (*Amorphophallus konjac*). Dispersible in both hot and cold water. It allows the formation of thermally reversible and thermally stable gels. Creates highly viscous solutions (Tab. 1) [27, 28].

Xanthan, E 415 – is a product obtained as a result of fermentation of the carbohydrate substrate by *Xanthomonas campestris* bacteria. Xanthan gains stability at pH 2.0–12.0. It dissolves quite well in cold and warm water, as well as in salt and sugar solutions and in milk. It creates stable solutions characterized by high viscosity, shows resistance to freezing and thawing (Tab. 1). Guar works more effectively in combination with gum [2, 15].

ADDITIVES USED IN GLUTEN-FREE PRODUCTS

In the composition of gluten-free products, in addition to the hydrocolloids listed above, there are also other additional substances that affect the quality of gluten-free products, among others influence many changes during the food production process, thus facilitating the manufacture of products.

The characteristics of the additives used for gluten-free cereal products discussed in the previous chapter are presented below:

Table 1. Characteristics of selected hydrocolloids used in the production of gluten-free bread
Tabela 1. Charakterystyka wybranych hydrokoloidów stosowanych w produkcji pieczywa bezglutenowego

NAME	DESCRIPTION	SOURCE OF RECEIVING	MAIN TECHNOLOGICAL FUNCTIONS
Agar	E 406	*Rhodophyta* extract	Gelling, thickening, stabilizing, clarifying, emulsifying agent
Carboxymethylcellulose	E 464	Cellulose and its derivatives	Thickener, stabilizer, emulsifier, substance to be applied to the surface, carrier
Carrageenan	E 407	*Chondrus crispus* extract	Gelling, thickening, stabilizing and clarifying substance
Guar gum	E 412	*Cyamopis tetragonoloba* seed meal	Thickening, stabilizing substance
Hydroxypropulomethylcellulose	E 466	Cellulose and its derivatives	Stabilizer, binder, carrier, bulking agent
Karob	E 410	*Ceratonia siliqua* seed meal	Thickener, stabilizer, emulsifier
Konjak gum	E 425(i)	Glucomannan obtained from tubers *Amorphophallus konjak*	Thickener, gelling agent, carrier
Xanthan	E 415	Product of fermenting the carbohydrate substrate by *Xanthomonas campestris*	Thickener, stabilizer, emulsifier, for use on the surface

Source: [25, 27]
Źródło: [25, 27]

Pectin, E 440 - occurs in the form of a powder or liquid concentrate, dissolves well in warm water, and swells in cold. Forms viscous mixtures in milk and sugar solutions. Pectin is a thickener, gelling agent, excellent carrier and stabilizer. This substance causes an increase in viscosity, however its action is less effective than other hydrocolloids [2].

Sodium bicarbonate – a fine crystalline powder or crystalline mass, odorless, white or colorless. This substance is soluble in water, but insoluble in ether and ethanol. Sodium bicarbonate is an acidity regulator, it has leavening, stabilizing and filling functions. It strengthens the smell and taste. It emits carbon dioxide in an acid environment, thanks to which it loosens the dough. Its high alkalinity affects the salty – sour taste of products. It is used for the production of baking powder [27].

Gluconic acid lactone, E 575 – a fine crystalline powder with a white color and low odor. This substance is an acidity regulator, it also has leavening properties. It strengthens the taste and smell. It works acidifying and coagulating. It is most often used for making mixtures of baking flour, desserts and jellies and baking powders [21, 27].

Citric acid, E 330 – white granulate or powder, odorless with a very sour tart taste. This acid is used as an antioxidant, stabilizer, acidity regulator and flavor. It is used to inhibit enzymatic processes by increasing acidity. It also has a low preservative effect. Together with salts, it creates buffer systems in food. It strengthens the action of other antioxidants. By forming complexes with metal ions, it prevents enzymatic and chemical reactions that contribute to changes in the color and appearance of products. As an acidity regulator, it is used in all branches of the food industry [24, 27].

Tartaric acid, E 334 – is a by-product formed during the production of grape wine and synthetically obtained from maleic acid. Odorless with a sour, tart, fruity taste. It plays the role of an acidity regulator, is a synergist and a flavoring substance. It has acidifying properties and enhances taste. With antioxidants, it has synergistic effects, thus preventing rancidity and cheese discoloration. It accelerates the growth of dough [27, 31].

Ascorbyl palmitate, E 304 – white or yellow powder with a lemon scent. It is difficult to dissolve in water while easily in fat and ethanol. This substance is an antioxidant, stabilizer and works synergistically with respect to other antioxidants, especially tocopherols. Compared with ascorbic acid, it has a stronger antioxidant effect on fat products that did not heat up during processing. It can also be used in low-fat products acting as a stabilizer [21, 27].

Disphosphates, E 450 – white granular powder. Used as an acidity regulator, it has stabilizing and emulsifying properties, is a leavening, acidifying, buffering and clarifying substance. It is most often used in the production of baking powder, confectionery, instant potato flour and cake concentrates [27, 31].

Mono- and diglycerides of fatty acids, E 471 – a substance soluble only in hot alcohol, insoluble in water. It acts as an emulsifier, carrier and stabilizer. Used in baking, they contribute to a stable dough characterised by tolerance to high temperature and kneading. By forming complexes with starch, they improve the quality of bread and increase its durability. They also influence the strengthening of flour gluten, thanks to which carbon dioxide is trapped and greater porosity as well as bread volume are obtained. In combination with hydrocolloids, they increase the freshness of bread and delicatessen bread [21, 27].

Mono- and diglycerides of fatty acids esterified with mono- and diacetylvinyl acid E 472 e – a thick, viscous liquid with a white-yellow color, which in a humid air undergoes the process of hydrolysis and releases tartaric acid. It acts as an emulsifier, stabilizer, carrier and is a dispersing substance. Together with starch and proteins, it helps to create systems. It strongly reacts with gluten, thanks to which it improves the baking value mainly of wheat flour. It has a positive effect on the consistency of pasta and increases the volume of bread. They are used for the production of confectionery and bakery

fats, wheat and semi-confectionery bread, creams, desserts, chocolate drinks and icing toppings [21, 27, 31].

Glycerin, E 422 – is a colorless or light yellow oily liquid, odorless and sweet taste. It acts as a carrier, stabilizer, solvent and is responsible for maintaining humidity in confectionery products and jellies. Supports texture formation with food gums and gelatin. It is most often used in food flavors. It is used, among others for the production of bread, desserts and cakes as well as icing for cakes [16, 27].

A mixture of tocopherols, E 306 – a red-brown oily liquid, colorless with a slight, mild odor. The main function of this substance is antioxidant activity. In the case of saturated fatty acids, they have a protective effect and prevent oxidation of vitamin A. They act as vitamin E, and also support oxygen transport to the muscles and heart [21, 27].

GLUTEN-FREE BREAD – NATURALLY GLUTEN-FREE CEREALS AND PSEUDO-CEREALS

Bread that is intended for people on a gluten-free diet is made of various types of flour and starch. The most commonly used is flour and starch made from corn and gluten-free wheat starch. Gluten-free oat flour [from controlled, certified crops and plants where there is no risk of gluten contamination], or rice starch and flour are also perfect for baking bread. Buckwheat flour with the addition of gluten-free wheat or corn starch is also increasingly used [23].

Due to the lack of gluten in bread dough, positive hydrocolloids are needed to improve the structure of the dough. On the market, the range of gluten-free bread is quite rich, thanks to which the gluten-free diet has become more varied.

People on a gluten-free diet must consume products that do not contain gluten, and the diet of the sick should not only be balanced and varied, but above all tasty. Pseudo-cereals and naturally gluten-free plants are available on the market, the starch of which can be used to produce gluten-free food [5]:

– buckwheat – the fruit of buckwheat is not ache, also called peanut. Its outer part is a fruit cover, and under it is a seed cover. Bielmo is the central part. Individual parts of buckwheat are characterized by a different chemical composition and different nutritional value. Hulled nuts contain approx. 12% water, proteins constitute approx. 10%, 71% are sugars, 3% fats, dietary fiber is approx. 4% and mineral substances approx. 1.7%. Buckwheat grains are rich in tocopherols, which there are more than in wheat or barley, as well as B group vitamins. Proteins contained in buckwheat grains have a high biological value and there is no α-gliadin, thanks to which buckwheat and its food processing products are used in the diet intended for people with celiac disease. Starch in buckwheat is low-energy because its fractions are resistant to the activity of amylolytic enzymes found in the digestive tract. Buckwheat is also a good source of fatty acids. The content of unsaturated fatty acids is about 80% of all fatty substances, and 40% are polyunsaturated acids. Buckwheat products prevent hypercholesterolemia because they have a beneficial effect on the content of cholesterol in the blood. Buckwheat also contains antioxidant substances such as phytosterol, flavonoids, phagopyrins and phenolic acids. Buckwheat flour has a high nutritional value (Tab. 2), which perfectly serves as a substitute for wheat flour in bakery [12].
– oats – consumption of oat-based bread is not as popular in Poland as in other countries. Complex carbohydrates, including starch, are one of the basic nutrients found in oats. The starch content fluctuates around 45–55%, which is almost 10% less comparing to other cereals. The high content of dietary fiber distinguishes it from other cereals. Soluble β-glucans are the bulk of the fiber fraction. Due to the possibility of producing colloidal solutions characterized by high viscosity, they play an important nutritional role. These solutions stimulate intestinal motility during movement in the gastrointestinal tract and absorb cholesterol. Oats are a good source of protein, and its amount is about 12–17% (Tab. 2). Proteins have a high nutritional value because they contain exogenous amino acids. The fat content is about 7%, unsaturated fatty acids such as linolenic acid are about 35–35% and oleic acid 35–50%. Saturated palmitic acid is present in an amount of about 15–20%. Oats are rich in vitamin E and B vitamins, mainly vitamin B1, PP, vitamin B6, vitamin B2, pantothenic acid and folates. Unfortunately, the amount of vitamin E can be significantly reduced when storing unprocessed beans at room temperature. The content of minerals in oats is much higher than in wheat and rye, it contains a lot of potassium, iron, zinc, copper and magnesium. Oats have antioxidant properties due to the presence of polyphenolic compounds mainly caffeic, hydroxycinnamic, phenolic acid and the presence of tetramid, whose activity is several times higher than caffeic acid. Oat sterols have antioxidant activity and contribute to reducing serum cholesterol. However, it should be noted that during the production of oat flakes sterols are destroyed. Oats and its food processing products are used in the treatment of people with diabetes, obesity or cardiovascular diseases. The presence of β-glucans largely affects its health values. They influence the reduction of the glycemic index, also contribute to the reduction of serum cholesterol by binding it in the digestive tract by the gels formed, and also increase the secretion of bile acids. Oats are mainly used for the production of flour, groats, flakes and bran [10].
– sorghum – only two varieties are grown in Poland for the purpose of being used for fodder for silage. Sorghum can be used to produce flour, groats and starch, as well as spirit and molasses. This plant can also be used to make couscous and as an addition to various pastries and tortillas. Groats that are made from sorghum do not stick after cooking and have good sensory and rheological properties. It is rich in protein, minerals and fiber. The flour we receive from sorghum is light, odorless and light. It can be perfectly used as a replacement for wheat flour for the production of pasta or pizza dough. Sorghum is a plant with high nutritional value (Tab. 2). It contains a large amount of carbohydrates approx. 75%, the protein content is approx. 11%. Sorghum grains are a rich source of dietary fiber about 6.8%, and its main fraction is hemicellulose. The fat content is 3.3%, including polyunsaturates. Minerals

are also found in large quantities, mainly potassium, iron and phosphorus. Sorghum is also a valuable source of vitamin B group. Sorghum seeds contain carotenoids and flavonoids, and anthocyanins are also present in the hulls. The presence of phytochemicals, tannins, phytosterols and phenolic acids has a positive effect on the human body due to their antioxidant properties, which are higher than in other cereals. However, sorghum bran contains more health-promoting ingredients than the whole grain. Contained sterols and polyphenols favorably affect the cardiovascular system, contributing, among others to reduce blood cholesterol. Tannins present in sorghum reduce the calorie content of food, thanks to which we can use it as one of the ingredients of a slimming diet. The sorghum also contains tannins, which destroy free radicals contributing to the immunity increase. They have also been shown to be anti-cancer because they inhibit the production of mutagenic toxins [8].

– millet – the nutritional value of millet is as high as that of other cereals (Tab. 2). The carbohydrate content in this grain is high, and starch dominates. Its amount is in the range of 56–63%. Carbohydrates present in millet are characterized by high bioavailability – 98%. Starch, thanks to its organized and homogeneous structure, absorbs large amounts of water and forms gels. The fiber content is lower compared to wheat or rye, which is why it is a more absorbable plant. The dominant fiber fraction is pentosans 6.6%, cellulose 1.6% and lignin 0.3%. Millet is a very good source of protein (Tab. 2), and its quantity is mainly influenced by genetic factors and environmental conditions. The amount of protein in millet is similar to that in wheat, but the millet protein has more essential amino acids, including lysine. The protein's bioavailability is also high, around 85%. The fat content is 4% and its bioavailability reaches 90%. Sterols, fatty acids and triglycerides are also present in millet. The amount of polyunsaturated acids is 40%. Millet is rich in minerals, mainly magnesium, potassium and iron. The distinguishing feature from other cereals is the base-forming effect of millet and the presence of silica, which is rarely found in cereal products. Vitamins found in millet are mainly B group vitamins. The yellow-pale variety of millet is rich in β-carotene, which is transformed into vitamin A. Millet groat can be obtained from millet. It is an easily digestible product with high nutritional value (Table 2), which we can perfectly be used as an addition to various dishes. Millet is also suitable for making flour. Gluten-free flour can be used for baking bread and various cakes. Its swelling ability, smell, color and nutritional value [tab. 6], as well as consistency mean that we can replace flour made of wheat for millet flour [9].
– Amarantus – also known as amaranth, only one variety is cultivated in Poland, with high nutritional value. Amaranth seeds consist of 64% starch, 17% fiber, 15% protein, 7% fat, and 3% ash. Comparing the nutritional value of amaranth with other cereals, they have more potassium, magnesium, calcium, phosphorus and iron (Tab. 2). Amarantus is also a valuable source of B vitamins, vitamins A, E and C. Proteins found in this plant have a lot of amino acids that contain sulfur and other essential amino acids necessary for the proper development of the body. Starch present in amaranth is even 2–4 times more bioavailable than starch present in millet. The fats contained in amaranth mostly consist of unsaturated fatty acids, among others linoleic and oleic, and in smaller quantities from peanut and linolenic acid. Amarantus also has biologically active substances that are recommended in diets used by people with heart disease and atherosclerosis, as well as in rejuvenating, gluten-free and high-protein diets. A very important nutrient and health-promoting component of this plant is squalene, which has many health-promoting properties, among others antioxidant. Amarantus can be used for the production of groats, cereals, muesli, gruel, popcorn and flour, which is suitable for making bread, biscuits and cakes and pasta. Amarantus is perfect for bakery products intended for people with allergies, celiac disease and atherosclerosis. We can get flour from amaranth, which acts as a natural bread improver. It increases its nutritional value and replaces synthetic additives. The addition of this flour can help improve the rheological properties of the dough, thanks to which it becomes more flexible and spongier. It also increases the bread volume and also shortens the dough fermentation process [3].
– quinoa – a plant originating in South America, is a very good source of protein, which is characterized by a large amount of exogenous amino acids. These proteins are characterized by high digestibility, which is about 80–90%. Quinoa also contains a large amount of carbohydrates (Table 2). Starch has the largest quantity among them (55–65%). Disaccharides are found in a small amount of 2–3%, while pentosans 3–4%. The prevailing fraction of quinoa is amylopectin, and the amount of amylose ranges from 25–27%. A similar quantity of these fractions also occurs in corn and wheat starch. The fat found in quinoa seeds is within 7–8%. The fatty acid content is similar to that in maize. There are more minerals present in quinoa than in traditional bread cereals. Potassium and phosphorus predominate here. The amount of calcium, magnesium and copper is also quite large. A distinctive feature is also a large amount of vitamins (Tab. 2), mainly A, C, E, as well as carotenoids. B vitamins are found in smaller amounts, primarily niacin and thiamine. Quinoa mainly provides seeds that are used in the baking industry and for the production of food concentrates [4].
– rice – is the basic cereal that makes the food of people in East and South Asia. Rice is an excellent addition to various dishes, it is also used for the production of flakes, flour, pasta and rice starch [18]. The energy value of flour is varied and depends on the rice variety (Tab. 2). Brown rice is considered to be more valuable, and this is mainly due to the fact that in the technological process brown rice retains a fruit-seed coat. The protein content is also higher in brown rice. Rice is a valuable source of carbohydrates, their total content in white rice is 79%, and in brown rice about 77%. This plant is also rich in dietary fiber, and its content is quite diverse. The fats found in rice are in small amounts, white rice contains 0.7%, and brown rice 1.9%. The majority of fatty acids is 30% linoleic acid. Rice is also a good source of vitamins, especially from group B, among others B1, B2 and niacin, as well as vitamin E [36].

Table 2. Nutritional value of selected gluten-free cereals and pseudo-cereals, Sources [20,33]
Tabela 2. Wartość odżywcza wybranych bezglutenowych zbóż i pseudozbóż, Źródła [20,33]

Nutrient Ingredient	Units	Flour											
		Wheat type 500	Rye type 580	Barley	Buckwheat	Oat	Millet	Sorgo	Amaranth	Quinoa	Rice	Corn	Teff
Energy value	kJ/kcal	1436 /343	1410 /337	1443 /345	1519 /363	1549 /370	1540 /368	1410 /337	1645 /393	1539 /368	1452 /347	1457 /348	1603 /383
Protein	g	10,10	5,10	10,50	13,10	14,00	11,60	5,90	15,90	14,12	7,20	5,90	13,30
Fat	g	1,20	1,50	1,60	2,70	8,00	2,90	3,00	7,40	6,07	0,70	3,00	2,40
Saturated fatty acids	g	0,31	0,36	0,34	0,64	1,60	0,70	0,53	2,10	0,71	0,15	0,38	0,40
Monounsaturated fatty acids	g	0,15	0,26	0,21	1,03	2,87	2,62	0,94	1,69	1,61	0,18	0,68	0,60
Polyunsaturated fatty acids	g	0,74	0,89	0,77	1,10	3,33	0,00	1,40	2,78	3,29	0,26	0,18	1,07
carbohydrates	g	74,00	78,50	74,50	68,60	55,00	75,90	78,00	60,10	64,16	76,90	70,50	73,10
Starch	g	70,50	68,40	63,62	60,50	57,80	69,88	68,00	57,30	52,22	74,90	68,30	36,56
Dietary fiber	g	2,30	5,60	10,10	5,90	11,00	3,20	7,60	11,40	7,00	2,30	7,50	8,00
Calcium	mg	18,00	19,00	32,00	40,00	55,00	13,00	7,00	186,00	47,00	10,00	7,00	180,00
Magnesium	mg	10,00	21,00	96,00	219,00	144,00	213,00	40,00	266,00	197,00	36,00	40,00	184,00
Potassium	mg	340,00	155,00	296,00	521,00	371,00	340,00	193,00	527,00	563,00	117,00	193,00	427,00
Iron	mg	1,10	1,10	2,68	4,00	4,00	4,30	3,00	7,20	4,75	1,10	3,00	7,60
Zinc	mg	0,08	1,04	2,00	3,75	3,20	3,66	0,84	2,87	3,10	0,80	0,84	3,63
Copper	mg	67,00	0,09	0,34	0,60	0,44	0,78	0,10	0,53	0,59	0,20	0,10	0,81
Phosphorus	mg	67,00	91,00	309,00	441,00	452,00	397,00	127,00	557,00	457,00	90,00	127,00	429,00
Manganese	mg	0,25	0,70	1,03	1,89	4,02	1,61	0,35	3,33	2,03	0,60	0,37	9,24
Vitamin E	mg	0,40	0,12	0,57	0,30	0,70	0,10	0,30	1,19	2,44	0,00	0,30	0,08
Vitamin B1	mg	0,11	0,15	0,37	0,58	0,69	0,20	0,37	0,12	0,36	0,08	0,37	0,40
Vitamin B2	mg	0,05	0,07	0,11	0,11	0,13	0,12	0,10	0,20	0,32	1,90	1,00	3,40
Vitamin PP	mg	0,93	0,57	6,27	4,72	1,47	5,63	1,32	0,92	1,52	10,00	1,32	0,94
Vitamin B6	mg	0,02	0,10	0,40	0,67	0,13	0,37	0,33	0,59	0,49	0,20	0,33	0,48

– Maize – initially it was grown only in America, and then spread to the African and Asian countries, it came to Poland later than to neighboring countries [19]. Corn is a good source of carbohydrates (Tab.2), but it contains far fewer than traditional bread cereals. Potassium, phosphorus and magnesium dominate among the minerals. Corn is also rich in B vitamins, mainly thiamine, riboflavin, niacin, as well as vitamin A and dietary fiber. Corn is a versatile plant. You can get flour, groats, cereals, oil and sugar from it, it can also be consumed immediately after cooking the flask [18]. Corn flour obtained during milling is yellow and its texture is granular or fine. It is mainly used for the production of bread raised by baking powder instead of yeast. The bread is light and fluffy. The structure of the dough has small pores and the color of the bread is golden. Comparing its nutritional value with other flours, it can be stated that it has the most carbohydrates, while mineral compounds, dietary fiber and vitamins are present in smaller amounts than in other flours [17].
– teff – Abyssinian love is cereal from Africa. The flour obtained from teff is very well suited for making sourdough bread. During the fermentation of the dough, numerous gas bubbles are formed that give a better quality of the final product. Abyssinian malka is a naturally gluten-free plant, its composition is similar to that of millet (Tab. 2). However, the amount of amino acids in teff is much higher than in other cereals. This plant is also a valuable source of calcium, magnesium and iron. The distinguishing feature of this grain from others is the high content of folic acid. Teffu grains are very stable, because they do not go rancid during storage [19].

Wheat, rye and barley flour, compared to flours obtained from the above-mentioned cereals and pseudo-cereals, has a nutritional value that is comparable to other flours (Tab. 2). It is not distinguished by a higher quantity of protein in total, but differs in its amino acid composition and technological quality as well as the impact on the structure of the final

product. Gluten-free bread contains less protein compared to rye or wheat bread. However, the calorific value, fat and carbohydrate content are comparable [7].

NUTRITIONAL VALUE OF SELECTED GLUTEN-FREE BREADS

Table 3 presents the nutritional value of 85 selected bakery products from the bread assortment from 4 producers who offer their products in Poland. The nutritional value for individual products was obtained from the websites of their producers.

The analysis of selected products showed a large diversity of bread on the Polish market. The offer includes, for example, products that are obtained on the basis of sourdough, with the addition of whole-grain flour and/or grains of various gluten-free cereals, because it affects their nutritional value and organoleptic characteristics.

The energy value of bread varied within a fairly wide range of 179-432 kcal/100 g of product (Tab. 3). The protein content is much lower compared to wheat bread. In addition, attention should be paid to the protein content of gluten-free flours used for baking bread – it was comparable to levels in wheat mat (Tab. 2). The differences that are observed for gluten-free and wheat bread are due, among others the technological quality of flour that does not contain gluten. In the production of gluten-free bread [12, 17], it is necessary to use other gluten replacement ingredients, including hydrocolloids, legume proteins and dietary fiber [31], which will improve the technological and organoleptic quality of the products obtained. The use of the above ingredients, however, significantly affects the nutritional value of the final product, including the reduction of the protein content.

Gluten-free bread is characterized by a much higher total fat content, which ranged from 1.8 to 11 g/100g of bread, on average 5.35 g in 100 g of product. Fat has an impact on the textural, structural and sensory characteristics of the final product. Variations in fat and protein amount can significantly influence the delicate and spongy structure of the breads, which as a result will have a higher acceptance among consumers [29].

The salt content of bread was varied. A slice of wheat bread weighing 25 g provides the body with about 1.6% of the recommended daily salt intake. Bread is one of the main sources of salt in the diet of Poles. In addition, it should be noted that bread is rarely consumed without additives, e.g. spreadable fat, cheese or sausages, which are also a source of salt. This is of great epidemiological importance, as excessive intake of salt is associated with an increased risk of hypertension, cardiovascular disease and stomach cancer [6, 22].

The content of dietary fiber in gluten-free products under analysis was quite high, e.g. three slices of bread with sunflower seeds or whole-grain breads provided up to 30 g of fiber. This is important for patients with celiac disease, as some of them may have problems with regeneration and intestinal motility immediately after diagnosis [26]. In such cases, doctors and dietitians recommend periodic use of an easily digestible diet rich in water-soluble fiber, rather than water-insoluble fiber dominant in bread. In addition, it should be noted that gluten-free products are high energy and for some patients it is important to provide dietary fiber with diet, which helps regulate and/or reduce weight [30].

