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A SUSTAINABLE APPROACH TO NEW GENERATION FOOD THICKENERS: APPLE FIBRE IN MEAT AND VEGETABLE BURGERS

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Abstract: At the 8th Environment Action Programme, the EU agreed on an environmental policy up to 2030 with a zero-emission ambition. The food production sector is credited with a significant impact on environmental pollution: e.g. agriculture accounts for 70% of global freshwater use. Therefore, it is extremely important to promote technological solutions that reduce the negative impact of food production to an absolute minimum. A perfect example of a sustainable approach is a patented method that uses extrusion to produce functional food fibres that act as food thickeners. The possibilities of using the apple fibre preparation (Lutkala Multifunctional) are wide. The aim of this study was to assess the impact of apple fibre preparation on selected physical properties of beef, pork, and vegetable pea protein burgers. The following methods were used: the gravimetric method to calculate weight loss and shape stability during heat treatment, texture profiling according to Texturometer TA.XT2, and colour measurement. The use of Lutkala in meat and vegetable burgers gives a number of benefits: technological (reduced water loss during thermal processing), organoleptic (obtaining a more delicate consistency), health (increased fibre content and reduced calories), and also gives the advantage of a clean label product and has a positive impact on the environment. The addition of apple fibre preparation reduced the hardness of beef burgers, making them more tender, while the plant-based substitute had the lowest cohesiveness, springiness, and chewiness. The inclusion of apple fibre preparation in the formulation composition of burgers significantly differentiated the surface colour parameters of the products. Based on the results obtained, it has been determined that the inclusion of Lutkala Multifunctional in the burger mixture, as per the prescribed recipe composition, should not surpass a maximum limit of 1.5%. The use of apple fibre preparation in burgers is an excellent example of the benefits of using next-generation sustainable hydrocolloids in the food industry.

Key words: apple fibre, extrusion, sustainable, clean label, burgers, thickener

INTRODUCTION

At the 8th Environment Action Programme, the European Union agreed on an environment policy until 2030, pursuing a zero-pollution ambition, including for air, water, and soil, as well as protecting the health and well-being of Europeans. The long-term priority objective is that, by 2050 at the latest, Europeans will live well, within planetary boundaries, in a well-being economy where nothing is wasted [1].

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The food production sector is credited with having a major impact on environmental pollution – for example: agriculture is responsible for 70% of global freshwater use. It is also responsible for biodiversity loss, the production of harmful food waste, and a large proportion of greenhouse gas emissions [2].

It is, therefore, vital that we all, no matter on which industry level we are, look for solutions that really make a difference to our environment, and that we make the Union's postulates a value that guides our decisions, both professional and private. Only then do we have a chance to be successful and have a real impact on the environment.

This study shows how our choices can contribute to achieving these goals using the example of hydrocolloids. These products are a large and very diverse group of food additives, used widely across the food industry. They can come from natural sources such as plants or animals, fungi or even bacteria. They can be minimally processed like raw fibre or highly processed, as modified starches or amidated pectin. They can be highly specialised or very general. They can also be responsible for various functions in food, such as texture, cohesion, consistency, taste, shelf life, stability, and many more [3].

What they have in common is the fact that they are irreplaceable functional additives in industrially produced food. The size of the hydrocolloid market was estimated at USD 10.24 billion in 2021, and the category growth is estimated at USD 13.36 billion in 2024 [4].

The size of this category shows that even a small percentage change in the types of products used can have a real impact on the environment. Therefore, it is worth considering the choice not only in terms of functionality, but also carefully looking at their origin and method of production.

Replacing popular hydrocolloids with sustainably produced functional fibres is one way to achieve this goal. Making this change is possible in most applications, although sometimes it requires adjustments to recipes or production lines. However, the environmental benefits far outweigh the contribution made when these raw materials are put into industrial production.

This article presents how the method of hydrocolloid production affects the environment using the example of Lutkala (a product of Lutkala Sp. z o.o., Poland). Figure 1 illustrates the potential contributions of Lutkala to various areas of the 8th Environment Action Programme of the EU. The raw material used to produce Lutkala is an apple pomace, i.e. a by-product from another production process. Therefore, it is a production that fits in with the aims of the Union's program relating directly to waste and recycling: ("EU action on waste management, treatment, and recycling"), as well as to the circular economy ("The EU's transition to a circular economy with a focus on green growth"), through the possibility of using in locally occurring raw materials. Moreover, Lutkala not only uses waste as a raw material, but its production process does not generate any solid or liquid waste. Therefore, it is a response to the next point on the agenda relating to water ("EU action on water issues to protect water resources"). This is because the production method is based on extrusion, an exclusively physical process that does not use any chemical reagents. For the part of the programme related to chemicals, "action to ensure chemicals are safe, for health and the environment," in this case, it is not only implemented 100% but even exceeded. This technology also supports the part about industry, which is "action to make industry more sustainable and reduce industrial emissions" [1, 5, 6].

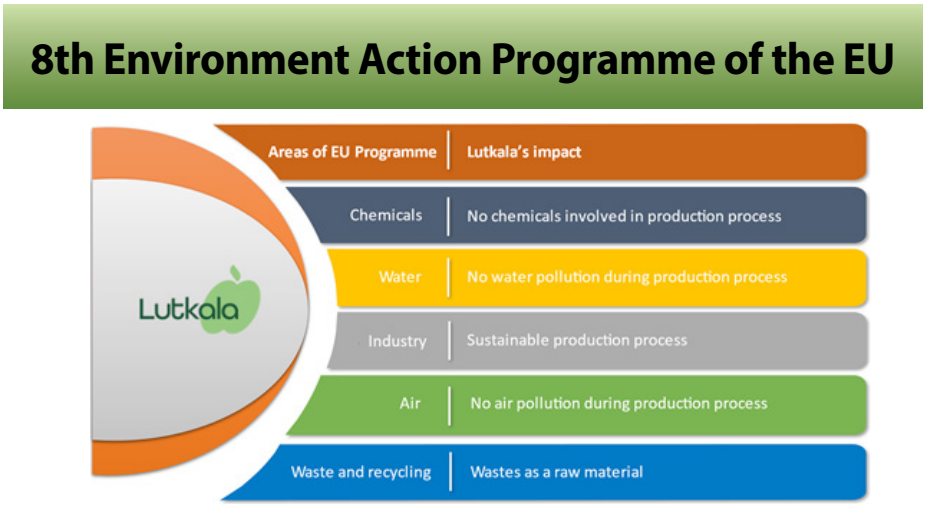

Figure 1. The possible contribution of Lutkala on different areas of the 8th Environment Action Programme of the EU
Source: own elaboration.

The aim of this study was to assess the impact of apple fibre preparation produced through a sustainable process on selected physical properties of meat and vegetable burgers.

MATERIAL AND METHODS

The research material was an apple fibre preparation produced in a patented extrusion method (Patent number: 241316) [7]. Lutkala Multifunctional (LM; 100% extruded apple pomace) is a powder with a caramel colour and aroma of dried apple. The physical and chemical parameters are shown in Table 1. The possibilities of using the product are wide. The above publication presents the effect of using LM in burgers prepared from various types of meat, and vegetable products based on pea protein (25%).

Table 1. Physical and chemical parameters of LM

Shelf life	18 months
Moisture	<10.0 %
pH*	3.7
Rheology	
Viscosity*	from 4000 to 4500 mPas
WHC (water holding capacity)	7.0 g/g
OBC (oil binding capacity)	2.8 g/g
Swelling index	21.0 ml/g
Chemical parameters	
Dietary fibre	60.0–76.0 w/w d.m.
Total sugars	12.5–21.0 w/w d.m.
Protein	6.1–9.4 w/w d.m
Fat	0.9–3.0 w/w d.m.
Ash	1.2–2.3 w/w d.m.

Explanatory notes: *7% water solution, RPM 100, temp. 25°C.

Source: own elaboration.

Apple fibre preparation was used as an additive to produce meat and vegetable burgers (characteristics of burgers shown in Table 2).

Table 2. Characteristics of prepared burgers

Main ingredient	Fat content [%]	Collagen to meat ratio [%]	Addition of apple fibre preparation [%]
Beef	<20.0	15.0	control; 1.5; 3.0
Pork	<7.0	11.0	control; 1.5; 3.0
Vegetable products based on pea protein (25%)	13.2	not applicable	control; 1.5; 3.0

Source: own elaboration.

The regular ground (mesh with a hole diameter of 4.5 mm) beef and pork, vegetable base, and LM were mixed to obtain a homogeneous mass and then shaped into disc-shaped patties with a diameter of 6.7 cm and a thickness of 1.0 cm. The burgers were subjected to heat treatment in an oven (Hendi, H90S) at a temperature of 165°C for 12 minutes, using forced air circulation. Subsequently, the burgers were set aside for 30 minutes to cool down at room temperature (20°C). Burgers without the addition of LM served as the reference material.

The cooking loss (*CL*) of the burger during heating was expressed as a percentage using the following formula:

$$CL = \frac{mi - mf}{mi} \times 100$$

where:
mi – the weight before heating
mf – the weight after heating.

The shape stability (*SS*) during heating was expressed as a percentage using the following formula:

$$SS = 100 - \frac{6.7 - d}{6.7} \times 100$$

where:
d – the diameter of the burger after heating.

The texture profile was determined using a TA.XT2 universal texturometer equipped with a cylindrical measuring probe with a diameter of 20 mm. The most popular test, TPA, known as the "double bite", was performed. The form of the sample was round. The tested samples were compressed at a speed of 0.5 mm/s to a depth of 5 mm; then, the probe was retracted by 5 mm and reinserted to a depth of 5 mm. Several textural parameters were obtained automatically after testing, including hardness, cohesiveness, springiness, elasticity, and chewiness.

Colour measurement was performed using a trichromatic colourimeter CR-310 (Minolta) under the following measurement conditions: observer 2°, illuminant D65, CIE Lab colour space (values: L – lightness, a and b for the red and yellow values). Additionally, the overall colour difference (ΔE) was calculated by the programme with reference to the burgers without the addition of LM.

The results were evaluated by one-factor analysis of variance, followed by the Tukey test in order to identify the difference among the mean values ($p < 0.05$).

RESULTS AND DISCUSSION

Dietary fibres present in the skin of the fruit are considered functional ingredients in the formulation of meat products due to their water-holding capacity and low cooking loss [8]. The addition of fibres to meat products can cause the following technological effects: increase the moisture-retaining capacity of minced products, improve the stability of emulsions, substitute fat, reduce fat content, increase the yield of the product, improve the texture of meat products, retain the shape of the product after heat treatment, and stabilises fats and proteins, which leads to increased storage stability [5, 8].

Table 3 presents the values of cooking loss and the shape of the burgers, depending on the type of meat used and the concentration of LM. The tested burgers significantly differed ($p < 0.05$) in shape as a result of heating, which was associated with the type of meat used in their production. Both 1.5 and 3.0% additions of LM did not significantly affect the change in size of the burgers. However, a significant improvement in burger mass retention was observed with the use of a 1.5% addition of LM. Increasing the dose to 3.0% resulted in further improvement in mass retention only in the case of beef, which had the highest weight loss among the analysed raw materials. Additionally, beef contained the highest amount of fat. Hydrocolloids often possess emulsifying properties that can improve fat retention during technological processes. The plant-based meat substitute exhibited the lowest weight loss, which could be attributed to the absence of other water-binding substances in its composition, such as methylcellulose and citrus fibre.

Table 3. The cooking loss and shape stability of burgers after heating

Contents [%]	CL [%]	SS [%]
Vegetable products based on pea protein [25%]		
0.0	14.8 ±0.6a	88.06 ±1.49d
1.5	11.9 ±1.3a	91.54 ±0.86d
3.0	11.9 ±2.3a	90.55 ±0.86d
Pork		
0.0	27.7 ±1.0cd	76.62 ±4.56bc
1.5	22.2 ±1.3bc	79.60 ±1.72c
3.0	21.0 ±0.8b	80.10 ±1.72c
Beef		
0.0	32.9 ±2.1d	69.65 ±2.28a
1.5	28.1 ±1.8cd	73.13 ±1.49ab
3.0	24.9 ±1.3bc	74.63 ±1.49abc

Explanatory notes: mean value ± standard deviation. Values labelled with the same letter in the column do not differ statistically significantly (ANOVA, Tukey HSD, $p < 0.05$).

Source: own elaboration.

Baioumy and Abedelmaksoud [9] show that cooking loss during heat treatment in beef burgers with orange albedo was a quarter lower than in the control sample. Shape stability was better in the case of burgers with a higher addition of LM. Younis and Ahmad [10] obtained similar results in their study where, as the pomace powder was increased in patties, the shrinkage in diameter was less than that of the control burgers.

Similarly to previous studies, the selected texture parameters of the burgers were strongly dependent on the origin of the raw material (Table 4). Burgers prepared from pork meat were assigned the highest values for all tested parameters of the universal texture profile. Beef meat enabled the production of burgers with lower hardness, while the plant-based substitute had the lowest cohesiveness, springiness, and chewiness. With a 1.5% addition of LM to the plant-based substitute, a decrease in cohesiveness and springiness was observed, while increasing the dose to 3% resulted in a reversal of these changes. The observed results may indicate texture relaxation at low doses, which is associated with improved water retention. Further increasing the LM dose does not improve water retention, resulting in stronger water binding manifested by a subsequent increase in texture parameter values. No statistically significant changes in the texture profile were observed in pork meat due to the addition of LM. This was likely associated with improved water retention, which was observed with both 1.5% and 3.0% additions of LM. The initial strong texturising properties of pork meat also played a significant role. In the case of beef meat, the addition of LM led to a decrease in hardness, springiness, and chewiness, allowing for a less "gummy" and more delicate texture of the burgers.

Table 4. Selected texture parameters of burgers with the addition of LM

Content of LM [%]	Hardness [*N*]	Cohesiveness [-]	Springiness [-]	Elasticity [-]	Chewiness [*N*/cm]
Vegetable products based on pea protein [25%]					
0.0	33.43 ±0.90c	0.53 ±0.01a	0.72 ±0.02a	0.29 ±0.01a	12.82 ±0.38bcd
1.5	33.45 ±2.00c	0.47 ±0.01a	0.67 ±0.02a	0.22 ±0.01a	10.49 ±0.46abc
3.0	35.65 ±2.76c	0.49 ±0.01a	0.69 ±0.02a	0.28 ±0.03a	12.18 ±1.41bcd
Pork					
0.0	33.74 ±4.47c	0.60 ±0.02b	0.80 ±0.01b	0.39 ±0.03b	16.11 ±1.92d
1.5	31.80 ±4.07bc	0.60 ±0.00b	0.83 ±0.02bc	0.43 ±0.00b	16.07 ±2.48cd
3.0	33.86 ±5.72c	0.61 ±0.01b	0.80 ±0.02b	0.43 ±0.01b	16.44 ±2.63d
Beef					
0.0	21.11 ±6.35b	0.62 ±0.01b	0.88 ±0.05c	0.52 ±0.02c	11.44 ±3.34b
1.5	16.55 ±4.45ab	0.60 ±0.01b	0.83 ±0.02bc	0.45 ±0.02b	8.19 ±2.06ab
3.0	10.05 ±1.14a	0.59 ±0.01b	0.82 ±0.02bc	0.44 ±0.03b	4.88 ±0.42a

Explanatory notes: mean value ± standard deviation. Values marked with the same letter do not differ statistically significantly (ANOVA, Tukey HSD, $p < 0.05$).

Source: own elaboration.

In the study by Younis and Ahmad [10], significantly higher values were obtained for the hardness parameter (from 47.85 to 109.54 N/cm^2) and chewiness parameter (from 17.19 to 29.60) for buffalo meat patties prepared with the addition of apple pomace powder at levels of 0, 2, 4, 6, and 8% [10]. The comparison of results suggests greater functionality of LM. The values of the cohesiveness and springiness parameters were comparable.

The colour of the burgers (Table 5) was strongly dependent on the type of meat used for production, as well as the concentration of LM. All burgers exhibited positive values of colour coordinates a* and b*, corresponding to red and yellow colours, respectively. The addition of LM, regardless of the type of meat used, resulted in a significant decrease in lightness (L*) and, to a lesser extent, chromatic colour coordinates a* and b*. The greatest impact of LM was observed for plant-based meat, as evidenced by high values of the overall colour difference (ΔE). This was largely due to a decrease in the values of both chromatic parameters, making the appearance of the burger similar to those prepared with both types of regular meat. On the other hand, with pork burgers, a decrease in lightness was mainly observed, gradually resembling the appearance of beef-based ones. Significant colour changes were also observed in beef burgers, as even at $\Delta E = 3.5$, consumers could perceive a significant difference between the products [11]. However, acceptance of such changes should not be a problem for consumers, as similar changes occur due to more aggressive heat treatment methods such as frying and grilling.

Comparing the results of the colour measurement to the results obtained by Younis and Ahmad [10], it can be concluded that the results achieved in this publication are slightly lower for all parameters.

Table 5**.** Results of the colour analysis of the burgers

Content of LM (%)	L*	a*	b*	ΔE
Vegetable products based on pea protein (25%)				
0.0	41.72 ±0.21c	11.58 ±0.49	25.64 ±0.41e	–
1.5	35.08 ±1.32ab	8.38 ±0.41de	16.82 ±1.52d	11.50
3.0	32.21 ±0.28a	7.22 ±0.46bcd	14.01 ±0.45c	15.64
Pork				
0.0	60.69 ±0.93d	7.42 ±0.23cd	12.74 ±0.38abc	–
1.5	53.99 ±0.94d	5.98 ±0.48ab	13.07 ±0.64bc	6.85
3.0	46.42 ±0.48d	5.32 ±0.23a	12.53 ±0.18abc	14.43
Beef				
0.0	40.20 ±0.41c	8.76 ±0.63e	11.68 ±0.82ab	–
1.5	35.99 ±2.08b	7.67 ±0.69cde	11.02 ±0.99ab	4.40
3.0	34.14 ±1.46ab	6.98 ±0.13bc	10.68 ±0.52a	6.39

Explanatory notes: mean value ± standard deviation. Values marked with the same letter do not differ statistically significantly (ANOVA, Tukey HSD, p <0.05); *attributes L – lightness–darkness, a – green–red, b – yellow–blue, ΔE – total colour change.

Source: own elaboration.

In the study, it was demonstrated that the use of hydrocolloids in meat processing is particularly important due to their ability to shape desired rheological properties, often accompanied by improved production efficiency.

Research by Zinina et al. [8] has summarised that by-product from apples has the following technological effect on meat products: modifying moisture, texture, and colour lightness of meat products, as well as improving emulsion stability and cooking yield, increasing shelf-life, and preventing lipid oxidation of chicken products. These conclusions were confirmed in this study.

Some authors evaluated the impact of adding vegetable fibres to chicken burger formulations as animal fat substitutes [12]. Comparing the physicochemical and technological properties of vegetable fibres evaluated by Huber et al., [12] LM is a more functional product. LM has more than two times higher WHC, three times higher swelling capacity, and about two times higher oil holding capacity compared to other fibres.

According to Huber et al., [12] the evaluated plant fibres may be an interesting alternative for the production of meat products with prebiotic and functional appeal. In this way, the use of a mixture of vegetable fibres as fat substitutes in chicken burgers demonstrated a promising option to check the functionality of foods considered unhealthy.

Additionally, Baioumy and Abedelmaksoud [9] show that the use of orange albedo as a functional additive has a major impact on the quality attributes and storage stability of beef burgers.

CONCLUSIONS

The use of Lutkala in meat and vegetable burgers gives a number of benefits: technological (reduced water loss during thermal processing), organoleptic (obtaining a more delicate consistency), health (increased fibre content and reduced calories), and also gives the advantage of a clean label product and has a positive impact on the environment. The addition of apple fibre preparation reduced the hardness of beef burgers, making them more tender, while the plant-based substitute had the lowest cohesiveness, springiness, and chewiness. The inclusion of apple fibre preparation in the formulation composition of burgers significantly differentiated the surface colour parameters of the products.

Based on the results obtained, it has been determined that the inclusion of Lutkala Multifunctional in the burger mixture, as per the prescribed recipe composition, should not surpass a maximum limit of 1.5%.

REFERENCES

[1] **DECISION (EU) 2022/591 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 6 APRIL 2022** on a General Union Environment Action Programme to 2030. Official Journal of the European Union (L14/22, 12.4.2022).

[2] **UGBEM CH. 2023.** "Wpływ produkcji i konsumpcji żywności na środowisko: zrównoważony system żywnościowy" (https://ichi.pro/pl/wplyw-produkcji-i-konsumpcji-zywnosci-na-srodowisko-zrownowazony-system-zywnosciowy-29189740103338, access 20.06.2023). www.ichi.pro.

[3] **MILANI J., MALEKI G., 2012.** "Hydrocolloids in food industry". [In:] Valdez B. (ed.) "Food Industrial Processes – Methods and Equipment" (17–37). In-Tech, Croatia.

[4] **IMR INTERNATIONAL HYDROCOLLOID INFORMATION CENTER**, (www.hydrocolloid.com, access: 20.06.2023).

[5] **CURUTCHET A., TRIAS J., TARREGA A., ARCIA P. 2020.** "Consumer response to cake with apple pomace as a sustainable source of fibre". Foods 10 (3), 499.

[6] **SCHMID V., TRABERT** A., **SCHÄFER J., M., HEIKE P KARBSTEIN, EMIN M.A. 2020.** "Modification of apple pomace by extrusion processing: studies on the composition, polymer structures, and functional properties". Foods 9(10): 1385.

[7] **PATENT NUMBER 241316.** "Use of extruded fruit and/or vegetable waste as an additive increasing the viscosity of food products" (WO/2020/209738).

[8] **ZININA O., MERENKOVA S., TAZEDDINOVA D., REBEZOV M., STUART M., OKUSKHANOVA E., YESSIMBEKOV ZH., BARYSHNIKOVA N. 2019.** "Enrichment of meat products with dietary fibers: a review". Agronomy Research 17(4): 1808–1822.

[9] **BAIOUMY A.A., ABEDELMAKSOUD T.G. 2021.** "Quality properties and storage stability of beef burger as influenced by addition of orange peels (albedo)". Theory and Practice of Meat Processing 6(1): 33–38.

[10] **YOUNIS K., SAGHIR A. 2018.** "Quality evaluation of buffalo meat patties incorporated with apple pomace powder". Buffalo Bulletin 37 (3): 389–401.

[11] **CARPENTER C.E., CORNFORTH D. 2001.** "Consumer preference for beef color and packaging affect eating satisfaction". Meat Science 57(4): 359–363.

[12] **HUBER E., FRANCIO D.L., BIASI V., MEZZOMO N., SALVADOR FERREIRA S.R. 2016.** "Characterization of vegetable fiber and its use in chicken burger formulation". Journal of Food Science and Technology 53: 3043–3052.

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THE ROLE OF HAND PEELING AND PLANT INGREDIENTS IN CONTROLLING MICROBIAL CONTAMINATION DURING REFRIGERATED STORAGE OF *LITOPENAEUS VANNAMEI*

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Abstract: Fresh shrimp are highly perishable, so in addition to chemical and physical methods, natural preservation methods are also applied to prolong their shelf life. A trial was carried out to assess the efficacy of hand peeling and the addition of garlic (*Allium sativum*) and chilli pepper (*Capsicum annum*) as natural conserving agents in the control of microbiological contamination in *Litopenaeus vannamei* shrimp during cold storage. The highest level of *Staphylococcus aureus* was found after 5 days of storage in unpeeled shrimps without additives (3.32 log cfu·g^{-1} = colony forming units per gram). There was a statistically significant effect (p <0.05) of all the factors tested, that is, the day of testing, the preparation method and the additive used on the average number of *S. aureus* in shrimp. The average number of *Vibrio parahaemolyticus* in the garlic-only and garlic and chilli samples was very similar, at 2.30 and 2.38 log cfu·g^{-1}, respectively. The highest average number of psychrotrophs was recorded in samples with garlic and chilli: 4.41–5.65 log cfu·g^{-1}, 5 days after purchase. The addition of plant additives used in this work inhibits the fungi in peeled shrimp. The composition of the ingredients used does not provide complete protection against spoilage, but to a greater extent, it improves the shelf life of the hand-peeled shrimp.

Key words: *Litopenaeus vannamei,* shrimp, hand peeling*, Allium sativum* (garlic), *Capsicum annum* (chilli pepper), microorganisms, quality

INTRODUCTION

Shrimps are among the products that are especially valued all over the world. In 2020, white-legged shrimp (*Litopenaeus vannamei*) was the most produced species, reaching 5.8 million tonnes [1]. *L. vannamei* has a high nutritional and protein content (16.8–17.6%). Shrimps contain essential omega-3 and omega-6 unsaturated fatty acids, minerals, and vitamins that positively affect human health [2]. Fresh shrimp are products prone to spoilage due to microorganism growth, lipid oxidation, and blackening (melanose) during post-harvest processing [3, 4, 5]. Shrimp contain a high proportion of nonprotein nitrogen compounds, which are easily metabolised by microorganisms and lead to more rapid spoilage [6, 7]. Certain groups of microorganisms (*Shewanella* spp., *Aeromonas* spp., *Enterobacteriaceae* spp., *Pseudomonas* spp., *Vibrio* spp.) are responsible for negative organoleptic properties such as unpleasant ammonia-like off-taste and fishy flavours [8, 9]. There are many methods by which

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shrimp are protected from quality losses during the storage process. The most common treatments to prevent the undesirable effects of this loss on the physical, chemical, and sensory properties of shrimp include the addition of preservatives (commonly 0.6% benzoic acid and 0.6% sorbic acid), irradiation, modified atmosphere packaging, ice cooling, freezing and high-pressure treatment. To extend shrimp shelf life, the cephalothorax and head are removed and glazed with ice to prevent undesirable quality changes and oxidation during storage [3, 5, 6, 10]. However, despite the application of the methods mentioned above, shrimp are still susceptible to microorganism growth, leading to a loss of quality in the final product. Shrimp available on the Polish market (Table 1) are usually sold frozen, pickled, blanched (whole) or raw (whole, defrosted).

Table 1. Shrimp types most frequently available on the Polish market

Shrimp type	Latin name	Origin
Whiteleg	*Litopenaeus vannamei/ Penaeus vannamei*	Bangladesh, Ecuador, India, Indonesia, Costa Rica, Thailand, Vietnam
Cocktail	Metapenaeus dobsoni	India
Cocktail	*Metapenaeus monoceros*	Bangladesh
Cocktail	Solenocera crassicornis	Western Indian Ocean
Argentine red	*Pleoticus muelleri*	Argentina
Tiger	*Penaeus monodon*	Ecuador, Thailand, Bangladesh, Vietnam
Banana	*Penaeus merguiensis*	Vietnam
Northern	Pandalus borealis	waters off Greenland

Source: own elaboration.

The shelf life of defrosted shrimp is short (it is recommended to consume them within 2 days of delivery), so besides chemical and physical methods, natural preservation methods are also being applied to maintain high-quality and fresh shrimp. Natural compounds of plant origin are very popular in the conservation of seafood. Their strong antimicrobial and antioxidant activity offers great potential for the food industry [11]. The aim of the study was to investigate the effects of hand peeling and the addition of garlic (*Allium sativum*) and chilli pepper (*Capsicum annum*) on the microbiological contamination of vacuum-packed *L. vannamei* white shrimp during cold storage.

MATERIAL AND METHODS

Test material

The test material consisted of thawed white shrimp (*Litopenaeus vannamei*) purchased in the MAKRO store immediately after delivery to the store. *L. vannamei* originated from the *Southeast Pacific* (Area 87) – Ecuador. In the MAKRO, the products were stored in Styrofoam containers filled with ice under controlled temperature conditions of 0 to 2°C. The shrimp were transported to the microbiological laboratory in the packaging mentioned above to ensure the continuity of the "cold distribution chain". After being transported (less than 15 minutes) to a research laboratory, the samples were analysed.

Method of shrimp preparation

After *L. vannamei* was delivered to the laboratory (approx. 1.5 kg), a portion of the shrimp (approx. 100 g) was discarded for microbiological testing before storage, while the rest was divided into two parts. Half of *L. vannamei* were peeled by hand under sterile conditions (with sterile gloves and in sterile boxes to minimise cross-contamination between the shell and meat tissue) [6], while in the second half, the tail was left with the intestine (Fig. 1). The division of shrimp into peeled and unpeeled was carried out to compare the spoilage rate. The removal of the cephalothorax, which contains organs rich in autolysis enzymes, should increase the storage quality of shrimp.

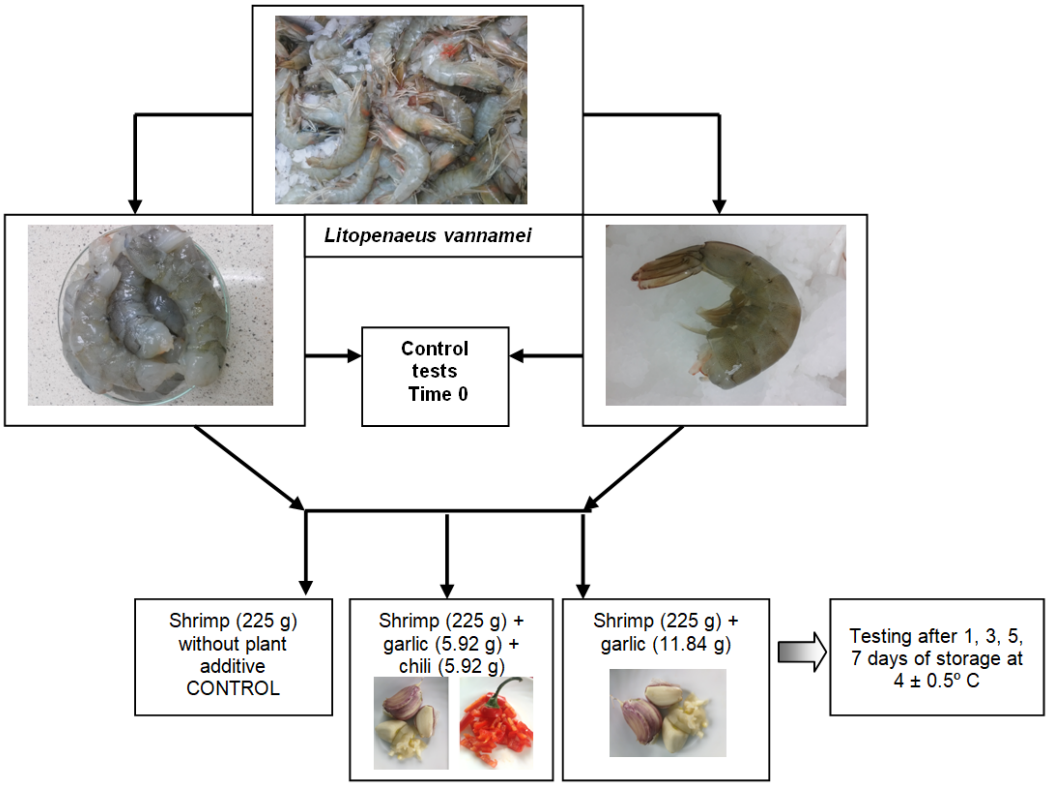


Figure 1. Test diagram

Source: own elaboration.

METHOD OF PLANT PREPARATION

As an accompaniment, vegetable ingredients: garlic (*Allium sativum*) and chilli peppers *(Capsicum annuum*), which are served most often in the kitchen, are used as additives to shrimp dishes. Garlic of the Harnaś variety and Cyklon red hot chilli pepper from Poland were used for the research. In addition to being very well suited to this type of seafood, they have antibacterial and antifungal properties [12, 13, 14, 15]. The ingredients were washed for 15 minutes in sterile distilled water to remove impurities from the surface and then crushed with a Grind & Chop Transa Electronics electric grinder (ARCOTECH, Opole, Poland). Cutting or crushing releases the enzyme alliinase, which converts alliin to active allicin [16]. Allicin is the main bioactive component in garlic products [17]. Before rinsing and crushing, the garlic husks and the small kernels of the chilli were removed. The plant components produced in this way were used for further experiments.

THE COURSE OF THE EXPERIMENT

Each 100 g of peeled and unpeeled *L. vannamei* was microbiologically examined before storage, while the remainder was divided according to the diagram shown in Figure 1. In sterile PE/PA bags intended for vacuum packaging of food, appropriate amounts of garlic and chilli peppers (to obtain a 5% addition) were added to 225 g of shrimp (popular single packs available in Poland) according to the diagram (in addition to the control tests); (Fig. 1). The contents were thoroughly and carefully mixed so that the shrimp were evenly covered with plant additives, then packed in PA/PE bags and vacuum welded using a CAS CVP-350/MS vacuum packing machine (Poland). The prepared samples were refrigerated for 7 days at a temperature of 4 ±0.5°C.

MICROBIOLOGICAL ASSAYS

In a chamber with laminar airflow, 20 g of the product was withdrawn and then homogenised with 180 mL of Ringer liquid with the use of a Stomacher Lab-Blender 400 (Seward, Worthing, UK). To determine the presence

of *Vibrio parahaemolyticus*, 25 g of the product was collected and then homogenised with 225 mL of alkaline peptone water. In the products studied, the following values were marked:

- psychrotrophic microbes, according to PN-ISO-17410:2004 [18],
- *Staphylococcus aureus,* according to PN-EN ISO 6888–1:2001/A1:2004 [19],
- fungi (moulds and yeasts), according to PN-ISO 21527–1:2009 [20],
- *V. parahaemolyticus,* according to ISO 8914:1990 [21].

Microbiological tests were carried out by sowing additional dilutions of 1 mL on the bottom of a sterile plate and then pouring a liquefied and cooled solid medium (approximately 15 mL) over. Microbiological analyses were carried out immediately after delivery to the laboratory and after 1, 3 and 5 days of cold storage (Fig. 1). Due to the unsuitable organoleptic characteristics (mucous surface, discolouration and darkening, rotten odour) of the shrimp stored for 7 days (Fig. 2), no microbiological tests were performed.

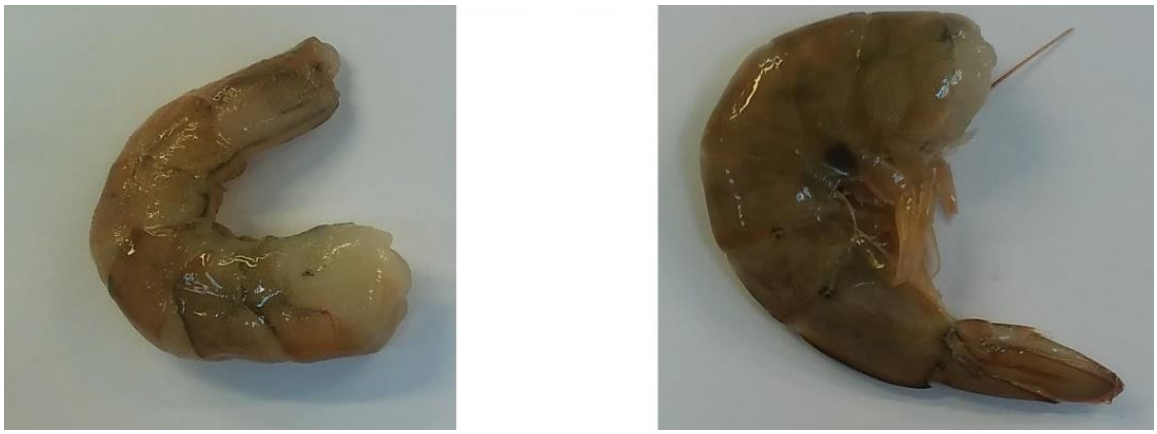


Figure 2. Shrimp (peeled and unpeeled) after 7-day storage
Source: own elaboration.

After incubation, the number of microorganisms was determined according to PN-EN ISO 7218:2008 [22]. Analyses were performed in three independent replicates.

STATISTICAL ANALYSIS

Data were logarithmically transformed (for mould, log cfu·g^{-1} + 1 transformation due to 'clean' samples without mould), and baseline values for location and variability were calculated for both the entire sample and subgroups based on the test day and sample preparation. A two-factor model (preparation, additives) of ANOVA with repeated measurements was used for the statistical analysis. The assumption of homogeneity of variance in the subgroups was tested with the Levene test. The Newman–Keuls post-hoc test was used to investigate the significance of the differences between subgroups. In addition, bifactorial ANOVA was used to determine the effect of the investigated factors on the content of the investigated microorganisms in shrimp on the fifth day after purchase.

RESULTS

The quality and safety of shrimp may be directly related to non-compliance with good seafood hygiene practices and contact with contaminated work surfaces, tables, and unwashed knives [23]. Table 2 shows shrimp contamination on the day of purchase: *S. aureus* with an average number of 1.35 log cfu·g^{-1} (with a minimum value of 1.00 and a maximum value of 1.85 log cfu·g^{-1}); *V. parahaemolyticus* – the mean number was 1.71 (1.48–1.95) log cfu·g^{-1}. Furthermore, the following were detected in the samples: psychrotrophic bacteria – 3.48 (2.99–4.23) log cfu·g^{-1}; mould – 1.36 (1.00–1.60) log cfu·g^{-1} +1 and yeast – 2.15 (1.70–2.58) log cfu·g^{-1}. The microorganism content of the product was slightly variable – V_x was no more than 36%.

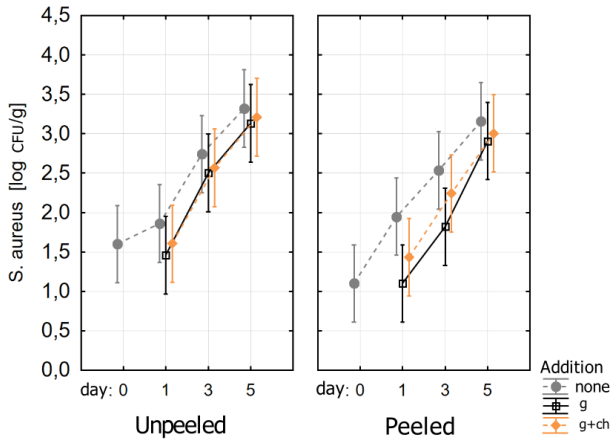
Table 2. Contaminating microbe count in shrimp on the day of purchase

Microbe type	*M*	–95% PU	+95% *PU*	Min.	Max.	*SD*	V_x [%]
S. aureus log cfu·g⁻1	1.35	1.01	1.69	1.00	1.85	0.32	35.6
V. parahaemolyticus log cfu·g⁻1	1.71	1.52	1.90	1.48	1.95	0.18	10.5
Psychrotrophs log cfu·g–1	3.48	2.95	4.01	2.99	4.23	0.50	14.5
Moulds log cfu·g^{-1} +1	1.36	1.06	1.66	1.00	1.60	0.28	20.9
Yeasts log jtk · g^{-1}	2.15	1.80	2.51	1.70	2.58	0.33	15.5

Explanatory notes: *M* – arithmetic average, *PU* – confidence interval, Min. – minimum, Max. – maximum, *SD* – standard deviation, V_x [%] – variability index.

Source: own elaboration.

There was a statistically significant effect (p <0.05) of all factors tested, i.e. the day of the test, the preparation method and the additive used on the average number of *S. aureus* in shrimp. Interactions between factors were found to be statistically insignificant. The average count of *S. aureus* 24 hours after purchase was 1.57 log cfu·g^{-1} with a 95% confidence interval of 1.39–1.75 log cfu·g^{-1}, and it statistically increased to 2.40 (2.15–2.66) log cfu·g^{-1} after 3 days of storage (p <0.001). The average number of *S. aureus* in unpeeled shrimp was 2.12 (1.98–2.27) log cfu·g^{-1}, statistically significantly higher than that of peeled shrimp, 1.85 (1.70–1.99) log cfu·g^{-1} (p <0.05). The average number of *S. aureus* in samples with garlic alone and with garlic and chilli was similar (Fig. 3). Statistically significant differences were observed between the group without additives and the samples with additives (p <0.05). The highest level of *S. aureus* was found after 5 days of storage in unpeeled shrimps without any additives (3.32 log cfu·g^{-1}), while the lowest level was found in peeled shrimp with only garlic (2.91 log cfu·g^{-1}), (Fig. 3).

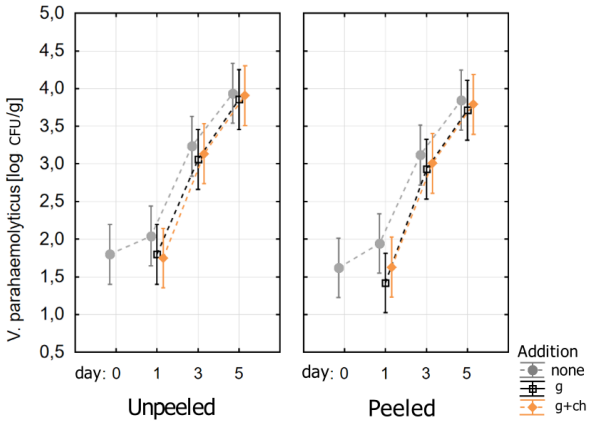


Explanatory notes: g – garlic, g + ch – garlic with chilli

Figure 3. Changes in the number of *S. aureus* depending on the day of testing, the preparation method, and the additive used

Source: own elaboration.

A statistically significant effect of the study day was observed on the average number of *V. parahaemolyticus* in shrimp. The remaining factors and interactions between them were found to be statistically insignificant. In shrimp tested 24 hours after purchase, the average number of *V. parahaemolyticus* was 1.76 (1.53–1.99) log cfu·g^{-1}; it increased statistically significantly 3 days after purchase to 3.08 (2.98–3.18) log cfu·g^{-1} (p <0.001). In unpeeled shrimp, *V. parahaemolyticus* was recorded at an average level of 2.50 (2.28–2.73) log cfu·g^{-1}, slightly higher than in peeled shrimp (2.34 (2.11–2.57) log cfu·g^{-1}). When analysing the effect of additives on the content of *V. parahaemolyticus* in shrimp, the highest number of 2.58 (2.31–2.86) log cfu·g^{-1} was found in samples without additives. The average number of *V. parahaemolyticus* in the garlic-only and garlic and chilli samples was very similar, at 2.30 (2.02–2.58) and 2.38 (2.10–2.66) log cfu·g^{-1}, respectively. The differences between the averages were not significant. Detailed changes in the number of *V. parahaemolyticus* according to the date and preparation of the test are shown in Figure 4.

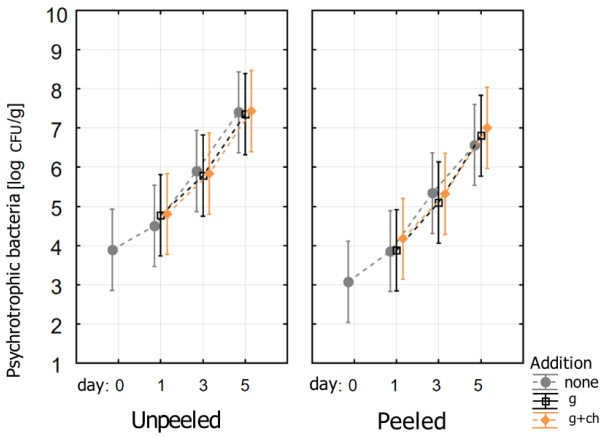


Explanatory notes: g – garlic, g + ch – garlic with chilli.

Figure 4. Changes in the number of *V. parahaemolyticus* depending on the day of testing, the preparation method, and the additive used

Source: own elaboration.

As in *V. parahaemolyticus*, a statistically significant effect on the average number of psychrotrophic bacteria was observed on the study day. The remaining factors and interactions between them were found to be statistically insignificant. The average number of psychrotrophic bacteria 24 hours after purchase was 3.27 (3.02–3.52) log cfu·g^{-1}, and 3 days after purchase, it statistically increased to 4.17 (3.70–4.64) log cfu·g^{-1} (p <0.001). The average number of these microorganisms in unpeeled shrimp was 5.27 (4.76–5.77) log cfu·g^{-1}, slightly higher than in peeled shrimp (4.61 (4.10–5.12) log cfu·g^{-1}). The highest average number of psychrotrophs was recorded in samples with garlic and chilli: 5.03 (4.41–5.65) log cfu·g^{-1}. The average number of these bacteria in the samples with only garlic and without additives was very similar, 4.88 (4.26–5.50) and 4.90 (4.28–5.52) log cfu·g^{-1}, respectively. The differences between the averages were not statistically significant. On day 5, the level of psychrotrophic bacteria in the peeled shrimp was almost 1 logarithmic cycle higher than in the peeled shrimp (Fig. 5).



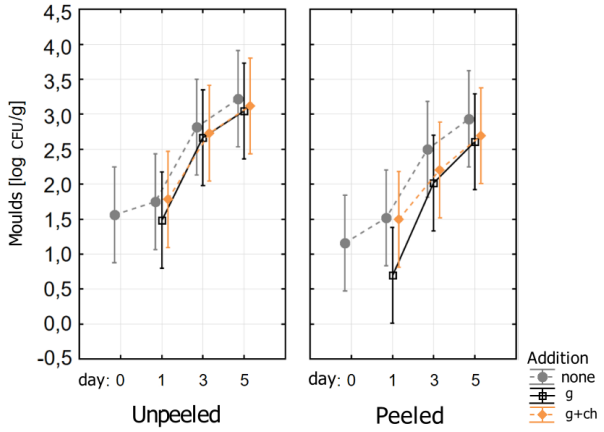
Explanatory notes: g – garlic, g + ch – garlic with chilli.