SUMMARY AND CONCLUSIONS

Celiac disease is an autoimmune disease that is characterized by gluten intolerance. As a result of the action of gluten on the gastrointestinal mucosa, intestinal villi in the small intestine disappears, which are responsible for the absorption of nutrients. **Celiac disease can appear at any age. If you do not use the gluten-free diet, you may have serious health problems related to, among others anemia, osteoporosis, mental disorders, problems with pregnancy and the risk of gastrointestinal cancers increases significantly.** The only treatment method for celiac disease is to follow a gluten-free diet throughout your life.

Gluten is a protein that is made from gliadin (or sekalin, hordein) and glutenin during dough kneading. It performs many technological functions, such as affecting the elasticity, viscosity, elasticity and plasticity of the dough. It allows the proper increase of dough volume during fermentation, and also increases the porosity of the bread and affects its rise.

For people with celiac disease, it is forbidden to consume products containing the above-mentioned cereals. These cereals can be replaced with other plants that do not form gluten and are suitable for the production of various products, among others for baking bread, making pasta or making cakes and cookies.

The nutritional value of the gluten-free bread assortment varies. It contains less protein than wheat bread that affects its nutritional value as well as technological quality, which results in the need to replace the structure-forming role of gluten.

PODSUMOWANIE I WNIOSKI

Celiakia to choroba o podłożu autoimmunizacyjnym, charakteryzująca się nietolerancją glutenu. W wyniku działania glutenu na śluzówkę przewodu pokarmowego, w jelicie cienkim dochodzi do zaniku kosmków jelitowych, które odpowiadają za wchłanianie składników pokarmowych. Celiakia może ujawnić się w każdym wieku. **W przypadku nie zastosowania leczenia dietą bezglutenową, może dojść do poważnych problemów zdrowotnych związanych m. in. niedokrwistością, osteoporozą, zaburzeniami psychicznymi, problemami z zajściem w ciążę oraz istotnie rośnie ryzyko wystąpienia nowotworów układu pokarmowego.** Jedyną metodą leczenia celiakii jest ścisłe przestrzeganie diety bezglutenowej przez całe życie.

Gluten jest białkiem, które powstaje z gliadyny (lub sekaliny, hordeiny) i gluteniny podczas miesienia ciasta. Pełni on wiele funkcji technologicznych, takich jak wpływ na elastyczność, lepkość, sprężystość i plastyczność ciasta. Umożliwia prawidłowy wzrost objętości ciasta podczas fermentacji, a także zwiększa porowatość pieczywa i wpływa na stopień jego wyrośnięcia.

W przypadku osób chorych na celiakię spożywanie produktów zawierających wyżej wymienione zboża jest zabronione. Zboża te należy zastąpić innymi roślinami, które nie tworzą glutenu i nadają się do wyrobu różnych produktów m.

in. do wypieku chleba, wyrobu makaronu czy produkcji ciast i ciasteczek.

Wartość odżywcza asortymentu pieczywa bezglutenowego jest zróżnicowana. Zawiera ono mniej białka niż pieczywo pszenne, co wpływa na jego wartość odżywczą oraz jakość technologiczną, co jest związane z koniecznością zastąpienie strukturotwórczej roli glutenu.

Table 3. Nutritional value of selected gluten-free bread available on the Polish market, Sources [38,39,40]

Tabela 3. Wartość odżywcza wybranego pieczywa bezglutenowego dostępnego na polskim rynku, Źródła [38,39,40]

Product name	Energy value		Fat	Staturated fatty acids	Carbohydrates	Sugars	Dietary fiber	Protein	Salt
	kJ	kcal	g						
Producer - Glutenex									
Buckweat bread	1266	299	3,7	0,5	65	4,6	ND*	1,1	1,4
Bread roll with sunflower seeds	1202	285	6,4	0,9	53	5,3	ND	2	1,6
Butter bread	329	10	4,6	58	12	1,2	ND	1	BD
Butter rolls	1826	432	8	6,6	87	14	ND	1,7	1,5
Dark bread	1240	293	4	1,5	63	7,3	ND	0,7	1,8
Dark kaiser roll	1111	263	3,9	0,7	55	5,3	ND	0,5	1,6
Dark vital bread with seeds	923	219	5,1	1,2	38	5,4	2,9	2,7	1,4
Gluten-free rolls	1111	263	4	0,7	55	5,5	ND	0,5	1,7
Kaiser roll	1118	265	4	0,7	55	5,5	ND	0,5	1,6
Light vital bread	859	204	3	0,7	40	2,9	5	2	1,5
Loaf braed	985	233	3,5	0,6	49	4,6	ND	0,4	1,5
Milk bread	1116	264	4,4	1	54	5,5	ND	1,2	1,2
Multigrain bread	1298	308	8,6	1,8	52	3,5	ND	4	1,5
Multigrain dark loaf	1152	274	7	1,7	48	4,8	ND	2,3	1,4
Multigrain light loaf	1159	257	7	1,7	49	4,9	ND	2,2	1,5
Poznan circular wedding bread	1271	302	9,3	2,6	49	5,4	1,1	3,1	5,7
Poznanska roll	1111	263	4	0,7	55	5,5	ND	0,5	1,7
Sandwich bread	1157	274	4,2	0,7	57	5,4	ND	0,5	1,7
Toast bread	1163	275	4,5	0,3	56	5,8	ND	1,6	1,5
Producer - Balviten									
Multigrain bread	1544	373	2,8	2,6	16	1,1	9,6	1	1,6
Bread "Chlebus"	1300	312	6,3	0,5	60	3,7	2,9	1,98	1,55
Bread with chia seeds	940	223	42	0,44	40	2,1	5,5	4,1	1,3
Bread with no added sugar	1019	241	2,9	0,22	50	0,6	2,8	2,8	1,2
Bread with sunflower seeds	1100	261	7,5	0,6	46	1	1,5	1,5	1,09
Ciabatta	792	188	2,8	0,2	34	1	5,3	3,6	1
Cumin Bread	906	215	3,7	0,3	38	BD	4,8	4,7	1,3
Daily bread	1062	252	4,8	0,5	50	2,9	3,7	0,8	1,2
Dark farmhouse bread	950	225	3,8	0,3	40	2	6,1	4,6	1,1
Dark sandwich bread	792	188	2,8	0,2	34	1	5,3	3,6	1
Dark supreme royal bread with grains	999	237	3,6	0,3	44	5,4	5,8	4,6	1,3
Galician bread	990	235	3,9	0,4	47	4,1	4,4	0,7	0,9
Home-made bread	993	237	4,2	0,3	48	4,1	2,2	0,53	0,95
Kaiser rolls	1250	300	5,8	0,4	58	3,3	3,5	1,4	1,2
Light bread	792	188	2,8	0,2	34	1	5,3	3,6	1
Light bread	752	179	5,5	0,38	31	3,6	1,2	0,84	1,2
Light farmhouse bread	950	225	3,8	0,3	40	2	6,1	4,6	1,1

Product name	Energy value		Fat	Staturated fatty acids	Carbohydrates	Sugars	Dietary fiber	Protein	Salt
	kJ	kcal	g						
Light supreme royal bread with grains	950	225	3,8	0,3	40	2	6,1	4,6	1,1
Mini baguette	792	188	2,8	0,2	34	1	5,3	3,6	1
Multigrain bread	908	216	5,9	0,5	33	1,5	6,7	4,8	0,94
Multigrain bread	1086	258	7,3	0,6	46	2,4	1,4	1,6	1,1
Our favourite bread	792	188	2,8	0,22	34	1	15,3	3,6	1
Rustic baguette	1109	264	8,4	1	38	4,4	5,9	5,5	1,4
Sunflower seed bread	1171	278	8,2	0,9	47	2,5	4,4	2,1	1,2
Supreme royal bread with grains	1102	263	8,3	0,7	38	5,5	7,6	5,2	0,9
Supreme royal rolls	1040	248	2,97	0,2	50	2,7	4,9	2,8	1,2
Toast bread	1036	246	4,7	0,4	48	4,6	3,7	0,7	0,8
Vbread with quinoa flour	1009	239	4,1	0,33	45	3	4	3,7	1,5
Producer - Bezgluten									
Mini baguette	1148	272	5,6	0,6	49	3,4	5,4	3,5	1,12
Bread with no added sugar	985	235	6,7	0,6	35	1,3	6,3	5,4	1,54
Ciabatta	1143	271	5,6	0,6	49	3,4	5,4	3,5	1,12
Daily bread	1099	262	6,6	0,8	43	4,6	9,1	3	1,4
Daily rolls	1065	253	5,4	0,9	45	5,5	6,6	2,8	1,1
Dark bread with pumpkin seeds and cranberries	1079	257	6	0,8	39	4,9	7,5	8,1	1,3
Hamburger rolls	1176	279	7,8	0,9	48	3,2	ND	4,2	1,07
Kaiser rolls	1143	271	5,6	0,6	49	3,4	5,4	3,5	1,12
Light loaf with black cumin	1059	254	10	1,1	30	3,7	13	4,4	0,9
Miltigrain bread with chia seeds	1109	264	7,6	0,8	41	2,6	9,7	3	1,1
Multigrain bread	1157	275	8	0,8	44	2,5	6,5	3,6	1,15
Multigrain bread	902	215	5,4	0,6	35	2,2	7,4	2,8	1,3
Noble brown bread	1080	257	7,2	1	39	4,5	9,1	4,6	1,1
Noble white bread	1008	239	4,8	0,6	41	3	6,5	4,8	1,03
Plain bread	976	232	4,3	0,4	43	1,6	6,5	2,1	1,25
Plain bread with sunflower seed	1078	257	7,9	0,8	40	1,9	6,2	3,3	1,1
Plain rolls	1148	272	5,6	0,6	49	3,4	5,4	3,5	1,12
Rolls with poppy seeds	1131	268	6,3	0,7	49	3,4	ND	3,8	1,1
Rosette rolls	1162	276	5,6	0,6	49	3,4	7,8	3,5	1,12
Sunflower seed bread	1135	270	7,6	0,8	43	4,2	10	2,5	1,3
Toast bread	1006	239	4	0,1	44	6	6,5	3,7	1,08
White bread	1068	253	5,1	0,6	47	2,5	5,1	2,3	1,3
White bread	1052	250	4,6	0,5	46	3,1	7,7	2,2	1,2
White bread	1008	240	5,7	0,6	42	1,1	6,4	1,9	0,88
Producer - Shär									
Ciabatta Rustica	1150	274	8,1	1	40	3,7	8,9	5,8	1
Bon matin	1236	293	7,3	3,9	51	14	3	3,4	0,75
Ciabatta	900	213	1,8	0,3	41	2,7	8,8	4,1	1
Focaccia Con Rosmarino	1064	253	6,1	0,8	42	4,1	3,8	BD	1,3
Maestro cereale	1042	248	6,2	0,9	40	2,8	7,4	4,3	0,85

Product name	Energy value		Fat	Staturated fatty acids	Carbohydrates	Sugars	Dietary fiber	Protein	Salt
	kJ	kcal	g						
Maestro classic	1009	239	3,4	0,5	45	3,3	7,3	3,5	1
Maestro vital	1099	262	9,2	1,1	36	0,9	8,8	4,5	1
Mehrkornbrotchen	1241	296	11	1,3	38	2,3	8	7,3	0,75
Pain campagnard	967	229	3,5	0,5	43	3	5,7	3,5	1,3
Pan blanco	889	211	2,7	0,4	41	7,9	ND	2,4	1,3
Pan multigrano	989	235	4,9	0,6	40	7	8	3,6	1,1
Pan rustico	954	239	2,4	0,4	44	6,3	6,7	3,8	1
Panini rolls	993	235	2,9	0,5	45	4,9	7,2	3,7	1
Vollkornbrot	990	236	7	0,8	31	2	9	7	0,83
Producer - Putka									
Wheat bread	1160	276	1,5	0,3	49	1,9	4,3	7,6	1,6
ND* - *no data*									

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THE INFLUENCE OF GENETIC FACTORS AND PRE-SLAUGHTER HANDLING ON THE QUALITY OF POULTRY MEAT®

Wpływ czynników genetycznych oraz obrotu przedubojowego na jakość mięsa drobiowego®

Currently, Poland is the largest producer of broiler chicken meat in the European Union. This dynamic increase in production was possible due to the development of production technology, the use of appropriate genetic material, optimization of nutrition and provision of appropriate environmental conditions for chicken rearing. High growth rate allows the production of cheap meat thanks to refining the above-mentioned factors. However, the intensive rearing conditions of birds negatively affect the physiological processes of chickens, which consequently increases the risk of meat quality defects and causes increased mortalities. It should be remembered that all of these factors influence on the quality of meat, creating its technological, microbiological and sensory quality.

Key words: broiler chicken, genetic factors, pre-slaughter handling.

Obecnie Polska jest największym producentem mięsa kurcząt brojlerów w Unii Europejskiej. Ten dynamiczny przyrost produkcji był możliwy dzięki opracowaniu technologii produkcji, zastosowaniu odpowiedniego materiału genetycznego, optymalizacji żywienia i zapewnieniu odpowiednich warunków środowiskowych dla odchowu kurcząt. Tak wysokie tempo wzrostu umożliwia produkcję taniego mięsa dzięki dopracowaniu wyżej wymienionych czynników. Intensywne warunki odchowu ptaków negatywnie oddziałują na procesy fizjologiczne kurcząt, co w konsekwencji zwiększa ryzyko wystąpienia wad jakościowych mięsa i jest przyczyną zwiększonych upadków. Należy pamiętać, że wszystkie te czynniki mają wpływ na kształtowanie jakości technologicznej, mikrobiologicznej oraz sensorycznej mięsa drobiowego.

Słowa kluczowe: kurczęta brojlery, czynniki genetyczne, obrót przedubojowy.

FACTORS AFFECTING THE QUALITY OF POULTRY MEAT

The quality of poultry meat is created, among others, during a series of changes (including the most important proteolytic and glycolytic ones) taking place in poultry muscles after slaughter. It is caused by many factors. The quality of broiler chicken meat is created throughout the entire production cycle. By "production cycle" is meant not only the broiler fattening period (from the insertion of chicks to slaughter), but also the handling of meat after slaughter (storage of meat, transport and properly conducted heat treatment) [39].

Meat quality can be divided into three basic elements: technological, microbiological and sensory quality. Technological quality includes parameters such as meat acidification (pH), colour parameters (CIE LAB L*a*b*), natural drip loss and cooking yield. The microbiological quality can be understood also as minimizing the risk of infection by using appropriate technological processes that can minimize this risk. Sensory quality, on the other hand, is the general product features and properties that determine the ability to meet the various needs of the consumer perceiving them through the prism of different sensory quality characteristics. Exemplary attributes determining the sensory quality are the external appearance, colour, odour, flavour, texture, tenderness, juiciness and overall quality of the product [41].

Factors that affect the quality of poultry meat can be divided into two main groups: genetic and environmental factors. Genetic factors include: species, line (referred to as genotype related factors), and gender and the age of the

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bird. Environmental factors, on the other hand, include: pre-slaughter handling and slaughter as well as housing and feeding conditions for birds, as well as slaughter and processing conditions for meat [41].

GENETIC FACTORS

The 25–45% of genetic factors determine the quality of poultry meat [32]. As mentioned earlier, genetic factors include: species, breed (poultry is more commonly referred to as "lines"), sex and age of the animal.

For broiler poultry, broiler chickens are produced the most; hybrid meat lines of Domestic hen (*Gallus gallus domesticus*) and broiler turkey; hybrid meat lines of Domestic turkey (*Meleagris gallopavo gallopavo var. domesticus*).

The increase in demand for poultry meat production obliged producers to ensure its high supply. Therefore, intensification of poultry production began. As a result of intensive crossing and genetic selection in the last 60 years began to receive genetic hybrids of meat breeds. The lines formed in this way are characterized by rapid growth (high daily growth), high value of feed conversion coefficient, low slaughter age and high slaughter capacity [3]. The most popular lines of fast-growing broiler chickens include: Ross 308, Ross 708, Cobb 500 and Cobb 700. In addition to fast-growing bird lines, there are also slow-growing hybrids, such as: Hubbard, Rowan Range, Cobb Sasso, Poulet de Bresse (France) and slow-growing Hubbard roosters (Label Rouge®). Slow-growing line birds are often kept in slow-range or restricted systems. Thanks to these maintenance systems, their well-being is significantly improved, as they can exhibit behavior characteristic of burrowing birds (searching for food in the soil and active movement). Contemporary consumers are increasingly aware and sensitive to animal welfare. Research in Germany shows that 56% of respondents show interest in bird welfare, and 82% would pay more for free range chickens [25]. Increased physical activity of birds kept in organic farming (free range) in comparison to conventional maintenance results in an increase in the share of muscle tissue and a decrease in the fat content in chicken carcasses [7].

The sex of chickens is another factor affecting meat quality. Differences in breast muscle colour and skin thickness depending on sex were noted. Breast muscles of cocks were characterized by greater saturation towards the red colour (higher value of the colour parameter a*) in relation to chickens [26]. The skin of cocks is thinner but contains more protein (collagen and elastin) and less fat than in chickens. This makes the skin of the cocks more durable and less susceptible to damage. As the birds ages, the protein content increases and the collagen fibers become stronger. With the age of the chicken, the thickness of the subcutaneous fat layer increases. As a result, the skin of chickens is more susceptible to injury than the skin of cocks. This applies in particular to birds that have high energy feeds [43].

The age of the birds determines the sensory quality of the meat [43]. The juiciness of meat decreases between 9 and 16 weeks of age, while the intensity of taste increases. Another attribute of sensory quality that is created and reaches its optimum at a later age of birds is odour [15]. It was on this basis and on the basis of an analysis of the French consumer market that the 'luxury' (and brand) poultry farming Label Rouge® was created. Table 1 presents the slaughter age of selected fast and slow growing breeds [1, 8, 20].

Table 1. Slaughter age of selected fast and slow growing breeds

Tabela 1. Wiek ubojowy wybranych linii kurcząt brojlerów szybko oraz wolno rosnących

Breed (line)	Fast growing	Slow growing	Slaughter age [days]
Ross 308	+		35-50
Ross 708	+		35-50
Cobb 500	+		35-50
Cobb 700	+		35-50
Hubbard		+	min. 63
Rowan Range		+	min. 63
Cobb Sasso		+	min. 91
Poulet de Bresse		+	min. 85
Male Hubbard (Label Rouge®)		+	81-110

Source: On the base [1, 8, 20]

Źródło: Na podstawie [1, 8, 20]

The factor that differentiates chickens of fast-growing and slow-growing lines is also the diameter of the muscle fiber. Slowly growing bird muscles have more thinner muscle fibers (hyperplasia). Consequently, such meat has greater water holding capacity. In contrast, fast-growing chicken muscles are often characterized by shorter muscle fiber cells with a larger diameter (hypertrophy). The result is less water-holding capacity in meat. On the other hand, free-range birds are more "runaway". This results in smaller glycogen reserves remaining in the muscle tissue, which results in a higher final pH value. As a result of the higher pH value, we get meat with a darker colour and a higher water holding capacity.

Tenderness is a very important attribute by consumers. The age of animals plays a very important role in creating it. Young animals due to relatively thin muscle fibers are characterized by higher meat tenderness than in older animals. In addition, an important element is the degree of collagen maturity and its ability to dissolve. That is why broiler meat, which is slaughtered at around 6 weeks of age, as a young slaughter poultry, is distinguished by satisfactory tenderness [22]. Studies show that slow-growing poultry, slaughtered at a later age, are generally characterized by meat with poorer tenderness. Therefore, meat from slow-growing chickens is not always desired by consumers.

Genetic factors have a huge impact on the level of sensitivity and the way the nervous system reacts to various stress factors [29]. Stress factors significantly affect the quality of broiler chicken meat. Fast-growing chicken lines that reach slaughter weight at a very early age are particularly sensitive to stress factors [19]. Połtowicz [30] showed that Starbo chickens had a higher pH15 (15 min post mortem) of breast muscles compared to other broiler lines; at the same time at a similar pH24 value (24 h post mortem) in all assessed genetic lines. This indicates a slower glycolysis course in these chickens,

while a higher pH may indicate that Starbo chickens are more resistant to stress factors [30].

ENVIRONMENTAL FACTORS

The environmental factors in 55-75% determine the quality of poultry meat [32]. Keeping chickens in conditions of intensive production is associated with the occurrence of stress factors. Environmental factors with potential stressors (nonspecific stimuli that induce a condition in individuals exposed to them as stress) are pre-slaughter, slaughter, bird housing and feeding [36].

Pre-slaughter handling and slaughter

The broadly defined pre-slaughter procedures with birds is of key importance in creating meat quality [42]. Ante-slaughter turnover is a series of activities from the beginning of pre-slaughter starvation on a poultry farm, to catching, loading, transporting chickens, ending with unloading at the slaughterhouse. During the entire pre-slaughter handling, birds are exposed to a number of stress factors that they do not encounter during rearing (sudden lack of access to feed and water, contact with people, violent movement, change of housing, disorder of the flock hierarchy, noise, movement and adverse ambient conditions). It is worth adding that the strongest stress responses are caused by emotional and polyietiological factors. Polyethiological factors are when several negative factors act at one time. One of the examples of such stress is the pre-slaughter handling [48]. The very change in the environment in which they find themselves causes that they feel fear, which is undoubtedly the main stress factor [48]. Frindt et al. [13] stated that differences in individual animal responses to a given stress factor differ significantly even within the same species. In addition, genetic factors play a huge role in creating sensitivity and how the nervous system reacts to various types of stressors [29]. Intensive genetic selection of broiler chickens aimed at achieving the largest possible muscle growth in the shortest possible time can lead to form, among others the "stress syndrome" [24].

Pre-slaughter starvation

Pre-slaughter starvation is an essential element of pre-slaughter handling. Starvation consists in putting the birds away from the feed (usually by raising feeders). This procedure is intended to empty the gastrointestinal tract of birds (mainly the esophagus and goiter) from residual digestive tract. Pre-slaughter starvation also reduces contamination of the feathers and legs of birds with feces [16]. The pre-slaughter period when starvation begins is extremely important. In the case of broiler chickens, the onset of starvation is included between 8 and 12 hours after slaughter [43]. It should be remembered that pre-slaughter starvation includes not only the period of withdrawal from feed and water until the birds leave the house, but also transport and waiting for broilers for slaughter. Shorter starvation time than 8 hours causes that the birds are fed (digestive tract filled with digestive content). This is an adverse occurrence, because during slaughter at the stage of plucking and evisceration, the filled digestive tract is susceptible to mechanical damage. Which, as a consequence, may cause it to tear and contaminate the carcasses with food content, and this may cause microbial contamination. Prolonging starvation may result in stressful behavior in birds, such as eating litter, coprophagia or even cannibalism [11]. In addition, the unnecessary extension of the duration of pre-slaughter starvation causes losses in slaughter capacity. Weight loss can range from 0.3 to 0.6% of live weight for each hour of prolonged starvation [4]. In addition, long starvation of birds causes depletion of glycogen, resulting in increased muscle pH. Pre-slaughter starvation for more than 36 hours has been shown to significantly reduce the pH of breast and femoral muscles and glycogen levels [23].

Catching and loading

The next stage of pre-slaughter handling, which causes stress in birds, is undoubtedly catching and loading broilers in transport containers. It is practically the first, greater contact of chickens with people. In order to minimize stress in birds, the broiler should be caught and loaded efficiently and respecting animal welfare principles. Due to the fact that the vast majority of Polish poultry farms use manual catching of chickens, the occurrence of wing damage is a frequent occurrence. The blood vessels of the wings are also damaged, which causes the formation of bloody ecchymoses (runaways) at their tips. These wounds result from the intense movement of the wings by birds, which in turn is the result of moving them in a non-physiological position; holding his head down [21]. In addition, incompetent grasping of broilers by the legs causes damage (joint dislocations and even fractures). Scaring and chasing birds in a small space causes their excessive accumulation. This contributes to an increase in cases of scratches and skin damage [17]. The capture of chickens is the least automated process in all ante-mortem proceedings. However, in many countries mechanical harvesters for catching poultry have been successfully used for years. Automated bird capture reduces stress levels, shortens the period of tonic immobilization, and allows you to restore normal heart function in less time [10]. In addition, some breeders use blue light when catching poultry. Light of this colour has a calming effect on birds. Placing birds in transport containers should be done with caution. The maximum capacity of the containers must not be exceeded, as crowding of birds hinders the free circulation of air in the cage. This crowding may cause heat stress. Therefore, often when loading poultry, fan batteries are used, which forcing the air movement to avoid overheating of birds at the stage of waiting for transport [43].