Figure 5. Changes in the number of psychrotrophic bacteria depending on the day of testing, the preparation method, and the additive used

Source: own elaboration.

The tests carried out showed a statistically significant effect of the test day and the preparation method on the average mould count in shrimp. The effects of additives and interactions between the factors investigated were not statistically significant. The average mould count 24 hours after purchase was 1.45 (0.08–1.62) log cfu·g^{-1}+1. However, 3 days after purchase, it increased statistically significantly to 2.49 (2.10–2.88) log cfu·g^{-1}+1 (p <0.001). The mean mould formation in unpeeled shrimp (2.20 (1.88–2.52) log cfu·g^{-1}+1) was significantly

higher than in peeled shrimp (1.74 [1.42–2.06] log cfu·g^{-1}+1). The highest average mould count was recorded in samples without additives and in those with garlic and chilli: 2.14 (1.75–2.54) and 2.05 (1.66–2.44) log cfu·g^{-1}+1, respectively. The average mould count in samples with only garlic added was 1.71 (1.32–2.11) log cfu·g^{-1}+1. Differences between mean values were not statistically significant. On the fifth day of storage, the mould count in the unpeeled shrimp was similar, regardless of the additive used. On the other hand, in peeled shrimp to which chilli and garlic and garlic alone were added, the mould count was lower by approximately a third of a logarithmic cycle compared to the shrimp without additions (Fig. 6).

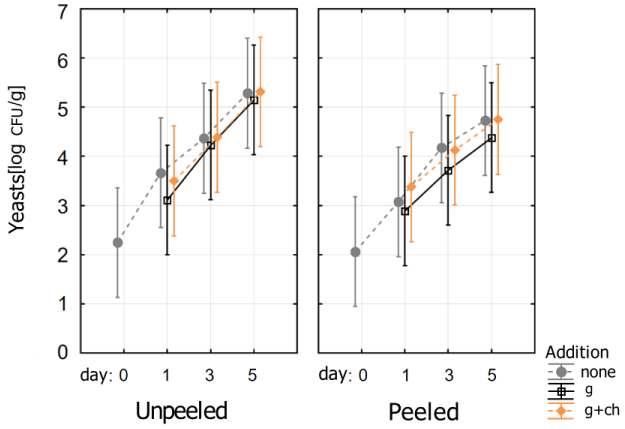


Explanatory notes: g – garlic, g + ch – garlic with chilli.

Figure 6. Changes in the number of moulds depending on the day of testing, the preparation method, and the additive used

Source: own elaboration.

The studies showed a statistically significant effect of the study day on the average yeast count in shrimp. Other factors and interactions between factors were found to be statistically insignificant. The average yeast count 24 hours after purchase was 3.27 (3.02–3.52) log cfu·g^{-1}, and 3 days after purchase, it statistically increased to 4.17 (3.70–4.64) log cfu·g^{-1} (p <0.001). The average yeast count in unpeeled shrimp (3.88 (3.41–4.35) log cfu·g^{-1}) was significantly higher than in peeled shrimp (3.56 (3.09–4.03) log cfu·g^{-1}). The highest average yeast count (such as in moulds) was recorded in samples without additives and in those with garlic and chilli: 3.82 (3.25–4.40) and 3.85 (3.27–4.42) log cfu·g^{-1}, respectively. On the other hand, the average yeast count in samples with only garlic was 3.49 (2.91–4.06) log cfu·g^{-1}. The differences between the mean values were not statistically significant. On day 5, the yeast content in the unpeeled shrimp was approximately 0.6 logarithmic cycles higher than in the peeled shrimp (Fig. 7).



Explanatory notes: g – garlic, g + ch – garlic with chilli.

Figure 7. Changes in the yeast count depending on the day of testing, the preparation method, and the additive used

Source: own elaboration.

DISCUSSION

Pathogenic bacteria in food can reach high levels without causing a noticeable change in odour or taste [23]. The use of plant extracts has been shown to prolong the shelf life of foods, including fish and fish products [24]. The presence of *S. aureus* in food is considered a potential hazard that may lead to food poisoning [8, 25]. The highest *S.aureus* level was found after 5 days of storage in unpeeled shrimp without additives (3.32 log cfu·g^{-1}), exceeding the limits for *S. aureus* laid down in EU Directive 2073/2005 [26]. The authors propose that the main active ingredient in the antimicrobial garlic extract is allicin, which can penetrate the cell wall and influence the cytoplasmic components and enzymes [27, 28]. Other authors' results have shown that the antibacterial activity of garlic is entirely dependent on allicin, which is three times more effective against Gram-positive bacteria than against Gram-negative bacteria [25]. This study shows a lower effect of garlic on psychrotrophic bacteria and *V. parahaemolyticus* than on *S. aureus* (Fig. 2–4). Mozaffari Nejad et al. [25] observed a significant effect of garlic extract on the growth of *S. aureus* in hamburgers. The number of psychrotrophic bacteria detected in this study after 3 days of storage was slightly lower than that of Premaratne et al. [29], but after two more days, the concentration of these bacteria exceeded 7 log cfu·g^{-1}. Products containing more than 7 log cfu·g^{-1} of psychrotrophic bacteria exhibit organoleptic perishability (off-flavour including fruity, stale, bitter, putrid, and rancid, as well as changes in odour, colour, and texture) [31, 32], which means that the fish product is spoiled [32]. The organoleptic changes observed in shrimps after 7 days of storage (unpleasant odour, changes in texture); (Fig. 2) were characteristic of the microbial degradation of amino acids. Fungi can flourish in both raw and processed foods, even if environmental conditions are unfavourable for most bacteria [33, 9]. References in the literature confirm the antifungal properties of garlic and chilli [34, 35]. The addition of garlic alone or garlic and chilli used in this work has an inhibitory effect on the fungi in the hand-peeled shrimp. Kim et al. [16] showed the activity of freeze-dried garlic against yeast, which develops in stored kimchi. After 5 days of storage, the results showed a yeast content higher than that of mould by approximately 2 logarithmic cycles. However, moulds in raw or processed seafood cause a change in the flavour, texture, odour, and nutrient quality, as well as the formation of mycotoxins [9]. Mycotoxins are very stable and, above all, heat-resistant, so they remain in food during processing and storage, leading to a serious food safety problem [33, 36]. Cruz da Silva et al. [37] observed in a study on *L. vannamei* that the 146 isolated fungi included 46 species, of which the genera *Aspergillus*, *Penicillium,* and *Fusarium* were the most dominant species. In hand-peeled shrimps to which garlic was added, less yeast and mould formation was observed on day 5 of refrigerated storage, which is confirmed by the reports by Liu *et al*. [38] on the inhibitory effect of chopped garlic added to minced meat. The addition of garlic (5 or 10%) to raw meat reduced the number of microorganisms in the range of the total number of aerobic mesophilic bacteria, yeasts and moulds [38]. *V. parahaemolyticus* is a bacterium that causes food poisoning from eating raw or lightly cooked seafood. Leaving the food product for 2–3 hours at room temperature can result in the growth of *V. parahaemolyticus* from 10^2–10^3 cfu·g^{-1} to or more than 10^5 cfu·g^{-1} [39]. According to Takoundjou *et al.* [39] to induce a disease with a 100% probability, an exposure value of 10^6 cfu/meal is required, while in our study, the maximum level ($2{,}1 \cdot 10^4$ cfu·g^{-1}) of *V.parahaemoliticus* was observed in 5-day storage of unpeeled shrimp. Basil, clove, garlic, horseradish, marjoram, oregano, rosemary, and thyme have been shown to have antibacterial activity against *V. parahaemolyticus* at 30°C, but at low temperatures, the herbs show little antibacterial effect [40]. It is possible that the storage temperature (4°C) used in this study reduced the activity of the herbs used. Although combinations of several spices have a greater antibacterial effect than single spices [38, 41], no such association was found for the combination of chilli and garlic in these studies. Studies by different authors have confirmed the potential of herbs as a substitute for synthetic additives used to prevent oxidation and degradation of food quality, especially fish and fish products [24, 25].

CONCLUSIONS

At the end of storage, slightly higher growth of microbes was shown in the unpeeled shrimps, as compared to the hand-peeled ones. The composition of the ingredients used does not provide complete protection against spoilage but does, to a greater extent, improve the shelf life of hand-peeled shrimp. With the use of a 5% garlic additive, the shelf life of peeled shrimp in refrigerated conditions can be extended from 2 to 5 days.

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REFERENCES

[1] **FAO. 2022.** The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation, Rome. https://doi.org/10.4060/cc0461en

[2] **TAWADE P.S., KOLI J.M., PATANGE S.B., SHARANGDHER S.T., MOHITE A.S. 2019.** "Biochemical and microbiological quality of cultured shrimp Litopenaeus vannamei of different farms of Ratnagiri". International Journal of Current Microbiology and Applied Sciences 8(6): 2110–2124.

[3] **ABD-EL-AZIZ N.A., MOHARRAM Y.G. 2016.** "Microbiological quality of imported frozen shrimp in Egypt". Annals of Agricultural Sciences 61(1): 35–40. https://doi.org/10.1016/j.aoas.2016.04.002

[4] **BASIRI S., SHEKARFOROUSH S.S., AMINLARI M., AKBARI S. 2015.** "The effect of pomegranate peel extract (PPE) on the polyphenol oxidase (PPO) and quality of Pacific white shrimp (*Litopenaeus vannamei*) during refrigerated storage". LWT – Food Science and Technology 60(2): 1025–1033. https://doi.org/10.1016/j.lwt.2014.10.043

[5] **HERIANTO S., SHIH M.K., LIN C.M., HUNG Y.C., HSIEH C.W., WU J.S., CHEN M.H., CHEN H.L., HOU C.Y. 2022.** "The effects of glazing with plasma-activated water generated by a piezoelectric direct discharge plasma system on whiteleg shrimp (*Litopenaeus vannamei*)". LWT – Food Science and Technology 154: 112547. https://doi.org/10.1016/j.lwt.2021.112547

[6] **BROEKAERT K., HEYNDRICKX M., HERMAN L., DEVLIEGHERE F., VLAEMYNCK G. 2013.** "Molecular identification of the microbiota of peeled and unpeeled brown shrimp (*Crangoncrangon*) Turing storage on ice and at 7.5 ºC". Food Microbiology 36: 123–134. https://doi.org/10.1016/j.fm.2013.04.009

[7] **KPOCLOU Y.E., ANIHOUVI V.B., AZOKPOTA P., SOUMANOU M.M., DOUNY C., IGOUT A., GALANAKIS C.M., SCIPPO M.L., HOUNHOUIGAN D.J. 2023.** "Preservation practices and safety of fresh shrimp (*Penaeus notialis*) sold in Beninese markets". Discover Food 3(4). https://doi.org/10.1007/s44187-023-00042-y

[8] **AMIN A.N., AHEMD A.M., AHMED O.M. 2021.** "Chemical and bacteriological risks of shrimp and clams (Gandofly) from Suez Gulf". *Food Research* 5(3): 281–288. https://doi.org/10.26656/fr.2017.5(3).635

[9] **TAHILUDDIN A.B., MARIBAO I.P., AMLANI M.Q., SARRI J.H. 2022.** "A review on spoilage microorganisms in fresh and processed aquatic food products". Food Bulletin 1(1): 21–36. https://doi.org/10.29329/foodb.2022.495.0

[10] **OKPALA C.O.R., CHOO W.S., DYKES G.A. 2014.** "Quality and shelf life assessment of Pacific white shrimp (*Litopenaeus vannamei*) freshly harvested and stored on ice". LWT – Food Science and Technology 55: 110–116. http://dx.doi.org/10.1016/j.lwt.2013.07.020

[11] **VIJAYAN A., SIVARAMAN G.K., VISNUVINAYAGAM S., MOTHADAKA M.P. 2021.** "Role of natural additives on quality and shelf life extension of fish and fishery products". [In:] M.A. Prieto and P. Otero (eds) "Natural Food Additives" (–). In-Tech, London. https://doi.org/10.5772/intechopen.99436

[12] **ALONSO-VILLEGAS R., GONZÁLEZ-AMARO R.M., FIGUEROA-HERNÁNDEZ C.Y., RODRÍGUEZ-BUENFIL I.M. 2023.** "The genus *capsicum*: a review of bioactive properties of its polyphenolic and capsaicinoid composition". Molecules 28(10):m4239. https://doi.org/10.3390/molecules28104239

[13] **BHATWALKAR S.B., MONDAL R., KRISHNA S.B.N., ADAM J.K., GOVENDER P., ANUPAM R. 2021.** "Antibacterial properties of organosulfur compounds of garlic (*Allium sativum*)". Frontiers Microbiology 12: 613077. https://doi.org/10.3389/fmicb.2021.613077

[14] **KĘDZIA A. 2010.** "Antimicrobial activity of garlic (*Allium sativum* L.)". Postępy Fitoterapii 1: 46–52.

[15] **PIEŃKO T. 2013.** "Capsaicin properties, applications today and future prospects". Biuletyn Wydziału Farmaceutycznego Warszawskiego Uniwersytetu Medycznego 2: 11–17.

[16] **KIM M.J., KANG S.E., JEONG C.H., MIN S.G., HONG S.W., ROH S.W., JHON D.Y., KIM T.W. 2021.** "Growth inhibitory effect of garlic powder and cinnamon extract on white colony-forming yeast in kim chi". Foods 10(3): 645. https://doi.org/10.3390/foods10030645

[17] **DOGANTURK M., DEMIRAY E., GURSOY O., YILMAZ Y. 2019.** "Kinetics of allicin potential loss in garlic slices during convective drying". Quality Assurance and Safety of Crops & Foods 11(3): 211–220. https://doi.org/10.3920/QAS2018.1343

[18] **PN-ISO 17410:2004.** "Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of psychrotrophic microorganisms".

[19] **PN-EN ISO 6888-1:2001/A1:2004**. "Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species) – Part 1: Technique using Baird-Parker agar medium".

[20] **PN-ISO 21527–1:2009.** Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of yeasts and moulds – Part 1: Colony count technique in products with water activity greater than 0,95".
[21] **ISO 8914:2002.** "Microbiology – General guidance for the detection of *Vibrio parahaemolyticus*".
[22] **PN-EN ISO 7218:2008**. "Microbiology of food and animal feeding stuffs - General requirements and guidance for microbiological examinations".
[23] **ARFATAHERY N., MIRSHAFIEY A., ABEDIMOHTASAB T.P., ZEINOLABEDINIZAMANI M. 2015.** "Study of the prevalence of *Staphylococcus aureus* in marine and farmed shrimps in Iran aiming the future development of a prophylactic vaccine". Procedia in Vaccinology 9: 44–49. https://doi.org/10.1016/j.provac.2015.05.008
[24] **VIJI P., VENKATESHWARLU G., RAVISHANKAR C.N., GOPAL T.K. 2017.** "*Role of plant extracts as natural additives in fish and fish products – a review*". Fishery Technology 54(3): 145–154.
[25] **MOZAFFARI NEJAD A.S., SHABANI S., BAYAT M., HOSSEINI S.E. 2014.** "Antibacterial effect of garlic aqueous extract on *Staphylococcus aureus* in hamburger". *Jundishapur Journal of Microbiology* 7(11): e13134. https://doi.org/10.5812/jjm.13134
[26] **COMMISSION REGULATION (EC) No 2073/2005** of 15 November 2005 on microbiological criteria for foodstuffs (OJ L338).
[27] **ABIDULLAH M., JADHAV P., SUJAN S.S., SHRIMANIKANDAN A.G., REDDY C.R., WASAN R.K. 2021.** "Potential antibacterial efficacy of garlic extract on *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae*: an in vitro study". *Journal of Pharmacy & Bioallied* Sciences 13 (Suppl 1): S590–S594. https://doi.org/10.4103/jpbs.JPBS_681_20
[28] **BAYAN L., KOULIVAND P.H., GORJI A. 2014.** "Garlic: a review of potential therapeutic effects". *Avicenna Journal of Phytomedicine* 4(1): 1–14.
[29] **PREMARATNE R.J., NIP W.K., MOY J.H. 1986.** "Characterization of proteolytic and collagenolytic psychrotrophic bacteria of ice-stored freshwater prawn, *Macrobrachium rosenbergii"*. Marine Fisheries Review 48(2): 44–47.
[30] **HASSAN M.A., SHALTOUT F.A., MAAROUFAND A.A., EL-SHAFEY W.S. 2014.** "Psychrotrophic bacteria in frozen fish with special reference to *Pseudomonas* species". Benha Veterinary Medical Journal 27(1): 78–83.
[31] **LEITÃO M.F.F., RIOS D.P.A. 2000.** "Microbiological and chemical changes in freshwater prawn (*Macrobrachium rosembergii*) stored under refrigeration". Brazilian Journal of Microbiology 31(3): 177–182. https://doi.org/10.1590/S1517-83822000000300006
[32] **FERNÁNDEZ-SEGOVIA I., ESCRICHE I., FUENTES A., SERRA J.A. 2007.** "Microbial and sensory changes during refrigerated storage of desalted cod (*Gadus morhua*) preserved by combined methods".International Journal of Food Microbiology 116: 64–72.
[33] **KRISCH J., RENTSENKHAND T., VÁGVÖLGYI C. 2011.** "Essential oils against yeast and moulds causing food spoilage". [In:] A. Méndez-Vilas (ed.) "Science against microbial pathogens: communicating current research and technological advances microbiology" (1135–1142). Formatex Research Center, Badajoz.
[34] **OMOLO M.A., WONG Z., MERGEN A.K., HASTINGS J.C., LE N.C., REILAND H.A., CASE K.A., BAUMLER D.J. 2014.** "Antimicrobial properties of chili peppers". *Journal of Infectious Diseases & Therapy* 2: 145. https://doi.org/10.4172/2332-0877.1000145
[35] **SITTISART P., YOSSAN S., PRASERTSAN P. 2017.** "Antifungal property of chili, shallot and garlic extracts against pathogenic fungi, *Phomopsis* spp., isolated from infected leaves of para rubber (*Hevea brasiliensis Muell. Arg*.)". Agriculture and Natural Resources 51(6): 485–491. https://doi.org/10.1016/j.anres.2018.03.005
[36] **AHMED W.A., ALAMEED A.I., KHALAF J.M. 2015.** "Identification of some species of fungi from shrimp". *International Journal of Advanced Research 3(5):* 127–129.
[37] **CRUZ DA SILVA L.R., CAMILO DE SOUZA O., DOS SANTOS FERNANDES M.J., MASSA LIMA D.M., RODRIGUES COELHO R.R., SOUZA-MOTTA C.M. 2011.** "Culturable fungal diversity of shrimp *Litopenaeus vannamei* boone from breeding farms in Brazil". *Brazilian Journal of Microbiology* 42(1): 49–56. https://doi.org/10.1590/S1517-83822011000100007
[38] **LIU Q., MENG X., LI Y., ZHAO C.N., TANG G.Y., LI H.B. 2017.** "Antibacterial and antifungal activities of spice". *International Journal of Molecular Sciences* 18(6): 1283. https://doi.org/10.3390/ijms18061283
[39] **TAKOUNDJOU A.C.K., BUGHE R.N., TONG A.N., KAMDEM S.S., ESSIA-NGANG J.J. 2022.** "Quantitative risk assessment of *Vibrio parahaemolyticus* toxi infection associated with the consumption of roasted shrimp (*Penaeus monodon*)", Journal of Food Quality 5965151. https://doi.org/10.1155/2022/5965151
[40] **BAPTISTA R.C., HORITA C.N., SANT'ANA A.S. 2020.** "Natural products with preservative properties for enhancing the microbiological safety and extending the shelf-life of seafood: A review". *Food Research International* 127: 108762. https://doi.org/10.1016/j.foodres.2019.108762
[41] **ADEGBENU P.S., ABOAGYE G., AMENYA P., TUAH B. 2020.** "Susceptibility of bacterial and fungal isolates to spices commonly used in Ghana". Scientific African 9: e00530. https://doi.org/10.1016/j.sciaf.2020.e00530

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POLISH CONSUMERS' PERCEPTION OF PLANT-BASED ALTERNATIVES

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Abstract: The study aimed to diagnose to what extent consumers know and consume plant-based alternatives and how they perceive them. The study was carried out on a nationwide sample of adult Poles (N = 1003) between June and September 2023. The CAWI method was used to collect data (Computer Assisted Web Interview). The results of our research indicate that the main association for meat alternatives was "soy products", while for milk alternatives, it was "plant-based drinks". At the same time, the analysis of the results of our research has shown that meat and milk alternatives belong to a group of products that can be considered rather unrecognizable by Polish consumers and have less positive associations. Among the recommendations for producers and processors of this category of food, it is worth pointing out that – along with the growing offer of alternatives – multi-channel communication with consumers should be used. This communication should be addressed in two ways: (1) to all consumers to interest them in this category of products and (2) to potential customers who know or are intentionally looking for meat and milk alternatives.

Key words: plant-based alternatives/substitutes, consumers, perception

INTRODUCTION

Meat and meat products play an important role in the diet because they are a good source of many nutrients needed for the proper functioning of the body [1]. However, their excessive consumption may contribute to the development of some diseases [2, 3]. While the consumption of foods of animal origin (e.g., red and processed meat) has been linked to harmful health effects, the health benefits of plant-based diets such as legumes, whole grains, nuts, vegetables, and fruits have been proven and described in the scientific literature [4, 5]. Dietary recommendations and greater awareness of the risks resulting from intensive animal production mean that consumers' eating habits are changing, with more and more people deciding to limit animal products in favor of plant-based foods [6]. Moreover, the food industry's selection of plant-based meat substitutes is becoming more and more popular [7, 8]. Nevertheless, insufficient knowledge of these products and their lower sensory

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attractiveness compared to meat may be a barrier to consuming plant-based alternatives [8, 9]. On the other hand, over recent decades, there has been a growing trend to promote healthy eating based on unprocessed, plant-based foods and organic products [10]. Consumers purchase plant-based meat substitutes for many reasons, including health problems, e.g., increased levels of certain cholesterol fractions in the blood, lifestyle changes towards veganism, and growing ethical concerns related to animal welfare [11]. Due to the above, the meat substitutes market has a growing trend, i.e., more and more categories of substitutes for animal products, as well as fish and seafood substitutes, appear on the market [12]. There is also growth in the market for milk substitutes and plant-based milk products [11, 13]. The studies carried out so far have assessed, among others, the share of food of plant origin in the diet, including plant-based substitutes for food of animal origin [14], while both the perception of this food category [15, 16, 17], as well as consumer expectations in this regard, still require recognition [7, 18].

Due to the increasing availability of plant-based substitutes on the market and the need to know what consumers' perception is about this category of products, the study aimed to diagnose to what extent consumers know and consume plant-based alternatives and how they perceive them.