Transport and unloading

Of all the pre-slaughter stages, transport is the most aggravating factor which negative effect on the chicken [28]. During transport, broilers can be exposed to a number of adverse stress factors, such as lack of food and water, adverse temperature (too low or too high) and microclimate, vibrations, movement, shocks, impacts, noise, and disruption of the social balance of the herd. These stressors may cause birds to experience stress, including heat stress, which has a significant impact on the decrease in the meat's pH value, and thus its colour [45]. It has been shown that stress during transport has an impact on slaughter performance and on the quality of the carcasses. There is a lot of research on transport stress and its impact on slaughter performance and broiler chicken meat quality. It is obvious that the weight loss of birds during transport varies and depends, on the season of the year,

the number of birds placed in transport containers, the method of pre-slaughter starvation, species, body weight, and naturally the method and time of transport [44]. Weight loss in the first two hours after loading is 0.75%, and after each subsequent hour 0.30%. During transport, the total weight loss should not exceed 3%, as losses these reduce the slaughter performance. The extent of these losses is related to the duration of transport [33]. The microclimate that prevails in the middle of transport (especially temperature) is the main factor that causes an increase in the mortality of birds during transport, a decrease in their welfare level; consequently, it causes a decrease in meat quality. Heat stress is one of the major stress factors during transport that broilers are exposed to. Temperature that fluctuates around 17°C may have relatively little effect on chicken mortality. However, higher temperatures favor deaths [46]. Considering the above, birds should be transported in the colder times of the day (early morning, late evening or night). Vehicle semitrailers should be well ventilated during the summer months. It has also been observed that the occurrence of heat stress in broilers causes a decrease in the total protein content in the muscles, while not affecting the carcase fat [42].

In studies [34] have shown that the duration of transport plays an important role in creating the tenderness and juiciness of poultry meat. In winter, during three hours of transport, juiciness decreases compared to one-hour transport by 3.7% (thigh muscles) and 3.4% (pectoral muscles). In the summer, however, the worst juiciness of meat was in birds, whose transport to the slaughterhouse took 4 hours. Compared to one hour transport, it decreased by 4.5% (thigh muscles) and 4.7% (pectoral muscles). The most tender tenderness was seen in the meat of these chickens, whose transport took 1 hour. According to [31], prolonged physical activity before slaughter may contribute to the improvement of poultry meat tenderness. Transporting broilers to the slaughterhouse should not take longer than 2 hours, but the maximum allowed time is 6 hours. After transport, the birds should not be tired, so you should transport them carefully (avoiding unnecessary shocks), there should not be more than 12 birds in one container [27]. If we are dealing with transport over considerable distances, the so-called pre-slaughter rest should be applied before slaughter. Determining the duration of this rest is not easy, because the return of the animal's body to physiological balance is possible if the correct conditions are provided. Chickens should be slaughtered after a minimum of 1 hour, but a maximum of 4 hours of ante-mortem resting. It should be remembered to provide birds with adequate air exchange during rest in order to properly oxygenate them [27]. It should be noted that too long transport and strong stress cause increased energy demand in birds. Naturally, with a lack of access to feed during transport and a short period of adaptation of the body to the prevailing conditions, there is an increase in the intensity of glycolysis. Slaughtering animals in this condition will cause post-mortem glycolysis disorders that appear in meat as a defect in PSE [44].

All factors causing stress in birds during transport and unloading can cause many injuries to chickens. Such as: scratches, bruises, fractures of the legs and wings, blood splash, haematomas and even death caused by exhaustion of the body, or suffocation. Contusions are the most numerous group. Almost 90% of bruises occur 12-18 hours before slaughter [40]. The formation of bruises and hence ecchymosis is favored by high ambient temperature, because the bird's blood vessels are then more dilated and are more easily damaged. It was also observed that 31.4% of bone fractures in broilers arise during unloading of chickens from transport containers and hanging them on the slaughter line; in the case of electric stunning [18]. It is not possible to eliminate stressors that affect broilers during transport, even in the best organized transport chain. However, care should be taken to ensure that the birds are as humanitarian and safe as possible, using appropriate, adapted means of transport. During transport, remember also about the loading density standards for animals. Minimizing stress factors related to loading, transport, unloading and hanging on the slaughter line (in the case of electric stunning) it is necessary to ensure high-quality meat and, above all, to ensure a high level of bird welfare.

Slaughter

Slaughter greatly affects the quality of poultry meat. Slaughter consists of many closely related stages. Slaughter stages include: stunning (electric, gas, LAPS), bleeding (preceded by interruption of the most common cervical blood vessels), cutting off the head, burning, plucking, eviscerating and cooling the carcasses. Appropriate conduct at each of these stages largely determines the quality of the meat. Undoubtedly, one of the phases of slaughter that most significantly affects the quality of meat is stunning.

Stunning

Stunning animals is designed to prevent animals from moving. They can be easily and safely maintained during slaughter. At the same time, it prevents sudden convulsions after cutting the vessels. However, the most important reason for stunning animals before slaughter is to ensure animal welfare during slaughter by depriving them of awareness, reducing pain and suffering to a minimum [9, 47]. There are several methods for stunning broiler chickens. Among them we distinguish electric and gas methods and stunning using low atmospheric pressure (LAPS).

Methods of electric stunning can be divided into: stunning in a water bath and individual stunning. The most widespread is electric stunning in a water bath (80% of stunned birds in the EU; [12]). This method involves immersing the heads of animals suspended in the stirrups of the suspended conveyor in a brine bath and at the same time exciting the flow of electric current depending on the voltage, impedance of the birds and the resistance of the medium in which the broilers are immersed. As a result, it stimulates the brain and causes epilepsy, which leads to a gradual loss of consciousness and pain sensitivity. Another way to stun poultry by using electric current is to paralyze only the bird's head. For this purpose, two dry electrodes are attached to both sides of the bird's head placed in the funnel nest (in automated lines) or manual electrode attachment [43].

Controlled stunning methods in a controlled atmosphere CAS (Controlled Atmosphere Stunning) in industrial slaughter of poultry are an alternative to methods based on the flow of electric current. They are used mainly to improve animal welfare, employee safety as well as to improve meat quality. These methods are based on subjecting the birds placed in the

slaughterhouse to a gas mixture (with different proportions of O2, CO2, N2 and Ar) in a one-stage or two-stage sequence. When using a one-stage process, a low (less than 2%) oxygen is added to the mixture, and when two stages are used; in the first, a mixture of gases with anesthetic effect (e.g. 40% CO2 and 30% N2 and O2 each) is administered, and in the second mixture causing death by asphyxiation (increase of CO2 content to 80%, lack of O2) [38]. It should be added that we distinguish two variants of this type of stunning: continuous and periodic operation.

The LAPS (Low Atmosphere Pressure Stunning) method is analogous to the gas stunning method, but instead of introducing a gas mixture into the chamber, oxygen is gradually removed, leading to suffocation. This method is not yet approved in the EU, but it is used in the United States [8]. The LAPS (Low Atmosphere Pressure Stunning) method is analogous to the gas stunning method, but instead of introducing a gas mixture into the chamber, oxygen is gradually removed, leading to suffocation. This method is not yet approved in the EU, but it is used in the United States [43].

The methods of stunning birds described above have advantages and disadvantages (Tab. 2). Due to the fact that the LAPS method is not used in Poland, it has not been enabled to Table 2.

Incorrectly performed stunning of animals has a huge impact on the decreasing of meat quality. The most damage to carcasses is noted in the case of electric stunning. These injuries include, but are not limited to: fractures of the sternum and wings, damage to the capillaries in the pectoral muscles („spraying" with blood on the muscle surface; blood splash), the appearance of cramps and bloody ecchymoses as a result of rupture of blood vessels and muscle damage [43]. In order to prevent the occurrence of the above problems, the gas stunning mentioned above is increasingly used. In addition, as previously mentioned, to calm the birds, blue light is used in the livestock warehouse, and stunning should be done in such a way as to minimize the impact of stressors to a minimum [35].

Chicken slaughter without stunning is also used worldwide (so-called Halal slaughter). It is used in Muslim countries and has a religious background. In the case of restrictive slaughter of Halal, any form of stunning is not allowed, and the cessation of cervical blood vessels by the shochet is interrupted with full animal awareness [14]. Kosher slaughter (used in Judaism) still has similar principles. In addition, salted meat after slaughter is used to remove as much blood as possible from kosher slaughter, as it is considered unclean [6].

Bleeding and head cutting

Bleeding is intended to remove blood from the chicken's body (about 50%), which in turn leads to its death. This occurs as a result of disruption of the blood vessels located in the broiler's neck. This process is carried out on the slaughter line using automatic knives. The exception is ritual slaughter, where cutting is done manually by a qualified shochet. Better bleeding efficiency is used for high frequency current stunning than for gas stunning [2, 39]. Naturally, the best level of bleeding is provided by ritual slaughter methods, but due to their controversy they are not widely used. After bleeding (about 180 s), the head is cut off and used for blood disposal [43].

Scalding

The purpose of scalding poultry is to facilitate the next stage of slaughter, i.e. plucking. This facilitation is the result of loosening the feather bags. The scald is carried out mainly by immersion in devices called scalds. The slaughtered birds are immersed in water at the appropriate temperature for a specified period of time, which allows them to loosen their feather bags. There are two main types of burns: low temperature (50-53°C for 60-180 s; used when processing burrowing poultry) and high temperature (55-65°C, up to 90 s; mainly used for water poultry) [35, 39]. Incorrectly performed scalding can have a major impact on the quality of meat. Too low temperature and/or too short duration of the process may cause carcass damage caused by the need to carry out more intense later plucking. On the other hand, too high temperature and/or too long burn time may cause partial denaturation of muscle proteins seriously reducing carcass quality [5].

Plucking

Plucking is used to deprive birds of feathers. It is carried out in automatic pluckers, equipped with rubber „fingers". Improper, too intense picking leads to carcass damage. In addition, a process that is not intensive enough results in the remaining feathers on the carcasses [2]. Such feather

Table 2. Advantages and disadvantages of electrical and gas stunning

Tabela 2. Zalety i wady oszałamiania kurcząt brojlerów elektrycznego i gazowego

Electrical stunning		Gas stunning	
Advantages	***Disadvantages***	***Advantages***	***Disadvantages***
cheap	„unfriendly" to birds (hanging live animals on shackles)	provides more „comfort" for birds	gas and installation costs
takes up little space in the slaughterhouse	hematoma in pectoral muscles (EU requirements for electrical current use for stunning)	smaller range of damage to blood vessels	takes up a lot of space in the slaughterhouse
relatively technologically uncomplicated	ergonomics (hanging live birds on shackles are complicated)	broilers are hung on shackles after prior stunning	more technologically advanced system
	risk of carcass damage (e.g. caused by flapping wings)	the birds are unloaded after stunning (depending on the system)	longer period from stunning to plucking (worse plucking results)

Source: On the base [43]

Źródło: Na podstawie [43]

residues mean that chicken carcasses have to be nipped or tan in order to thoroughly remove any remaining plumage. The visual assessment of carcasses depends on the correctness and effectiveness of plucking [39].

Evisceration

Evisceration, i.e. gutting, involves removing the guts from the carcass. This is done using automated gutting spoons after the carcasses have passed the evisceration line. At this stage, offal is separated from post-slaughter waste for disposal. Veterinary inspection takes place before disposal. Incorrectly conducted evisceration may lead to microbiological contamination of carcasses, especially in the case of fed birds (with poorly carried out pre-slaughter starvation) [37]. At the end of evisceration, the carcasses are rinsed with pressurized water (outside and inside) to remove any entrails [39].

Chilling

There are three basic methods for cooling poultry carcases after slaughter: immersion (immersion) water, air and mixed air with sprayed water (fog) or spraying. The most common is the air (wind deflector) method. This method gives the best results in terms of reducing natural drip loss during meat storage [39]. Comparison of the pros and cons of chilling methods for poultry carcases is presented in Table 3.

CONCLUSION

Genetic and environmental factors (including pre-slaughter handling) have a huge impact on the development of technological, microbiological and sensory quality of poultry meat. Genetic factors, such as the appropriate selection of genetic material, lines, sex or slaughter age of birds play an important role in creating the quality of poultry meat. The key determinants affecting the quality of poultry meat are numerous environmental factors, including a number of operations during pre-slaughter handling and slaughter. Pre-slaughter handling and slaughter are one of the main stressors, which consequently affect the quality of poultry meat. One of the most stressful pre-slaughter handling operations is undoubtedly the transport of birds to the slaughterhouse. On the other hand, stunning birds before slaughter and chilling the carcasses are slaughter operations having a huge impact on the quality of meat. Incorrectly carried out pre-slaughter operations handling and slaughter decreases the quality of the meat. This is showed by negative changes in the pH value of meat, colour parameters, the appearance of a large amount of natural drip loss. These changes indirectly lead to decreasing of technological, microbiological and sensory quality as well as various quality defects of poultry meat.

Table 3. Advantages and disadvantages various methods of chilling poultry carcasses

Tabela 3. Zalety i wady różnych metod wychładzania tuszek drobiowych

Chilling methods	Immersion (in water)	Air	Mixed (combine air method with water spray or water dispersed in the fog)
Advantages	– the fastest and most effective – uniformity and brightening of the carcass colour – carcass weight increase (increase in post-slaughter efficiency)	– eliminating water consumption to chilling – reduced microbiological risk – lower drip loss (in comparison to immersion)	– reduction of cooling time (evaporative chilling) – reducing the amount of water consumed (in comparison to immersion) – spraying the surface prevents weight loss – higher carcass production rate (in comparison to air) – no discoloration of the epidermis – reduced microbiological risk – no excessive absorption of "foreign water" by carcasses
Disadvantages	– huge water consumption (6 dm^3 per carcass) – formation of drip loss during packaging and distribution of poultry meat – running the dripping process – carcass absorption „foreign water" from the cooler – the possibility of cross microbial infections – limited product stability in the case of chilled distribution of poultry	– higher cost (than immersion) – longer process duration – causes increased skin discoloration and external defects – no "foreign water" retention	– higher cost (than immersion)

Source: On the base [39]

Żródło: Na podstawie [39]

PODSUMOWANIE

Czynniki genetyczne i środowiskowe (w tym obrót przedubojowy) mają ogromny wpływ na jakość technologiczną, mikrobiologiczną i sensoryczną mięsa drobiowego. Czynniki genetyczne, takie jak: odpowiedni dobór materiału genetycznego, linii, płci lub wieku ubojowego ptaków odgrywają ważną rolę w kształtowaniu jakości mięsa drobiowego. Kluczowymi determinantami wpływającymi na jakość są liczne czynniki środowiskowe, w tym szereg operacji podczas postępowania przed ubojem jak i po uboju. Obrót przedubojowy i ubój są jednym z głównych stresorów, które w konsekwencji wpływają na jakość mięsa drobiowego. Jedną z najbardziej stresujących operacji przedubojowych jest bez wątpienia transport ptaków do rzeźni. Ponadto, oszałamianie ptaków przed ubojem i schładzanie tuszek są etapami, które mają ogromny wpływ na jakość mięsa. Nieprawidłowo przeprowadzone czynności przedubojowe i ubój obniżają jakość mięsa. Przejawia się to pogorszeniem wartości pH mięsa, parametrów barwy, pojawieniem się dużej ilości wycieku naturalnego. Zmiany te prowadzą pośrednio do obniżenia jakości technologicznej, mikrobiologicznej i sensorycznej, a także pojawienia się różnych wad jakościowych mięsa drobiowego.

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MODIFIED PRODUCTION OF FISH FEED BASED ON FISH MEAL ANALOGUES®

Zmodyfikowane wytwarzanie paszy dla ryb na bazie zamiennika mączki rybnej®

This article presents an analysis of the possibilities of reducing energy consumption in the production of plant-fish extruded fish feed with reduced fish meal content. This is accomplished by replacing the meal with unprocessed raw fish of an equivalent dry matter content. It was revealed that, in comparison with the traditional, energy-intensive technology of manufacturing extruded feed, the changes presented permit savings of 170 - 190 kWh/t of product, depending on extrusion moisture.

Key words: fish feed, extrusion, energy.

W artykule przedstawiono mozliwość zmniejszenia energochłonności produkcji roślinno-rybnych pasz dla ryb.Można to osiągnąc przez dodanie do mączki rybnej nieprzetworzonego do jej postaci surowca rybnego o pożądanej zawartości suchej masy. Przedstawione w artykule wyniki badań pozwalają na oszczędność 170 - 190 kWh/t produktu, w zależności od wilgotności ekstrudowanej mieszaniny surowców.

Słowa kluczowe: pasza dla ryb, ekstruzja, energia**.**

INTRODUCTION

Recent research on the nutrition of cultivated fishes has indicated that as much as 80% of the fish meal component, until recently the dominant ingredient, can be replaced by alternative sources of protein including soy meal or other plant protein concentrates. This permits lowering costs while maintaining nutritional values as the cost of fish meal is much higher than that of substitute plant components.

This is not the only way to reduce costs in the manufacture of extruded feed. The analysis of the production process [1] indicates that there is potentially another way of substantially reducing the cost of manufacturing feeds with lowered fish meal content. The key is to replace fish meal completely with partially dewatered, unprocessed raw fish material.

ANALYSIS OF THE POSSIBILITY OF REPLACING FISHMEAL WITH UNPROCESSED RAW FISH MATERIAL

The analysis was based on the following assumptions:

the feed is extruded with the widely-used single screw extruder;

the dry matter of the components of the extruded mixture (fish meal, plant component, and additives) is 90%,

the extrusion moisture is 70%,

the dry matter content of the water is negligible.

In the classic method for manufacturing plant-fish extruded feeds, water is added to the fish meal, plant component, and additive mixture during extrusion in quantities that lower the dry matter of the mixture from 90% to even 68%.

In this case, from the amount of water m_w added to the mixture weighing m_m with a dry matter of $dm_{m1} = 0.9$ it is easy to calculate the dry matter balance from the calculation:

$$m_m \times dm_{m1} = (m_m + m_w) \times dm_{m2} \quad (1)$$

where: m_m – amount of extruded mixture,
m_w – amount of water,
dm_{m2} – content of dry matter in the extruded mixture ($dm_{m2} = 0.7$).

After transforming formula (1) to:

$$m_w = m_m(dm_{m1} - dm_{m2})/dm_{m2} \quad (2)$$

it can be calculated with formula (2) that m_w = 28.6 kg of water is added to each 100 kg of plant-fishmeal mixture that is extruded.

Let's assume that 128.6 kg of mixture with a dry matter of 70% is produced with m_p kg of plant component, mixed with other additives, and partially dewatered fish component, which has not been processed into fish meal. The fish component will be comprised of raw fish weighing m_f, just like that which is obtained after dewatering in a press during the fish meal production process. Its dry matter is 50% [2], while the dry matter of mixture m_p is 90%, in accordance with the assumptions outlined earlier. The dry matter of this mixture is as follows:

$$0.7 \times 128.6 = 0.9m_p + 0.5m_f \quad (3)$$

Provided that:

$$m_p + m_f = 128.6 \text{ [kg]} \quad (4)$$

it can be calculated that m_p = 64.3 kg and m_f = 64.3 kg.

The weight of 64.3 kg of dewatered raw fish material with a dry matter of 50% is equal to 35.72 kg of fishmeal with a dry matter of 90%. Thus, these two components are equivalents with regard to composition and dry matter.

With this modified technology, fish meal is replaced with initially dewatered raw fish feed material. The equivalent of the fish meal content in the feed is determined not only by the quantity of initially dewatered raw fish feed material, but also by its degree of dewatering. Of course, if the introductory dewatering of the raw fish material is lower, then its maximum share in the feed is equal to a correspondingly smaller quantity of fish meal.

The key to the modification of the fish meal production process is to stop it at the stage when the heat-processed fish material is dewatered. This product is then used as a component in extruded mixtures. Since the dewatering of raw fish material to obtain fish meal is omitted, the energy savings are significant. In the case analyzed presently, it is 28.6 kg of water per 100 kg of extruded mixture. Assuming that the temperature of the partially dewatered fish in the boiler is 70°C, it is easy to calculate that heating this quantity of water to 100°C and its subsequent evaporation requires 19 kWh. Thus, omitting this stage of drying the raw fish material following heat processing and dewatering permits energy savings of 190 kWh/t of product.

Using the dry matters, it is simple to demonstrate the following for the assumptions made earlier (e.g. extruded mixture dry matter is 70%, fish meal, plant component, and additives dry matter content - 90%):

– the weight m_f of initially dewatered raw fish material to dry matter content dm_f, equivalent fish meal weight m_{fm} in 128.6 kg of extruded mixture ($m_p + m_{fm} + m_w$) is equal:

$$m_f = m_{fm} + 28.6 \text{ [kg]} \quad (5)$$

weight m_f should be initially dewatered to a dry matter content:

$$dm_f = 0.9 m_{fm} / m_f \quad (6)$$

It is equally easy to demonstrate that, regardless of the fish protein content of the feed, the energy saved with a set quantity of weight m_f dewatered to dry matter dm_f is constant at 190 kWh/t of product.

Modifying the production process depends on dewatering the raw feed materials to a dry weight the permits manufacturing a product with a prescribed fish protein content. This requires determining:

– an effective method for the introductory dewatering of raw feed materials,
– the dependency between the parameters of the dewatering method and the dry matter content of the dewatered raw material.

DEWATERING FISH FEED RAW MATERIALS

Dewatering can be accomplished using thermal, mechanical, or thermal-mechanical methods.

Due to the associated high-energy costs, thermal dewatering is the least cost-effective method. Mechanical dewatering requires the least amount of energy; it is, however, the least effective in dewatering raw fish material. This stems from the nature of raw fish in which the majority of its water is linked strongly with proteins. A compromise solution is the thermal-mechanical method, which is frequently applied, when feasible, to the expression of fluid from biological solids. In this method, the raw material is dewatered following initial preheating. In the case analyzed in this paper, the application of the thermal-mechanical method of dewatering is possible when the raw material is subjected to extrusion cooking in a later stage of processing. This is also why it is assumed that in the modified method of manufacturing extruded feed, the raw fish material will be dewatered with the thermal-mechanical method in the same way that it is in the production of fish meal. This means that typical, proven machines that comprise fish meal production lines can be utilized, i.e. cookers and twin screw presses. In this case the dry matter of raw fish material is 50% and its upper limit in the extruded mix calculated with formulae (5) and (6) is equal to a 35.7% share of fish meal. If a final product with an equivalent amount of fish meal of less than 35.7% is desired, then raw fish material of a lower dry matter content should be used when composing the mixture ingredients. The dry matter content of raw fish material that is the equivalent of the accepted fish meal content is presented in Figure 1 and was obtained from transformed formulae (5) and (6).

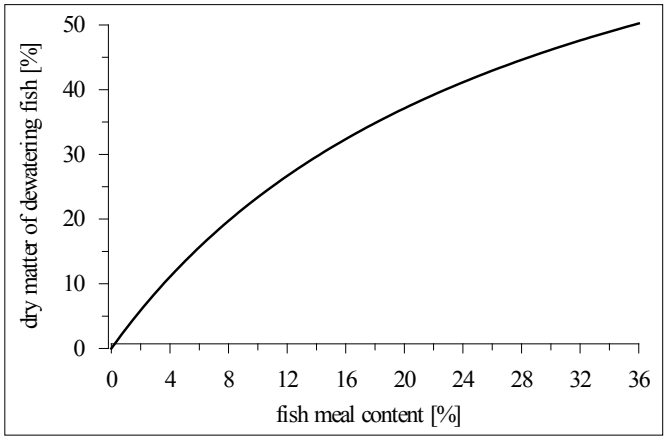

Fig. 1. The dry matter content of raw fish material that is the equivalent of the accepted fish meal content.

Rys. 1. Sucha masa surowca rybnego równoważącego przyjętą zawartość mączki rybnej w paszy.

Source: Own study

Źródło: Opracowanie własne

Raw fish material of a desired dry matter content can be obtained in two ways:

– dewatering raw fish material in a invariable manner to a constant dry matter content (e.g. like in fish meal plants) and then adding an appropriate amount of water to the extruded mixture;
– dewatering raw fish material in a controlled manner to a dry matter content that is equivalent of the accepted fish meal content (see Fig. 1).

The second method is decidedly more advantageous as energy costs are lower and it is simpler to realize. However, in case of pressing with a twin screw press under invariable conditions, it does require determining the dependencies between the temperature of preheated of fish raw material

and its dry matter as well as fat content after pressing. The regulation of the temperature of preheating should not present technical problems since boilers are equipped with thermal regulation systems.

CONCLUSIONS

The analyses presented in this paper indicate that the production of feed with a lowered fish meal content (maximum of up to approximately 36%) is less energy-consuming when fish meal is replaced with unprocessed raw fish material. The omission of the fish meal production stage will not influence microbiological purity of the product. Extrusion temperature is sufficiently high to secure the elimination of pathogens present in raw material that could possibly contaminate the feed.

The analyses also indicated that if the extrusion moisture is equal to 30%, the amount of energy saved is 190 kWh/t of product. This is independent of the share of the dewatered fish component. Only extrusion moisture has an impact; for single screw extruders it ranges from 22 – 32% (e.g. [3, 4]), which means that the amount of energy saved ranges from 140 – 190 kWh/t of product.

Obviously, with large-scale catches, processing into fish meal remains the best method to prevent spoilage, and to facilitate storage, distribution, and further processing. However, the modified technology of manufacturing plant-fish extruded feed presented here may be an attractive proposition for small enterprises that have a local source of raw fish feed materials. Not only does this method allow them independence from fish meal deliveries, it also permits reducing the costs of feed production, These savings will exceed those estimated in the analysis since the thermal efficiency of heat generators and dries used to dry the press cake were not considered. This modified production process is also significant in that it is more environmentally friendly since press cake drying, a source of unpleasant odour, is eliminated.

It should be added that the possibility of using raw fish feed material is increased significantly when twin screw extruders are employed since the moisture content of the extruded mixture can be as high as 75% [5]. Using these machines would facilitate producing a feed with significantly higher fish protein content, or allow the initial dewatering of the raw feed materials to be omitted.

WNIOSKI

Przedstawiona w artykule analiza wskazuje, że produkcja paszy dla ryb o obniżonej zawartości mączki rybnej (maksymalnie do około 36%) jest mniej energochłonna, gdy mączka rybna zastąpiona zostanie nieprzetworzonym surowym materiałem rybnym. Pominięcie etapu produkcji mączki rybnej nie wpłynie na czystość mikrobiologiczną produktu. Temperatura ekstruzji jest wystarczająco wysoka, aby zapewnić eliminację patogenów obecnych w surowcu, które mogłyby ewentualnie zanieczyścić paszę.

Analiza wykazała również, że w przypadku 30% zawartości wilgoci w ekstrudowanym materiale oszczędnośc energii w procesie produkcji paszy wyniesie 190 kWh/t produktu.

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VARIETIES OF DATE PALM FRUITS (*PHOENIX DACTYLIFERA L.*), THEIR CHARACTERISTICS AND CULTIVATION®

Odmiany owoców palmy daktylowej (*Phoenix dactylifera L.*), ich charakterystyka i uprawa®

The date palm Phoenix dactylifera L., due to deep and strong rooting, uses deep groundwater and can survive in oases in desert areas with low humidity and rainfall, even for over 100 years. It begins to bear fruit on average at the age of 5, and gives maximum yield only after 30-40 years. The date fruit is a berry consisting of skin, pulp, inner layer and seeds. There are over 600 varieties of dates around the world that differ in shape, size and properties of the fruit pulp. In addition, dates vary in color, shape and texture, depending on the ripening phase in which they are harvested: Hababouk, Kimri, Khalal, Rutab and Tamar. Appearance also depends on the type of crop and climatic conditions. In the immature state, the dates are green. However, during the ripening process, depending on the variety, they change color from yellow to red or brown. Dates also differ in water and sugar content, depending on the ripening phase. The sugar content in the early stages of ripening is about 20% of dry matter, and in ripe fruit reaches 72-88%. In terms of humidity and texture, dates are divided into fresh and soft, semi-dry and dry. About 90% of date palms are grown in the Middle East and North Africa. The main date producers are: Egypt, Saudi Arabia, Iran, Algeria, Iraq, Pakistan, Sudan, Oman United Arab Emirates and Tunisia.

Key words: *Phoenix dactylifera* L., date palm, dates chracteristics, dates varieties, cultivation.

Palma daktylowa Phoenix dactylifera L., dzięki głębokiemu i silnemu ukorzenieniu, korzysta z głębokich wód gruntowych i może przetrwać w oazach na terenach pustynnych o niskiej wilgotności i opadach, nawet ponad 100 lat. Zaczyna owocować średnio w wieku 5 lat, a maksymalny plon daje dopiero po 30-40 latach. Owocem daktylowca jest jagoda, składająca się ze skóry, miąższu, warstwy wewnętrznej i pestki. Na całym świecie jest ponad 600 odmian daktyli różniących się kształtem, wielkością i właściwościami miąższu owocu. Ponadto daktyle różnią się barwą, kształtem i teksturą, w zależności od fazy dojrzewania w której są zbierane: Hababouk, Kimri, Khalal, Rutab i Tamar. Wygląd zależy również od rodzaju uprawy i warunków klimatycznych. W stanie niedojrzałym daktyle są zielone. Natomiast podczas procesu dojrzewania, w zależności od odmiany, zmieniają barwę od żółtej po czerwoną lub brązową. Daktyle różnią się także zawartością wody oraz cukru, w zależności od fazy dojrzewania. Zawartość cukru we wczesnych stadiach dojrzewania wynosi około 20% suchej masy, a w dojrzałych owocach osiąga 72-88%. Pod względem wilgotności i tekstury daktyle dzielą się na świeże i miękkie, półtwarde i twarde, wysuszone. Około 90% palm daktylowych jest uprawianych w regionie Bliskiego Wschodu oraz Afryki Północnej. Głównymi producentami daktyli są: Egipt, Arabia Saudyjska, Iran, Algieria, Irak, Pakistan, Sudan, Oman Zjednoczone Emiraty Arabskie i Tunezja.

Słowa kluczowe: *Phoenix dactylifera L.*, palma daktylowa, właściwości daktyli, odmiany daktyli, uprawa.

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INTRODUCTION

Date palm *Phoenix dactylifera* L., otherwise known as date palm or date tree [18] is one of the oldest cultivated plants in the world [20]. It has been cultivated in the Middle East and North Africa for over 5,000 years [8]. His homeland was most probably the Persian Gulf [21]. However, due to the fact that this plant has been cultivated since the ancient times, its origin is difficult to determine [16].

Most noble date varieties are grown around Baghdad and along the Shat-El-Arab River. Palms of very old varieties that give inferior quality fruit are grown in Egypt and Sudan. For the followers of Islam, dates from Medina are regarded as the best in the world, where according to beliefs Muhammad himself fed them [17].

CHARACTERISTICS OF A DATE PALM

Phoenix dactylifera L. belongs to the *Arecaceae* palm family and can live over 100 years [10, 21]. The date palm reaches up to 35 m in height, and the diameter of its flexible trunk can be up to 50 cm [16]. At the end of it there is a plume of large, stiff, feathery leaves 3–6 m long [21]. There may be 80 to 120 leaves on one palm. One leaf lives up to 7 years, after which it dries [16]. As for rooting of the date palm, it characterizes with the fact that it does not develop the main root. Numerous roots, which go deep into the ground in search of water, grow from the base of the trunk [1, 16]. In addition, their characteristic features is that they have uniform diameters along their entire length, about 1.5 cm [16]. Thanks to such rooting, the tree can benefit from deep groundwater and can survive for a long time in oases in desert areas [5].

The date tree is a dioecious plant - it has both female and male flowers that are very similar to each other [6, 16]. Small, yellow flowers of the date palm are collected in very large inflorescences, from which, after 5 months of pollination, about 200 fruit – dates are formed [16, 17]. One female inflorescence can contain up to 10,000 flowers, and male many times more [1, 16]. Despite the large number of flowers, there is far too little pollen for proper pollination by the means of wind. In connection with this, for thousands of years man has been interfering in the process of pollinating the date palm manually [1].

The date tree begins to bear fruit on average at the age of 5, and gives maximum yield only after 30-40 years [21]. The fruit of the date palm is an ovate-cylindrical berry called the date, and its length is up to 7 cm [1]. The date palm blooms from February to June, and reaches full maturity in late autumn, when the color of its fruit changes from green to red-yellow [14, 17]. Until they dry up and a dark brown color appears, they are left on the tree [14].

The average date palm produces 40 kg of fruit per year. With intensive crop management, the amount of produced fruit can reach up to 100 kg, while with low input, the production is only 20 kg per year [8].

CHARACTERISTICS OF THE DATE PALM FRUIT

The date fruit is monocots up to 7 cm long. The date has an oblong shape, but some species can reach a sphere-like shape [1]. The date fruit consists of exocarp (skin), mesocarp (pulp), endocarp (inner layer) and seeds (pits). Mesocarp is

Table 1. Characteristics of the most popular date varieties [5, 13, 15]

Tabela 1. Charakterystyka najpopularniejszych odmian daktyli [5, 13, 15]

Variety	Color	Characteristics
Amari	dark brown	soft, sweet, medium size fruit, eaten as dried
Barhi	amber to red-brown	soft fruit, shape broadly ovate to rounded, skin medium thick, smooth and translucent, sweet, very delicious and luscious recommended for consumption fresh at the khalal stage
Deglet Nour	dark brown	shape oblong-ovate, skin medium thick, fruit semi-dry, firm, soft with a unique taste
Fard	dark brown	semi-dry, fruit sweet and pungent shape of thick cylindrical, skin medium thick
Hadrawi	dark brown	dry dates. sweet and fleshy
Hallawy	golden brown	fruit soft, sweet, caramel-like, translucent, shape of oblong with rounded apex, skin thin
Hayani	black and shiny	soft date with not too sweet taste, fruit with an oblong shape
Kabkab	dark brown to black	soft, long shape, unripe date can be consumed after cooking and drying
Khadrawi	red to brown	fruit soft, melting and caramel-like, shape of elliptical to ovate, skin medium thick and tender
Khalas	amber to red-brown	delicious fruit, shape oblong-oval, skin thin, fruit tender, melting, translucent
Khasab	red to brown-black	shape of rounded oval, tough separating skin, fruit thick
Lulu	dark amber	soft and sweet, shape of oblong-oval, fruit thick, less fibrous flesh
Mazafati	dark brown to black	soft and fleshy, cylinder shape, desirable taste
Medjool	light brown to dark brown	fruit soft, large and sweet with an attractive appearance, consumed soft or dry
Piarom	dark brown to black	semi-dry and fleshy, long and thin shape, one of the most expensive and desirable in the world
Rabbi	red to dark brown	semi-dry and fleshy, long and thin shape
Zahidi	yellow to brown	dry, semi-dry, oblong-ovate shape, skin thick, fruit firm, not very sweet with smooth consistency

Table2. Date ripening phases [1, 2, 3, 8, 16, 19]. Source of photo [3] Available via license: CC BY-NC-SA 3.0
Tabela 2. Fazy dojrzewania daktyli [1, 2, 3, 8, 16, 19]. Źródło zdjęć [3] licencja CC BY-NC-SA 3.0

Appearance	The maturation phase	Characteristics of the fruit	Duration of the phases
	Hababouk	The fruit is round, cream-colored to light green, the fruit has a slow growth rate.	4 – 5 weeks
	Kimri	Fruits in this phase significantly increase their size and weight, are green, unripe with a high concentration of tannins	9 - 14 weeks
	Khalal	In this phase, the rate of weight gain and size decreases significantly, the fruit is already physiologically ripe, full-size, characterized by a red-yellow color, crispy and hard texture, tart taste resulting from the high content of tannins	3- 5 weeks
	Rutab	The fruit in this phase is semi-ripe, juicy, the color of the skin darkens to an amber color, brown or black, the fruit becomes less tart, and begins to soften from the top	2 – 4 weeks
	Tamar	The fruit in this phase is already fully ripe, soft, brown in color, characterized by low moisture content and high sugar concentration	2 – 4 weeks

the bulk of the fruit (85-90%), consists of epithelial cells and is divided into external and internal mesocarp [11, 13]. The flesh is surrounded by a thin layer of skin that is meant to protect the fruit [11].

However, the date seed represents 6-15% of the fruit weight, depending on the species, and is a valuable by-product of the date processing industry. The steed characterizes with the presence of a furrow of variable depth and width along its length. Seeds of different date varieties differ in the depth of the furrow. The date palm fruit seed characterizes with a high content of dietary fiber and can be used to increase the content of dietary fiber in some products [13]. The seed contains mainly insoluble fractions of dietary fiber, e.g. the date seed Deglet Noor contains 50% cellulose and 20% hemicellulose. Date seeds are mainly used in the production of animal feed [23].

DATE VARIETIES, THEIR CHARACTERISTICS AND STAGES OF RIPENING

There are over 600 varieties of dates differentiated around the world based on shape and organoleptic properties [11]. There is a significant intra-species diversity, manifesting itself in the variable shape, size and properties of the fruit flesh [21]. It is possible to guess the origin of dates by their appearance, color and taste. Table 1 presents the characteristics of the most popular date varieties.

The variety of color, shape, size and appearance of dates is shown on a selected example of date varieties grown in Libya (Fig. 1).

However, Medjool, which characterized with their large size and attractive appearance and taste, Deglet Nour best known in the Middle East with for its unique taste and Barhi recommended for consumption at the Khalal stage belong to the most desirable date varieties [5].

In the immature state, the dates are green. However, during the ripening process, depending on the variety, they change color from yellow to red or brown [1, 21]. Maturation can be distinguished in five stages: Hababouk, Kimri, Khalal, Rutab, Tamar [1, 3] whose detailed characteristics regarding color, taste and texture changes are presented in table 2.

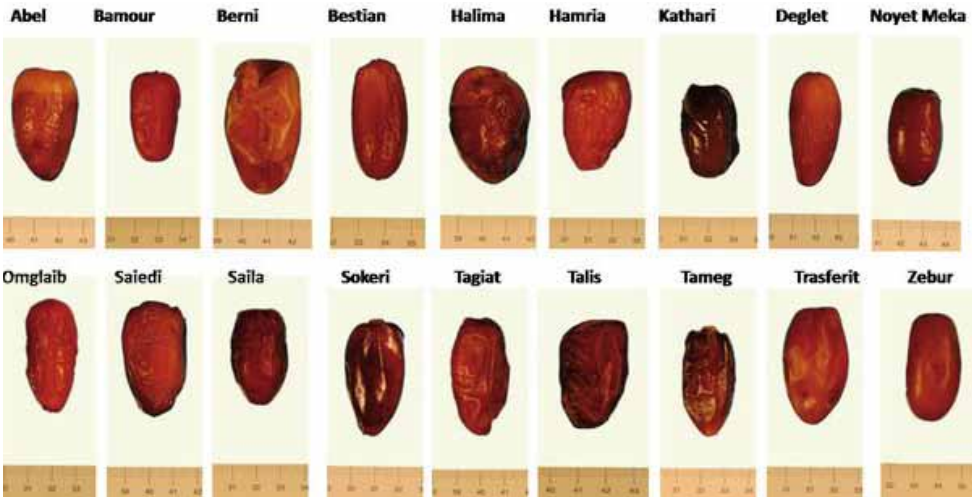

Fig. 1. Varieties of dates grown in Libya [22] Source: (IAO photograph archive).
Rys. 1. Odmiany daktyli uprawianych w Libi [22] Źródło: (IAO photograph archive).

The date variety has a huge impact on the harvest period. As a result of increasing sweetness, reducing bitterness, improving structure and juiciness, the fruits become edible in the last 3 stages of maturity Khalal, Rutab and / or Tamar [13]. The fruit with the highest nutritional value is the Khalal ripeness phase and then it is the most often consumed by the Arab population. However, for Europeans, they are too bitter [16]. Therefore, mainly fully riped dates, which are sweet, soft and juicy, are intended for export [2, 21]. They are oval in shape, reminiscent of plum and are sensitive to mechanical pressure [21]. Their fleshy pulp has a honey taste and a greasy consistency [16]. In addition, they are much easier to conserve than immature dates [2].

At Tamar, dates vary in size, shape, color, texture and taste depending on the variety, crop types and climatic conditions [8]. The shape varies from oval to cylindrical with dimensions: 3 - 11 cm in length and 2-3 cm in diameter. They are available in yellow, brown, red and black. Date varieties also differ in hardness and are classified according to humidity (Tab. 3) into three groups, soft, semi-dry and dry [4, 13, 16].

Table 3. Division of dates according to humidity and hardness [4, 13, 16]

Tabela 3. Podział daktyli w zależności od wilgotności i twardości [4, 13, 16]

Fruit hardness	Fruit moisture	Date varieties
soft	≥ 30%	Barhi, Halawy, Khadrawi, Medjool
semi-dry	20 - 30%	Dayri, Deglet Nour, Zahidi
dry	≤ 20%	Thoory

The water content of young fruits is 75-80%, and it decreases rapidly as ripening progresses. Depending on the ripening phase, the water content of dates changes, but also the sugar level changes. In the early stages of ripening, the sugar content in dates is about 20% of dry matter, and in ripe fruits it reaches 72–88% [8].

Soft dates, which are delicate and have a sweet honey flavor [17] contain mainly invert sugars (fructose and glucose), while they have a low sucrose content. Dry varieties, due to their high starch content, have a hard flesh, so in order to sense their delicate sweetness, they must be chewed and chewed for a long time [16, 17]. They also contain a relatively high sucrose content. Dry and hard dates are intended only for consumption by the local population and are highly valued especially in the Arab region [16]. In some areas, especially inhabited by a poor society, dry and hard dates are almost the only food for many months [16, 17].

According to Codex Standards for dates [9], dates are divided into cane sugar varieties containing mainly sucrose such as Deglet Noor and Deglet Beidha and invert sugar varieties containing mainly invert sugar – glucose and fructose, e.g. Barhi, Saidy, Khadrawa, Halawa, Zahidi, Sayer.

The amount of sugars and the ratio between the sucrose content and invert sugars (glucose and fructose) seems to affect the moisture, consistency and hardness of the fruit. Varieties with a high sucrose content are generally hard, while those with a high content of invert sugars are usually soft [13].

CULTIVATION AND PRODUCTION OF DATES IN THE WORLD

The date palm is one of the oldest cultivated plants by humans and has been used as food for almost 6,000 years. It is grown in a very warm and dry climate. To produce a large crop, these trees require a long and intensely hot summer with low rainfall and very low humidity, especially during the pollination to harvest. Ensuring constant access to water or frequent irrigation is also key [8, 16]. The daily intake of water by an adult palm is estimated around 150 – 200 liters. Not without reason one of the old proverb says that the date palm grows „with feet in water and head on fire." Moisture negatively affects the quality of the fruit, because high humidity leads to its cracking [19]. The ideal temperature for the growth of date palm is between 25 and 32°C [5]. For flowering it needs a temperature above 18 °C, and for fruit ripening above 25°C. However, these plants can withstand the heat up to 50°C and temporary frosts – 5°C [8]. Date palm grows on various soil types, but the best yield is obtained on sandy loams [5]. It is relatively resistant to saline and alkaline soils, which is why it can be planted in soils with varying levels of organic and mineral nutrients [8, 19]. The date palm tolerates salinity best of all cultivated fruit plants [19, 25].

In the regions of the Arabian Peninsula, North Africa and the Middle East, date cultivation is one of the most important fruit crops [8]. Due to the rapidly growing demand for dates, their production has increased significantly in recent years [1], as evidenced by, among others its introduction to production areas in South Africa, the United States, Australia, India and Mexico [8]. It is estimated that there are over 100 million trees in the area of 1 million hectares worldwide [11]. About 90% of the palm trees are grown in the warm and dry region of the Middle East and North Africa. The main producers of date fruit are: Egypt, Saudi Arabia, Iran, Algeria, Iraq, Pakistan, Sudan, Oman United Arab Emirates and Tunisia. Most dates are produced in Egypt [12]. Table 4 lists date varieties produced by the largest producers in the world.

Small date plantations are also found in Europe, including in Spain, southern Greece and the Ligurian Coast and many Mediterranean islands. Date palms are also grown near Rome, but mainly to supply the city's inhabitants with palm leaves during Palm Sunday [17].

Dates play an extremely important role in the functioning and development of the economy, society and the environment of Saudi Arabia, Egypt and Iran [8]. Date cultivation is the main source of income and is the basis of nutrition for local populations, e.g. domestic consumption in Saudi Arabia is 58 kg, and in Iraq 50 kg per person per year [8, 21]. In Egypt, Iran, Pakistan and Saudi Arabia, most of the production is directed to local markets. In contrast, Iraq, Algeria, Morocco and Tunisia focus on the export of raw material to Europe [5]. The largest date exporters include: United Arab Emirates, Pakistan, Iraq and Iran. Then Tunisia, Israel, Saudi Arabia. Egypt, Algeria and Oman have a much smaller share in exports [12]. It is estimated that around 250,000 tonnes of dates are sold on the international market [5].

India, the United Arab Emirates and Morocco belong to the largest date importers. Date exports, especially to the United States of America and the European Union, are subject to

Table 4. Countries that are the largest producers of dates and varieties of cultivated dates [4, 12, 13, 15]
Tabela 4. Kraje, które są największymi producentami daktyli i odmiany uprawianych daktyli [4, 12, 13, 15]

Country	Varieties of cultivated dates
Egypt	Amhat, Hayany, Samany, Siwi, Zoghloul
Saudi Arabia	Ajwa, Al-Barakah, Al-Qaseem, Berhi, Gur, Helwet El-Goof, Hiladi, Hulwa, Khalasah, Khasab, Majnaz, Mishriq, Miskani, Nabbut Ghrain, Nabtat Seyf, Rothanat, Ruzeiz, Sag' ai, Sebakat Al-Riazh, Sahal, Sellaj, Shashi, Sokkary, Tanjeeb, Tayyar, Thamani, Umelkhashab, Um Rahim, Zamil, Zaghloul
Iran	Allmehtari, Barhi, Dayri, Estamaran, Gantar, Halawi, Kabkab, Khassui, Khazravi, Mazafati, Mordarsang, Piarom, Pyarom, Rabbi, Sayer, Shahani, Shakkar, Sowaidani, Zahedi
Algeria	Deglet Nour, Iteema, Thoory
Iraq	Amir Hajj, Barhi, Dayri, Halawy, Khadrawi, Khastawi Maktoom, Sayer, Zahidi
Pakistan	Basra, Dhakki, Gulistan, Hsaini, Kajur, Khadrawi, Mobini, Mozafati, Obaidullah, Sabzo, Shakri, Zaidi
Sudan	Abid Rahim, Barakawi, Bentamoda, Birier, Gondaila, Jawa, Khatieb, Kulma Suda, Medina, Mishriq, Mishriq Wad, Mishriq Wad Lagi, Zughloul
Oman	Fard, Khalas, Khasab
United Arab Emirates	Berhi, Bomaan, Khalas, Lolo, Fard
Tunisia	Ammari, Angou, Arichti, Bejjou, Bisr Helou, Bouhattam, Brance de dates, Deglet Nour, Eguiwa, Ftimi, Garn ghazel, Gounda, Gousbi, Hamraya, Hissa, Kenta, Kentichi, Ksebba, Korkobbi, Lagou, Lemsi, Mattata, Mermella, Rouchdi, Touzerzayet

international marketing standards [25]. This involves, among other things, the creation of specialized farms, packaging stations and warehouses that must meet international quality requirements [5]. Dates with standardized color, size, texture, and resistance to pests and insects are widely accepted worldwide [25]. The most commonly used standards are those recommended by Codex Standards for dates [9]. The Codex limit for dates is 6% of defective fruits, regardless of whether the damage is visual or is due to the presence of dead insects [25]. At present, the lack of international standards has a negative impact on the date industry market in Saudi Arabia, United Arab Emirates, Oman, and Kuwait. These countries account for around 30% of world date production [25]. However, the need to meet international standards is associated with a reduced diversity of date species in new plantations. Growing only a few species of dates leads to an increased risk of damage caused by pests or disease [5].

APPLICATION OF DATES

Dates, depending on the species, can be consumed raw or dried [7]. They can be used to create products such as date flour, jams, juices, dietary fiber concentrates, date-based fruit bars, functional ingredients in drinks. They are used in the dairy and bakery industry [13] for the production of alcoholic beverages [21] or date butter [17]. Date syrup or date sugar can be used as a substitute for sucrose [24].

However, the big problem is the overproduction of dates, especially those of low quality, which leads to huge losses of raw material [19]. They are used to produce refined sugar, concentrated juice, confectionery pastes and fermented products [23]. Fruits of the lowest quality are dehydrated, ground and mixed with grains to create feed for camels and horses in the desert [13].

CONCLUSIONS

The cultivation of dates in the regions of the Arabian Peninsula, North Africa and the Middle East is one of the most important, which is largely due to the adaptability of the date palm to harsh climatic conditions, low humidity, lack of rainfall and high soil salinity. The cultivation of the date palm is also the main source of income, and dates are the basis of nutrition for local populations. For example, in Iraq, the consumption of dates per person per year is 50 kg. Despite the huge number of varieties of dates characterizing with various sensory, nutritional and health-promoting properties creating great possibilities of their use in the food industry, their popularity in other parts of the world is not high. In addition, despite the numerous possibilities of managing lower-quality dates, huge losses of raw material occur every year, which is why new solutions are needed to fully utilize them.

PODSUMOWANIE

Uprawa daktyli w regionach Półwyspu Arabskiego, Afryki Północnej i Bliskiego Wschodu należy do jednych z najważniejszych, co w dużym stopniu wynika ze zdolności adaptacyjnych palmy daktylowej do trudnych warunków klimatycznych, niskiej wilgotności, braku opadów i dużego zasolenia gleby. Uprawa palmy daktylowej stanowi także główne źródło dochodów, a daktyle są podstawą żywienia dla lokalnych populacji. Przykładowo w Iraku konsumpcja daktyli na jedną osobę w ciągu roku wynosi 50 kg. Pomimo ogromnej ilości odmian daktyli chrakteryzujących się różnorodnymi właściwościami sensorycznymi, odżywczymi i prozdrowotnymi stwarzającymi duże możliwości ich wykorzystania w przemyśle spożywczym, ich popularność w innych zakątkach świata nie jest duża. Ponadto pomimo licznych możliwości zagospodarowania daktyli niższej jakości, co roku dochodzi do ogromnych strat surowca, dlatego potrzebne są nowe rozwiązania pozwalające na ich pełne zagospodarowanie.