MATERIAL AND METHODS

The study was carried out on a nationwide sample of adult Poles ($N = 1003$) between June and September 2023. The inclusion criteria for the sample included gender, age (18–83), and level of education. The CAWI method (Computer Assisted Web Interview) was used to collect data.

For this study, open-ended questions were used regarding the perception of animal products. The respondents were asked to indicate the associations that come to mind when they hear "plant-based meat substitute" and "plant-based milk substitute". Then, the respondents were asked whether they knew and/or consumed any plant-based substitutes for animal products. The respondents could choose one of the following answers: (1) I don't know of them (I'm not familiar with them), (2) I know of them (I'm familiar with them), but I have never consumed them, and (3) I consume them. Before starting the statistical analysis, the answers obtained in the open questions were categorized. Table 1 presents associations concerning meat and milk alternatives.

Table 1. Associations regarding meat and milk alternatives (%, *N*).

Associations relating to meat alternatives	
negative evaluation (e.g., "nothing good")	17.2 (173)
I don't know of them/no answer	16.6 (166)
soy products	11.8 (118)
other	10.2 (102)
Plant-based products (e.g., plant-based sausages, burgers, etc.)	9.8 (98)
positive evaluation ("similar"/"meat-like")	9.4 (94)
"tasteless"/distasteful	5.8 (58)
Associations relating to milk alternatives	
I don't know of them/no answer	32.7 (328)
plant-based drinks	22.8 (229)
negative evaluation (e.g., "nothing good")	18.7 (188)
other	10.1 (101)
soy	5.0 (50)

N – number of respondents.

The analysis used the chi-square test to confirm differences in associations regarding plant-based substitutes for meat and milk, taking into account their knowledge and/or consumption. Differences were assumed to be significant at $p < 0.05$. In a further stage of data analysis, data mining analysis using general CHAID (Chi-Squared Automatic Interaction Detection) models was used to identify associations that are related to the knowledge and/or consumption of plant-based substitutes. To classify the dependent variable, two groups of classification variables were used (associations regarding meat substitutes and associations regarding milk substitutes). Two models were performed, and the distribution of the dependent variable is presented in Table 2.

Table 2. Distribution of the dependent variable regarding knowledge and/or consumption of alternatives (%, *N*)

Statements referring to knowledge and/or consumption of alternatives	%	*N*
I don't know of them (I'm not familiar with them)	33.9	340
I know of them but, I do not consume them (I'm familiar with them, but I do not consume them)	27.8	279
I consume them	38.3	384

N – number of respondents.

Associations that were declared by respondents at least 50 times were used as classification variables in the models. The models also used the variable "gender" because it was assumed that women in the household are responsible to a greater extent for purchasing decisions on the food market and are characterized by taking greater care for health and, therefore, may be more interested in plant-based products than men [19, 20, 21]. The statistical analysis was carried out using the Statistica 13.3 statistical package [22, 23].

RESULTS AND DISCUSSION

Table 3 presents the sociodemographic characteristics of the study sample. The sample consisted of 1003 adults. About 70% of the surveyed people declared secondary and higher education, and 40% of people lived in cities with at least 100,000 inhabitants. People aged 18–44 constituted approximately 60% of the participants. Half of the people assessed their financial situation as quite good and very good (respectively: "We live frugally and have enough for everything" – 37.6% and "There is enough for everything without saving much" – 17.0%) (Table 3).

Table 3. Characteristics of the study sample (*N*, %)

		N	%
Gender	Male	483	48.2
	Female	520	51.8
Education level	Primary	100	10.0
	Vocational	180	18.0
	Secondary	403	40.2
	Higher	320	31.8
Place of residence	Village	377	37.5
	Towns up to 20,000 residents	139	13.9
	Towns with over 20,000 residents up to 100,000 residents	187	18.6
	Cities with over 100,000 residents up to 200,000 residents	104	10.4
	Cities with over 200,000 residents up to 500,000 residents	93	9.3
	Cities with over 500,000 residents	103	10.3
Age	18–24 years	104	10.4
	25–34 years	193	19.2
	35–44 years	205	20.4
	45–54 years	162	16.2
	55–64 years	221	22.0
	over 64 years	118	11.8
Subjective assessment of their financial situation	There is enough for everything without saving much	170	17.0
	We live frugally and we have enough for everything	377	37.6
	We live very frugally to save for major purchases	269	26.7
	There is only enough money for the cheapest food and clothing	88	8.8
	There is only enough money for the cheapest food, and not enough for clothes	41	4.1
	There is not enough money even for the cheapest food and clothing	13	1.3
	I don't know/It's hard to say	45	4.5

N – number of respondents.

The analysis of the collected data presented in Table 4 showed that the three most common associations relating to plant-based meat substitutes included the following: associations negatively describing the substitutes, e.g., "nothing good" (number of indications – 173) and "soy products" (118), and in addition, 166 people indicated the answer "I don't know/I have no opinion". Among people who declared that they had negative associations with plant-based meat substitutes, the largest share (39.3%) were people who declared that they knew of these products but did not consume them. In the case of people who were unable to provide any association, the largest percentage (58.4%) were people who declared knowledge of these products. Among people who associated plant-based meat substitutes with soy products, the majority of respondents (59.3%) declared that they consumed this category of products. Research by other authors indicates that regarding plant-based substitutes, the respondents' associations were mainly related to taste, perceived protein content, satiety, and domestic origin [24].

Table 4. Associations regarding meat and milk alternatives, taking into account the declared knowledge and/or consumption (%, *N*)

Associations relating to meat and milk alternatives		Declaration of knowledge and/or consumption				*p*-value
		I don't know of them (I'm not familiar with), *N* = 340	I know of them (I'm familiar with), but I have never consumed them; *N* = 279	I consume *N* = 384	Total *N* = 1003	
Plant-based meat alternatives						
Negative evaluation (e.g., "nothing good")	association	36.4 (63)	39.3 (68)	24.3 (42)	100.0 (173)	<.0001
	no association	33.4 (277)	25.4 (211)	41.2 (342)	100.0 (830)	
Soy products	association	15.3 (18)	25.4 (30)	59.3 (70)	100.0 (118)	<.0001
	no association	36.4 (322)	28.1 (249)	35.5 (314)	100.0 (885)	
I don't know/No answer	association	58.4 (97)	22.9 (38)	18.7 (31)	100.0 (166)	<.0001
	no association	29.0 (243)	28.8 (241)	42.2 (353)	100.0 (837)	
Plant-based milk alternatives						
Plant-based drinks	association	14.0 (32)	26.6 (61)	59.4 (136)	100.0 (229)	<.0001
	no association	39.8 (308)	28.2 (218)	32.0 (248)	100.0 (774)	
Negative evaluation (e.g., "nothing good")	association	45.7 (86)	33.0 (62)	21.3 (40)	100.0 (188)	<.0001
	no association	31.2 (254)	26.6 (217)	42.2 (344)	100.0 (815)	
I don't know/No answer	association	48.8 (160)	29.9 (95)	22.3 (73)	100.0 (328)	<.0001
	no association	26.6 (180)	27.3 (184)	46.1 (311)	100.0 (675)	

N – number of respondents.

As many as 328 people did not indicate any association with plant-based milk substitutes (I don't know/I have no opinion), while these products were associated with plant-based drinks by 229 people and described negatively (e.g., "nothing good") by 188 people. Among those declaring no opinion, almost half (48.8%) of the respondents were people declaring that they did not know this category of products. Among the respondents who associated plant-based milk substitutes mainly with plant-based drinks, the majority (59.4%) declared that they consumed them. However, in the group negatively describing substitutes, 45.7% were people who did not know of these products, and 33.0% were people who knew of these products but did not consume them. Research by other authors indicates that among the associations regarding plant-based milk substitutes and products, the most common positive ones included associations related to, among others, suitability for people who are lactose intolerant. However, the negative association terms were referring to, among others, nutritional value, unnatural character, and price [25].

The results regarding associations related to plant-based meat substitutes obtained using the decision tree are presented in Figure 1. The first classification criterion for a given sample (ID1) was the lack of any association – "I don't know/no answer" (ID3). Among people who declared no opinion, the largest share was mainly people who did not know of these products (58.4%); however, only 18.7% consumed them. This node is the determination node, i.e., it is not subject to further division. The remaining people (83.4%) with associations regarding plant-based meat substitutes (ID2) are mainly people consuming these products (42.2%); those who knew but did not consume these products constituted 28.8%, and those who did not know of these products was 29.0%. This node was further divided by the variable "negative assessment" – "nothing good". Those who expressed this opinion (ID5) constituted 8.6% of the shared variable, and the vast majority of them (77.27%) were people who did not consume substitutes (43.9% – I do not know of them, and 33.3% – I know of them but do not consume them).

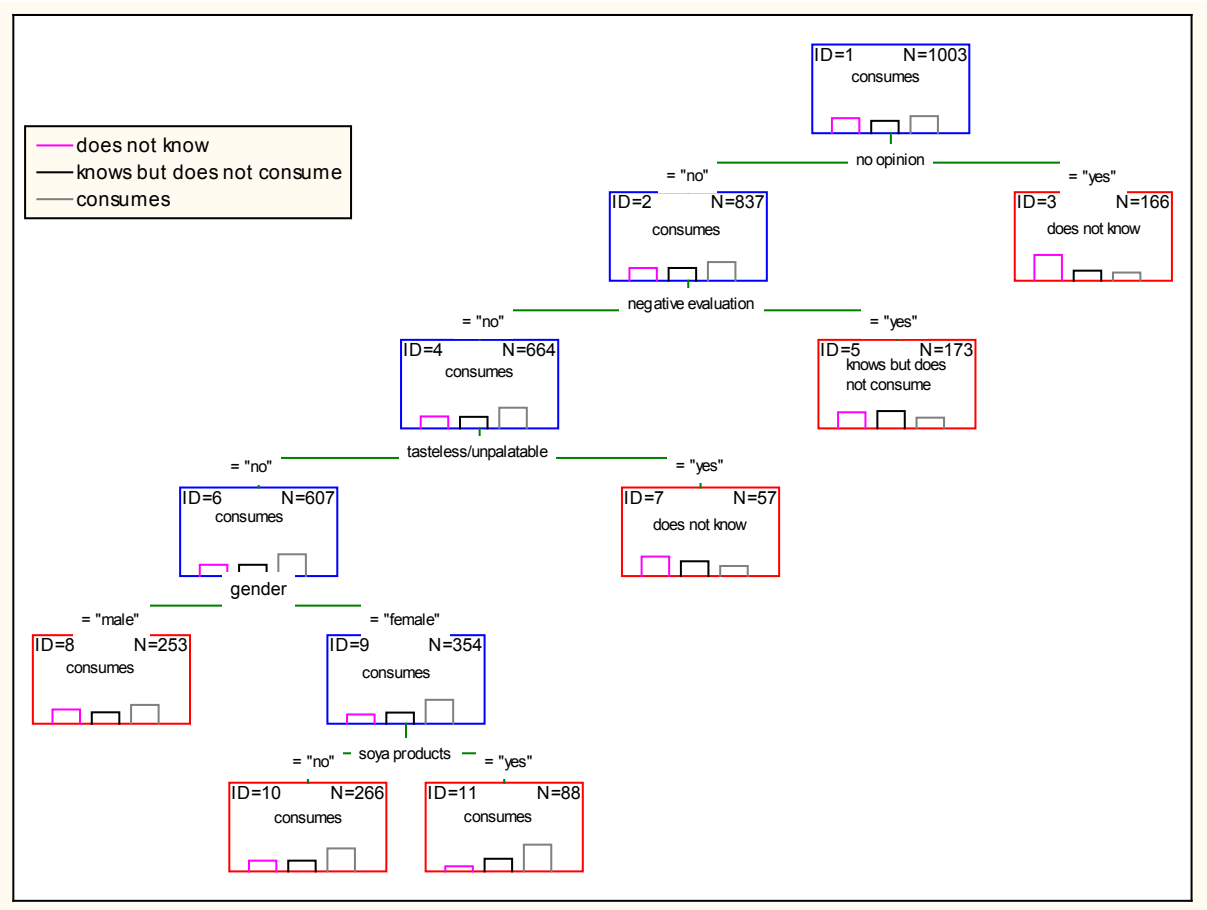

Figure 1. Graphical representation of the CHAID model referring to plant-based meat

Respondents who did not express a negative opinion about plant-based meat substitutes (ID4) constituted 79.3% (of them – 46.8% consumed these products). This node was further divided by the "tasteless/unpalatable" variable. People who expressed such an opinion (ID7) constituted 8.6%, of whom 43.9% did not know of them, and 33.3% knew of them but did not consume them. The second node is people who do not share this opinion (ID6), constituting 91.4% of respondents, of whom almost half (49.1%) consume substitutes, while 25.5% did not know of them, and 25.4% knew of them but did not consume them. This node was further divided by the gender variable. A male node (ID8) was separated, which became the determination node in which the largest share (42.3%) was people consuming meat substitutes. There were 32.0% who did not know of them and 25.7% who knew of them but did not consume them. In node ID9, 54.0% of respondents consumed substitutes. This node was then split into 2 end nodes by the variable "soy products". People who declared such an association (ID11) constituted 24.0%, and among them, as many as 60.2% of people consumed substitutes. It was similar in the second node from this division (ID10), which accounted for 75.0%, and in it, over half (51.2%) were consumers who declared the consumption of meat substitutes.

The lack of interest in plant-based substitutes for meat products among people participating in our study was caused by two factors: lack of knowledge about them and reluctance to eat them; they have similar percentages among respondents. In the case of meat substitutes, gender did not significantly differentiate preferences related to these products.

Research by other authors indicates that in recent years, many types of alternative products to those of animal origin have appeared on the market, containing, e.g., cereals, legumes, or mushrooms as a source of protein [16], and the main barriers to the consumption of meat alternatives have been defined as ignorance and lower sensory attractiveness of plant-based products compared to meat [9]. Other factors hindering the transition to vegetarian and vegan diets include concerns about the taste, price, and convenience of plant-based foods [26]. Consumers' concerns may also be related to the fact that there is a false belief about the healthiness of these products because of their plant origin. Research shows that a great number of plant-based meat alternative products available in Spanish supermarkets have a variable nutritional composition depending on the product category [27]. Although

there is research showing that plant-based meat has a more favorable nutrient profile than its meat counterparts [28], other research also shows that when replacing red and processed meat with plant-based meat alternatives, caution should be taken to decrease the risk of deficiencies for some micronutrients [29]. Moreover, it was noted that for both people who are and are not consumers of substitutes for animal products, the ideal meat alternative should be cheaper, contain more protein and vitamins, and have a lower caloric value [16]. Other research made among consumers from Ireland shows that of those consumers who report eating plant-based meat alternatives, one-third reported that they select these products because of health, about 20% because of taste, and about 15% because of climate change [30].

The results regarding the associations related to plant-based milk substitutes obtained using the decision tree are presented in Figure 2. Regarding the associations related to milk substitutes, the first variable classifying the dependent variable was "plant-based drinks". People who declared such associations (ID3) constituted 22.8% of the entire sample, and the majority of them (59.4%) were people consuming plant-based milk substitutes, and only 14.0% of them did not know of these products. This node was further split by "gender" into two determination nodes. The "male" node (ID6) included 31.0% of people, and among them, 57.7% consumed plant-based milk

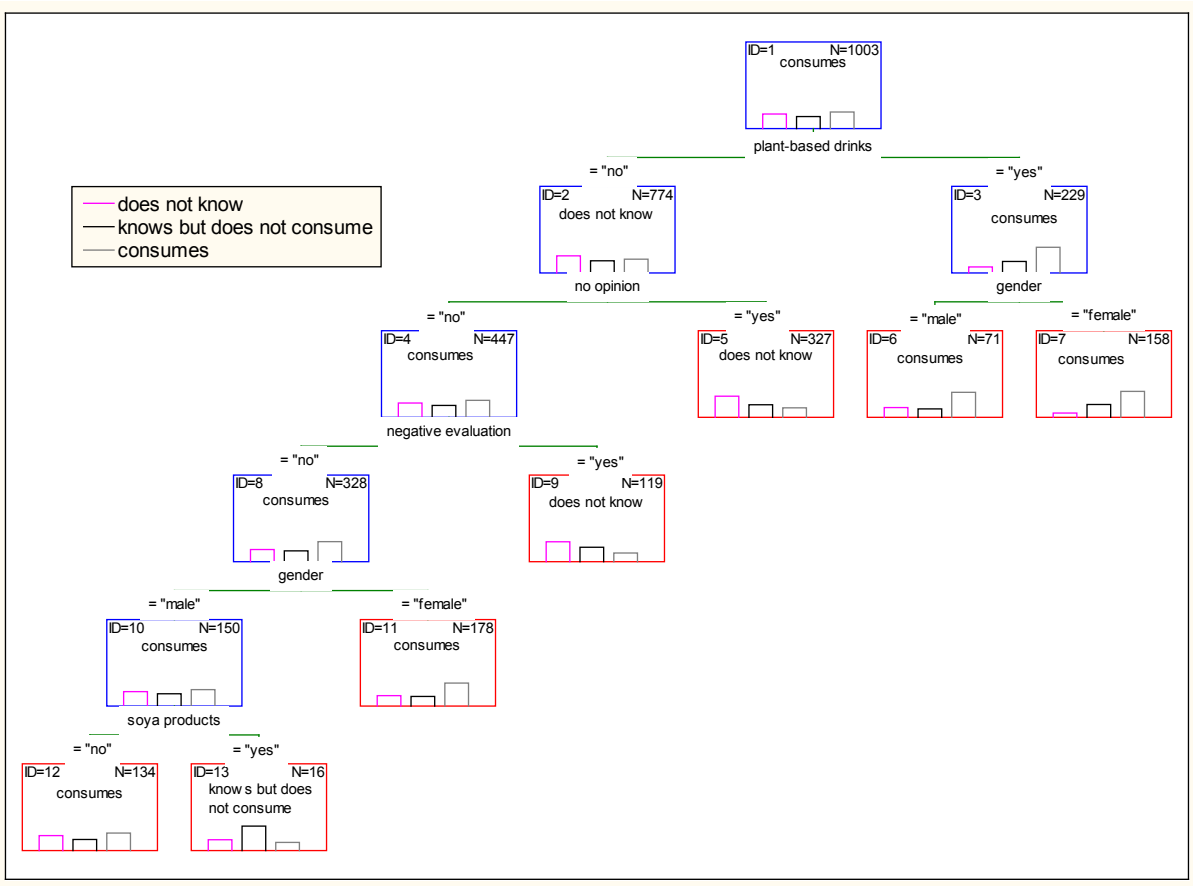

Figure 2. Graphical representation of the CHAID model referring to plant-based milk

substitutes. Among women (ID7) – 69.0%, the largest share was people consuming substitutes (60.0%), and 30.0% declared that they did not consume them. In the case of 77.2% of respondents who had no associations with plant-based drinks (ID4), people who did not know of these products dominated (39.8%), followed by people who knew of them but did not consume them (28.2%). This node was further divided by the variable "I don't know/ /no answer", in which 42.2% said yes (ID5), and among them, there were also mainly people who did not know of these alternatives (48.9%) and those who knew of them but did not consume them (29%). Among those who had an opinion on this subject (ID4; 57.8%), the division of the dependent variable was similar to that in the entire sample (with a small predominance of people consuming plant-based milk substitutes). This node was divided by the variable "negative evaluation" – "nothing good"). People who declared this opinion (ID9) constituted 26.6%, and the vast majority did not consume substitutes (46.2% did not know of them, and 33.6% knew of them but did not consume them). People who did not share this opinion (ID8) constituted 73.4% and formed a node in

which 46.3% of people consumed these substitutes. This node was further divided by the variable "gender". In the determination node "female" (ID11), constituting 54.3%, it was dominated by people who consumed substitutes (53.4%). In the "male" node, there was a fairly even distribution of responses (33.3% did not know of them, 28.7% knew of them but did not consume them, and 38.0% consumed them). This node was eventually split into two end nodes by the "soy products" variable. People who associated plant-based milk substitutes with soy (ID13; 10.7%) did not consume this type of food (56.3%). People who do not declare associations with "soy products", constituting 89.3%, mainly consume these types of products (40.3%) or do not know of them (34.3%).

In the case of plant-based milk substitutes, a situation similar to that of meat substitutes was reported. Not consuming substitutes results either from lack of knowledge (lack of experience with them) or aversion to them. Among people who did not declare a negative assessment of milk alternatives, women had a positive attitude toward consuming them, while men – who associated these products with soy – did not consume them.

Studies have shown that milk substitutes are popular among consumers, and therefore, a large number of plant-based milk alternatives have been introduced to the market in recent years – e.g., plant-based drinks, plant-based yogurt substitutes, and plant-based cheese substitutes [30]. However, as noted in our research, despite the growing offer of these products on the Polish market, they are not fully recognized by the respondents. The slightly greater interest in these products among women noted in our research is confirmed in other studies and may generally result from, among others, women's greater care for their health, including paying more attention to appropriate nutrition [19, 20, 21].

CONCLUSIONS AND FUTURE PERSPECTIVES

The results of our research indicate that the main association for meat alternatives was "soy products", while for milk alternatives, it was "plant-based drinks". At the same time, it should be emphasized that the analysis of the results of our research has shown that meat and milk alternatives belong to a group of products that can be considered rather unrecognizable by Polish consumers and have rather less positive associations. Regarding milk alternatives, women were slightly more willing to declare that they consumed this category of products.

Among the recommendations for producers and processors of this food category, it is worth pointing out that – along with the growing offer of substitutes – multi-channel communication with consumers, including social media, should be used in parallel. Moreover, as market observation indicates, a significant part of those interested in limiting or completely giving up the consumption of animal products are rather young consumers. This communication should be addressed in two ways: (1) to all consumers to interest them in this product category and (2) to potential customers who know or are intentionally looking for meat and milk alternatives. It can also be assumed that popularizing the planetary diet, and even more broadly, sustainable consumption, may also increase consumer interest in consuming plant-based alternatives.