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BUSINESS DEVELOPMENT INSPIRED BY THE HERITAGE OF THE LOCAL FOOD PRODUCT®

Rozwój przedsiębiorczości inspirowany dziedzictwem lokalnego produktu żywnościowego®

Cultural heritage is a part of the economy that should be successfully used. Traditional food products are becoming a kind of investment for local communities and an incentive to achieve socio-economic benefits. They are part of the heritage, and given the changing trends and the growing demand for local food products, they can contribute to the development of entrepreneurship.

Key words: business development, cultural heritage, local food.

Dziedzictwo kulturowe jest częścią gospodarki, którą należy z sukcesem wykorzystać. Tradycyjne produkty spożywcze stają się dla lokalnych społeczeństw swoistą inwestycją w przyszłość i stymulatorem do osiągania korzyści społeczno-gospodarczych. Stanowią element dziedzictwa, a uwzględniając zmieniające się trendy i rosnący popyt na lokalne produkty żywnościowe mogą przyczyniać się do rozwoju przedsiębiorczości.

Słowa kluczowe: rozwój przedsiębiorczości, dziedzictwo kulturowe, lokalny produkt żywnościowy.

INTRODUCTION

Socio-economic development has contributed to the conscious shaping of entrepreneurship and product.

The concept of entrepreneurship is constantly modified under the influence of changes in the operating conditions of economic entities. Entrepreneurship is commonly associated with economic and economic issues, in particular the process of organizing and running a business as well as taking the associated risk. Entrepreneurship is perceived as an attitude that brings the assumed effects using non-standard activities and innovations [3, 5, 6].

The development of entrepreneurship of individual entities largely depends on the local environment. Entrepreneurial environments arise as various forms of interdependence and cooperation within a given territory. There are local and regional entrepreneurial environments that are the result of cooperation between the private, public and social sectors and the creation of rational entrepreneurial behavior of various market players. The entrepreneurial environment operates on the principles of its own logic, the basics of which should be sought in the cooperation of various entities involved in local development. Their partnership based on interrelationships and a system of stable relationships that develop over time allows them to better value the resources they have. Mutual relations between partners and cooperation contribute to the generation of special external effects. An important role here is knowledge of dependencies, which is a set of rules of conduct in socio-economic contacts dominating in a given territory [2].

The market of traditional and regional products is a relatively young branch of the Polish food industry. Traditional and regional products, not only are a permanent element of menus, they also shape local identity, becoming an important product of the tourism industry. The wealth of traditional, regional food, which is a material trace of the past, reflects an important idea that has an impact on building identity. The region's culinary achievements and tradition are not only a regional value, but also a significant part of Polish and European heritage [8].

The purpose of the study, which is theoretical and review, is to show the role of the local food product in the development of entrepreneurship.

ENTREPRENEURSHIP

Entrepreneurship is an interdisciplinary issue whose role we see in many areas of economic life. This is a socio-economic phenomenon, and for this reason it should not be considered only one-dimensional.

Economic dynamics, the ability to raise income and improve the standard of living of members of society depend on the entrepreneur and the entrepreneurship he exhibits. Entrepreneurship is a manifestation of freedom, dynamism and creativity. A feature of a well-functioning state, society and economy is the creation of conditions for the greatest opportunity to decide about the development of the individual, by himself. This is the foundation of the subsidiarity principle on which the institutional order in the European Union and in Poland is built. The functioning of enterprises located in

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various regions of the country is subject to the impact of factors occurring on a regional, national, EU and global scale. The development of local entrepreneurship ensures a higher quality of life, affects human and social capital, and also brings specific benefits to entrepreneurs and local authorities. In the era of increasing competition and overproduction of all kinds of products, it is extremely important to stand out on the market and win the trust of customers [19].

THE HERITAGE OF A LOCAL FOOD PRODUCT

The heritage of a local food product is not only a guarantee of arousing interest and attracting consumers or investors, but also a very strong support for the development of innovative processes and increasing the competitiveness of local enterprises.

According to the definition contained in the PWN Polish Dictionary, heritage is the cultural, scientific and artistic goods left by previous generations. Values that can take various forms are a key determinant of heritage elements. These values can fall into different categories and can be identified by different entities. Heritage points to its role as a testimony to the lives of our ancestors, the way we understand reality and the recognized system of values, helping us learn about our roots and shape our identity. A sense of cultural community is also created on the foundations of heritage. By discovering and highlighting the potential and heritage of the region, you can create an attractive offer for specific users. Heritage is perceived as a market product with an important share in the local development proces [10, 16].

It becomes appropriate to determine the economic value of the elements of cultural heritage constituting its local resource. To use them properly, attention should be paid to the potential that may affect development. Consumers appreciate the authenticity, ingenuity and quality of the product. It is worth developing and promoting authentic products based on a local, traditional resource [14].

The social values of heritage will result from the recognition of specific elements of heritage as important in shaping or consolidating identity. Elements of heritage, including local food products are treated as a resource for the development of entrepreneurship. Regional and local cultural heritage is often part of the tourist product that finds buyers. However, the share of heritage in tourism is not the only way to use its economic value. Local cultural heritage enjoying social recognition is increasingly becoming an important resource for the cultural industry and the creative sector, which in the world is considered one of the future sectors of the economy, and can also be an important factor in local entrepreneurship. Awareness and knowledge about heritage and its creative use can contribute to building identity and interpersonal relationships. Therefore, heritage can fulfill an integrating function at a time when fewer and fewer factors maintain social bonds. The heritage of a local food product is also a resource from which you can draw inspiration and content to organize cultural and social life in a commune. Cultural heritage is also an opportunity for economic development based on innovation and local entrepreneurship and using cultural diversity as a factor of competitiveness. The heritage of a local food product is a resource that can be used in a variety of ways by different actors. Thanks to this, it can contribute to the growth of absolute economic values, such as the number of jobs or the number of business entities operating in the commune. At the same time, the locality of cultural heritage means that it will "work", above all, for its community. Heritage as a resource is multidimensional, so rational planning and implementation of its protection and use of its value can bring many benefits to the municipality. In addition, a wisely used and effectively protected heritage resource can serve the municipality continuously and a community with lasting relationships can be built around it [7, 15].

Of the local consumer goods offered, local food, known as traditional, regional or local, deserves special attention. European Union policy prioritizes the production of traditional food and original agricultural products, creating a special food protection and promotion system. The important role of food in the development of the European Union is emphasized by the European Commission, which clearly indicates in its documents that the EU has a diverse culinary heritage that should be fully utilized.

LOCAL, TRADITIONAL AND REGIONAL PRODUCTS

Local, traditional and regional products have a positive impact on local communities, strengthening local social ties, consolidating the environment, consolidating the favorable image of the region in the eyes of the whole society. Traditional food products with special quality features are part of the Polish cultural heritage, which for centuries created values, customs, culinary habits and flavors.

The Act of 17 December 2004 on the registration and protection of names and designations of agricultural products and foodstuffs as well as on traditional products (Dz.U. z 2019, poz. 915 ze zm) ordered the Polish system of regional and traditional products. Pursuant to the provision of art. 47 of the Act, traditional products are agricultural products and foodstuffs (...) and spirit drinks, (...) whose quality or unique features and properties result from the use of traditional production methods, which are part of the cultural heritage of the region in which they are produced, and being part of the identity of the local community._Traditional methods of production are considered to have been used for at least 25 years [16].

The concept of traditional food was introduced by the Council Regulation EC No. 510/2006 of 20 March 2006 (Dz. Urz. UE L 93 z 31 marca 2006 r.) [13] on the protection of geographical indications and designations of origin for agricultural products and foodstuffs as well as the Regulation of the Council EC No. 509/2006 of 20 March 2006 (Dz. Urz. UE L 93 z 31 marca 2006 r.) [12] on agricultural products and foodstuffs that are guaranteed traditional specialties, as well as the Act of 25 August 2006 on food safety and nutrition (Dz.U. z 2019, poz. 1252 ze zm) [18].

The European Commission has given a definition of traditional food products, according to which the adjective 'traditional means proven use on the Community market for at least 25 years, handed down from generation to generation'. Traditional products are therefore characterized

by the traditional method of production, using traditional raw materials, use native animal breeds, and information about them is passed down from generation to generation. The regional product refers to its relationship with the natural environment of the area (topography, climate, soil type). Its high quality and reputation is related to the region in which it is produced, but the region does not have to be a region in a geographical sense, but rather means the area with which the production of the product is associated.

MARGINAL, LOCAL AND LIMITED ACTIVITIES

The possibility of conducting marginal, local and limited activity (MOL) is a response to the expectations of entrepreneurs operating on a small scale in family factories producing a certain type of products, often with specific characteristics for which there is a demand mainly on the local market. Such manufacturers are usually not interested in placing their products on the market outside the territory of the Republic of Poland. Detailed conditions enabling the activity to be considered as marginal, local and limited, including the scope and area of production, as well as the volume of deliveries of animal products to plants carrying out retail trade for the final consumer are specified in the Regulation of the Minister of Agriculture and Rural Development of 21 March 2016 on the detailed conditions for recognition of marginal, local and limited activities (Dz.U. z 2016 r. poz. 451) [11]. This regulation also indicates some additional veterinary requirements that should be met when conducting this type of activity (in addition to the requirements set out in Regulation 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs). It is most often this group of entrepreneurs who runs family plants producing products for the local market. MOL's domain is regional products, manufactured according to a traditional recipe. MOL's activities may be conducted only to a marginal extent in relation to the basic agricultural activity, locally and only to a limited extent, and products of animal origin processed on the farm should be sold directly to final recipients. It is also possible to supply these products to other retail establishments for the final consumer. The nature of MOL's activities is also determined by its area of operation. Places of production and sales, as well as plants conducting retail sales must be located in the area of one voivodship in order to confirm its local character or in the areas of neighboring poviats located in other voivodships. As part of MLO's operations, it is also allowed to sell products in the areas of cities that are the seat of the voivode or regional council in the voivodships neighboring the voivodship in which these products are produced. The restrictions on the sales area do not apply during exhibitions, festivals, fairs and fairs organized to promote these products. In such a situation, the entity must inform about the intention to sell the poviat veterinary officer competent for the place of sale. The information should be provided in writing within 7 days before the start of this sale. Activities can be considered marginal, local and limited if the establishment conducts: cutting of fresh beef, pork, sheep, goat, horse, poultry or lagomorphs, cutting of fresh meat of game animals shot in accordance with hunting law, cutting of fresh meat of wild animals kept in farm conditions, production of minced meat, raw meat products, production of meat products, production of pre-processed or processed fishery products, production of dairy products or products based on colostrum made from milk or colostrum, obtained on a milk production farm within the meaning of Regulation No 853/2004 or on an agricultural holding where raw milk or colostrum production is carried out, for direct sale, the production of egg products obtained as a result of working or processing and eggs that have been previously cooked in shells, the production of prepared meals (dishes) from animal products (mentioned above), or with the participation of these products, provided that at least one animal product belonging to the main meal ingredients has been produced in this establishment.

The global trend of returning to natural food products means that entrepreneurship inspired by the heritage of a local food product is a fact. An important opportunity for producers of local, traditional and regional food is cooperation between various entities.

The development of the regional, traditional and natural high-quality food sector and the creation of sales places will lead to the development of entrepreneurship, including connected with tourism. An important aspect is also establishing interregional cooperation in the field of local development. Local food products can create a region's market advantage and influence the development of entrepreneurship in a given area. Increasingly, tourists are looking for real products that have their own history, manufacturer, are specific and unique for this area. Such products are local food products, unique and unavailable in other places. These products are characterized by high quality, which is associated with the place and the traditional method of production. Culinary heritage becomes for local societies a kind of investment in the future and a stimulus for achieving socio-economic benefits, including the development of entrepreneurship.

SUMMARY

Culinary heritage becomes for local societies a kind of investment in the future and a stimulus for achieving socio-economic benefits, including the development of entrepreneurship. Every economic initiative starts with an idea and a resource on which ideas can be developed. Then you need a market, i.e. someone who will buy our product or service. It is important to be noticed, that the product is unique, that there is a demand for it. All these classic elements of entrepreneurship work for products created on the basis of the local food product heritage. The development of entrepreneurship inspired by the heritage of the local food product makes it possible to implement especially those undertakings whose idea is based on locality, neighborhood, ecology, nature, social authenticity and corporate responsibility. This is the opportunity to create something unique, different from the competitors' offer. The combination of traditional products with modern methods of processing, presentation and sales creates an innovative, highly competitive product. Products of local food heritage create a new clientele among tourists who are more and more aware consumers and residents who want to identify with the place of origin or residence. Local food products can create a region's market advantage and influence the development of entrepreneurship in a given area.

PODSUMOWANIE

Dziedzictwo kulinarne staje się dla lokalnych społeczeństw swoistą inwestycją w przyszłość i stymulatorem do osiągania korzyści społeczno-gospodarczych, w tym do rozwoju przedsiębiorczości [1]. Każda inicjatywa gospodarcza zaczyna się od pomysłu i zasobu, na bazie którego pomysły można rozwijać. Następnie potrzebny jest rynek zbytu, czyli ktoś, kto kupi nasz produkt czy usługę. Ważne, żeby zostać zauważonym, aby produkt był wyjątkowy, aby istniało zapotrzebowanie na niego. Wszystkie te klasyczne elementy przedsiębiorczości działają w przypadku produktów tworzonych na bazie dziedzictwa lokalnego produktu żywnościowego. Rozwój przedsiębiorczości inspirowany dziedzictwem lokalnego produktu żywnościowego umożliwia realizację zwłaszcza tych przedsięwzięć, których pomysł opiera się na lokalności, sąsiedztwie, ekologii, naturze, autentyczności społecznej i odpowiedzialności biznesu. To możliwość stworzenia czegoś wyjątkowego, różnego od oferty konkurentów. Połączenie tradycyjnych produktów z nowoczesnymi metodami obróbki, prezentacji, sprzedaży tworzy innowacyjny, bardzo konkurencyjny produkt [4]. Produkty dziedzictwa lokalnego produktu żywnościowego tworzą nową klientelę wśród turystów, którzy są coraz bardziej świadomymi konsumentami oraz mieszkańców, którzy chcą identyfikować się z miejscem pochodzenia czy zamieszkania [17]. Lokalne produkty spożywcze mogą tworzyć przewagę rynkową regionu i wpływać na rozwój przedsiębiorczości na danym obszarze [9].

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THE MARKETING COMMUNICATION INNOVATIONS IN RELATIONS WITH CUSTOMERS OF CATERING ENTERPRISES – CASE OF POLAND®

Innowacje w komunikacji marketingowej w relacjach z klientami przedsiębiorstw gastronomicznych – przykład z Polski®

The article of the study was the analysis of innovative activity in the field of marketing communications in companies catering in Poland for 2014-2016. *It has been shown that in most companies changed the aesthetics of the interior of the premises or introduced other creative modifications, eg. new dishes, menu cards, logos, or whether the ambient. Managers implemented new or significantly changed ways of communicating with the client, including the methods of selling and providing services (eg. e-marketing, delivery of meals at home). The effect of the marketing novelties implemented was to increase the range of product or service offer, company prestige and share and competitiveness on the market.*

Key words: innovations, marketing communication, customers, catering enterprises, relations with customers.

Celem artykułu jest analiza aktywności innowacyjnej w obszarze komunikacji marketingowej w przedsiębiorstwach gastronomicznych w Polsce w latach 2014-2016. *Wykazano, że w przedsiębiorstwach najczęściej zmieniano estetykę wnętrza lokalu lub wprowadzano inne twórcze modyfikacje, np. nowe potrawy, karty menu, logo, obiektu czy otoczenia. Przedsiębiorcy wdrażali nowe lub istotnie zmieniali sposoby komunikacji z klientem, w tym również metody sprzedaży i świadczenia usług (tj. e-marketing, dostawa posiłków do domu). Efektem wdrażanych nowości marketingowych było powiększenie asortymentu oferty produktowej lub usługowej, prestiżu firmy oraz udziałów i konkurencyjności na rynku.*

Słowa kluczowe: innowacje, komunikacja marketingowa, klienci, przedsiębiorstwa gastronomiczne.

INTRODUCTION

The development of the gastronomic services market, rapid technological and technical progress as well as permanently changing customer needs and expectations influence the importance of maintaining and building their loyalty. In addition, increasing globalization, intensified competition and increased access of consumers to modern technologies necessitate increased innovative activity of modern gastronomic enterprises. Close and lasting customer relationships allow companies to achieve many benefits related primarily to improving communication, reducing costs, increasing turnover and providing better, more satisfying customer service [16, 24, 32, 42].

Innovative activity is primarily related to the development and implementation of technical, organizational and marketing innovations, such as research and development, the purchase of licenses, purchase and assembly of machinery and equipment, and the construction, extension or modernization of buildings or technological lines to implement innovation, implementation work, personnel training or marketing of new and modernized products [28, 34]. The ability to create and implement new products is the foundation of progress and determines its economic dynamism on the market [7, 10, 29, 37].

Nowadays, in such a competitive market, for the sake of sustainable management, catering companies are forced to focus on strengthening customer satisfaction [11, 43]. Modern enterprises attract consumers with convenience, time savings and diversity of offered products and services. Enterprises must distinguish themselves by something unique, which is the most interacting in a multi-sensory way, so that the customer can have as many positive associations as possible with a given place or product. Traveling, staying in an unusual gastronomic establishment and eating meals there are both learning about the atmosphere of a given place, as well as interesting flavours of dishes or original cuisine [12].

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The aim of this study is to analyze selected aspects of innovative activity in the field of marketing communication in catering enterprises. A research hypothesis was made: innovative activity and effects of these activities demonstrated in catering enterprises in Poland show differences due to the period of functioning on the market, the area of basic activity and the financial standing of the catering enterprise.

To achieve the aim of the study and to verify the presented research hypothesis, the results of secondary data based on a critical analysis of the literature and primary research from individual interviews with persons responsible for management processes in catering establishments were used.

MODERN MARKETING SOLUTIONS THAT BUILD CUSTOMER RELATIONSHIPS CATERING COMPANY

Satisfied and loyal customers are the largest capital of every modern enterprise. The key to success is the emotional bond and care for customer satisfaction that favors consumer loyalty. Loyalty and trust are the result of a strong relationship with the client company [6, 26, 41, 45].

Strong and long-term relationships between the company and its clients, from the point of view of maintaining a competitive advantage on the market, are becoming more and more important in the service sector. These relationships should be of a reciprocal nature, guaranteeing constant communication and unrestricted flow of information between the service provider and the client. The interpersonal nature of services fosters the building of such ties and allows for achieving a number of benefits, mainly acquired as a result of mutual information exchange, mutual planning and risk sharing, reconciliation of activity ranges or joint investments. These include: better communication with the client, better organization of customer service processes, faster adaptation of the offer to the customer's needs and increasing sales [16].

Modern competitiveness is facing many difficulties, mainly due to the increasingly frequent emergence of new technologies and platforms. In order for companies to be innovative and successful, managers have to face these challenges [9]. Therefore, enterprises are increasing the efficiency and continuous efforts to improve the quality of their services by introducing state-of-the-art marketing management and communication support applications [33]. Also the Polish market of gastronomic services in the last decade has been dominated by IT system solutions that support activities in the field of marketing as well. Solutions are used to facilitate customer access to the offer and information about it. Catering companies on their websites post information about operating hours, the range of the offer, menus, additional services, and present photo galleries. Specialized portals allow for quick retrieval of the consumer catering offers, compare prices, get to know the opinion of other users on the quality of services provided. In addition, among the modern technologies are used, among others: Smartphone's to book a table or ordering dishes in a stationary or delivery to a designated place, tablets or interactive tables instead of information folders or menu cards in a restaurant. Payments for services rendered can be made online, and special applications allow the use of loyalty programs, which entails financial benefits [3, 36, 47]. IT systems intended for gastronomy are also designed to speed up the service and make it easier for the owner or manager of the premises to manage the company. Properly selected software affects the acceleration and improvement of the service, as well as the reduction of losses resulting from staff errors, bad dispensing of articles or theft [4].

Regardless of the type of input product or service, the trader must communicate with its customers through a broad marketing activities. Therefore, marketing innovation means the use of a new marketing concept or strategy, e.g. changes in the way the service is presented, promoted, positioned, priced or distributed. It is a reflection of human creativity and is closely related to the skilful use of resources [15, 17, 28, 42].

Table 1 presents examples of innovative activity on the polish market of gastronomic services in this area.

To shape relationships with the client, you can use a well-functioning and satisfying loyalty program that customers want to belong to. This type of marketing creates a stable and beneficial network of customer connections [21, 45]. This programs are specially designed by enterprises in order to create the differences in features and adequate customer care. The behaviour patterns and emotional reaction of consumer towards rewards in loyalty program and membership system itself play a role in terms of enhancing the purchasing of the existing customers and drawing mew clients [2, 5]. The main task of loyalty programs is to reward regular, selected clients with attractive and targeted offers only. The most common forms of loyalty programs are: cards of regular customers (entitling to various types of discounts); company periodicals for clients containing information about the company, current offer; letters to buyers (facilitate the transfer of relevant information); hot phone lines (a method of direct communication with clients); advising consumer clubs and creating offer co-designers from them; joint, special events of a special events nature, in order to create a family atmosphere between the company and clients [6, 21, 30, 45]. In addition, in gastronomy, hot spots, bookstores, concerts, performances, shows, sports events, galleries in premises, as well as special playgrounds etc. [36]. Businesses are increasingly looking for innovative solutions in the field of marketing, which will enable them to successfully acquire new customers and strengthen relationships with current buyers and, consequently, improve their competitive position. Marketing innovation innovations implemented by them should increase the value of the entire offer perceived by the buyer [42, 44].

MATERIALS AND METHODS

To the goal of work were used individual data from individual structured interviews conducted in the period 2014-2016 with persons responsible for the management and implementation of innovative actions in the 99 catering establishments. The scope of research included news regarding marketing activity, which includes all improvements in communication, concluding transactions and providing information, both at B2B and B2C level. The study takes into account the diffusion to the level „new for the enterprise".

The statistical package SPSS 24 (Imago4.0) was used to analyze the data. The study specifies the percentage of enterprises that have implemented selected forms of innovation. A statistical analysis was carried out using the

Table 1. Examples of innovative marketing activities in catering enterprises in Poland
Tabela 1. Przykłady innowacyjnych działań marketingowych w przedsiębiorstwach gastronomicznych w Polsce

	The catering enterprises
1. Product design	Activities consisting in increasing the attractiveness of the product or restaurant and its brand: • changes in the appearance, form and color of the logo of the institution or the introduction of a completely new logo • changes in the appearance, form and color of the environment • new concepts of interior premises • new menu card • posting information on the composition, nutritional value, allergens in the menu
2. Product placement	Activities involving the introduction of new guest service methods and sales channels: • new forms of customer service (self-service, mixed-up, service) • new opening hours of the facility, location of the facility • virtualization of premises, presentations in 3D • modern forms of table and meal reservations (ordering via the www website, reservation system, a mobile application on a smartphone or tablet, etc.) • modern forms of food distribution - delivery to the customer, classic catering, event catering, mobile (food truck), etc. • new technologies: GPS, SMS, WAP, chips, biometrics, remote fingerprint reading and proximity interfaces • new market segments (clients)
3. Product promotion	Activities consisting in introducing new concepts of brand promotion: • cards or programs, loyalty applications authorizing rebates, advisory consumer clubs (co-designers of the offered product), special, joint events with the character of special events, etc. • wine tasting, special dishes etc. • organizing competitions where the reward may be a meal at the cost of the premises, announced by stationary or via websites • bonuses in the form of another product included free of charge when purchasing a selected product from the offer • advertising eg. Social media, blogs, etc., POS TV, animations / tasting, new equipment exhibition, price promotions, discounts, advertising on the facade of the building, own website • use of a known person shown as a user in advertising.
4. Pricing	Activities related to the price of the offer, consisting primarily of its periodic reduction: • promotional price cuts, not lasting longer than 1-2 weeks • happy hours - a specific time interval during the day in which the promotional offer applies • last minutes - last-minute offer, etc. • offers of promotional dishes such as a dish of the day or lunch, usually in a more attractive form and price for the customer, etc.

Source: The own study based on [35, 39]
Źródło: Opracowanie własne na podstawie [35, 39]

chi2 independence test showing whether there is a statistically significant difference in the number of enterprises that have implemented selected forms of innovation between gastronomic premises. The strength of the relationship was assessed on the basis of V-Cramer's contingency coefficient.

Taking into account the organizational and legal forms among catering enterprises, the majority of companies operated as: economic activity of a natural person (35% of entities), limited liability companies (25%) and civil (13%).

One of the elements differentiating the surveyed entities was the length of the operating period on the market. Among catering enterprises, the largest share were young entities operating up to 5 years (45%), then above 15 years (21%), then 10–15 years (19%) and 5–9 years (15%) respectively. These enterprises usually operated on the local market (67% of entities), to a much lesser extent on the regional and national market (8 and 12% respectively). Only 13% of these enterprises had an international reach.

The surveyed catering companies conducted business activity in the following polish provinces: Mazowieckie (about 75%), Kujawsko-Pomorskie and Łódzkie (2 companies each) and 1 company each provinces inDolnośląskie, Lubelskie, Opolskie, Śląskie, Świętokrzyskie and Wielkopolskie.