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REFERENCES

1. **PEREIRA P.M., VICENTE A.F. 2013.** "Meat Nutritional Composition and Nutritive Role in the Human Diet". Meat Science 93(3): 586–592. https://www.doi.org/ 10.1016/j.meatsci.2012.09.018
2. **MIGDAŁ W. 2007.** „Spożycie mięsa a choroby cywilizacyjne". ŻYWNOŚĆ. Nauka. Technologia. Jakość 6(55): 48–61.
3. **PAROL D., MAMCARZ A. 2015.** „Diety roślinne w kontekście chorób układu sercowo-naczyniowego". Folia Cardiologica 10(2), 92–99. https://www.doi.org/10.5603/FC.2015.0019
4. **FRESAN U., RIPPIN H. 2021.** "Nutritional quality of plant-based cheese available in Spanish supermarkets: How do they compare to dairy cheese?". Nutrients 13(3291): 1—10. https://www.doi.org/10.3390/nu13093291
5. **SHORT E.C., KINCHLA A.J., NOLDEN A.A. 2021.** "Plant-based cheeses: A systematic review of sensory evaluation studies and strategies to increase consumer acceptance". Foods, 10(725), 1–12. https://www.doi.org/10.3390/foods10040725

6. **HARGUESS J.M., CRESPO N.C., HONG M.Y. 2020.** "Strategies to reduce meat consumption: A systematic literature review of experimental studies". Appetite 144(1): 104478. https://www.doi.org/10.1016/j.appet.2019.104478
7. **LAASSAL M., KALLAS Z. 2019.** "Consumer preferences for dairy-alternative beverage using home-scan data in Catalonia". Beverages 5(3)55: 1–18. https://www.doi.org/10.3390/beverages5030055.
8. **NEVALAINEN E., NIVA M., VAINIO A. 2023.** "A transition towards plant-based diets on its way? Consumers' substitutions of meat in their diets in Finland". Food Quality and Preference 104: 104754. https://www.doi.org/10.1016/j.foodqual.2022.104754
9. **LEA E., WORSLEY A. 2002.** Benefits and barriers to the consumption of a vegetarian diet in Australia". Public Health Nutrition 6(5): 505–511. https://www.doi.org/10.1079/PHN2002452
10. **Przybyłowicz K., Danielewicz A. 2022**. "Eating Habits and Disease Risk Factors". Nutrients 14(3143): 1–4. https://www.doi.org/10.3390/nu14153143
11. **HARPER A.R., DOBSON R.C.J., MORRIS V.K., MOGGRÉ G.J. 2022.** "Fermentation of plant-based dairy alternatives by lactic acid bacteria. Microbial Biotechnology" 15(5): 1404–1421. https://www.doi.org/10.1111/1751-7915.14008.
12. **KAZIR M., YOAV D. 2021.** "Plant-Based Seafood Analogs". Molecules 26(6): 1559. https://www.doi.org/10.3390/molecules26061559.
13. **BAYARRI S., CARBONELL I., BARRIOS E.X., COSTELL E. 2010.** Acceptability of yoghurt and yoghurt-like products: Influence of product information and consumer characteristics and preferences. Journal of Sensory Studies 25(s.1): 171–189, https://www.doi.org/10.1111/j.1745-459X.2009.00271.x
14. **CRAIG W.J., BROTHERS C.J. 2021.** "Plant-Based Yogurt Alternatives. Nutrients", 13(11): 4069. https://www.doi.org/10.3390/nu13114069
15. **HARTMANN C., SIEGRIST M. 2017.** "Consumer perception and behaviour regarding sustainable protein consumption: A systematic review". Trends in Food Science & Technology 61: 11–25. https://www.doi.org/10.1016/j.tifs.2016.12.006
16. **MICHEL F., HARTMANN C., SIEGRIST M. 2021a.** "Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives". Food Quality and Preference 87: 104063. https://www.doi.org/10.1016/j.foodqual.2020.104063
17. **MICHEL F., KNAAPILA A., HARTMANN C., SIEGRIST M. 2021b**. "A multi-national comparison of meat eaters' attitudes and expectations for burgers containing beef, pea or algae protein". Food Quality and Preference 91: 104195. https://www.doi.org/10.1016/j.foodqual.2021.104195
18. **LAILA A., TOPAKAS N., FARR E., HAINES J., MA D., NEWTON G., BUCHHOLZ A. 2021.** "Barriers and facilitators of household provision of dairy and plant-based dairy alternatives in families with preschool-age children". Public Health Nutrition 24(17): 5673–5685. https://www.doi.org/10.1017/S136898002100080X
19. **ALAE-CAREW C., GREEN R., STEWART C., COOK B., DANGOUR A.D., SCHEELBEEK P.F.D. 2022.** "The role of plant-based alternative foods in sustainable and health food systems: Consumption trends in the UK". Science of The Total Environment 807(151041): 1–9. https://www.doi.org/j.scitotenv.2021.151041
20. **BOAITEY A., MINEGISHI K. 2020.** "Determinants of household choice of dairy and plant-based milk alternatives: Evidence from a field survey". Journal of Food Products Marketing 26(9): 639–653, https://www.doi.org/10.1080/10454446.2020.1857318
21. **GAZAN R., VIEUX F., LLUCH A., DE VRIESE S., TROTIN B., DARMON N. 2022.** "Individual diet optimization in French adults shows that plant-based „dairy-like" products may complement dairy in sustainable diets". Sustainability 14(5)2817: 1–17. https://www.doi.org/10.3390/su14052817.
22. **STATISTICA 13.3.** (https://statistica.software.informer.com, access 09.01.2024).
23. **STRZELECKA A., ZAWADZKA D. 2023.** "The use of Chi-squared Automatic Interaction Detector (CHAID) analysis to identify characteristics of agricultural households at risk of financial self-exclusions". Procedia Computer Science, 225: 4443–4452, https://www.doi.org/10.1016/j.procs.2023.10.442
24. **SPENDRUP S., HOVMALM H.P. 2022.** "Consumer attitudes and beliefs towards plant-based food in different degrees of processing – The case of Sweden", Food Quality and Preference, 102: 104673. https://www.doi.org/10.1016/j.foodqual.2022.104673
25. **ADAMCZYK D., JAWORSKA D., AFFELTOWICZ D., MAISON D. 2022.** "Plant-based dairy alternatives: consumers' perceptions, motivations, and barriers – results from a qualitative study in Poland, Germany, and France". Nutrients 14(2171): 1–14. https://www.doi.org/10.3390/nu14102171
26. **BRYANT C.J. 2022.** "Plant-based animal product alternatives are healthier and more environmentally sustainable than animal products". Future Foods 6(100174), https://www.doi.org/10.1016/j.fufo.2022.100174
27. **RIZZOLO-BRIME L., ORTA-RAMIREZ A., PUYOL MARTIN Y., JAKSZYN P. 2023.** "Nutritional assessment of plant-based meat alternatives: A comparison of nutritional information of plant-based meat alternatives in Spanish supermarkets. Nutrients", 15(6), 1325: 1–11. https://www.doi.org10.3390/nu15061325
28. **ALESSANDRINI R., BROWN M.K., POMBO-RODRIGUES S., BHAGEERUTTY S., HE F.J., MACGREGOR G.A. 2021.** "Nutritional Quality of Plant-Based Meat Products Available in the UK: A Cross-Sectional Survey". Nutrients 13(4225): 1–11, https://www.doi.org/10.3390/nu13124225

29. **VATANPARAST H., ISLAM N., SHAFIEE M., RAMDATH D.D. 2020.** "Increasing Plant-Based Meat Alternatives and Decreasing Red and Processed Meat in the Diet Differentially Affect the Diet Quality and Nutrient Intakes of Canadians". Nutrients, 12, 2034: 1–14. https://www.doi.org/10.3390/nu12072034
30. **SHKEMBI, B., HUPPERTZ, T. 2023.** "Impact of dairy products and plant-based alternatives on dental health: Food matrix effects". Nutrients, 15(6), 1469: 1–14. https://www.doi.org/10.3390/nu15061469

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ANALYSIS OF FACTORS INFLUENCING INITIATION AND CONTINUATION OF BREASTFEEDING IN A GROUP OF POLISH MOTHERS

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Abstract: Recommendations for healthy infant nutrition emphasise exclusive breastfeeding during the first 6 months of an infant's life. The report "Breastfeeding in Poland" showed that 98% of newborns were fed with their mother's milk in the first days of life. Unfortunately, later on, the percentage decreased significantly to as low as 46% in the 6th week of the infant's life.

The study was aimed at identifying factors which favoured the commencement and continuation of breastfeeding in a selected group of women. The survey was conducted in 2017–2022. The data were acquired during face-to-face interviews and by sharing a relevant questionnaire on social media. Complete data sets were obtained from 754 women with children aged 0.5–3 years. The study found 98% of the women to have made an attempt to breastfeed their babies. The factors conducive to breastfeeding were: the mother's age of >19 years, having older children, and natural childbirth at term. On the other hand, the factors conducive to the continuation of breastfeeding in the sixth month of a child's life were: the mother's age of >26 years, a good financial situation, the mother's poorer education, having older children, natural childbirth at term, breastfeeding starting no later than the first day after birth, and lactation guidance. In the study group, lactation counselling resulted in breastfeeding being continued throughout the first six months of a child's life. The counselling should especially target women who are younger (<26 years), better educated, experiencing a poor financial situation, giving birth to their first child, and delivering prematurely by caesarean section.

Key words: breastfeeding, breastfeeding duration, socio-demographic factors, perinatal factors

INTRODUCTION

Proper nutrition at the first stage of life, whereby the infant is provided with the necessary energy and nutrients, is essential for the physical and cognitive development of a child. Nutrition during that time also plays a role in metabolic, nutritional, and health programming [1]. Exclusive breastfeeding for the first 6 months of life is considered the "gold standard" for infant and young child feeding, and breastfeeding continuation for as long as desired by the mother and child is regarded as the best option [2, 3, 4]. Breastfeeding is beneficial for the health of both the child and the mother. The benefits of breastfeeding for the child include a reduced risk of gastrointestinal and respiratory tract infections, middle ear inflammation until the age of 2 [5], a lower risk of malocclusion [6], and potentially a lower risk of obesity and type 2 diabetes; a better intellectual development has also been listed

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among the benefits [7, 8]. Research also indicates a lower incidence or milder course of bacterial meningitis, sepsis, urinary tract infections, and necrotising enterocolitis in breastfed infants [9]. Moreover, a probability of reduced risk of sudden infant death syndrome [10], type 1 diabetes [11], lymphoma, leukaemia [12], and allergic diseases [13] has been referred to as well. In the Netherlands, exclusive breastfeeding of all children for at least 6 months, should it be applied, has been estimated to have the potential of preventing 50, 20, 47, and about 10% of gastrointestinal and ear infections, Crohn's disease cases, leukaemia, and obesity, respectively, compared to a situation when only 35% of infants are still breastfed at 6 months of age [14]. The benefits of breastfeeding for the mother include a decreased risk of postpartum bleeding [15], a faster uterine involution, a quicker return to pre-pregnancy weight, increased bone remineralisation [16], and a decreased risk of ovarian and breast cancer post-menopause [17, 18]. Health benefits result not only from exclusive breastfeeding, but are also derived from partial breastfeeding [19]. Therefore, promoting breastfeeding as well as protecting and supporting breastfeeding mothers are among the most effective strategies for improving public health worldwide [20].

Research indicates that, during pregnancy and early motherhood, women have a desire to breastfeed; 91.5% of pregnant women expressed their intention to breastfeed their child and would like to do so for as long as possible; 32.3% of women intended to breastfeed until their child reaches one year of age, and 22% wished to breastfeed for more than a year [21]. However, bringing these intentions to fruition seems to be challenging. According to data from the 2015 report "Breastfeeding in Poland", 98% of newborns were initially breastfed. Unfortunately, this percentage significantly dropped in the subsequent weeks, with only 46% of infants still being breastfed by the sixth week of life.

As there are no current data on factors conducive to, or preventing, at least partial breastfeeding in Poland, the research presented here was aimed at determining the factors that contribute to the initiation and continuation of (even partial) breastfeeding in a selected group of women.

MATERIALS AND METHODS

The study was conducted between 2017–2022. The survey targeted women who had finished breastfeeding but had children aged 0.5–3 years. Data were collected during direct interviews (by a researcher and two properly instructed students) and by collecting information via social media and online forums (using the Computer-Assisted Web Interview, or CAWI, method). The study involved a total of 861 women. Complete data were acquired from 754 women (87.6%): 321 and 433 subjects were interviewed directly and using the CAWI, respectively. The inclusion criterion for the study was the absence of contraindications to breastfeeding in the mother and child.

The first part of the survey consisted of questions covering socio-demographic data, such as the mother's age, place of residence, education, financial situation, and the presence of older children. The questions in the second part of the survey referred to the timing and method of delivery as well as the lactation guidance provision. Lactation guidance was defined as at least an hour-long meeting (also online), individual or in a group, and with a consultant who provided a theoretical background, gave practical feeding instructions and answered questions the subjects might have had. Delivery was defined as preterm if it occurred before the 37th week of pregnancy was completed. The key questions covered information about breastfeeding initiation after birth, time of the first feed, duration of exclusive breastfeeding, overall breastfeeding duration, and reasons for stopping breastfeeding. Respondents also defined the dominant method of feeding the baby in the first six months of life. Based on the information obtained, the women in the study group were assigned to three subgroups, based on the dominant method of feeding in the first half-year of life. The subgroups were defined as follows:

- Dominant breastfeeding: women who primarily breastfed their child, possibly supplementing breastfeeding with a formula used scantily (1–2 × per day) and/or introduced complementary feeding with other products,
- Mixed feeding (breast + formula milk): women who fed their child, in equal amounts, with their milk and formula and/or introduced complementary feeding with other products,
- Formula feeding: women who fed their child a formula and/or introduced complementary feeding with other products.

This division stemmed from the absence of current research on factors conducive to, or precluding, even partial breastfeeding. The available literature allows for identifying factors which encourage exclusive breastfeeding in the initial months of the child's life [22, 23, 24, 25].

The results obtained were analysed statistically using Microsoft Excel and Statistica 13. To test the independence of qualitative variables (between socio-demographic and perinatal factors, the initiation of breastfeeding and the method of feeding the child in the sixth month of life), the Pearson χ^2 test was used.

Characteristics of the women comprising the study group are summarised in Table 1.

Table 1. Characteristics of the studied group of women (n = 754)

Characteristic	%
Age	
<19 years	1.9
19–26 years	33.0
27–35 years	56.0
>35 years	9.1
Place of residence	
urban	87.0
rural	13.0
Financial situation	
poor	1.6
average	26.9
good	52.9
very good	18.6
Education	
vocational	8.5
secondary	32.7
higher	58.8
Number of children in the family	
1	65.5
2	29.4
≥3	5.1
Due date	
correct	93.5
preterm	6.5
Delivery method	
natural	62.2
caesarean section	37.8

Source: own study

RESULTS AND DISCUSSION

Analysis of the results obtained revealed that over 93% of the respondents reported a full-term birth, i.e., after the completion of the 37th week of pregnancy – Table 1. However, nearly 38% of the women surveyed gave birth by caesarean section – Table 1. These figures are somewhat lower than the national data presented in the document titled "Government Programme for Comprehensive Reproductive Health Protection in Poland for the years 2021–2023". According to it, approximately 43% of births were by caesarean section, one of the highest rates in Europe. In Scandinavian countries, the percentage is considerably lower, ranging from 16.1% in Iceland to 21.6% in Denmark [26]. According to the World Health Organization (WHO) recommendations, the caesarean section rate should be 10–15% at most [27].

As many as 98% of the women surveyed in this study reported initiating breastfeeding after birth, the majority of them (67%) starting within the first hour after delivery – Table 2. The WHO recommends early breastfeeding commencement, i.e., within 1 hour after birth [48]. This promotes proper lactogenesis, allows for the delivery of immunity bodies to the child, and provides support to the newborn during the postpartum period due to the colostrum produced by the mammary gland [28]. The data on the percentage of women starting breastfeeding after birth is similar to the results reported by Królak-Olejnik et al. [29] and published in the "Breastfeeding in Poland" report [21].

Table 2. Characteristics of breastfeeding in a selected group of women (n = 739)

Characteristic	Respondents (%)
Breastfeeding after childbirth	
yes	98.0
no	2.0
Breastfeeding commencement after delivery	
in the first hour after birth	67.1
on the first day after delivery	20.7
on the second day after delivery	7.3
in the first week after delivery	3.4
later	1.5
Duration of exclusive breastfeeding	
up to the age of 1 month	23.6
until the age of 3 months	57.6
until the age of 6 months	18.8
Dominant feeding method in the 6th month	
breastfeeding	57.6
mixed feeding (breast + formula milk)	29.9
feeding with modified milk	12.5

Source: own study

By the sixth month of the child's life, as few as 18.8% of children were exclusively breastfed, and 68.7% were supplemented – Table 2. The percentages of children being exclusively or partially breastfed in the sixth month of life are significantly higher than those reported by Królak-Olejnik et al. [29], who found that by the sixth month of life, only 38% of infants were breastfed, and exclusive breastfeeding concerned just 4% of respondents. As reported by Zagórecka and Piotrowska-Jastrzębska [30], the corresponding percentages were 64.9 and 3.7%. Differences in the results obtained by us and by other authors could have resulted from a different selection of study groups. In the present study, a significant portion of the data was supplied by women participating in information exchange in online forums and social media groups for mothers. This could have been a group of women more motivated to breastfeed and seeking support. In addition, our research covered the period of the COVID-19 pandemic, which may have had a positive impact on the duration of breastfeeding [31]. A very good breastfeeding rate has been reported from Norway, with as many as 99% of women starting breastfeeding after delivery and nearly 80% of them continuing after six months [32].

The percentage of mothers who breastfeed depends, among other factors, on the support provided to women during lactation. Higher percentages of breastfeeding women are reported from regions where local, effective actions have been taken to promote breastfeeding and to provide systemic support for breastfeeding women. An example is the programme called "Natural feeding of a child as prevention against adverse environmental influences", implemented, among others, by the Certified Lactation Consultants (CLC) and financially supported by the City of Gdańsk. Two years into the programme, breastfeeding indicators were observed to improve substantially, with an increase in breastfeeding from 18 to 33% in the sixth month of the child's life [33]. Although the staff of obstetric and neonatal departments are obligated to promote breastfeeding and support women during early lactation [34, 35], less than half of the women (46%) in this study declared to have received lactation advice after giving birth – Fig. 1. Women in Poland rarely receive lactation guidance. Possible reasons may include a low number of qualified lactation consultants, midwives' work organisation and overburden, and a short duration of hospitalisation after delivery (2–3 days), during which it is difficult to provide the woman with lactation support. Lactation advice is also not reimbursed by the National Health Fund.

Among the reasons for discontinuing breastfeeding in the first six months of a child's life, the respondents primarily mentioned insufficient milk production (nearly 40% of respondents) and difficulties that could not be overcome, including problems with properly latching the child to the breast, altogether reported by 29.8% of respondents – Table 3. According to the data in the report "Breastfeeding in Poland", one of the main reasons for giving up breastfeeding was insufficient sufficient milk production [21]. Similarly, as reported by de Jager et al. [36], mothers indicated that they could not maintain lactation at an appropriate level for the child and reported a milk deficiency as the main cause of lactation problems. Another common problem pointed out by mothers was no lactation support. Most mothers considered guidance and advice from a lactation consultant to be helpful for the extension of breastfeeding.

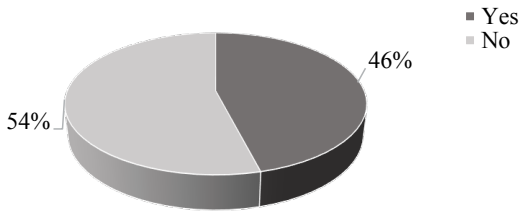

Figure 1. Lactation guidance after delivery (n = 754)

Source: own study.

Table 3. Reasons for discontinuing breastfeeding (n = 739)

Reason	Respondents (%)
Insufficient milk production	39.5
Difficulties on the part of the mother or child that have not been overcome	15.0
Problems with a proper latch of the baby to the breast	14.8
Loss of milk	9.1
Medical considerations	5.8
The baby was too big to be breastfed	3.2
Feeding was embarrassing in public places	2.5
Other	10.1

Source: own study.

Effects of socio-demographic and perinatal factors on breastfeeding initiation by the women surveyed and on the dominant method of feeding in the first six months of the baby's life were analysed statistically. Detailed data for only those factors which exerted a statistically significant effect ($p \leq 0.05$) are shown in Tables 4 and 5.

Table 4. Relationships between socio-demographic and perinatal factors and breastfeeding initiation (n = 754)

Factor	Breastfeeding taken up (%)		p
	yes	no	
Mother's age			
<19 years	85.7	14.3	
19–26 years	97.5	2.5	0.021
27–35 years	97.5	2.5	
>35 years	100	0.0	
Number of children in the family			
1	96.2	3.8	0.008
2	100	0.0	
≥3	100	0.0	
Due date			
correct	98.2	1.8	0.000
premature	87.8	12.2	
Method of delivery			
natural	99.1	0.9	0.000
caesarean section	94.8	5.2	

Source: own study.

The initiation of breastfeeding after birth was demonstrated to be influenced by: the mother's age, having older children, and the timing and method of delivery – Table 4. Breastfeeding after childbirth was more often initiated by mothers who were older than 19, had older children, gave birth at term, and gave birth naturally. Perinatal difficulties, such as preterm birth and/or caesarean section delivery, can influence a woman's decision about how to feed her child [37]. Factors inhibiting or delaying lactogenesis after preterm delivery include surgical delivery, perinatal stress, and no breast emptying, the latter resulting in a gradual milk production decline due to a decreasing concentration of lactogenic prolactin and the feedback inhibition of milk secretion in an autocrine

mechanism. Therefore, perinatal care after premature delivery should also include actions aimed at maintaining lactation. Breastfeeding has been shown to be less burdensome and stressful for a premature baby than bottle feeding [38]. Although parenteral and enteral nutrition is often applied to prematurely born infants with low birth weight, a mother's lactation should be maintained by regular removal of the milk, which can then be fed to the child. There are no strict guidelines as to when breastfeeding preterm infants should start, but the transition to breastfeeding should occur gradually, especially in infants born before the 34th week of pregnancy.

Table 5. Relationships between socio-demographic and perinatal factors and the dominant feeding mode in the first six months of a baby's life (n = 754)

Factor	Dominant breastfeeding	Mixed feeding (breast + formula milk)	Feeding with modified milk	p
Mother's age				
<19 years	28.6	28.6	42.8	
19–26 years	26.6	35.4	38.0	0.000
27–35 years	67.2	25.9	6.9	
>35 years	49.3	42.0	8.7	
Material situation				
poor	66.5	0.0	33.5	
average	51.3	27.8	20.9	0.000
good	59.9	30.5	9.6	
very good	62.2	31.4	6.4	
Mother's education				
vocational	65.9	28.8	5.3	0.000
intermediate	49.4	30.2	20.4	
higher	37.6	31.2	31.2	
Number of children in the family				
1	54.9	30.7	14.4	0.021
2	64.2	27.5	8.3	
≥3	72.2	22.2	5.6	
Due date				
correct	59.1	29.5	11.4	0.001
premature	42.9	28.6	28.6	
Method of delivery				
natural	62.7	28.7	8.6	0.000
caesarean section	50.6	30.7	18.7	
Time of breastfeeding initiation				
in the first hour after birth	60.8	29.4	9.8	
on the first day after delivery	63.8	26.3	9.9	0.000
on the second day after delivery	54.0	23.0	23.0	
in the first week after delivery	36.0	50.0	14.0	
later	36.3	50.5	13.2	
Lactation guidance provided				
yes	63.1	30.1	6.8	0.042
no	50.5	37.3	12.2	

Source: own study.

The method of feeding the baby during the first six months of its life was influenced by the mother's age, her financial situation, education, the number of children in the family, the timing and method of delivery, the time of starting breastfeeding after birth, and provision of lactation guidance – Table 5. Women under the age of 26, in a poor or average financial situation, better educated, without older children, giving birth prematurely, via caesarean section, who started breastfeeding on the second day of the infant's life or later, and who did not receive any lactation advice were more prone to give up any (full, partial) breastfeeding (cf. the modified milk feeding group) in the first 6 months of the baby's life – Table 5. The relationship between women's age and the number of children they have and early weaning was also reported by Kaczorowska et al. [39]. They found a higher percentage of children of mothers older than 30 and children with siblings were still breastfed at the age of six months. Women with older children may have knowledge and skills associated with breastfeeding and are aware of the related difficulties from previous experiences; they may also be less stressed about giving

birth and more confident in their actions. The initiation and continuation of breastfeeding may also depend on the woman's attitude towards breastfeeding [40]. The relationship between socio-demographic factors such as age, marital status, socio-economic conditions, having children, and professional activity on the one hand and women's attitudes towards breastfeeding on the other was examined by Bień et al. [41]. They showed a statistically significant relationship between the attitude towards breastfeeding and the age of the respondents, and the strength of the positive attitude towards breastfeeding increased with the respondents' age. The women who rated their socio-economic conditions as satisfactory and the women with children also had a stronger positive attitude towards natural feeding. The data on the relationship between breastfeeding duration and socio-economic situation are ambiguous. According to Barennes et al. [42], women with the highest socio-economic status in developing countries stopped breastfeeding earlier. The relationship between the socio-economic situation and the duration of breastfeeding may also depend on the woman's professional status, including whether she plans to return to work earlier. Women with prestigious, better-paid job positions are more likely to decide to return to work earlier and, therefore, shorten the duration of breastfeeding.

Women who did not receive lactation support after childbirth were more prone to give up breastfeeding. Health strategies recommend that national healthcare systems organise a system of professional advice and assistance in feeding infants and small children, including lactation counselling [43]. In the present study, less than half of the mothers declared receiving lactation guidance after childbirth. The lack of professional lactation support results in lactation disorders or complications, unnecessary supplementation of the child with modified milk and shortening of the natural feeding duration. The procedure for support is described in the perinatal care standard [44]. The first assessment of the infant's ability to suck and take milk from the breast should take place in the maternity and newborn ward, and mothers should be taught how to learn whether the feeding is effective or not [45, 46]. However, the relevant procedures are not commonly and routinely followed, and the level of knowledge about lactation among the medical staff providing perinatal and environmental care is low, which presents a problem as well [47].

CONCLUSIONS

The factors favouring breastfeeding initiation included natural delivery and at term, the mother's age of >19 years, and having older children. On the other hand, the factors conducive to breastfeeding continuation in the child's sixth month of life included the mother's age of >26 years, a good financial situation, the mother's vocational education, having older children, natural delivery and at term, breastfeeding initiation no later than the first day after delivery, and obtaining lactation guidance.

Lactation counselling was found to be conducive to breastfeeding continuation for the first six months of a child's life. Such guidance should especially target younger (<26 years of age) and better-educated women as well as those in an adverse financial situation, giving birth to their first child, and delivering prematurely by caesarean section.

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REFERENCES

[1] **AGOSTI M., TANDOI F., MORLACCHI L., BOSSI A. 2017.** "Nutritional and metabolic programming during the first thousand days of life". Pediatria Medica e Chirurgica 39(2): 157. https://www.doi.org/10.4081/pmc.2017.157

[2] **SZAJEWSKA H., SOCHA P., HORVATH A., RYBAK A., ZALEWSKI A.M., NEHRING-GUGULSKA M., MOJSKA H., CZERWIONKA-SZAFLARSKA M., GAJEWSKA D., HELWICH E., JACKOWSKA T., KSIĄŻYK J., LAUTERBACH R., OLCZAK-KOWALCZYK D., WEKER H. 2021.** „Zasady żywienia zdrowych niemowląt. Stanowisko Polskiego Towarzystwa Gastroenterologii, Hepatologii i Żywienia Dzieci". Standardy Medyczne. Pediatria 18:7–24. https://www.doi.org/10.17444/SMP2021.18.02

[3] **FEWTRELL M., BRONSKY J., CAMPOY C., DOMELLÖF M., EMBLETON N., FIDLER MIS N., HOJSAK I., HULST J.M., INDRIO F., LAPILLONNE A., MOLGAARD CH. 2017.** "Complementary Feeding: A Position Paper by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) Committee

on Nutrition". Journal of Pediatric Gastroenterology and Nutrition 64(1):119–132. https://www.doi.org/10.1097/MPG.0000000000001454.

[4] **EIDELMAN A.I., SCHANLER R.J., JOHNSTON M. LANDERS S., NOBLE L., SZUCS K., VIEHMANN L. 2012.** "Section on Breastfeeding: Breastfeeding and the use of human milk". Pediatrics 129(3):e827-e841. https://doi.org/10.1542/peds.2011-3552

[5] **DUIJTS L., RAMADHANI M.K., MOLL H.A. 2009.** "Breastfeeding protects against infectious diseases during infancy in industrialized countries. A systematic review". Maternal & Child Nutrition 5(3):199–210. https://www.doi.org/10.1111/j.1740-8709.2008.00176.x

[6] **ABATE A., CAVAGNETTO D., FAMA A., MASPERO C., FARRONATO G. 2020.** "Relationship between Breastfeeding and Malocclusion: A Systematic Review of the Literature". Nutrients 12(12):3688. https://www.doi.org/10.3390/nu12123688.

[7] **ELBELTAGI R., AL-BELTAGI M., SAEED N.K., BEDIWY A.S. 2023.** "Cardiometabolic effects of breastfeeding on infants of diabetic mothers". World Journal Diabetes 14(5):617–631. https://www.doi.org/10.4239/wjd.v14.i5.617

[8] **ALTHUNEYYAN D.A., ALGHAMDI F.F., ALZAIN R.N., ALDHAWYAN Z.S., ALHMLY H.F., PURAYIDATHIL T.S., ALGINDAN Y.Y., ABDULLAH A.A. 2022.** "The Effect of Breastfeeding on Intelligence Quotient and Social Intelligence Among Seven- to Nine-Year-Old Girls: A Pilot Study". Frontiers in Nutrition 9:726042. https://www.doi.org/10.3389/fnut.2022.726042

[9] **SPATZ D.L. 2012.** "Breastfeeding is the cornerstone of childhood nutrition". Journal of Obstetrics and Gynecological Investigations 41(1):112–113. https://www.doi.org/10.1111/j.1552-6909.2011.01312.x.

[10] **VENNEMANN M.M., BAJANOWSKI T., BRINKMANN B., JORCH G, YÜCESAN K., SAUERLAND C., MITCHELL E.A., GESID STUDY GROUP. 2009.** "Does breastfeeding reduce the risk of sudden infant death syndrome?" Pediatrics 123(3):e406-10. https://www.doi.org/10.1542/peds.2008-2145

[11] **CARDWELL C.R., STENE L.C., LUDVIGSSON J., ROSENBAUER J., CINEK O., SVENSSON J., PEREZ-BRAVO F., MEMON A., GIMENO S.G., WADSWORTH E.J , STROTMEYER E.S., GOLDACRE M.J., RADON K., CHUANG L-M., PARSLOW R.C., CHETWYND A., KARAVANAKI K., BRIGIS G., POZZILLI P., URBONAITĖ B., SCHOBER E., DEVOTI G., SIPETIC S., JONER G., IONESCU-TIRGOVISTE C., DE BEAUFORT C.E. HARRILD K., BENSON V., SAVILAHTI E., PONSONBY A.L., SALEM M., RABIEI S., PATTERSON CH.C. 2012.** "Breast-feeding and childhood-onset type 1 diabetes: a pooled analysis of individual participant data from 43 observational studies". Diabetes Care 35(11):2215–2225. https://www.doi.org/10.2337/dc12-0438.

[12] **KARIMI M., HAGHIGHAT M., DIALAMEH Z., TAHMASBI L., PARAND S., BARDESTANI M. 2016.** "Breastfeeding as a Protective Effect Against Childhood Leukemia and Lymphoma". Iranian Red Crescent Medical Journal 18(9):e29771. https://www.doi.org/10.5812/ircmj.29771

[13] **NUZZI G., DI CICCO M.E., PERONI D.G. 2021.** "Breastfeeding and Allergic Diseases: What's New?" Children (Basel) 8(5):330. https://www.doi.org/10.3390/children8050330

[14] **VAN ROSSUM C., BUCHNER F., HOEKSTRA J. 2005.** "Quantification of health effects of breastfeeding. Review of the literature and model simulation". RIVM Report 350040001. (https://www.mambaby.com/uploads/tx_dddownload/Abstract1905.pdf, access: 03.07.2023).

[15] **ABEDI P., JAHANFAR S., NAMVAR F., LEE J. 2016.** "Breastfeeding or nipple stimulation for reducing postpartum haemorrhage in the third stage of labour". Cochrane Database of Systematic Reviews 2016(1):CD010845. https://www.doi.org/10.1002/14651858.CD010845.pub2

[16] **SALARI P., ABDOLLAHI M. 2014.** "The influence of pregnancy and lactation on maternal bone health: a systematic review". Journal of Family and Reproductive Health 8(4):135–48.

[17] **DEL CIAMPO L.A., DEL CIAMPO I.R.L. 2018.** "Breastfeeding and the Benefits of Lactation for Women's Health". Revista Brasileira de Ginecologia e Obstetrícia 40(6):354–359. https://www.doi.org/10.1055/s-0038-1657766

[18] **QIU R., ZHONG Y., HU M., WU B. 2022.** Breastfeeding and Reduced Risk of Breast Cancer: A Systematic Review and Meta-Analysis. Computational and Mathematical Methods in Medicine 8500910. https://www.doi.org/10.1155/2022/8500910

[19] **CHIU C.Y., LIAO S.L., SU K.W., TSAI M.H., HUA M.C., LAI S.H., CHEN L.C., YAO T.C., YEH K.W., HUANG J.L. 2016.** "Exclusive or Partial Breastfeeding for 6 Months is Associated With Reduced Milk Sensitization and Risk of Eczema in Early Childhood: The PATCH Birth Cohort Study". Medicine (Baltimore) 95(15):e3391. https://www.doi.org/10.1097/MD.0000000000003391

[20] **WHO, UNICEF. 2017.** "Tracking Progress for Breastfeeding Policies and Programmes: Global breastfeeding scorecard" (https://www.who.int/publications/m/item/global-breastfeeding-scorecard-2017-tracking-progress-for-breastfeeding-policies-and-programmes, access 22.06.2023).

[21] **CENTRUM NAUKI O LAKTACJI. 2015.** „Raport Karmienie piersią w Polsce". (https://cnol.kobiety.med.pl/wp-content/uploads/2019/01/Raport_Karmienie_Piersia_w_Polsce_20151.pdf, access 27.06.2023).

[22] **ARIF S., KHAN H., ASLAM M., FAROOQ M. 2021.** "Factors influencing exclusive breastfeeding duration in Pakistan: a population-based cross-sectional study". BMC Public Health 21(1):1998. https://www.doi.org/10.1186/s12889-021-12075-y

[23] **INANO H., KAMEYA M., SASANO K., MATSUMURA K., TSUCHIDA A., HAMAZAKI K., INADERA H., HASEGAWA T. 2021.** "Japan Environment and Children's Study (JECS) Group: Factors influencing exclusive breastfeeding rates until 6 months postpartum: the Japan Environment and Children's Study". Scientific Reports 11(1):6841. https://www.doi.org/10.1038/s41598-021-85900-4

[24] **SANTACRUZ-SALAS E., ARANDA-RENEO I., SEGURA-FRAGOSO A., COBO-CUENCA A.I., LAREDO--AGUILERA J.A., CARMONA-TORRES J.M. 2019.** "Mothers' Expectations and Factors Influencing Exclusive Breastfeeding during the First 6 Months". International Journal of Environmental Research and Public Health 17(1): 77. https://www.doi.org/10.3390/ijerph17010077

[25] **FERREIRA H.L.O.C., OLIVEIRA M.F., BERNARDO E.B.R., ALMEIDA P.C., AQUINO P.S., PINHEIRO A.K.B. 2018.** "Factors Associated with Adherence to the Exclusive Breastfeeding". Cien Saude Colet (3): 683–690. https://www.doi.org/10.1590/1413-81232018233.06262016

[26] **MINISTERSTWO ZDROWIA. 2021.** „Program polityki zdrowotnej Ministra Zdrowia „Rządowy program kompleksowej ochrony zdrowia prokreacyjnego w Polsce na lata 2021–2023 r." (https://www.gov.pl/web/zdrowie/program-kompleksowej-ochrony-zdrowia-prokreacyjnego-w-polsce-w-2021-r, access 03.07.2023).

[27] **BETRAN A.P., TORLONI M.R., ZHANG J.J., GÜLMEZOGLU A.M. 2016.** "WHO Working Group on Caesarean Section: WHO Statement on Caesarean Section Rates". International Journal of Obstetrics & Gynaecology 123(5): 667–670. https://www.doi.org/10.1111/1471-0528.13526

[28] **KIM Y.J. 2021.** "Immunomodulatory Effects of Human Colostrum and Milk". Pediatric Gastroenterology, Hepatology & Nutrition 24(4): 337–345. https://www.doi.org/10.5223/pghn.2021.24.4.337

[29] **KRÓLAK-OLEJNIK B., BŁASIAK I., SZCZYGIEŁ A. 2017.** "Promotion of breastfeeding in Poland: the current situation". Journal of International Medical Research 45(6):1976–1984. https://www.doi.org/10.1177/0300060517720318

[30] **ZAGÓRECKA E., PIOTROWSKA-JASTRZĘBSKA J. 2007.** „Żywienie niemowląt – wybrane aspekty". Pediatria Polska 82(7): 559–566.

[31] **ANTONIOU E., TZITIRIDOU-CHATZOPOULOU M., VOYATZAKI C., ILIADOU M., ESKITZIS P., DAGLA M., PALASKA E., OROVOU E. 2023.** "What Are the Implications of COVID-19 on Breastfeeding? A Synthesis of Qualitative Evidence Studies". Children (Basel) 10(7): 1178. https://www.doi.org/10.3390/children10071178

[32] **NORWEGIAN INSTITUTE OF PUBLIC HEALTH. 2020.** "Spekost 3 Landsomfattende undersøkelse av kostholdet blant spedbarn i Norge, 12 måneder" [Spekost 3 Nationwide survey of the diet among infants in Norway, 12 months].

[33] **CENTRUM NAUKI O LAKTACJI. 2018.** „Raport Karmienie piersią w Polsce" (http:// cnol.kobiety.med.pl/wp-content/uploads/2019/01/ Rapor t_karmienie_w_Polsce_2018.pdf, access 26.06.2023).

[34] **MARCZYŃSKA-KOŁACZ B., SZEPIENIEC W.K, SZYMANOWSKI P. 2019.** „Ocena poziomu wiedzy wśród kobiet rodzących pierwsze dziecko o zaletach karmienia naturalnego i deklarowanej długości karmienia piersią". Państwo i Społeczeństwo 1(19): 43–55.

[35] **RADOFF K., FORMAN R. 2019.** "Lactation Education for Resident Obstetricians: Promoting Breastfeeding Advocates for the Future". Journal of Midwifery & Women's Health 64(6): 754–762. https://www.doi.org/10.1111/jmwh.13037

[36] **DE JAGER M., HARTLEY K., TERRAZAS J., MERRILL J. 2012.** "Barriers to Breastfeeding. A Global Survey on Why Women Start and Stop Breastfeeding". European Society of Gynecology 7(Suppl 1): 25–30.

[37] **CASTELLI C., PERRIN J., THIRION X., COMTE F., GAMERRE M., COURBIERE B. 2015.** "Maternal factors influencing the decision to breastfeed newborns conceived with IVF". Breastfeeding Medicine 10(1): 26–30. https://www.doi.org/10.1089/bfm.2014.0078

[38] **BLACK A. 2012.** "Breastfeeding the premature infant and nursing implications. Adv Neonatal Care" 12(1): 10–11. https://www.doi.org/10.1097/ANC.0b013e3182425ad6

[39] **KACZOROWSKA M., BULSA K., BULSA M., JANASIK-ZWARZANY M., CZAJA-BULSA G. 2016.** „Karmienie piersią w teorii i praktyce w regionie Pomorza Zachodniego". Pediatria Polska 91(3): 199–207.

[40] **COX K.N., GIGLIA R.C., BINNS C.W. 2015.** "The influence of infant feeding attitudes on breastfeeding duration: evidence from a cohort study in rural Western Australia". International Breastfeeding Journal 10: 25. https://www.doi.org/10.1186/s13006-015-0048-3

[41] **BIEŃ A., SIEROCIŃSKA-MAZUREK A., ĆWIEK D., KULESZA-BROŃCZYK B. 2022.** „Czynniki warunkujące postawy kobiet wobec karmienia piersią ocenione na podstawie kwestionariusza The Iowa Infant Feeding Attiude Scale". Medycyna Ogólna i Nauki o Zdrowiu 28(4): 326–332. https://doi.org/10.26444/monz/157264

[42] **BARENNES H., EMPIS G., QUANG T.D., SENGKHAMYONG K., PHASAVATH P., HARIMANANA A., SAMBANY E.M., KOFFI P.N. 2012.** "Breast-milk substitutes: a new old-threat for breastfeeding policy in developing countries. A case study in a traditionally high breastfeeding country". PLoS One 7(2): e30634. https://www.doi.org/10.1371/journal.pone.0030634

[43] **KOMISJA EUROPEJSKA, DYREKTORIAT ZDROWIA PUBLICZNEGO I OCENY RYZYKA 2004.** „Ochrona, propagowanie iwspieranie karmienia piersia w Europie: wzorzec dzialania", Luksembourg (https://cnol.kobiety.med.pl/wp-content/uploads/2019/12/Ochrona-propagowanie-i-wspieranie-karmienia-piersia-w-Europie_-wzorzec-dzialania.pdf, access: 26.06.2023).

[44] **ROZPORZĄDZENIE MINISTRA ZDROWIA Z DNIA 20 WRZEŚNIA 2012 R.** w sprawie standardów postępowania medycznego przy udzielaniu świadczeń zdrowotnych z zakresu opieki okołoporodowej sprawowanej nad kobietą w okresie fizjologicznej ciąży, fizjologicznego porodu, połogu oraz opieki nad noworodkiem (Dz.U. 12.1100 z dn. 4.10.2012).

[45] **KRÓLAK-OLEJNIK B., NEHRING-GUGULSKA M., OSLISLO A. 2012.** „Standard postępowania poporodowego sprzyjający karmieniu naturalnemu noworodków z małą urodzeniową masą ciała". Medical Standards – Pediatrics 9: 405–411.

[46] **NEHRING-GUGULSKA M., ŻUKOWSKA-RUBIK M. 2014.** „Niedostateczny przyrost masy u dziecka karmionego wyłącznie piersią – diagnoza, postępowanie, stymulacja laktacji". Postępy Neonatologii 2(21): 53–63.

[47] **KARCZ K., KRÓLAK-OLEJNIK B. 2021.** „Wiedza personelu medycznego i matek karmiących piersią dotycząca wybranych aspektów laktacji – „diety" i pozażywieniowego zastosowania mleka". Standardy Medyczne. Pediatria 18(3): 377–385.

[48] **WHO. 2023.** "Infant and young child feeding" (www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding, access: 04.07.2023).

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CONSUMPTION OF SELECTED FOODS BY ADOLESCENTS IN GDYNIA AS DETERMINANTS OF HEALTH BEHAVIOUR: A PILOT STUDY

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Abstract: The aim of the study was to assess the dietary habits of adolescents aged 15–18 years, including the frequency of consumption of products that are an important source of dietary fibre, saturated fatty acids and products containing nutrients recommended for the prevention of depression, as well as the self-assessment of the study group regarding the frequency of symptoms characteristic of depression, including depression and/or irritability and the ability to concentrate. Purposive group selection was used. The empirical study was conducted in 2022 in a group of adolescents (n = 242) attending secondary schools in Gdynia. Three aspects of dietary behaviour were assessed using the food frequency questionnaire method: 1. Consumption of products that are important sources of dietary fibre; 2. Consumption of products high in saturated fats or important sources of dietary fat; 3. Consumption of selected foods containing nutrients recommended for the prevention of depression. The study results presented are limited by the small sample size and scope of the study. However, the analysis of the consumption of selected food groups by the respondents showed that gender, BMI, and dietary habits have an impact on the type of selected foods consumed by adolescents and, therefore, on the satisfaction of individual nutrient requirements and the occurrence of symptoms characteristic of depression: depression and/or irritability. It is useful and legitimate to carry out research on the nutritional behaviour of adolescents, since there is an established need to take action in the field of health and to pay more attention to the mental and physical state of adolescents and their parents (families).

Key words: health behaviour, eating behaviour, quality of life, adolescents

INTRODUCTION

The analysis of changes in consumer behaviour around the world allows us to hypothesise that trends in food consumer behaviour are a consequence of the risks that are occurring, which translate into food and food security [1]. The above values are known to be closely linked to the Sustainable Development Goals (SDGs), providing a roadmap for transforming and reshaping the world [2]. Caring for health and the environment is becoming an important part of

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the life of societies [3, 4]. The choice of food for consumption is strongly focused on its beneficial effects on human health [5, 6, 7, 8] and on the selection of products free from chemical contaminants and synthetic additives [9, 10].

According to the World Health Organization, depression is one of the most common diseases in the world [11]. The diet of whole populations and individuals affects many aspects of life, including symptoms and risk of depression [12]. A systematic review of randomised trials confirmed the beneficial effect of dietary interventions in reducing symptoms of depression [13, 14]. There are publications in the literature on the role of diet and specific nutrients in the development and treatment of depression [12, 15, 16]. The rationale for research in this area is particularly influenced by the growing consumer awareness of the link between people's dietary behaviour and their health status.