INNOVATIVE ACTIVITY OF GASTRONOMIC ENTERPRISES BASED ON OWN RESEARCH

Changes in marketing communication are inextricably linked and may be the consequence of activities related to the introduction of a new product or service or a change in the production process and provision of a service in a gastronomic establishment [15, 17, 42]. Table 2 presents the scope of marketing innovative activity of the surveyed enterprises in the period 2014–2016.

Table 2. Marketing innovations implemented in the period 2014-2016 in catering enterprises (N=99)

Tabela 2. Innowacje marketingowe wdrażane w okresie 2014-2016 w przedsiębiorstwach gastronomicznych (N = 99)

Specification	Percent of answers	Period of activity on the market		Area of activity		Financial condition	
		p	V*	p	V	p	V
The changes introduced for aesthetic or other creative modifications (not technology), eg. Logo, object, environment, menu cards, etc.	43,4	0,027	0,32	0,919	ns	0,236	ns
It has implemented new ways of communicating with the client	36,4	0,184	0,23	0,310	ns	0,482	ns
Implemented new or significantly modified ways of selling or providing services (eg sales via the Internet, home delivery)	27,3	0,105	ns	0,64	ns	0,821	ns
Marketing research has been introduced to introduce a new product or service	27,3	0,104	ns	0,255	ns	0,732	ns
The concept (strategy) of the company's marketing was significantly changed	18,2	0,518	ns	0,134	ns	0,451	ns
Implemented new forms of promotional activities, new pricing strategies	17,2	0,775	ns	0,033	0,32	0,243	ns

**V –contingency coefficient V-Cramera, ns - no statistically significant relationship at p <0.05*

Source: The own study
Źródło: Badania własne

Among the surveyed companies from the food service sector is dominated by the use of changes of an aesthetic nature, or other non-technological, creative modifications, eg. Logo, object, environment or menu card, etc. (43% of responses). In addition, the entrepreneurs implemented new or significantly modified ways of communicating with the client as well as new forms of sales and service provision (eg sales via the Internet, delivery of meals to the home). In both cases, there is a statistically significant difference due to the duration of the company's operation on the market (Tab. 2). In both cases, there was no "line" dependence, and the largest percentage had companies operating on the market for 5 to 9 years.

An important aspect in the context of changes in the perception of the image of a catering company is the logo design, form or colour of the enterprise environment. This is one of the elements of the brand whose importance in consumer behaviour is significant [13, 23]. According to the results of studies by Kwiatkowski et al. (2017), in order to visually distinguish themselves from the competition, over 44% of the gastronomic premises of the Warsaw agglomeration made changes in the appearance, form or colour of the surroundings, by giving a more exclusive or modern appearance [22]. In addition, 26% of companies introduced changes in the appearance, form or color of the logo of the facility. The purpose of redesign is to attract new customers and deepen relationships with existing buyers of services [46].

Communication with the client is an important, integral instrument of the marketing strategy and practical implementation of the market objectives of various enterprises. It is a company's intentional activity in a competitive market environment. Due to the increasing globalization and intensifying competition in the services sector, new ways of marketing communication are becoming more and more important, which are closely related to other types of innovative activities in this area, help shape the needs of modern buyers and focus their behaviour on the gastronomic market. The essence of this innovative approach to communication of original solutions is the process of creating a comprehensive image of new directions focused on satisfying higher-order needs, i.e. recognition and self-fulfillment of consumers. This trend is reflected, for example, in gastronomy, the concept of Food design and the offer of ethnic, molecular or Fusion cuisine [17, 18, 20, 39, 40].

As world experience shows, the basis for effective and effective marketing communication in catering services is their integration around a coherent message of the market message and the image of the entire undertaking. It consists not only of the package of services offered or the menu offer (including the type of cuisine, taste, smell, nutritional value of the dishes produced, etc.), but also the interior, its equipment and style, climate, service and, above all, the originality of the solutions and their innovativeness in relation to the new needs of clients using these services [12, 20, 39, 40].

Other marketing innovations identified in the surveyed catering enterprises were: implementation of new ways of selling or providing services or conducting marketing research to introduce new products (27%). Changes in the manner of selling or providing services in the analyzed premises usually related to sales via the Internet or delivery of dishes directly to the customer's home. More and more companies decide to operate in virtual space [14].

As a result, this market is becoming more and more competitive, its product and service offer is systematically expanding, and companies are using new technological possibilities (eg mobile applications) and communication (e-advertising, direct marketing, loyalty programs) to simplify the process shopping, increase the sense of security in conducting transactions via the Internet and, as a result, encourage customers to e-shopping [8, 27, 38]. Over the last years there has been rapid development of e-commerce, both in Poland and in the world. In 2013, the value of e-transaction amounted to PLN 26 billion, and in 2016 it is estimated at PLN 50 billion [8, 27]. Likewise, in 2016 approximately 5%

of Polish internet users were making purchases online, this number increased to 62% in 2019 [8]. It is also estimated that half of Polish online customers are so-called heavy shoppers, that is shopping on a daily basis or even a few times a day. They also spend relatively large portion of their time on preparing for various purchases by *inter alia* analyzing discounts found throughout the internet. This is facilitated by new technology such as apps which in turn grant the loyal customer special discounts and points.

It is the development of the mobile devices as well as the change of using Internet that prompted the rapid growth of e-commerce including the gastronomy sector. The use of mobile devices in the end of 2018 translated into 70% of consumer trends in both online shopping as well as regular stores. One of the key trends in Polish e-commerce in 2018 was personalization, that is possibility to create tailor-made offers and targeted marketing as well as customer experience with a certain brand. The concept of customer experience encompasses the whole shopping process starting with the first offer, choice of the right option up until fast and secure payment for the good followed by trouble-free delivery [31]. According to the report „E-commerce w Polsce. Gemius dla e-Commerce Polska", online shopping in 2019 became easier (52%) and cheaper (44%) [8].

There are internet systems on the polish market used to sell services in gastronomy, where through the Internet, thanks to such platforms as: Just Eat, Takeaway, Pyszne.pl, Uber Eats, Gastrobooking, Quandoo, Gasatronauci.pl or Rezerwator.pl, you can order meals with delivery to the indicated place, and also to book a table or meal at a stationary location. An important element of the sales of catering services are also group shopping websites (eg Lunchroom, Groupon, Multilunch, etc.). Payment for the services provided can be made online, and special applications allow the use of loyalty programs, which is associated with the financial benefits of customers. The structure of the market is changing dynamically, as the business of ordering food online in the opinion of many analytical companies is currently the most promising service sector [19].

According to the recent report of Deloitte (2019), restaurants in London, Madrid, Paris and Warsaw can sell 1.6 mln meals weekly thanks to the food ordering platforms. These platforms are also the reason behind the rapid growth of the gastronomy sector; companies in this sector increased their profits by 285 mln EUR and revenues by 500 mln EUR. It is estimated that if the current growth trend in this sector stays at 10%, then the European gastronomy market will be worth 25 bln dollars by 2023. Even though deliveries amount to only 2 to 5% of the total orders, the increase of the online orders is dynamic and amounts to around 20% in London, Paris and Warsaw. Deloitte's consultancy firm in fact forecasts a significant rise in popularity of the food ordering platforms and its impact on the growth of the sector as a whole. Restaurants working with Uber Eats in London, Paris, Warsaw and Madrid are already experiencing the increased sales (59-74% since they joined the platform [25].

According to the results of own research, the least catering enterprises significantly changed the marketing strategy and implemented new forms of promotional activities or new pricing strategies (Tab. 2). There is a relationship between introducing changes to the promotion or prices, and the area of the company's activity. The wider the area, the range of promotional or price tools increased. However, the largest share in these activities (over 55%) had enterprises operating on the domestic market.

According to the research carried out by Kwiatkowski et al. (2017) in 2014-2016 gastronomic companies were putting their advertisements on the online platforms and websites www. Outdoor ads were used less frequently. Moreover, pricing strategies were an innovation in the companies' marketing (loyalty programmes). Pricing strategies are usually implemented in order to stand out and attract larger group of customers to the service [22].

Most of the surveyed catering enterprises pointed to the estimated effects of introducing the above-mentioned marketing innovations. They were not very spectacular achievements, because they usually oscillated at the level of up to 30%, as presented in Tab. 3. Due to the use of new products in marketing communication, gastronomic establishments increased by 10-30%: company prestige (about 25%), product range or service (about 22%) and market shares (about 17%). It is worth noting that the survey included companies that declared the effects of introducing innovative activities in the area of marketing at the level above 30% or even 50%.

Table 3. The effects of marketing innovations introduced in catering enterprises in the period 2014-2016 (N = 99)

Tabela 3. Efekty wprowadzanych innowacji marketingowych w przedsiębiorstwach gastronomicznych w okresie 2014-2016 (N=99)

	The level of effects					Period of activity on the market		Area of activity		Financial condition	
	NC	to 10%	10-30%	30-50%	>50						
	in %					p	V**	p	V	p	V
1. Increasing the range of products / services	16,2	15,2	22,2	11,1	8,1	0,167	ns	0,224	ns	0,018	0,34
2. Opening new markets	30,3	12,1	12,1	15,2	2,0	0,206	ns	0,039	0,33	0,029	0,33
3. Increasing market share	22,2	14,1	17,2	14,1	5,1	0,530	ns	0,072	ns	0,481	ns
4. Increasing the company's prestige	21,2	10,1	25,3	8,1	7,1	0,073	ns	0,04	0,37	0,79	ns
5. Increased competitiveness on the market	20,2	18,2	14,1	12,1	8,1	0,649	ns	0,013	0,32	0,956	ns

**NC -no change; ** V-Cramer's contingency coefficient; ns - no statistically significant relationship at p <0.05*

Source: The own study

Źródło: Badania własne

According to the statistical analysis, there is a relationship between the area of basic business activity and the opening of new markets or increase of shares on the existing market and increasing prestige and competitiveness (Tab. 3). This effect (usually at the level of 10 - 30%) was noticeable primarily in companies operating on local market (within the city or poviat). The better the financial condition of the catering establishment, the more often the impact of introducing marketing innovation on the increase of the range of products and services on offer (gluten at 10-30%) was declared. The high number of indications in terms of increasing the assortment, prestige and market share indicates that the innovative activity of the surveyed enterprises concerns the implementation of improvements and actions aimed at satisfying the widest possible range of clients.

The results of our own research confirm previous scientific reports on the impact of increased innovative activity of enterprises on making the assortment more attractive, in order to better meet customer needs, strengthen market position or create new sales markets, which results in increased competitiveness of enterprises. Achieving competitive effects over a long period of time requires high marketing efficiency and continuous expansion of the technological base [1, 42, 44].

CONCLUSIONS

Among the marketing tools in the gastronomic premises, the aesthetics were changed most frequently, or modifications were made to the object, logo, surroundings, dishes or menu cards. Entrepreneurs also implemented new or significantly changed ways of communication with the client, including methods of selling and providing services (eg online sales, delivery of meals to the home) or conducting marketing research to introduce new products. These activities were aimed at satisfying the needs of the widest possible group of clients.

Least catering enterprises has significantly changed the marketing strategy and implement new forms of promotional activities and new pricing strategies. The wider area of activity in the market this range of promotional tools (egcompany advertising on portals and web services), or the price increase.

Marketing innovations are an important channel for the exchange of information and opinions, often decisive for the perception of the brand and having a significant impact on the final choice of place of food, and thus the way of nutrition and ultimately consumer health. Thanks to the use of new products in marketing communication, the analyzed gastronomic premises increased (up to 30%) the prestige of the company, the range of product or service offer and market shares. These were usually smaller companies operating on the local market.

WNIOSKI

Spośród narzędzi marketingowych w lokalach gastronomicznych najczęściej zmieniano estetykę lub wprowadzono modyfikacje: obiektu, logo, otoczenia, potraw czy karty menu. Przedsiębiorcy wdrażali też nowe lub istotnie zmienione sposoby komunikacji z klientem, w tym również metody sprzedaży i świadczenia usług (tj. sprzedaż online, dostawa posiłków do domu) czy prowadzenie badań marketingowych w celu wprowadzenia nowości. Działania te miały na celu zaspakajać potrzeby jak najszerszej grupy klientów.

Najmniej przedsiębiorstw gastronomicznych istotnie zmieniło strategię marketingową i wdrożyło nowe formy działań promocyjnych czy nowe strategie cenowe. Im szerszy obszar działania na rynku tym zakres narzędzi promocyjnych (reklamy firmy na portalach i serwisach www), czy cenowych się zwiększał.

Innowacje marketingowe stanowią istotny kanał wymiany informacji i opinii, często decydujący o postrzeganiu marki oraz posiadający znaczny wpływ na ostateczny wybór miejsca wyżywienia, a tym samym sposobu żywienia i ostatecznie zdrowia konsumenta. Dzięki zastosowaniu nowości w komunikacji marketingowej badane lokale gastronomiczne zwiększały (na poziomie do 30%) prestiż firmy, asortyment oferty produktowej lub usługowej oraz udziały w rynku. Były to najczęściej mniejsze firmy działające na rynku lokalnym.

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THE USE OF CORPORATE SOCIAL RESPONSIBILITY IN SHAPING THE IMAGE AND COMPETITIVE ADVANTAGE OF DAIRY ENTERPRISES IN POLAND®

Zastosowanie społecznej odpowiedzialności biznesu w kształtowaniu wizerunku i przewagi konkurencyjnej przedsiębiorstw mleczarskich w Polsce®

CSR (corporate social responsibility), i.e. corporate social responsibility is understood as the concept of enterprise management, consisting of conscious and sustainable action. Currently, issues related to the use of CSR is the subject of many studies and analyzes, because nowadays corporate social responsibility is an important factor in shaping the image and competitive advantage on the market. The aim of the article was to analyze and evaluate the application of the concept of corporate social responsibility in dairy enterprises in Poland in shaping the image and competitive advantage. The article's literature was used to define the concept of CSR and social responsibility reports published by leading dairy enterprises in Poland. The article uses simple descriptive and cause-and-effect methods. Based on the analyzes carried out, it was found that CSR has a global dimension, and the benefits it brings to enterprises, employees, the local community and the environment are significant. There was a positive perception among Polish society of dairy enterprises that implemented CSR activities, which contributes to increasing the stability of these enterprises. The article is a voice in the discussion on showing opportunities and creating competitive advantages in the aspect of social innovations and changing business models.

Key words: corporate social responsibility, milk market, competitiveness, image.

CSR (corporate social responsibility), czyli społeczna odpowiedzialność biznesu rozumiana jest jako koncepcja zarządzania przedsiębiorstwem, polegająca na świadomym i zrównoważonym działaniu. Obecnie zagadnienia związane zastosowanieniem CSR jest przedmiotem wielu badań i analiz, gdyż współcześnie społeczna odpowiedzialność biznesu jest ważnym czynnikiem w kształtowaniu wizerunku oraz przewagi konkurencyjnej na rynku. Celem artykułu była analiza i ocena zastosowania koncepcji społecznej odpowiedzialności w przedsiębiorstwach mleczarskich w Polsce w kształtowaniu wizerunku i przewagi konkurencyjnej. W opracowaniu artykułu wykorzystano literaturę przedmiotu, która posłużyła do zdefiniowania koncepcji CSR oraz raporty społecznej odpowiedzialności opublikowane przez przodujące przedsiębiorstwa mleczarskie w Polsce. W artykule zastosowano proste metody opisowe i przyczynowo-skutkowe. Na podstawie przeprowadzonych analiz stwierdzono, że CSR ma wymiar globalny, a korzyści, które niesie dla przedsiębiorstw, pracowników, społeczności lokalnej oraz środowiska są znaczące. Zaobserwowano pozytywne postrzeganie wśród społeczeństwa polskich przedsiębiorstw mleczarskich, które wdrożyły działania CSR, co przyczynia się do zwiększenia stabilności funkcjonowania tych przedsiębiorstw. Artykuł stanowi głos w dyskusji w zakresie pokazywania możliwości i tworzenia przewag konkurencyjnych w aspekcie innowacji społecznych i zmieniających się modeli biznesowych.

Słowa kluczowe: społeczna odpowiedzialność biznesu, rynek mleka, konkurencyjność, wizerunek.

INTRODUCTION

Issues of corporate social responsibility – CSR (ang. *Corporate Social Responsibilty*) aroused interest from the very beginning of the establishment of the first enterprises that applied relevant provisions and rules in this respect. The first definitions of the concept of corporate social responsibility appeared at the end of the 19th century. The mainstream corporate social responsibility has remained unchanged for decades, placing the main emphasis in business operations on caring for self-interest, while combining it with simultaneous attention to ensuring benefits for its stakeholders. Modern enterprises are obliged to comply with the principles

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consistent with corporate social responsibility, and their prestige and credibility are subject to evaluation and criticism of the society. Society requires companies to apply generally accepted norms and rules of conduct in their activities and puts pressure to properly implement their commitments. To this end, enterprises use appropriate codes of conduct, conduct their activities in a transparent manner and often employ employees responsible for performing such tasks in specialized organizational units [4].

Poland's accession to the structures of the European Union meant that Polish enterprises, including the dairy industry, belong to the single European market, which is characterized by increased competition for acquiring a customer for whom products of the highest quality and safe for health are key [5, 10]. Poland's accession to the European Union has contributed to carrying out adaptation activities in the food industry, including the dairy industry to meet EU requirements. Actions taken mainly concerned the modernization of technology, adaptation of hygiene and veterinary standards, as well as requirements in the field of improving animal welfare and environmental protection. All these activities were undertaken to build a competitive advantage of enterprises by improving the quality of health-safe products [10]. One of such tools in building competitive advantage of enterprises may also be the use of corporate social responsibility, which is currently the subject of many studies and analyzes, and its application contributes to improving the company's image.

The dairy industry is one of the industries in the food industry that uses the CSR tool. The dairy industry is one of the basic divisions of the domestic agri-food sector. In Poland, milk is one of the most important agricultural products – it has the highest share (16.3% in 2015) in agricultural commodity production [7, 10]. The Polish dairy industry is a permanent source of income for people working in this sector and guarantees food for a significant number of farms [6, 7].

The aim of the article was to analyze and evaluate the application of the concept of corporate social responsibility in dairy enterprises in Poland in shaping the image and competitive advantage. As part of the research, the importance of corporate social responsibility as the development potential and competitive advantage of dairy industry plants in Poland was determined.

CORPORATE SOCIAL RESPONSIBILITY IN DEFINITION

CSR is an acronym for the words Corporate Social Responsibility. In recent years, the concept of CSR has become the subject of research and analysis by economists, but also lawyers, political scientists and business ethics. The concept of CSR is characterized by interdisciplinarity, which indicates the necessity to integrate and combine knowledge in various fields of science and business practice [3].

The idea of CSR is based on the concept of sustainable development created in the United States and Western Europe at the turn of the 1960s and 1970s, according to which it is believed that in economic development, apart from the economic aspect, the social and ecological aspect are also important [3]. According to Bogdanienko, "social commitment allows striving to maintain a balance between the economic, ecological and social aspects in the enterprise's operations, which can contribute to achieving sustainable development goals such as protecting natural resources and maintaining the stability of ecosystems, with all positive effects in the form of improvement the state of human health and the improvement of overall safety and well-being"[2].

In terms of definition, the concept of social responsibility has no strict definition. As part of the review of the definition of the concept of corporate social responsibility, it was found that their mainstream concerns social sciences, in particular economics, sociology and philosophy. For the purposes of the presented study, the most suitable and suited to the agri-food sector were selected. In institutional terms, the World Business Council for Sustainable Development CSR defines as a continuous commitment of the company that contributes to economic development, while improving the quality of life of employees, their families and society "[4, 14]. In accordance with ISO 26000, CSR is defined as the organization's responsibility for the impact of its decisions and activities on society and the environment, through transparent and ethical behavior that:

- contributes to sustainable development, including the health and well-being of society;
- takes into account the expectations of stakeholders (individuals or groups who are interested in the decisions or activities of the organization;
- compliant with applicable law and consistent with international standards of conduct;
- it is integrated with the organization's activities and practiced in activities undertaken within its sphere of influence [11].

Contemporary CSR strategies are built at different levels: company, region, country, supranational communities, and their goal is to take on such challenges as: climate change, environmental degradation, social exclusion, poverty [4, 8]. Currently, there is no specific definition that would explain exactly what corporate social responsibility is. One of the most current CSR terms is the Rybak task, where it states that as part of corporate social responsibility, "management is required to choose such decisions and actions that contribute to both caring for self-interest and protecting and multiplying social well-being" [4, 12].

CSR does not apply only to large companies, as the *corporate* name might indicate, but also to small and medium-sized enterprises. CSR has a universal dimension, where sustainable development plays a key role [3]. Problems that are dealt with by corporate social responsibility are considered from a legal, economic and ecological point of view. In turn, when considering the food industry as a branch of the agri-food sector, it is necessary to emphasize the legitimacy of implementing the principles of corporate social responsibility in the dairy industry, which faces the challenge of satisfying the needs of consumers who, due to their health conditions, such as lactose intolerance, cannot consume dairy products. Consumers are increasingly interested in consuming healthy products, produced in conditions accepted by the society, usually including pro-ecological and pro-environmental measures. Manufacturers of dairy products more and more often react to changes in trends applicable to consumed food,

respect the standards in force in the production of so-called healthy products, care for the environment and try to implement and apply more modern CSR management strategies. Many of them, like Danone and Mlekovita, implement social projects focused on meeting CSR principles in a long-term manner, which should result in the right dimension of their effectiveness in the future. The concept of corporate social responsibility is positively received by producers operating in the food industry, who believe that by using it they increase the image of the company, as well as contribute to creating a positive image of the company and strengthening their economic position [1, 4].

METHODS AND MATERIALS

The research material mainly included literature on the subject, which contributed to the definition of the concept of corporate social responsibility, as well as reports on corporate social responsibility published by leading dairy enterprises in Poland, which allowed to determine the impact of implemented CSR strategies on shaping the competitive advantage and image of dairy enterprises belonging to "TOP 10" lists, such as MLEKOVITA, Mlekpol, Polmlek, Lacpol, Spomlek, Sierpc, Koło, and Gostyń. As part of the article, the following research problem was demonstrated: CSR activities are positively correlated with economic results and export activity in dairy enterprises. When presenting the test results, the descriptive and cause-effect methods were used, including tables and drawings.

RESULTS AND DISCUSSION

In Poland, the leaders in the dairy industry are enterprises located mainly in Podlasie, which include Mlekovita (based in Wysokie Mazowieckie), Mlekpol (with headquarters in Grajewo) and Okręgowa Spółdzielnia Mleczarska Piątnica. Other major dairy enterprises located throughout Poland include: Polmlek, Lacpol, Spomlek, Sierpc, OSM Koło, OSM Gostyń and companies with foreign capital such as: Danone and Hochland. The dynamic development of Podlasie dairy industry has been observed for a long time. An example is, among others, a significant number of cheeses included in the list of traditional products of the Ministry of Agriculture. Swiss type Hajnowo curd, cheese from Wiżajno and homemade "Koryciński" cheese. Podlasie dairy companies also offer numerous product innovations, e.g. Mlekpol offers dairy products without lactose, and Mlekovita, which offers over 800 products, is the only company producing ice cream on an industrial scale in Podlasie. In 2015 alone, 116 new products were launched [13].

In recent years, it can be seen that the strategy of corporate social responsibility is gaining importance in the food market, including the dairy industry. The leader in Poland in implementing CSR tools in the dairy industry is Danone, in which the first corporate social responsibility activities were introduced in the early 1990s. Mlekovita, on the other hand, has become a leader on the milk market since 2014, which owes its strong position to having 19 production dairy companies throughout Poland. Figure 1 below presents the ranking of the 10 largest producers in the dairy industry in Poland in 2009-2017 (at the bottom of the figure the position of the given company in the ranking in the figure is marked).

The figure shows the positions of the 10 largest dairy enterprises in Poland in 2009–2017 depending on the marketing trends. Based on Figure 1, it can be concluded that in 2017 the leading dairy enterprises in Poland were in order, Mlekovita, then Polmlek, Mlekpol, OSM Łowicz, Lacpol, OSM Piątnica, Spomlek, OSM Koło, Lactalis, OSM Gostyń. It would seem that dairy companies without foreign capital that compete with leading major dairy companies, such as Danone, Dr. Oetker or Hochland, may go bankrupt. However, since 2004, after Poland's accession to the EU structure, the cooperative of dairy enterprises has proved to be a global phenomenon, and dairy enterprises with foreign capital began to lose recognition of customers, which deteriorated their financial results. Some dairy companies began to lose their profitability, therefore some of them were taken over by Mlekovita, Mlekpol and Polmlek, whose total revenues could already exceed PLN 10 billion [13, 28].