Regarding specific dietary nutrients and their effects on depressive symptoms, beneficial effects in the treatment of depression have been demonstrated for n-3 fatty acids [17], zinc [18, 19], N-acetylcysteine [20], B vitamins (including folate) [21] and vitamin D [22]. According to Wawer [16], magnesium deficiency is an important factor in the development of depression, and dietary magnesium supplementation may improve the efficacy of antidepressant medication [15, 16, 23]. In addition, dietary selenium deficiency has been shown to affect depressive mood [12, 16]. The literature suggests that consumption of foods containing B vitamins, particularly vitamins B_1, B_2, B_6, B_{12} and folic acid, may benefit nervous system function. These vitamins are most abundant in foods such as meat, cereals, legumes, dairy products, eggs, fish, and leafy vegetables [24]. Long-chain polyunsaturated fatty acids of the n-3 family, found in fish and vegetable oils, have also been shown to be responsible for neuronal maturation and brain myelination, and are involved in synaptogenesis and neurogenesis. It has been reported that supplementation with n-3 fatty acids may have some beneficial effects in alleviating symptoms of depression [23]. Unfortunately, there is no precise data on the effect of antioxidant supplementation on the reduction or prevention of depressive symptoms [25]. According to Lai et al. [26], a diet rich in fruit, vegetables, and fish was associated with a lower risk of depression, whereas a diet high in simple carbohydrates and highly processed foods was associated with a higher risk of depression. A Mediterranean diet and higher fish consumption have been confirmed to be associated with reduced serum [27] and urinary markers of oxidative stress [28]. An analysis of the literature revealed a lack of data on potential associations between the frequency of consumption of selected foods and the absence of depressive symptoms in adolescents and adults, as well as improvements in the health of patients with mental disorders. The aim of this study was to assess the dietary habits of adolescents aged 15–18 years, including the frequency of consumption of products that are an important source of dietary fibre, saturated fatty acids and products containing nutrients recommended for the prevention of depression, as well as the self-assessment of the study group regarding the frequency of symptoms characteristic of depression, including depression and/or irritability and the ability to concentrate.

MATERIAL AND METHODS

To achieve the intended purpose, a survey was conducted from September to December 2022 using the CAWI (computer-assisted web interview) technique for data collection. Purposive group selection was used. The empirical survey was conducted among a group of young people aged between 15 and 18 years (n = 242) attending secondary schools in Gdynia: II High School, Academic High School, XIV High School, Refrigeration Technical School, Economics Technical School, and Hotel Technical School. Respondents gave informed and voluntary consent to participate in the study. The parents or legal guardians of the adolescents agreed to their children's participation in the study. They also confirmed that they were aware of the risk factors associated with administering the CAWI survey. The young people and their parents were informed that the results would be made available in publications and presentations. The results made available will be aggregated (grouped) data, without individual results. The students and their parents were also informed that all electronic data would be encrypted and stored on a computer that was password-protected. Our research focused on the expression of opinions by respondents belonging to a specific age group, but participating in the survey voluntarily and anonymously, about which the survey participants were informed. The survey itself was not related to their health status and was not carried out in units of the broader health service. The study did not have the character of medical research.

The questionnaire consisted of thematic blocks, including information characterising the study population (gender, age, height, body weight), expression of the respondents' opinions on the individually implemented dietary recommendations recommended by the National Institute of Public Health-National Institute of Hygiene (NIPH-NIH); (Poland) for their population group, assessment of the frequency of consumption of selected food groups (including foods containing saturated fatty acids, fibre, B vitamins, selenium, zinc, and magnesium, whose intake is recommended in sufficient quantities to prevent depressive symptoms) as well as an assessment of the prevalence of feelings of depression and/or irritability and problems concentrating on daily tasks.

Three aspects of dietary behaviour were assessed using the food intake frequency questionnaires: 1. intake of foods that are important sources of dietary fibre intake; 2. intake of foods high in saturated fats or important sources of dietary fat; 3. intake of selected foods containing nutrients recommended for the prevention of depression. Two validated questionnaires were used for the assessment: 1. the Block Screening Questionnaire for Fruit/Vegetable/Fibre Intake (BSQFVF) [19]; 2. the Block Screening Questionnaire for Fat Intake (BSQF) [28] as modified by Czarnocińska et al. [29].

The Block Screening Questionnaire for Fruit/Vegetable/Fibre Intake was used to obtain data on the usual frequency of consumption of 9 food groups that are sources of dietary fibre. Respondents were asked about their intake of salads, legumes, potatoes, other vegetables, fruit and vegetable juices, fruit, coarse grains, and wholemeal bread. Five categories of intake frequency were used for scoring: less than once a week – 0 points, once a week – 1 point, 2–3 times a week – 2 points, 4–6 times a week – 3 points, daily – 4 points. Fibre intake was expressed on a point scale (0–36 points). Based on the sum of the points, people with a fibre intake were distinguished: very low (<20 points), insufficient (20–29 points), sufficient (≥30 points).

The Block Screening Questionnaire for Fat Intake was used to collect information on the usual frequency of consumption of 13 food groups that are either separate fats or important sources of fat in the diet. Questions were asked about: burgers/cheeseburgers/lasagne/pizza/casseroles, red meat, fried poultry, sausages/frankfurters/ /kabanos, fatty sausages/pâté/black pudding/minced meat/bacon, salad dressings/mayonnaise, margarine/butter, yellow cheese/processed cheese, 3.2% fat milk, and crisps/chips. Five categories of frequency of consumption were used to assign points: "less than once a month" (0 points), "2–3 times/month" (1 point), "1–2 times/week" (2 points), "3–4 times/week" (3 points), "5 or more times/week" (4 points). Fat intake was expressed on a point scale (0–44 points). Based on the sum of the points, individuals were classified as having very high (>27 points), high (25–27 points), moderately high (22–24 points), low (18–21 points), or very low (best) (<18 points) fat intake.

In order to assess the frequency of consumption by adolescents of selected products containing nutrients recommended for the prevention of depression, information was collected on the usual frequency of consumption of 6 food groups. Questions were asked about the frequency of consumption of: fish and fish products, legumes, cereal products, fresh fruit and vegetables, milk and dairy products, and eggs. Five categories of frequency of consumption were assessed and scored: very often (4 points), often (3 points), rarely (2 points), very rarely (1 point), never (0 points). Product consumption was expressed on a point scale ranging from 0 to 24 points. Based on the sum of the points, individuals were distinguished with regard to their consumption of products recommended for the prevention of depression: high (best); (>16 points), medium (8–16 points), low (<8 points).

The inference was performed according to the methodology for assessing the frequency of consumption of selected food groups developed and validated by Czarnocińska et al. [29]. The study used the questionnaire based on the works of Lai et al. [26], Leszczyńska and Pisulewski [24], Łojko et al. [15], Majkutowicz, Tyszko and Okręglicka [23], Psaltopoulou et al. [30], Rahe, Unrath and Berger [31], Szczygieł and Samochowiec [12], Wawer [16], and Wolski et al. [25], which indicate that foods such as fish and fish products, legumes, cereals, fresh fruits and vegetables, milk and dairy products, and eggs provide nutrients (B vitamins (B1, B2, B6, B12, folic acid), selenium, zinc, magnesium, polyunsaturated fatty acids of the n-3 family) that are beneficial for the functioning of the human nervous system.

The degree to which respondents implemented the dietary recommendations [32] was determined by the sum of the points awarded for each behaviour implemented. Each statement describing a single behaviour was assigned 1 point. In total, the daily implementation of 8 dietary recommendations was assessed: I eat my meals at regular times, I wait 3–4 hours between meals, I do not eat sweet and salty foods between meals, I eat my last meal no later than 2 hours before bedtime, I avoid excess salt in my diet, I avoid excess fat in my diet, I avoid excess sugar in my diet, I read product labels. Implementation of the dietary recommendations was expressed on a scale of 0 to 8 points. Based on the sum of the points, the respondents were divided into 3 groups. A range of 1/3 and 2/3 points was used as a criterion for division: low level of implementation of recommendations (<1/3 range: 1–2.99 points), moderate level of implementation of recommendations (1/3 to 2/3 range: 3.00–5.66 points), high level of implementation of recommendations (> 2/3 range: 5.67–8 points).

The adolescents were asked about the frequency of feeling depressed or irritable and having problems concentrating on school and homework. Five response categories were used to assess the frequency of feeling depressed or irritable: every day, several times a week, 1–2 times a week, several times a month, never. In response to the question "Are you able to concentrate on your lessons and homework?", students could give 1 (out of 3) answers: yes, no – I have always had a problem with this, no – it has been difficult for me for some time.

Body mass index (BMI) was calculated based on the anthropometric indices of the respondents: height and body weight. Height and weight were recorded in duplicate by trained staff. Height was measured using an ultrasonic body height measuring device. The subject was in the standing upright position (no shoes), with hips and shoulders perpendicular to the central axis, heels against the footboard, knees together, arms hanging loosely at the sides, and the head in the Frankfurt plane. Height was recorded to the nearest millimetre; if the difference between measurements exceeded 4 mm, a third measurement was taken. Body weight was recorded in light underwear to the nearest 0.05 kg, using a digital medical scale (Charder MS 4202L, Poland). A third measurement was taken in the case of a difference between measurements equal to or exceeding 0.3 kg. The students' privacy was guaranteed during the anthropometric measurements in the schools.

Body mass index (BMI) was calculated as the ratio of weight in kilograms and the square of height in metres. Age and gender-specific point estimates of the prevalence of being underweight, normal body weight, or overweight (including obesity) were calculated according to the centile grids of the weight/height ratio of girls and boys aged 3–18 years (OLAF and OLAF study; measurements of children and adolescents in 2007–2012 in Poland) [33]. The data analysis made it possible to divide the respondents into three groups: group 1 – respondents who are underweight; group 2 – respondents with normal body weight; group 3 – respondents who are overweight or obese.

A reliability test – Cronbach's alpha coefficient – was carried out. A result of $\alpha = 0.76$ was obtained, which indicates that the test is reliable.

The results were analysed taking into account qualitative variables: gender, BMI, and the degree of implementation of the dietary recommendations recommended for adolescents in Poland. The collected data were analysed using Statistica 13.3 (Tibco Software, Palo Alto, USA). The results of the study were presented using percentages (%). The mean and median were calculated from the numerical values assigned to each frequency of use category of each product group. The mean values of the characteristics were compared. The Mann-Whitney U test was used to compare gender, and the Kruskal-Wallis test was used to compare BMI and adherence to dietary recommendations. The chi-squared test of independence with Yates's correction was used to assess differences in the percentage distribution of responses between groups categorised by gender, BMI, and level of implementation of dietary recommendations. Spearman's rank correlation coefficient was used to examine the correlation between gender and level of adherence to dietary recommendations. The results were significant at a p-value < 0.05.

RESULTS AND DISCUSSION

A total of 242 respondents participated in the study, including 140 girls (representing 57.9% of the study population) and 102 boys (representing 42.1% of the study population). 19.4% of the respondents, including 18.6% of the boys and 20.0% of the girls, were characterised by being underweight. The majority of respondents (63.2%), including 63.7% of boys and 62.9% of girls, were of normal body weight. 17.4% of respondents were found to be overweight or obese, including 17.6% of boys and 17.1% of girls (Table 1). The mean BMI in the study group was 22.0 ±3.6 [kg/m^2].

Table 1. Study sample characteristics

Parameters	Number of Respondents [n]	Percentage [%]
Gender		
Female	140	57.9
Male	102	42.1
Age		
15	63	26.0
16	72	29.8
17	68	28.1
18	39	16.1
BMI		
Underweight	47	19.4
Normal body weight	153	63.2
Overweight or obese	42	17.4

Source: own elaboration.

Consumption of foods that are sources of dietary fibre, saturated fatty acids and nutrients that are recommended for the prevention of depression

Among the items that were sources of dietary fibre intake, cooked potatoes had the highest mean frequency of intake (2.38 points), but at a moderate level. Moderate mean intake frequencies were also found for day-old fruit and vegetable juices (1.69 points), raw and frozen fruit (1.92 points), raw vegetables and vegetable salads (1.96 points), other vegetables (cooked, frozen, pickled); (1.71 points) and flour products made from wholemeal, rye flour or bran or groats (1.69 points) and dark rye bread (1.60 points). When assessing the average frequency of intake of fibre sources, boys were significantly more likely than girls to report consumption of brown rice and quinoa (1.36 points), and underweight subjects were significantly more likely to report consumption of cooked potatoes (2.75 points). Subjects with high or moderate levels of implementation of dietary recommendations were significantly more likely than those with low levels to report consumption of raw and frozen fruit (2.33 and 2.31 points, respectively), raw vegetables and vegetable salads (2.75 and 2.44 points), and legumes (1.42 and 1.43 points). In addition, those with a moderate level of implementation of dietary recommendations were significantly more likely to report consumption of flour products (2.0 points) and dark rye bread (2.01 points); (Table 2). Consumption of fibre products is associated with a number of health benefits, including a reduction in the incidence of cardiovascular disease, diabetes, obesity, colorectal cancer and certain gastrointestinal disorders. Fibre intake also appears to improve immune function [34, 35]. As a result of the inadequate dietary fibre intake of the survey respondents, it can be concluded that they may be at risk of developing many noncommunicable diseases and immune dysfunction in the future.

Table 2. Frequency of consumption of products that are sources of fibre in the diet (in points)

Products	Gender			BMI				Level of implementation of dietary recommendations			
	Boys	Girls	*p***	Underweight	Normal body weight	Overweight and obesity	*p****	Low	Moderate	High	*p****
Day-old fruit/vegetable juice	1.86*	1.56	0.13	1.45	1.76	1.71	0.60	1.63	1.78	2.00	0.57
Raw and frozen fruit	1.89	1.94	0.78	1.59	2.03	1.86	0.16	1.71	2.31	2.33	**<0.01**
Raw vegetables and vegetable salad	1.85	2.04	0.28	2.00	1.99	1.82	0.73	1.68	2.44	2.75	**<0.01**
Cooked potatoes	2.31	2.42	0.39	2.75	2.24	2.45	**0.03**	2.37	2.40	2.25	0.99
Legumes (beans, peas, lentils)	1.32	1.06	0.07	1.30	1.20	0.98	0.43	1.03	1.43	1.42	**0.04**
Other vegetables (cooked, frozen, pickled)	1.59	1.81	0.16	1.70	1.78	1.53	0.43	1.61	1.97	1.50	0.09
Flour products made from wholemeal, rye flour or bran or groats	1.74	1.66	0.72	1.70	1.72	1.61	0.82	1.59	2.00	1.17	**0.02**
Dark rye bread	1.62	1.58	0.84	1.70	1.59	1.53	0.83	1.39	2.01	1.83	**<0.01**
Brown rice or quinoa	1.36	1.01	**0.05**	1.34	1.12	1.14	0.81	1.03	1.40	1.42	0.07

Explanatory notes: *mean, **Mann-Whitney U-test, ***Kruskal-Wallis test.

Source: own elaboration.

Among the items that are sources of saturated fats, the highest moderate average consumption frequency was found for melted and yellow cheese (2.07 points), milk (3%); (2.03 points), eggs (2.0 points), confectionery (1.72 points), fried chicken or turkey (1.7 points), margarine or butter (1.91 points), salad dressings and mayonnaise (1.39 points), and crisps and chips (1.35 points). Pizza, casseroles, lasagne, and burgers (1.08 points), beef, steak, and roasted meat (1.00 point), sausages, frankfurters, and kebabs (1.14 points), ice cream (0.94 points), and fatty sausages (0.94 points) were found to be consumed less frequently on average. When assessing the mean values of frequency of consumption of products that are a source of saturated fat in the diet, boys were significantly more likely to consume pizza, casseroles, lasagne, and burgers (1.24 points), beef, steak, and roasted meat (1.28 points), fried chicken or turkey (2.02 points), sausages, frankfurters, and kabanos (1.37 points), fatty cold cuts (1.17 points),

and whole milk (2.34 points). When the respondents were divided into three BMI groups, significant differences were observed only for the frequency of consumption of beef, steak, and roasted meat (underweight subjects – 1.11 points, normal body weight – 1.07 points and overweight and obesity subjects – 0.69 points). Regarding the level of implementation of dietary recommendations, those with low implementation were characterised by the highest value of the average frequency of consumption for most products. The groups differed significantly in the frequency of consumption of pizzas, casseroles, lasagne, and burgers (1.18 points), beef, steak, and roasted meat (1.10 points), sausages, frankfurters, and kebabs (1. 27 points), fatty cured meats (1.06 points), margarine or butter (2.05 points), melted yellow cheese (2.23 points), whole milk (2.17 points), crisps and chips (1.56 points), and ice cream (1.15 points) (Table 3). It is encouraging that the fat intake of the adolescent group studied was moderate to low. It is important to remember that noncommunicable diseases are the leading cause of death worldwide, and cardiovascular disease is the leading cause of death [36, 37]. Cardiovascular disease is multifactorial. Modifiable factors include a high intake of saturated fat and a low intake of fruit and vegetables [38, 39].

Table 3. Frequency of consumption of products that are sources of saturated fatty acids in the diet (in points)

Specifications	Gender			BMI				Level of implementation of dietary recommendations			
	boys	girls	*p***	underweight	normal body weight	overweight and obesity	*p****	low	moderate	high	*p****
Pizza, casserole, lasagne, hamburger	1.24*	0.97	**0.04**	1.09	1.14	0.92	0.42	1.18	0.99	0.42	**0.02**
Beef, steak, roasted meat	1.28	0.79	**<0.01**	1.11	1.07	0.69	0.05	1.10	0.89	0.33	**0.04**
Chicken or fried turkey	2.02	1.47	**<0.01**	1.98	1.56	1.86	0.10	1.70	1.76	1.33	0.54
Sausages, frankfurters, kabanos	1.37	0.97	**0.01**	1.11	1.08	1.33	0.34	1.27	1.01	0.17	**<0.01**
Fatty cold cuts, pâté, black pudding, mince, bacon	1.17	0.78	**<0.01**	1.09	0.89	0.96	0.56	1.06	0.81	0.17	**0.02**
Salad dressings, mayonnaise	1.50	1.31	0.28	1.48	1.33	1.49	0.69	1.40	1.43	1.00	0.61
Margarine or butter	2.10	1.78	0.14	2.16	1.86	1.84	0.52	2.05	1.78	0.92	**0.04**
Eggs	2.11	1.93	0.28	2.09	1.95	2.10	0.69	1.94	2.19	1.75	0.28
Processed and yellow cheeses	2.27	1.91	**0.04**	2.20	1.94	2.31	0.21	2.23	1.81	1.42	**0.03**
Whole milk (3%)	2.34	1.80	**<0.01**	2.25	1.95	2.06	0.43	2.17	1.83	1.33	0.05
Potato chips and French fries	1.45	1.27	0.28	1.32	1.32	1.45	0.62	1.56	1.00	0.67	**<0.01**
Ice cream	0.99	0.98	0.89	0.98	1.06	0.76	0.26	1.15	0.65	0.83	**0.01**
Doughnuts, cakes, cookies, waffles and other confectionery products	1.72	1.72	0.92	1.70	1.79	1.53	0.48	1.82	1.63	1.00	0.07

Explanatory notes: *mean, **Mann-Whitney U-test, *** Kruskal-Wallis test.

Source: own elaboration.

Among the items that were sources of dietary intake of nutrients recommended for depression prevention, fresh fruit and vegetables (3.18 points), milk and dairy products (3.10 points), cereals (2.9 points), and eggs (2.69 points) had the highest average frequency of intake. For the other products identified in the survey, a moderate frequency of consumption was found, based on an average score of 1.83 points for legumes and 1.68 points for fish and fish products.

When assessing the average frequency of consumption of products that are a source of nutrients in the diet for the prevention of depression, girls were significantly more likely than boys to report consumption of fresh fruit and vegetables (3.35 points), and those with a normal body weight and those with a high level of implementation

of dietary recommendations were significantly more likely to report consumption of pulses (1.93 points and 2.25 points, respectively). Those with a moderate level of implementation of dietary recommendations were significantly more likely to report consumption of cereals (3.04 points), and respondents with a high level of implementation of dietary recommendations were significantly more likely to report consumption of fresh fruit and vegetables (3.58 points); (Table 4). A meta-analysis of observational studies suggests that a Mediterranean-style diet has a protective effect against the onset of depression, whereas a dietary pattern described as a Western diet, characterised by a high intake of saturated fatty acids and a low intake of fibre, increases the likelihood of developing depression [30, 31].

Consumption of selected foods and prevalence of symptoms characteristic of depression in the study group of adolescents

According to Beyer and Payne [40], the type of food consumed and the body's nutritional status affect a person's mental health. For the functioning of the brain and the maintenance of its morphology (structure), it is necessary to provide energy (which represents a significant part of the total energy contained in food) and many nutrients (lipids, vitamins, macro- and micronutrients, cofactors of antioxidant reactions, catalysts – synthesis of neurotrophic factors and many others). Thus, dietary patterns and the closely related development of eating habits indirectly influence the onset and course of many psychiatric disorders and could, therefore, be a target for therapeutic intervention and prevention [15].

As the influence of nutrients on the functioning of the human nervous system is well documented, the influence of gender, BMI, and dietary habits on the type of selected foods consumed by adolescents, and thus on the achievement of individual nutrient requirements, and on the occurrence of symptoms characteristic of depression, including mood swings or irritability and problems concentrating in class and on daily chores, was assessed. For the total intake of products that were a source of fat, respondents differed significantly by gender and level of implementation of dietary recommendations ($p = 0.02$). Very low and low fat intakes (i.e. those most beneficial to health) were more common among girls (29.8 and 10.3%, respectively) than boys (16.5 and 4.6%, respectively). Very high fat intake was reported by 7.4% of girls and 11.9% of boys. In terms of the level of implementation of dietary recommendations, those with a low level were characterised by very low and very high intakes of products that are an important source of dietary saturated fat (27.7 and 16.1%, respectively) (Table 5). According to the literature, young women in Poland have mostly positive attitudes towards health and the health value of foods, but they do not pay attention to the cholesterol and saturated fat content of the foods they consume [41]. In addition, the prevalence of inappropriate eating behaviours, such as eating while working, and eating irregularly, has been reported among girls aged 14–19 years (in Poland) [42]. These eating behaviours are harmful because they increase the risk of metabolic and neurological diseases.

For total dietary fibre intake, the groups differed significantly in meeting dietary recommendations ($p = 0.02$). The study group was dominated by those with very low and insufficient dietary fibre intakes and was characterised by low (13.2 and 51.7%, respectively) and moderate (11.6 and 17.8%, respectively) levels of implementation of dietary recommendations (Table 5). The results of our study are in line with those of other authors. According to the literature, adolescents in Poland do not consume sufficient amounts of dietary fibre [43]. Although fibre intake is higher in girls than in boys, it is too low compared to the current recommendation for Polish adolescents, which is 21 g per day [44].

For the total intake of selected products as a source of nutrients recommended for the prevention of depression, respondents did not differ significantly by gender, BMI or level of implementation of dietary recommendations ($p \leq 0.05$).