One of the key aspects that dynamically evolved after Poland's accession to the EU structures in the dairy industry is the concept of corporate social responsibility. The aspect of social responsibility is decisive in the food market. The leader in the introduction and development of the concept of corporate social responsibility in the Polish dairy industry is Danone, which used the first CSR tools in Poland in 1992 [13, 16]. The Danone Group was founded in 1973 from the merger of BSN (manufacturer of glass packaging and beverages) and Geravis Danone (food producer). It has been operating under its current name since 1994. During over 30 years of operation,

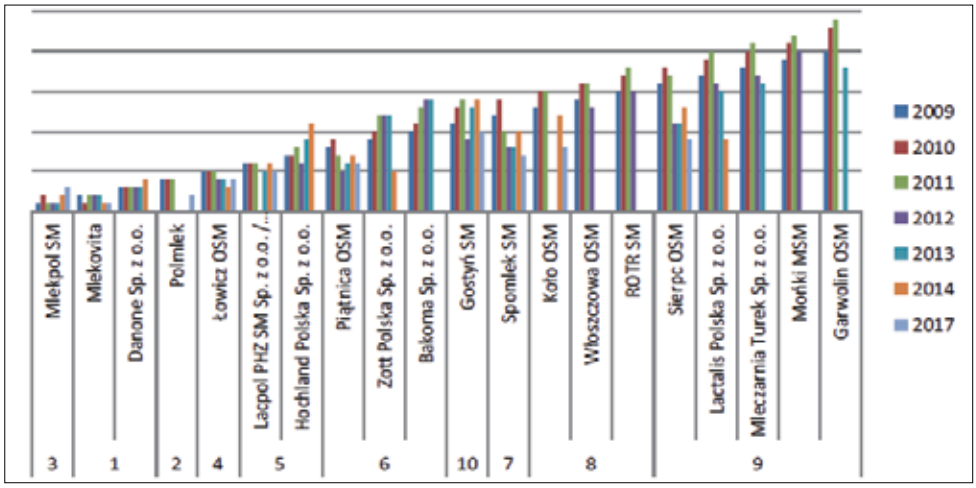

Fig. 1. The 10 largest producers in the dairy industry in Poland in 2009–2017.
Rys. 1. 10 największych producentów w branży mleczarskiej w Polsce w latach 2009–2017.

Souce: Based on [13, 16. 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28]
Źródło: Na podstawie: [13, 16. 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28]

it has become one of the largest food companies in the world. Danone products have been available on the Polish market since 1990. Initially, they were only imported, but at the end of 1992 it was decided to start production in Poland, in a Warsaw factory – in rented halls of Zakład Mleczarski Wola, which was bought two years later. In 1995, Danone was enriched with another factory – in Bieruń, Silesia. The company's range includes products intended for children, the elderly, as well as brands that bring health benefits to people with digestive problems or elevated cholesterol. All products manufactured in factories in Poland are made exclusively from Polish milk. Danone's suppliers ensure the highest quality milk, which guarantees the safety of products made from it [18]. Corporate social responsibility of Danone is an inseparable element of its functioning on the market, achieving business goals and building value [18]. This strategy is closely integrated with the business development strategy, which assumes being the most caring brand chosen by consumers every day, a reliable, trustworthy and responsible company that cares about health, people and the environment. Its main goal is to build consumer loyalty and increase sales. As part of it, the Danone Sustainable Development Plan 2012–2016 was developed and implemented, in which offering products meeting the diverse needs of consumers, supporting proper nutrition, promoting an active lifestyle and combating child malnutrition were adopted as priorities. Its implementation means that the company engages employees in building responsible business, raises standards of cooperation with suppliers and customers, cares for natural resources and sustainable agriculture [9]. As part of the concept of sustainable development and CSR, Danone has implemented the following activities in its enterprises:

– packaging innovations that have enabled the use of packaging that does not pollute the environment,
– innovations in animal nutrition with appropriate feeds, noting the harmful effects of methane,
– care for employee development, creating a friendly organizational culture,
– regular payments to farmers, assistance in the development of suppliers,
– responsible transport, e.g. wall-to-wall factory, for Actimel products, packaging is produced next to the yogurt production site; planning transport routes in such a way as to reduce the number of kilometers driven, thus optimizing the loading of goods,
– promoting a culture of sales and consumption, building lasting business relationships,
– promoting knowledge about the proper storage of products, placing products on the market in response to diagnosed nutritional and health needs of Poles,
– introducing functional products such as: Danonki, Danacol, Activia, Actimel, i.e. nutrients to have a beneficial effect on the body,
– launching the "Share your meal" campaign – combating malnutrition of children in Poland,
– the emergence of a new trend in innovation – the "Milky Start" cereal product created in cooperation with the Mother and Child Institute, Lubella and Biedronka;
– measurable and documented results of water and energy consumption reduction creating a new environmental strategy [16].

On the example of Danone, which applied the concept of CSR to an advanced extent, in accordance with OECD guidelines, many Polish leading dairy enterprises began to apply the CSR concept in their own enterprise. However, in most cases dairy enterprises implemented CSR tools in the philanthropic and marketing aspect, departing from the strategic model of the concept of corporate social responsibility. The degree of implementation of the CSR concept in the dominant Polish dairy enterprises is summarized in Table 1.

Table 1. Approach to the aspect of corporate social responsibility among the top 10 dairy enterprises in Poland

Tabela 1. Podejście do aspektu społecznej odpowiedzialności biznesu wśród 10 najważniejszych przedsiębiorstw mleczarskich w Polsce

Place in the 2017 ranking	Dairy plant	CSR section on the website	The person responsible for CSR	CSR policy	Mission and values	Social report	CSR products – market	CSR environment / development	CSR employees	CSR Society	Certyficates and awards
1.	Mlekovita SM										
2.	Mlekpol SM										
3.	Danone Sp. z o.o.										
4.	Polmlek										
5.	Lacpol PHZ SM Sp. z o.o.										
6.	Piątnica OSM										
7.	Spomlek OSM										
8.	Koło OSM										
9.	Sierpc OSM										
10.	Gostyń SM										

Souce: Based on [13, 16. 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28]

Źródło: Na podstawie [13, 16. 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28]

Based on Table 1, it can be concluded that of the 10 dominant dairy enterprises in Poland, only Danone informs the consumer about the use of CSR practices using developed social reports and placing information on its own website (Table 1). Despite the fact that all of the surveyed dairy enterprises declare the use of the CSR concept in their enterprises, this does not change the fact that most of them focus mainly on offering the highest quality products, while CSR is still perceived in marketing terms. This does not mean, however, that dominant Polish companies in the dairy industry do not use CSR tools to improve the image and financial situation of the company. This is evidenced by the actions taken by the indicated enterprises in improving product quality, introducing innovations, applying actions aimed at caring for the natural environment and promoting a healthy lifestyle among consumers [13].

The introduction of CSR practices in dairy enterprises indicated in Table 1 has contributed to improving their image among consumers, improving their position, increasing their competitive advantage on the domestic and foreign market, and increasing innovation in dairy product manufacturing practices. An example of this is, among others, the use of innovation on the new Skyr yogurt offered by OSM Piątnica, which was made according to a traditional recipe, enjoying popularity among consumers in Europe and the United States. This yogurt is high in protein and is also free from fat. The product is particularly desirable for consumers leading an active and healthy lifestyle. The cooperative from Piatnica offers its consumers four flavors, as well as natural Skyrnica [21]. An interesting idea offering rewards for farmers for high quality milk is the "Farm of the Year" competition – the flagship initiative of Spomlek Cooperative Dairy, which aims to award a modern and thriving farm. Such an initiative of Spomlek emphasizes the success of dairies in cooperation with suppliers. During the gala awards were given to cooperating farms that dynamically develop and provide the highest quality raw material [22]. In recent years, changes in the export situation of Polish dairy cooperatives can be observed. An example is SM MLEKPOL, which allocates a significant portion of production for export, sending its products to almost all countries of the world. They reach European Union countries mainly to Italy, France, Germany, the Netherlands, Belgium, Spain, the Czech Republic and the United Kingdom, as well as Africa and the Far East. The export offer includes long-ripening cheese, skimmed milk powder, butter and whey powder [17]. MLEKOVITA has also been successful in exporting. The value of exports, especially to Germany, accounts for over 20% of all exports. It is the largest and the most dynamically developing supported external market. In 2017, MLEKOVITA sold on the German market, among others: 2,955 tonnes of ripening hard cheese, 20,615,658 liters of UHT milk, 2,620 tonnes of powdered milk, 175 tonnes of butter. In 2018, during the Gala, which took place during the international food fair Polagra, MLEKOVITA was honored with the title of Leading Polish Food Exporter - Leading Polish Food Exporterm [19].

Corporate social responsibility in the context of sustainable development is increasingly becoming applicable in the dairy industry, which, due to the growing needs of stakeholders, shapes high quality and innovation. These practices are increasingly affecting the growth of exports and determine competitive advantage in the global market [13].

SUMMARY

The concept of corporate social responsibility is becoming more and more valuable and should be present in all areas of the company's operation. A competitive company strengthens its position on the market, and the use of the CSR concept has a positive effect on creating profits, motivating employees and is an incentive for further positive actions. Corporate social responsibility means excluding profit as the only motive for taking action. The CSR concept is often described as necessary in building a competitive advantage on the market.

Corporate social responsibility plays a dual role in the age of globalization. On the one hand, CSR is a tool to defend against the negative effects of globalization resulting from the activities of enterprises, in particular corporations. In this respect, the concept of CSR is an instrument that protects the environment and society against the dangers of this process. On the other hand, the progressing globalization has caused that modern enterprises operate in conditions of strong competition and growing pressure of consumers on actions in accordance with the principles of CSR. This fact means that only companies operating in a socially responsible manner can count on success [15]. Honest corporate social responsibility consists in renouncing any practices that are harmful to others, and not making the impression that the company cares about the environment and all stakeholders, while in reality it only seeks dividends for shareholders and board bonuses. Then CSR is nothing more than another marketing technique. Or a way of earning money for some and spending money for others.

The concept of CSR in corporate strategies allow not only to assess the progress of a given organization as socially responsible, but also to assess the position, in this case of dairy plants, in the global system. CSR is a set of activities aimed at implementing the principles of sustainable development. The article contributes to further in-depth research. Based on the analysis of the largest dairy enterprises in Poland, it was found that they implement CSR strategies to a greater or lesser extent. However, the approach of most dairy companies to CSR business models is philanthropic and marketing, but strategic and transformative approaches are also emerging. Significant changes related to CSR and the development of Polish dairy companies appeared after Poland's accession to the European Union. Since then, Polish dairy companies have been systematically becoming more competitive than existing leaders.

PODSUMOWANIE

Koncepcja społecznej odpowiedzialności biznesu zyskuje coraz bardziej na wartości i powinna być obecna we wszystkich obszarach funkcjonowania firmy. Konkurencyjna firma umacnia swoją pozycję na rynku, a stosowanie koncepcji CSR korzystnie wpływa na kreowanie zysków, motywację pracowników i jest bodźcem do dalszych pozytywnych działań. Społeczna odpowiedzialność firmy oznacza wykluczenie zysku jako jedynego motywu do podjęcia działań. Koncepcja CSR jest często określana jako niezbędna w budowaniu przewagi konkurencyjnej na rynku.

Społeczna odpowiedzialność biznesu w czasach postępującego procesu globalizacji pełni podwójną rolę. Z jednej

strony, CSR jest narzędziem obrony przed negatywnymi skutkami globalizacji wynikających z działalności przedsiębiorstw, a w szczególności korporacji. W tym zakresie koncepcja CSR jest instrumentem, który chroni środowisko i społeczeństwo przed zagrożeniami ze strony tego procesu. Z drugiej zaś strony postępująca globalizacja spowodowała, iż współczesne przedsiębiorstwa działają w warunkach silnej konkurencji oraz rosnącej presji konsumentów na działania w zgodzie z zasadami CSR. Fakt ten sprawia, iż jedynie firmy prowadzące działalność w sposób społecznie odpowiedzialny mogą liczyć na sukces [15].Uczciwa społeczna odpowiedzialność biznesu polega na wyrzekaniu się wszelkich praktyk, które są szkodliwe dla innych, a nie na robieniu wrażenia, że firma dba o otoczenie i wszystkich interesariuszy, podczas gdy tak naprawdę zabiega jedynie o dywidendy dla akcjonariuszy i bonusy dla zarządu. Wtedy CSR jest niczym więcej jak jeszcze jedną techniką marketingową, albo sposobem zarobkowania przez jednych i wydawania firmowych pieniędzy przez drugich.

Koncepcja CSR w strategiach korporacyjnych pozwala nie tylko oceniać stopień zaawansowania danej organizacji jako społecznie odpowiedzialnej, ale także ocenić pozycję (w tym przypadku zakładów mleczarskich), w systemie globalnym. CSR to zbiór działań mających na celu wdrażanie zasad zrównoważonego rozwoju. Artykuł stanowi wkład w dalsze dogłębne badania. Na podstawie dokonanej analizy największych przedsiębiorstw mleczarskich w Polsce stwierdzono, że wdrażają one strategie CSR w większym lub mniejszym stopniu. Podejście większości przedsiębiorstw mleczarskich do modeli biznesowych CSR ma charakter filantropijny i marketingowy, ale pojawiają się również strategiczne i transformacyjne podejścia. Znaczące zmiany związane z CSR i rozwojem polskich firm mleczarskich pojawiły się po przystąpieniu Polski do Unii Europejskiej. Od tego czasu polskie przedsiębiorstwa mleczarskie systematycznie stają się bardziej konkurencyjne niż dotychczasowi liderzy.

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DEVELOPMENTAL NEEDS OF THE POLISH AGRI-FOOD SECTOR AND THE PROPOSED ACTIONS UNDER THE COMMON AGRICULTURAL POLICY OF THE EUROPEAN UNION®

Potrzeby rozwojowe polskiego sektora rolno-żywnościowego a proponowane działania w ramach wspólnej polityki rolnej Unii Europejskiej®

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Mistakes made in Polish agricultural policy after 1989, rather than eliminated after Poland's accession to the EU in 2004, have a chance to be corrected by implementing the actions provided for in the Strategy for sustainable development and the Strategy for sustainable development of rural areas, agriculture and fisheries 2030. First of all, it is necessary to start egalitarian (and not elite) development of Polish agriculture, and this means that it is necessary to activate the production and economy of all agriculture, and not only development farms. This is particularly important for smaller farms, which are largely excluded both in production and on the agri-food market. Such an elite and pro-corporate agricultural policy threatens food security, especially in the case of socio-economic and political-military crises, and adversely affects the natural environment.

Changes in Polish agricultural policy should be favored by the proposals put forward by European Commission, including Commissioner for Agriculture Janusz Wojciechowski, with regard to the future common EU agricultural policy. Generally, it is proposed to create so-called European Green Deal through the egalitarian economic support of all farms, including smaller ones, which by their very nature guarantee sustainable development because they generally produce in a closed cycle, as well as their management is environmentally friendly. Unfortunately, these proposals may be relatively unrealistic in view of the anticipated economic crisis. The feasibility of the proposed directions for the development of EU agriculture may be increased by the proposed renationalization of the common agricultural policy.

Key words: sustainable development, food processing, agricultural policy, European Union.

Błędy popełniane w polskiej polityce rolnej po 1989 roku, a nie wyeliminowane po akcesji Polski do UE w 2004 roku, mają szanse na skorygowanie poprzez wdrożenie działań przewidzianych w Strategii na rzecz zrównoważonego rozwoju oraz w Strategii zrównoważonego rozwoju wsi, rolnictwa i rybactwa 2030. Przede wszystkim, niezbędne jest rozpoczęcie realizacji egalitarnego (a nie elitarnego) rozwoju polskiego rolnictwa, a to oznacza, że niezbędne jest aktywizowanie produkcyjno-ekonomiczne całego rolnictwa, a nie tylko gospodarstw rozwojowych. Szczególnie istotne jest to w odniesieniu do gospodarstw mniejszych obszarowo, w praktyce w dużym stopniu wykluczonych zarówno w produkcji, jak i na rynku rolno-żywnościowym. Tak realizowana elitarna i prokorporacyjna polityka rolna zagraża bezpieczeństwu żywnościowemu (food security), zwłaszcza w przypadku kryzysów społeczno-gospodarczych i polityczno-militarnych oraz niekorzystnie oddziałuje na środowisko naturalne.

Zmianom w polskiej polityce rolnej powinny sprzyjać propozycje Komisji Europejskiej, w tym Komisarza do spraw rolnictwa Janusza Wojciechowskiego, w odniesieniu do przyszłej wspólnej polityki rolnej UE. Generalnie, proponuje się kreowanie tzw. Europejskiego Zielonego Ładu poprzez egalitarne wsparcie ekonomiczne wszystkich gospodarstw rolnych, w tym mniejszych obszarowo, które z natury swojej gwarantują rozwój zrównoważony, ponieważ produkują na ogół w obiegu zamkniętym, jak również ich gospodarowanie jest przyjazne środowisku naturalnemu. Niestety, propozycje te mogą być względnie nierealne wobec przewidywanego kryzysu gospodarczego. Realność proponowanych kierunków rozwoju rolnictwa unijnego może zwiększać proponowana renacjonalizacja wspólnej polityki rolnej.

Słowa kluczowe: rozwój zrównoważony, przetwórstwo spożywcze, polityka rolna, Unia Europejska.

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INTRODUCTION

The *Strategy for Responsible Development* assumes that the country's development will be socially and territorially balanced. The essence of sustainable development is also the protection and conservation of the natural environment. In relation to agriculture and rural areas, it concerns both living conditions in the countryside and in agriculture, food security, but also the natural environment [8, p. 156].

Polish agricultural policy after 1989 does not stimulate the sustainable development of agriculture and its surroundings. It dominates activities forcing area restructuring, instead of egalitarian activities, activating productively and economically family farms in all area groups, which is in line with the constitutional provisions on family farms. In addition, the natural environment of agriculture and the countryside is treated in an exploitative manner, urban chaos appears in the rural space, and the natural environment is shrinking – especially outside of Natura 2000 areas.

A particularly elite development model is implemented after Poland's accession to the European Union (EU), in which the development of the so-called development farms, which in effect causes the so-called deagrarization of agriculture and villages, manifested e.g. in the disappearance of massive livestock farming. This raises many contradictions and adverse phenomena in agriculture and its surroundings. First of all, it is not fully used (or not used at all in the event of abandonment of both plant and animal production) production potential of smaller areas, including several hectares of family farms. These farms, with proper production and market activation and the right direction of production, with a possible complementation to the activities of rural residents for production in the non-agricultural sector are able to provide a satisfactory level of agricultural income. Unfortunately, this type of comprehensive activities in terms of agricultural production and market activation, adapted to the needs of smaller farms, did not include any of the pre-existing rural development programs. In addition, the possibilities of so-called work at a distance arise in the performance of tasks for enterprises and institutions in large urban centers. The existing coronavirus pandemic is likely to significantly expand the scope of work performed remotely, both nationally and internationally. This is a particularly important factor for finding a job and income corresponding to women who generally have higher qualifications in rural areas than men.

The agri-food sector is becoming more and more corporate at the expense of small producers, including farmers. As J. Zegar writes - *All farms should be of interest to agricultural policy [...]*. Meanwhile, as he writes - *The dominant global tendency is to strive to ensure food security based on a global corporate system (large retail chains)* [8, 19, 20]. This is demonstrated, for example, by the very high import intensity of Polish agri-food exports. This export is growing, and with it the agri-food import is growing, at the expense of the unused production potential of smaller family farms. Elite and somewhat corporate Polish agricultural policy is a direct or potential (in the event of socio-economic or political-military crises) a threat to national food security. It is worth emphasizing that it shrinks and degrades the natural environment and natural and landscape space, which is directly related to the concentration and intensification of the Polish agri-food sector. The quality of life in the countryside is deteriorating, which, among other things, limits the prospects for the development of agritourism, which is important both for rural development and for cheap and ecological recreation for urban residents.

The development trends and accompanying phenomena presented above are contrary to the principle of responsible and sustainable development. One can even talk about the productive exclusion of smaller farms. Proper implementation of the strategy of responsible and sustainable development, in line with social expectations and suggestions, is an opportunity to implement actions that eliminate or at least limit the mentioned contradictions and adverse phenomena. *Report on public consultations about the 2030 Strategy for Sustainable Development of Rural regions, Agriculture and Fisheries* contains many interesting comments which, when taken into account, can have a positive impact on the relevance and effectiveness of actions envisaged under the Strategy.

The purpose of this study is to articulate real needs for the development of the Polish agri-food sector, in the light of the statements of Janusz Wojciechowski - the new Commissioner for Agriculture in the European Commission (EC).

WSTĘP

W *Strategii na rzecz Odpowiedzialnego Rozwoju* zakłada się, że rozwój kraju będzie społecznie i terytorialnie zrównoważony. Istotą rozwoju zrównoważonego jest również ochrona i konserwacja środowiska naturalnego. W odniesieniu do rolnictwa i obszarów wiejskich, dotyczy on zarówno warunków życia na wsi i w rolnictwie, bezpieczeństwa żywnościowego, ale również środowiska przyrodniczego [8, s. 156].

Polska polityka rolna po 1989 roku nie stymuluje zrównoważonego rozwoju rolnictwa i jego otoczenia. Dominują w niej działania wymuszające restrukturyzację obszarową, zamiast działań egalitarnych, aktywizujących produkcyjno-ekonomicznie gospodarstwa rodzinne we wszystkich grupach obszarowych, co jest zgodne z zapisami konstytucyjnymi dotyczącymi gospodarstw rodzinnych. Ponadto, otoczenie przyrodnicze rolnictwa i wsi jest traktowane w sposób eksploatatorski, w przestrzeni wiejskiej pojawia się chaos urbanistyczny, a środowisko naturalne kurczy się – zwłaszcza poza obszarami Natura 2000.

Szczególnie elitarny model rozwoju jest realizowany po akcesji Polski do Unii Europejskiej (UE), w ramach którego preferuje się rozwój tzw. gospodarstw rozwojowych, co w efekcie powoduje tzw. dezagraryzację rolnictwa i wsi przejawiającą się np. w zaniku masowego chowu zwierząt gospodarskich. Rodzi to wiele sprzeczności i niekorzystnych zjawisk w rolnictwie i jego otoczeniu. Przede wszystkim, nie jest w pełni wykorzystywany (lub w ogóle nie jest wykorzystywany w przypadku zaniechania produkcji zarówno zwierzęcej, jak i roślinnej) potencjał produkcyjny mniejszych obszarowo, w tym kilkunastohektarowych gospodarstw rodzinnych. Gospodarstwa te, przy właściwej aktywizacji produkcyjno-rynkowej i odpowiednim kierunku produkcji, przy ewentualnym uzupełnieniu działalności mieszkańców obszarów wiejskich o produkcję w sektorze pozarolniczym są w stanie zapewnić zadowalający poziom dochodu rolniczego. Niestety tego typu

kompleksowych działań w zakresie rolniczej aktywizacji produkcyjno-rynkowej, dostosowanej do potrzeb gospodarstw mniejszych obszarowo, nie zawierał żaden z dotychczasowych programów rozwoju obszarów wiejskich. Ponadto, w coraz większym stopniu rosną możliwości tzw. pracy na odległość w wykonywaniu zadań dla przedsiębiorstw i instytucji w dużych ośrodkach miejskich. Istniejąca pandemia koronawirusa prawdopodobnie w sposób zasadniczy rozszerzy zakres prac wykonywanych na odległość, zarówno w układzie krajowym, jak też międzynarodowym. Jest to czynnik szczególnie ważny dla znalezienia pracy i dochodów odpowiadających kobietom, które generalnie posiadają na obszarach wiejskich wyższe kwalifikacje niż mężczyźni.

Sektor rolno-żywnościowy staje się coraz bardziej korporacyjny kosztem drobnych producentów, w tym rolników. Jak pisze J. Zegar – *Przedmiotem zainteresowania polityki rolnej powinny być wszystkie gospodarstwa […].* Tymczasem, jak pisze dalej – *Dominującą tendencją światową jest zmierzanie do zapewnienia bezpieczeństwa żywnościowego (food security* – dopisek autorów*) w oparciu o globalny system korporacyjny (wielkie sieci handlowe)* [8, 19, 20]. Świadczy o tym np. bardzo duża importochłonność polskiego eksportu rolno-żywnościowego. Eksport ten rośnie, a wraz z nim rośnie import rolno-żywnościowy, niejako kosztem niewykorzystanego potencjału produkcyjnego mniejszych obszarowo gospodarstw rodzinnych. Elitarna i poniekąd korporacyjna polska polityka rolna stanowi bezpośrednie lub potencjalne (na wypadek kryzysów społeczno-gospodarczych czy polityczno-militarnych) zagrożenie dla krajowego bezpieczeństwa żywnościowego (*food security*). Warto podkreślić, że kurczy się i degraduje środowisko naturalne i przestrzeń przyrodniczo-krajobrazowa, co jest bezpośrednio związane z koncentracją oraz intensyfikacją polskiego sektora rolno-żywnościowego. Pogarsza się jakość życia na wsi, co między innymi ogranicza perspektywy rozwoju agroturystyki, ważnej zarówno dla rozwoju wsi, jak i dla taniego i ekologicznego wypoczynku dla mieszkańców miast.