There were significant differences between boys and girls in feeling depressed or irritable. Feeling depressed or irritable every day was reported by 23.9% of respondents, of whom 16.9% were girls. A frequency of several times a week was reported by 24.8% of respondents, of whom 15.7% were girls. In contrast, one in three respondents felt depressed or irritable several times a month, of whom 18.2% were boys. The results of our study are in line with those of other authors who reported that 25.5% of girls and 27.4% of boys felt irritable more than once a week, while depressed feelings were experienced by 15.7% and 20.6%, respectively. Over time, a greater proportion of adolescents experienced negative emotions more than once a week, and this was associated with persistent poorer well-being [45]. No significant differences ($p \leq 0.05$) were found between the groups according to gender, BMI, and level of implementation of dietary recommendations in terms of concentration in class and chores performed (Table 5). The results of our study are not confirmed by the literature; a previous study found

Table 4. Frequency of consumption of selected foods as sources of nutrients recommended for prevention of depression (in points)

Products	Gender			BMI				Level of implementation of dietary recommendations			
	boys	girls	*p***	underweight	normal body weight	overweight and obesity	*p****	low	moderate	high	*p****
Fish and fish products	1.77*	1.61	0.23	1.41	1.76	1.69	0.12	1.61	1.85	1.67	0.19
Legume seeds	1.84	1.83	0.83	1.55	1.93	1.80	0.05	1.70	2.07	2.25	**0.01**
Cereal products	2.98	2.84	0.18	2.89	2.90	2.88	0.94	2.87	3.04	2.42	0.04
Fresh fruits and vegetables	2.94	3.35	**<0.01**	3.14	3.27	2.96	0.10	3.07	3.35	3.58	**<0.01**
Milk and dairy products	3.20	3.03	0.37	3.27	3.09	2.98	0.43	3.18	3.00	2.67	0.33
Eggs	2.80	2.61	0.14	2.59	2.73	2.65	0.59	2.70	2.74	2.25	0.35

Explanatory notes: *mean, ** Mann-Whitney U-test, *** Kruskal-Wallis test.

Source: own elaboration.

Table 5. Consumption of selected foods and occurrence of symptoms characteristic of depression in the group of adolescents studied

Specification	Gender			BMI				Level of implementation of dietary recommendations			
	Percentage [%]										
	boys	girls	*p**	underweight	normal body weight	overweight and obesity	*p*	low	moderate	high	*p*
Consumption of products that are sources of saturated fatty acids in the diet											
Very high	11.9	7.4		4.6	11.6	3.3		16.1	3.3	0.0	
High	2.9	3.3		0.4	5.4	0.4		3.7	1.7	0.8	
Moderately high	6.2	7.1	0.02	3.3	6.2	3.7	0.13	8.7	4.6	0.0	0.02
Low	4.6	10.3		2.5	7.4	5.0		9.1	5.4	0.4	
Very low (best)	16.5	29.8		7.4	30.1	8.7		27.7	14.8	3.7	
Consumption of products that are sources of dietary fibre											
Adequate	1.2	0.0		0.0	1.2	0.0		0.4	0.4	0.4	
Very low	29.7	43.4	0.07	12.4	43.8	17.0	0.29	51.7	17.8	3.7	0.02
Inadequate	11.2	14.5		5.8	15.7	4.1		13.2	11.6	0.8	
Consumption of selected products that are sources of nutrients recommended in the prevention of depression											
High	16.9	20.3		5.1	24.8	7.4		21.5	14.5	1.2	
Moderate	24.4	37.2	0.46	13.2	35.5	12.8	0.18	42.6	15.3	3.7	0.09
Low	0.8	0.4		0.0	0.4	0.8		1.2	0.0	0.0	
Frequency of feeling depressed or irritated											
Daily	7.0	16.9		4.6	13.5	5.8		17.4	4.6	2.1	
Several times a week	9.1	15.7	0.02	5.0	17.4	2.5	0.26	15.6	8.3	0.8	0.39
1–2 times a week	7.9	9.9		2.9	9.5	5.4		11.6	5.8	0.4	
Several times a month	18.2	15.3		5.8	20.2	7.4		20.6	11.2	1.6	
Self-assessment of focus on lessons and duties performed											
I have no problem concentrating	22.3	28.1		9.1	30.5	10.7		30.6	16.9	2.9	
I have always had trouble concentrating	8.7	16.1	0.43	3.3	15.7	5.8	0.71	17.4	6.6	0.8	0.63
It has been difficult for me to focus for some time now	11.2	13.6		5.8	14.5	4.6		17.4	6.2	1.2	

Explanatory note: *Chi^2

Source: own elaboration.

that up to half of students in lower secondary schools (13–16 years) and technical schools (16–20 years) in Poland have problems with concentration, and in high schools it is about 30% of students [46].

In the study group, a significant but weak positive correlation (p <0.05); (Spearman's rank correlation) was observed between male gender and consumption of selected fatty products such as beef, steak, roasted meat and chicken or roast turkey, and a weak but significant association (p <0.05) between female gender and consumption of fresh fruit (Table 6). On the other hand, taking into account the level of implementation of dietary recommendations, a significant but weak positive correlation (p <0.05) was observed between the implementation of recommendations and consumption of vegetable salads, raw vegetables, brown rice, bread and legume seeds. A weak negative correlation (p <0.05) was observed between the implementation of recommendations and the consumption of potato chips and French fries (those with a higher level of implementation of dietary recommendations were significantly less likely to report their consumption); (Table 6).

Table 6. Consumption of selected products vs. gender and level of adherence to dietary recommendations (Spearman's rank correlation)

Food products	Gender	Level of implementation of dietary recommendations
Day-old fruit/vegetable juice	0.10	0.06
Raw fruit, frozen fruit	–0.02	**0.18**
Vegetable salads, raw vegetables	–0.07	**0.34**
Potatoes boiled in water or steamed	–0.06	0.01
Legumes (beans, peas, lentils)	0.12	**0.17**
Other vegetables (cooked, frozen, pickled)	–0.09	0.11
Flour products made of graham, wholemeal or rye flour, or bran or groats	0.02	**0.13**
Dark rye bread	0.01	**0.26**
Brown rice or quinoa	0.12	**0.14**
Fish and fish products	0.08	0.09
Legume seeds	0.01	**0.21**
Cereal products	0.09	0.10
Fresh fruits and vegetables	–0.27	0.17
Milk and dairy products	0.06	–0.11
Eggs	0.10	–0.06
Pizza, casserole, lasagne, hamburger	**0.13**	–0.12
Beef, steak, roasted meat	**0.24**	–0.11
Chicken or fried turkey	**0.22**	0.04
Sausages, frankfurters, kabanos	0.18	–0.15
Fatty cold cuts, pâté, black pudding, mince, bacon	**0.19**	–0.11
Salad dressings, mayonnaise	0.07	0.00
Margarine or butter	0.10	–0.09
Eggs	0.07	0.11
Processed and yellow cheeses	**0.13**	–0.11
Whole milk (3%)	0.18	–0.15
Potato chips and French fries	0.07	**–0.28**
Ice cream	–0.01	**–0.17**
Doughnuts, cakes, cookies, waffles and other confectionery products	0.01	**–0.13**

Explanatory notes: bold indicates statistically significant correlations.

Source: own elaboration.

No significant correlations were found between the use of products recommended for depression prevention and the gender of the respondent in terms of feeling depressed, being irritable, and having problems concentrating in class or at home.

Table 7. Influence of consumption of selected foods as a source of nutrients recommended for the prevention of depression, by gender, on feelings of depression and concentration problems (Spearman's rank correlation)

Food products	Feeling depressed or irritable		Difficulty concentrating on lessons and duties performed	
	boys	girls	boys	girls
Fish and fish products	0.11	0.02	–0.06	0.11
Legume seeds	–0.01	0.13	–0.11	–0.01
Cereal products	–0.11	0.10	0.19	–0.11
Fresh fruits and vegetables	–0.04	0.01	0.13	–0.04
Milk and dairy products	–0.06	0.06	0.02	–0.06
Eggs	–0.07	0.01	–0.16	–0.07

Source: own elaboration.

CONCLUSIONS AND FUTURE PERSPECTIVES

The results of the study presented here are limited by the small sample size and scope of the study. However, the analysis of the consumption of selected food groups by the respondents showed that gender, the degree of body nutrition and dietary habits influenced the type of selected foods consumed by the adolescents and thus on the achievement of individual nutrient requirements and the occurrence of symptoms characteristic of depression: feelings of depression and/or irritability. The diet of adolescents was found to be rich in animal fats and poor in fruit and vegetables. Most of the adolescents interviewed did not follow the principles of a rational diet. The analysis showed no significant association between group differentiating factors (gender, BMI, level of implementation of dietary recommendations) and the frequency of feelings of depression and/or irritability and difficulty concentrating. According to the authors, research into the dietary choices of adolescents in Poland should be continued, as the results of the pilot study indicate that they are inappropriate and put young Poles at risk of developing depression. If adolescents do not pay attention to the impact of the products they consume on their health, do not eat a balanced diet and consume products rich in simple carbohydrates and saturated fats, their risk of developing symptoms characteristic of depression will increase significantly. It is useful and legitimate to carry out research on the nutritional behaviour of adolescents since there is an established need to take action in the field of health and to pay more attention to the mental and physical state of adolescents and their parents (families).

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REFERENCES

[1] **KOZŁOWSKA-BURDZIAK M. 2019.** „Warunki bezpieczeństwa żywnościowego Polski (ze szczególnym uwzględnieniem województwa podlaskiego)'. Optimum. Economic Studies 3(97): 33–48. https://doi.org/10.15290/oes.2019.03.97.03.

[2] **WIŚNIEWSKA M.Z. 2022.** „Ewolucja trendów i zagrożeń w konsumpcji żywności w świetle celów zrównoważonego rozwoju". Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie 995(1): 63–79. https://doi.org/10.15678/ZNUEK.2022.0995.0104

[3] **DIDKOWSKA A., ORŁOWSKA B., JACHNIS A., ANUSZ K. 2017.** „Wartość odżywcza ekologicznych produktów spożywczych pochodzenia zwierzęcego jako element bezpieczeństwa żywności". *Życie* Weterynaryjne 92(03): 208–210.

[4] **ŻAKOWSKA-BIEMAS S. 2011.** "Barriers to buy organic food in the context of organic food market development". Journal of Research and Applications in Agricultural Engineering 56(4): 216–220.
[5] BŁASZCZAK A., GRZEŚKIEWICZ W. 2014. „Żywność funkcjonalna – szansa czy zagrożenie dla zdrowia". Medycyna Ogólna i Nauki o Zdrowiu 20(2): 214–221. https://doi.org/10.5604/20834543.1112240.
[6] **BRYLA P. 2018.** „Uwarunkowania skłonności do płacenia wyższej ceny za żywność ekologiczną w porównaniu z produktami konwencjonalnymi". Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu 526: 203–213 http://dx.doi.org/10.15611/pn.2018.526.18
[7] **FABISIAK A., GROCHOWICZ J. 2018. „Żywność funkcjonalna – aspekty prawne i znaczenie wybranych składników bioaktywnych".** Zeszyty Naukowe Uczelni Vistula 60(3): 143–153.
[8] **KOŁODZIEJCZYK A., WOJCIECHOWSKI P. 2020.** „Nowe regulacje dotyczące znakowania żywności bez GMO". Przemysł Spożywczy 74(2): 20–23.
[9] **HERMANIUK T. 2018.** „Postawy i zachowania konsumentów na rynku ekologicznych produktów żywnościowych". Handel Wewnętrzny 2(373): 189–199.
[10] **GADOMSKA J., SADOWSKI T., BUCZKOWSKA M. 2014**. „Ekologiczna żywność jako czynnik sprzyjający zdrowiu". Problemy Higieny i Epidemiologii 95(3): 556–560.
[11] **NIK. 2022.** „Depresja – jak pomóc sobie i bliskim?". (https://www.nik.gov.pl/aktualnosci/uwaga-depresja.html, access: 01.07.2022).
[12] **SZCZYGIEŁ K., SAMOCHOWIEC J. 2019.** „Wpływ żywienia na zdrowie psychiczne w opinii psychiatry". Psychiatria 16(3): 164–153.
[13] **OPIE R.S., O'NEIL A., ITSIOPOULOS C., JACKA F.N. 2015.** "The impact of whole-of-diet interventions on depression and anxiety: A systematic review of randomised controlled trials". *Public Health Nutrition* 18(11): 2074–2093 https://doi.org/10.1017/S1368980014002614.
[14] **JACKA F.N., O'NEIL A., OPIE R., ITSIOPOULOS C., COTTON S., MOHEBBI M., CASTLE D., DASH S., MIHALOPOULOS C., CHATTERTON M.L., BRAZIONIS L., DEAN O.M., HODGE A.M., BERK M. 2017.** "A randomised controlled trial of dietary improvement for adults with major depression (the 'SMILES' trial)". BMC Medicine 15(1): 23. https://doi.org/10.1186/s12916-017-0791-y
[15] **ŁOJKO D., STELMACH M., SUWALSKA A. 2018.** "Is diet important in bipolar disorder?". Psychiatria Polska 52(5): 783–795. https://doi.org/10.12740/PP/OnlineFirst/78703
[16] **WAWER I. 2017.** „Dietetyczne niedobory mikroskładników i suplementacja w chorobach neurologicznych". Neurologia Praktyczna 6: 1–8.
[17] **MISCHOULON D., FREEMAN M.P. 2013.** "Omega-3 fatty acids in psychiatry". Psychiatric Clinics of North America 36(1): 15–23. https://doi.org/10.1016/j.psc.2012.12.002.
[18] **LAI J.S., A. MOXEY, G. NOWAK, K. VASHUM, K. BAILEY, MCEVOY M. 2012.** "The efficacy of zinc supplementation in depression: Systematic review of randomised controlled trials". Journal of Affective *Disorders* 136(1–2): 31–39 https://doi.org/10.1016/j.jad.2011.06.022
[19] **STYCZEŃ K., SOWA-KUĆMA M., SIWEK M., DUDEK D., RECZYŃSKI W., SZEWCZYK B.. 2017.** "The serum zinc concentration as a potential biological marker in patients with major depressive disorder". Metabolic *Brain Disease* 32(1): 97–103. https://doi.org/10.1007/s11011-016-9888-9
[20] **BENNETT J., STEVENS G., MATHERS C.D., BONITA R., REHM J., KRUK M.E., RILEY L.M., DAIN K., KENGNE A.P., CHALKIDOU K., BEAGLEY J., KISHORE S.P., CHEN W., SAXENA S., BETTCHER D.W., GROVE J.T., BEAGLEHOLE R., EZZATI M. 2018.** "NCD Countdown 2030: worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4". Lancet 392(10152): 1072–1088. https://www.doi.org/10.1016/S0140-6736(18)31992-5
[21] **FAVA M., MISCHOULON D. 2009.** "Folate in depression: Efficacy, safety, differences in formulations, and clinical issues". *Journal of Clinical Psychiatry* 70 (Suppl. 5): 12–17. https://doi.org/10.4088/JCP.8157su1c.03
[22] **EYLES D.W., BURNE T.H.J., MCGRATH J.J. 2013.** "Vitamin D, effects on brain development, adult brain function and the links between low levels of vitamin D and neuropsychiatric disease". *Frontiers* in *Neuroendocrinology* 34(1): 47–64. https://doi.org/10.1016/j.yfrne.2012.07.001
[24] **LESZCZYŃSKA T., PISULEWSKI P.M. 2004.** „Wpływ wybranych składników żywności na aktywność psychofizyczną człowieka". ŻYWNOŚĆ. Nauka. Technologia. Jakość 1(38): 12–24.
[23] **MAJKUTEWICZ P., TYSZKO P., OKRĘGLICKA K. 2014.** „Leczenie żywieniowe depresji". Family Medicine & Primary Care Review 16(1): 48–50.
[25] **WOLSKI T., KALISZ O., GERKOWICZ M., SMORAWSKI M. 2007.** „Rola i znaczenie antyoksydantów w medycynie ze szczególnym uwzględnieniem chorób oczu". Postępy Fitoterapii 2: 82–90.
[26] **LAI J.S., HILES S., BISQUERA A., HURE A.J., MCEVOY M. 2014.** "A systematic review and meta – analysis of dietary patterns and depression in community-dwelling adults". *American Journal* of *Clinical Nutrition* 99(1): 181–197. https://doi.org/10.3945/ajcn.113.069880
[27] **FITÓ M., GUXENS M., CORELLA D., SÁEZ G., ESTRUCH R., DE LA TORRE R., FRANCÉS F., CABEZAS C., DEL M., LÓPEZ-SABATER C., MARRUGAT J., GARCÍA-ARELLANO A., ARÓS F., RUIZ-GUTIERREZ**

V., ROS E., SALAS-SALVADÓ J., FIOL M., SOLÁ R., COVAS M.-I. 2007. "Effect of a traditional Mediterranean diet on lipoprotein oxidation: A randomized controlled trial". Archives of Internal Medicine 167(11): 1195–1203. https://doi.org/10.1001/archinte.167.11.1195

[28] **MITJAVILA M.T., FANDOS M., SALAS-SALVADÓ J., COVAS M.I., BORREGO S., ESTRUCH R. 2013.** "The Mediterranean diet improves the systemic lipid and DNA oxidative damage in metabolic syndrome individuals. A randomized, controlled, trial". *Clinical Nutrition* 32(2): 172–178. https://doi.org/10.1016/j.clnu.2012.08.002

[28] **THOMPSON F.E., BYERS T. 1994.** "Dietary Assessment Resource Manual". Journal of Nutrition 124: 2245–2317. https://doi.org/10.1093/jn/124.suppl_11.2245s

[29] **CZARNOCIŃSKA J., JEŻEWSKA-ZYCHOWICZ M., BABICZ-ZIELIŃSKA E., KOWALKOWSKA J., WĄDOŁOWSKA L. 2013.** „Postawy względem żywności, żywienia i zdrowia a zachowania żywieniowe dziewcząt i młodych kobiet w Polsce". Wydawnictwo Uniwersytetu Warmińsko-Mazurskiego w Olsztynie, Olsztyn.

[30] **PSALTOPOULOU T., SERGENTANIS T.N., PANAGIOTAKOS D.B., SERGENTANIS I.N., KOSTI R., SCARMEAS N. 2013.** "Mediterranean diet, stroke, cognitive impairment, and depression: A meta-analysis". Annals of *Neurology* 74(4): 580–591. https://doi.org/10.1002/ana.23944

[31] **RAHE C., UNRATH M., BERGER K. 2014.** "Dietary patterns and the risk of depression in adults: A systematic review of observational studies". *European Journal of Nutrition* 53(4): 997–1013. https://doi.org/10.1007/s00394-014-0652-9

[32] **JAROSZ M. 2019.** „Piramida Zdrowego Żywienia i Stylu Życia Dzieci i Młodzieży". Narodowy Instytut Zdrowia Publicznego. Państwowy Zakład Higieny-Państwowy Instytut Badawczy, Warszawa (https://ncez.pzh.gov.pl/dzieci-i-mlodziez/piramidazdrowego-zywienia-i-stylu-zycia-dzieci-i-mlodziezy-2/, access: 01.07.2022).

[33] **KUŁAGA Z., LITWIN M., TKACZYK M., PALCZEWSKA I., ZAJĄCZKOWSKA M., ZWOLIŃSKA D., KRYNICKI T., WASILEWSKA A., MOCZULSKA A., MORAWIEC-KNYSAK A., BARWICKA K., GRAJDA A., GURZKOWSKA B., NAPIERALSKA E., PAN H. 2010.** Polish 2010 growth references for school-aged children and adolescents. European Journal of Pediatrics 170(5), 599–609. https://doi.org/10.1007/s00431-010-1329-x

[34] **MASLOWSKI K.M., MACKAY C.R. 2011.** "Diet, gut microbiota and immune responses". Nature Immunology 12(1): 5–9. https://doi.org/10.1038/ni0111-5

[35] **SLAVIN J. 2013.** "Fiber and prebiotics: mechanisms and health benefits". Nutrients 5(4): 1417–1435. https://doi.org/10.3390/nu5041417

[36] **BERK M., MALHI G.S., GRAY L.J., DEAN O.M. 2013.** "The promise of N-acetylcysteine in neuropsychiatry". Trends in Pharmacological Sciences 34(3): 167–177. https://www.doi.org/10.1016/j.tips.2013.01.001

[37] **WHO. 2022.** "World Health Statistics 2022: monitoring Health for the SDGs, Sustainable Development Goals". World Health Organization, Geneva.

[38] **RICCARDI G., GIOSUÈ A., CALABRESE I., VACCARO O. 2022.** "Dietary recommendations for prevention of atherosclerosis". Cardiovascular Research 118(5): 1188–1204. https://doi.org/10.1093/cvr/cvab173

[39] **VESNINA A., PROSEKOV A., ATUCHIN V., MININA V., PONASENKO A. 2022.** "Tackling atherosclerosis via selected nutrition". International Journal of Molecular Sciences 23915: 8233. https://doi.org/10.3390/ijms23158233

[40] **BEYER J.L., PAYNE M.E. 2016.** "Nutrition and bipolar depression". Psychiatric Clinics of North America 39(1): 75–86. https://www.doi.org/10.1016/j.psc.2015.10.003

[41] **PLATTA A., SAWLEWICZ K. 2022.** "Dietary behaviour and attitudes of a selected group of women (in Poland) towards health and health-promoting foods". Management and Quality – Zarządzanie i Jakość 3: 172–188.

[42] **PLATTA A., KACZMARSKA P. 2022.** "Selected health behaviours of girls aged 14 to 19 years and the risk of eating disorders: a pilot study". ŻYWNOŚĆ. Nauka. Technologia. Jakość 29, 3 (132): 100–112. https://doi.org/10.15193/zntj/2022/132/426

[43] **SITKO D.M., WOJTAŚ M., GRONOWSKA-SENGER A. 2012.** „Sposób żywienia młodzieży gimnazjalnej i licealnej". Roczniki Państwowych Zakładów Higieny, 63(3): 319–327.

[44] **WOLNICKA K., JACZEWSKA-SCHUETZ J., TARASZEWSKA A., CHARZEWSKA J., JAROSZ M.2017.** „Częstotliwość spożycia warzyw i owoców przez dzieci i młodzież w szkołach podstawowych i gimnazjach w Polsce". Żywienie Człowieka i Metabolizm 44(4): 258–267.

[45] **MAZUR J. (ED.). 2015.** „Zdrowie i zachowania zdrowotne młodzieży szkolnej w Polsce na tle wybranych uwarunkowań socjodemograficznych". Wydawnictwo Instytut Matki i Dziecka, Poland, Warszawa.

[46] **MALARA B., JOŚKO J., KASPERCZYK J., KAMECKA-KRUPA J. 2010.** „Rozpowszechnienie zaburzeń odżywiania wśród młodzieży w wybranych miastach województwa śląskiego". Problemy Higieny i Epidemiologii 91(3): 388–392.