Przedstawione powyżej tendencje rozwojowe i towarzyszące im zjawiska są sprzeczne z zasadą odpowiedzialnego i zrównoważonego rozwoju. Można wręcz mówić o wykluczeniu produkcyjnym gospodarstw mniejszych obszarowo. Właściwa realizacja strategii odpowiedzialnego i zrównoważonego rozwoju, zgodna z oczekiwaniami i sugestiami społecznymi, stanowi szansę na realizację działań eliminujących lub przynajmniej ograniczających wspomniane sprzeczności i niekorzystne zjawiska. *Raport z konsultacji publicznych Strategii zrównoważonego rozwoju wsi, rolnictwa i rybactwa 2030* zawiera wiele interesujących uwag, które uwzględnione mogą pozytywnie wpłynąć na trafność i skuteczność działań przewidzianych w ramach *Strategii.*

Celem artykułu jest wyakcentowanie realnych potrzeb dotyczących rozwoju polskiego sektora rolno-żywnościowego, między innymi w świetle wypowiedzi Janusza Wojciechowskiego – nowego Komisarza do spraw rolnictwa w Komisji Europejskiej (KE).

CONDITIONS FOR EGALITARIAN (SUSTAINABLE) DEVELOPMENT OF THE POLISH AGRICULTURAL FOOD SECTOR AND ITS ENVIRONMENT

In the socio-economic sphere, starting from 2015, there is a positive verification of Polish economic policy, in accordance with social expectations and the needs of economic development, and in accordance with the Polish national interest, as is the case in many, especially "old" EU countries. Comprehensive socio-economic changes will be implemented based on *Strategy for Responsible Development* (SRD), and in the agri-food sector – on the basis of the *Strategy for sustainable development of rural areas, agriculture and fisheries 2030* (SZRWRiR) [10, 13].

It is necessary to move away from the implementation of the elite in favor of egalitarian treatment of farms in Polish agricultural policy. This would aim to revive in a production and market area, somewhat excluded nowadays in this area, smaller farms, relatively more multifunctional farms than large farms. The Strategy (SZRWRiR) emphasizes that the multifunctional and sustainable agriculture model guarantees food security [13].

The basis for creating egalitarian development of agriculture are the provisions of the above-mentioned Strategies, while comprehensive administrative organizational and financial activities are necessary, including as part of the future rural development program (RDP 2021-2027).

Smaller, although sometimes over 20 hectares farms should *intensively organize and produce extensively*. This rule means the occurrence of smaller labor-intensive production lines on farms with relatively small use of industrial means of production, i.e. fertilizers, plant protection products, and industrial feed. It should be remembered that this guarantees higher food safety. At the same time, industrial means of production are widely used, except for organic farms, while labor-intensive production lines are still more preferred on smaller farms, although they also occur on large farms that employ external employees, including seasonal ones [3, 4].

However, at present, there is a tendency in Polish agriculture to limit production directions, including monoculture in plant production, which reduces soil fertility and at the same time adversely affects the natural environment. The revitalization of smaller farms will allow for a more widespread use of crop rotation management, and thus crop biodiversity.

The development of production and economic activation of smaller farms requires administrative support and activities in the field of:

- development of production niches (directions) for smaller farms (not only for organic farms), both as part of plant and animal production, as well as small processing (sold as part of direct sales). The necessity to look for niches for agricultural producers is highlighted in the *Strategy* (SZRWRiR), as necessary in connection with the prospect of future loss of *cost competitiveness* in Polish agri-food exports;
- organization of wholesale (apart from direct sales, including the local and retail market functioning somewhat spontaneously), manufactured products,

their processing and export. A positive contribution to state intervention on the agri-food wholesale market is the creation of the Food Platform, which started buying operations on March 11 this year. When it comes to organizing the wholesale purchase of agricultural products, the producer groups may be just one of many desirable forms of empowerment on the market, especially for small farmers. In many cases, it seems more expedient to revive co-operative forms of buying agricultural products, partly supported by the state, which were liquidated after 1989;

- increasing controls on imported agri-food products, often of lower quality than domestic products, as postulated by the Visegrad countries chambers of agriculture [9];
- incentives for running smaller farms, including ones with intensive production, e.g. animal production, through simplification and certain decentralization (renationalization) of the EU's common agricultural policy, regulations and administrative and veterinary procedures, by supporting the start of young farmers, the higher the more intensive the direction of production on the farm [14].

According to the authors, administrative and veterinary regulations and procedures, are excessively developed, burdensome and not adapted to the essence of functioning of smaller area (traditional) farms, and are one of the main conditions for the production and economic exclusion of these farms and agricultural and rural deagrarization, which also directly affects the food processing industry, including the production of regional products [2, 5, 6].

It should also be remembered that the protection and promotion of regional and traditional products is one of the most important factors affecting the sustainable development of rural areas. This not only contributes to the diversity of employment in rural areas by creating non-agricultural sources of income in the countryside, but also increases the income of agricultural producers and the food processing industry. It is highly important for remote areas and less-favored areas (LFA), as it prevents depopulation of these areas. The protection of regional production also significantly contributes to the attractiveness of rural areas and the development of agritourism [11].

The involvement of state administration in the process of creating egalitarian agricultural policy should be supported by the aforementioned renationalization of the EU's common agricultural policy, which, due to the large number of Member States, will never be able to fully solve the differing national agri-food sectors. Therefore, it is necessary to increase the competences of the Member States in creating agricultural policy adapted to the needs and specificity of a given agri-food and processing sector.Many of the comments contained in the *Report on public consultations about the 2030 Strategy for Sustainable Development of Rural regions, Agriculture and Fisheries* are concerning issues related to the production and economic activation of farms [12]:

- Note 33 it is stated, that creating a program should considered for such activation of rural areas and agricultural production methods, as it would keep Polish citizens in the countryside. You have to realize that this is a difficult task, because agricultural production is by nature relatively low profitable compared to non-agricultural production lines, and generally the income of the rural population is relatively low. The Strategy (SZRWRiR) provides for income disparity, compared to income, outside the rural and outside agriculture, respectively, for the rural population at only 75%, while for the agricultural population at only 68%;
- Note 24 states that the *demand for organic farming products is increasing in Poland*;
- Note 173 states that agricultural deagrarization is most pronounced in areas with the most fragmented farm structure, where this leads to *the disappearance of the agricultural function*;
- Note 375 states that with regard to small processing on the farm, it is necessary to *support the processing of niche, regional and ecological products through promotion, purchase of machinery and technology (shortening of the food chain);*
- One of the conditions for optimal production and economic activation of Polish farms is the gradual repolonization of the non-agricultural food sector (processing, wholesale market and somewhat retail) and restoration wherever possible and necessary, strong links between agriculture and the agri-food processing and food market (Note 236);
- Productive and economic activation of farms will consolidate their multi-functional character, including positive, protective and preserving impact on the natural environment. The destruction of "natural refuges" in land concentration processes should be prevented, and at the same time, further enhancing the pro-environmental functions of farms under Green Deal from EU funds allocated to "greening", concluded in Pillar II. This is shown in Note 4 and Note 5, where it is stated *that we are proposing to add a [...] paragraph - protection of small, biologically active elements of the agricultural landscape: ponds, streams, balks, wetlands and mid-field woodlands;*
- The revitalization of smaller farms will not only favor the development of spatial order in the countryside and agriculture, but also by arranging the rural and agricultural space will improve the quality of life and aesthetic feelings of managing farmers, which to some extent will consolidate the family farming system in agriculture.

The *Strategy* (SZRWRiR) states that there are *significant delays in regulating spatial management at the municipal level.* Note 102 of the *Report* also states that spatial development plans lack *designated land protection zones for agricultural production, and up to 70% of built-up areas are allocated in non-urban communes.* In note No. 546, the Association of Rural Municipalities of Poland states, among other things, that it is necessary to *introduce urban planning standards in spatial planning, taking into account landscape protection, revitalization of rural areas, and preventing excessive dispersion of settlement buildings* [7, 12].

ASSESSMENT OF THE PROPOSED MEASURES UNDER THE EU COMMON AGRICULTURAL POLICY AND THE PROBLEMS OF POLISH AGRICULTURE

A synthesis of actions in relation to the EU's common agricultural policy after 2020 is contained in the letter of the President of the European Commission – Urszula von der Leyen, addressed to Janusz Wojciechowski, Commissioner for Agriculture [15, pp. 4-5]. The letter obliges the Commissioner to prepare a new *long-term vision for rural areas, which will ensure a balance between EU-wide objectives and national priorities*.

Features of a modern and simplified common agricultural policy:

- Food production should be competitive (with use of digital technologies) as well as healthier, more sustainable, profitable and supportive for young farmers;
- Food production should be sustainable throughout the entire food chain "from farm to fork", including the development of organic production;
- Food security should be implemented in parallel with environmental (and biodiversity) and climate goals, also by *reducing the use of pesticides, fertilizers and chemicals in Europe and abroad*;
- *The geographical indications system*, which contributes to maintaining high quality of food and protects European, cultural, gastronomic and local heritage, should be strengthened.

The proposed multi-faceted common agricultural policy of the EU, compared to currently implemented goals, is not only expanded to include climate goals, which are planned to allocate as much as 40% of the total budget of the common agricultural policy, but also to tasks in the scope of ecological goals, implemented, among others, by limiting chemization of the agri-food sector. The common agricultural policy planned in this way cannot be effectively implemented against the already assumed limited budget, and its deficit may be even more radically limited due to the anticipated economic slowdown and the crisis caused by the coronavirus epidemic. The implementation of such ambitious goals, with a limited budget for the common agricultural policy, will inhibit the technical-economic and production development of agriculture, reduce the efficiency of agri-food production and will not allow a satisfactory increase in agricultural income. Thus, this will result in further liquidation of many farms, including smaller farms, which are particularly important in the process of creating the European Green Deal, because by their very nature they run circular economy and produce less schematic production. It should be remembered that in the last 10 years, around 4 million EU farms have abandoned production. Thus, perhaps, the ambitious assumptions about creating a Green Deal will prove to be unrealistic in practice.

In view of the likelihood of an unsatisfactory amount of funds, both EU and national, directed to agriculture, the concept of decentralization (renationalization) of the common agricultural policy is becoming more important through, as Janusz Wojciechowski states, increasing the *possibilities of creating own national agricultural policy and creating own national preferences.* The internal division of the envelope into direct payments should be the *responsibility of the Member State* [16]. Direct payments should be targeted mainly tat holdings actually carrying out agricultural production. Preferential payment rates should be applied to particularly onerous directions of agricultural production, e.g. livestock, and should be directed to farms located in less-favored areas (LFA).

The renationalization of the EU's common agricultural policy, which is proposed by Commissioner Janusz Wojciechowski, should enable the implementation of the concept of universal activation of Polish farms, in particular smaller ones, whose management would naturally and relatively cheaply contribute to shaping the Green Deal. Perhaps the renationalization of the common agricultural policy is particularly necessary in the context of the anticipated global economic crisis.

In the statements of Commissioner Janusz Wojciechowski there are many other important issues concerning the development of agriculture and the EU market:

- The existing need to simplify the common agricultural policy [18]. According to the authors, these are necessary actions, but it should be emphasized that the EC's previous assurances about the implementation of the simplification of the common agricultural policy are in practice cosmetic, resulting with provisions and procedures being still burdensome for manufacturers.

  Particularly outstanding examples can be the restrictions still in force related to the breeding and trade of farm animals. They are humiliating for animal breeders. They testify to the dismissive attitude of the agricultural administration towards the farmer, as well as the complete lack of confidence in his professional responsibility. Such negative treatment of needs since Poland's accession to the EU, especially the needs existing in smaller, traditional farms, indicates the lack of decision-making by the national administration in relation to EU regulations and the pro-corporate approach of the administration, favoring agri-food imports and the sale of food in large commercial networks;
- It will be possible to use a relatively greater support for smaller farms, by granting a lump sum as part of the distribution of direct payments [18, p. 15];
- It is necessary to strengthen the position of farmers in the market and to eliminate unfair commercial practices applied in the market in relation to farmers. This is possible through the implementation into national legislation of the Directive of the European Parliament of April 2019 regarding the elimination of these practices [18, p. 15];
- It is necessary to apply crop rotation management on farms. It is of utmost importance, although difficult to implement for large farms, in order to prevent soil sterilization. At the same time, it will be conducive to the protection of nature, especially wildlife [17, p. 10];
- The problem for EU agriculture, as stated by J. Wojciechowski, are overly intensive and industrial farms, which are even a pathology of agriculture (*I see the problem with too much intensive and too much industrial farming*

[...]. This is the kind of pathology in our agriculture). In addition, J. Wojciechowski also sees the negative, anti-ecological features of agribusiness, which in a way forces excessive chemization of agriculture, contrary to the idea of Green Order [1, p. 20, 27];

- Another problem for EU agriculture is according to J. Wojciechowski agri-food imports from South America, which use pesticides that are not allowed in the EU, as well as excessive imports of agri-food raw materials to the EU, which is harmful to EU agriculture and is a threat to *food security*. According to J. Wojciechowski*, farmers cannot be victims of international trade* [1, pp. 11, 18].

SUMMARY

The above analysis leads to the following conclusions:

1. Since the beginning of the system transformation period, i.e. since 1989, the development of the Polish agri-food sector has a meandering, chaotic and unbalanced character. Many production entities, including cooperatives, of the sector (especially in food processing) have been excluded from production and taken over by private entities, as well as foreign corporations, weakly connected with the domestic resource base. As a result, especially due to the abolition of the cooperative system for the purchase of agricultural products, somehow smaller farms were doomed to extermination;
2. The situation has not only not improved, but even worsened after Poland's accession to the EU in 2004. An elite agricultural policy was implemented, favoring the so-called developmental farms, and in addition cumbersome administrative and veterinary restrictions were implemented, which in effect led to the so-called deagrarization, i.e. the disappearance of agricultural production, mainly livestock production in most farms, especially in smaller areas. The development of Polish agriculture has become irresponsible and unbalanced, because on one hand, it does not use the production, economic and income potential existing in smaller farms. On the other hand, agri-food imports cover the gap in the supply of agri-food raw materials for the agri-food industry, the internal market and exports. Growing Polish agri-food export is very import-intensive, at the cost of excluding many farms from production;
3. Exclusion or even exclusion of smaller farms from agricultural production (disappearance of mass and spatially widespread agricultural production, especially animal production), while the dominant, weakly connected with domestic production, large-scale retail food trade (often imported), potentially reduces Polish food security (food security) in the event of socio-economic or political-military crises. This is contradictory with the Polish *raison d'état*;
4. Due to the increase in production intensity on developmental farms, many unfavorable phenomena occur, such as the disappearance of crop rotation and the dominance of monocultural crops, the disappearance of grazing animals, especially in livestock farming, a clear decline in the population of many wild animal species found in agricultural areas, reduction of biodiversity crop on permanent arable land, etc. As a result, the quality of life in agriculture and the countryside is deteriorating;
5. The implementation of the *Strategy for responsible development and the Strategy for sustainable development of rural areas, agriculture and fisheries 2030* provides an opportunity for egalitarian and sustainable development of entire Polish agriculture, including smaller farms [13]. With this in mind, it is necessary to provide state aid in the area of increasing the position of farms on the agri-food market, inter alia, by rebuilding the cooperative market, in terms of productive and economic activation of smaller farms, while liberalizing and simplifying administrative-veterinary provisions and procedures, as well as by supporting the purchase of agricultural and food products (e.g. as part of the recently created Food Platform) and by supporting agri-food processing and export;
6. This articulation of the need for the development of the Polish agri-food sector is consistent with the proposed changes, including renationalization and actions under the EU's common agricultural policy, which constitute the process of creating the Green Deal. The implementation of the Green Deal concept is conditioned by stimulating the development of production and economic activation of family farms, especially those smaller in area, managing the so-called closed circulation, which is particularly necessary nowadays in relation to Polish agriculture;
7. The newly appointed Commissioner for Agriculture Janusz Wojciechowski proposes many solutions within the framework of the common agricultural policy, converging with the development needs of Polish agriculture;
8. Unfortunately, the anticipated economic crisis can significantly verify the plans and actions envisaged in the framework of the creation of the European Green Deal. Perhaps, the necessary remedy for this is the renationalization of the common agricultural policy, especially in some of its areas.

PODSUMOWANIE

Powyższa analiza upoważnia do następujących wniosków:

1. Od początku okresu transformacji ustrojowej, tj. od 1989 roku, rozwój polskiego sektora rolno-żywnościowego ma charakter meandryczny, chaotyczny i niezrównoważony. Wiele podmiotów produkcyjnych, w tym spółdzielczych, sektora (zwłaszcza w przetwórstwie żywnościowym) zostało wyłączonych z produkcji i przejętych przez podmioty prywatne, również zagraniczne korporacje, słabo powiązane z krajową bazą surowcową. W efekcie, zwłaszcza wobec zlikwidowania spółdzielczego systemu skupu produktów rolnych, niejako na zagładę zostały skazane mniejsze obszarowo gospodarstwa rolne;
2. Sytuacja nie tylko nie uległa poprawie, a wręcz pogorszyła się po akcesji Polski do UE w 2004 roku. Wdrożono elitarną politykę rolną, faworyzującą tzw. gospodarstwa rozwojowe, a ponadto wdrożono uciążliwe obostrzenia administracyjno-weterynaryjne, co w efekcie doprowadziło do tzw. dezagraryzacji, tj. zaniku produkcji rolnej, głównie zwierzęcej w większości gospodarstw rolnych, zwłaszcza mniejszych obszarowo. Rozwój polskiego rolnictwa nabrał charakteru nieodpowiedzialnego

i niezrównoważonego, gdyż z jednej strony, nie wykorzystuje potencjału produkcyjno-ekonomicznego oraz dochodowego istniejącego w mniejszych obszarowo gospodarstwach rolnych. Z drugiej strony, lukę w podaży surowców rolno-żywnościowych na potrzeby przemysłu rolno-spożywczego, rynku wewnętrznego i eksportu pokrywa import rolno-żywnościowy. Rosnący polski eksport rolno-żywnościowy jest bardzo importochłonny, niejako kosztem wyłączenia z produkcji wielu gospodarstw rolnych;

3. Wyłączenie, czy wręcz wykluczenie z produkcji rolnej gospodarstw mniejszych obszarowo (zanik masowej i powszechnej przestrzennie produkcji rolnej, zwłaszcza zwierzęcej), przy jednocześnie dominującym, słabo powiązanym z krajową produkcją, wielkosieciowym handlem detalicznym żywnością (często importowaną), obniża potencjalnie polskie bezpieczeństwo żywnościowe (*food security*) na wypadek kryzysów społeczno-gospodarczych, czy polityczno-militarnych. Jest to sprzeczne z polską racją stanu;
4. Na skutek wzrostu intensywności produkcji w gospodarstwach rozwojowych pojawia się wiele niekorzystnych zjawisk, takich jak: zanik gospodarki płodozmianowej i dominacja upraw monokulturowych, zanik wypasu zwierząt, zwłaszcza w chowie fermowym, wyraźny spadek populacji wielu dzikich gatunków zwierząt występujących na terenach rolniczych, ograniczenie bioróżnorodności roślinnej na trwałych użytkach rolnych, itp. W efekcie pogarsza się jakość życia w otoczeniu rolnictwa oraz na wsi;
5. Wdrożenie *Strategii na rzecz odpowiedzialnego rozwoju* oraz *Strategii zrównoważonego rozwoju wsi, rolnictwa i rybactwa 2030* stanowi szansę na egalitarny i zrównoważony rozwój polskiego rolnictwa, wszystkich, w tym mniejszych obszarowo, gospodarstw rolnych [13]. W tym celu, niezbędna jest pomoc państwa w zakresie zwiększenia pozycji gospodarstw rolnych na rynku rolno-żywnościowym, między innymi poprzez odbudowę spółdzielczego rynku zbytu, w zakresie aktywizacji produkcyjno-ekonomicznej gospodarstw mniejszych obszarowo, przy jednoczesnym zliberalizowaniu i uproszczeniu przepisów i procedur administracyjno-weterynaryjnych, jak również, poprzez wsparcie skupu produktów rolnych i żywnościowych (np. w ramach działań powstałej ostatnio Platformy Żywnościowej) oraz poprzez wsparcie przetwórstwa rolno-żywnościowego i eksportu;
6. Tak wyartykułowane potrzeby rozwoju polskiego sektora rolno-żywnościowego są zbieżne z proponowanymi zmianami, w tym renacjonalizacją i działaniami w ramach wspólnej polityki rolnej UE, składającymi się na proces tworzenia Zielonego Ładu. Realizację koncepcji Zielonego Ładu warunkuje stymulowanie rozwoju aktywizacji produkcyjno-ekonomicznej gospodarstw rodzinnych, zwłaszcza mniejszych obszarowo, gospodarujących w tzw. obiegu zamkniętym, co jest szczególnie niezbędne obecnie w odniesieniu do polskiego rolnictwa;
7. Nowo powołany Komisarz do spraw rolnictwa Janusz Wojciechowski proponuje wiele rozwiązań w ramach wspólnej polityki rolnej, zbieżnych z potrzebami rozwojowymi polskiego rolnictwa;
8. Niestety, przewidywany kryzys gospodarczy może istotnie zweryfikować plany i działania przewidywane w ramach tworzenia Europejskiego Zielonego Ładu. Być może, koniecznym *remedium* na to jest renacjonalizacja wspólnej polityki rolnej, zwłaszcza w niektórych jej obszarach.

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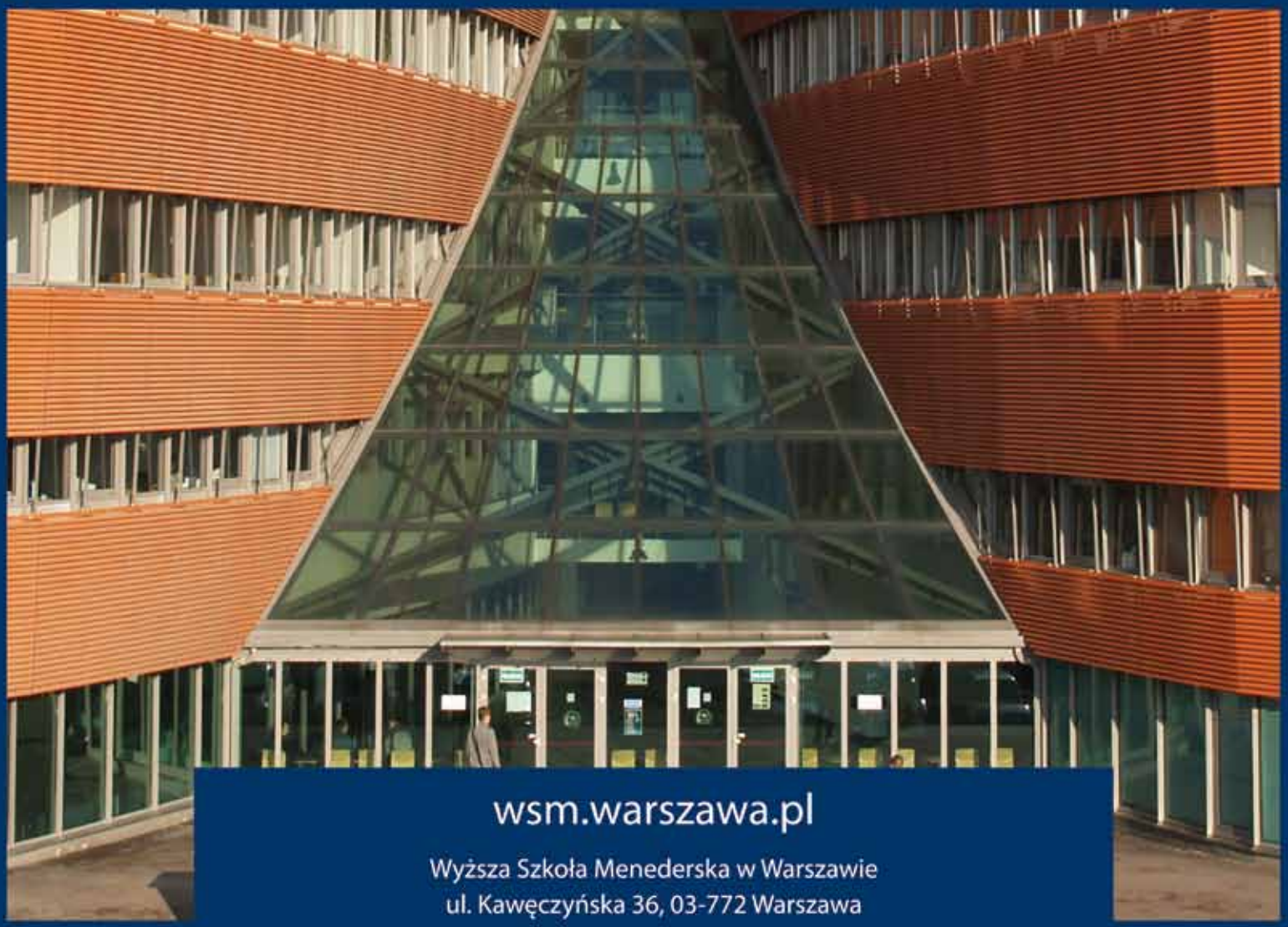

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