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TECHNOLOGICAL INGREDIENTS AND NUTRITIONAL VALUE OF GLUTEN FREE BREAD®

Składniki technologiczne i wartość odżywcza pieczywa bezglutenowego®

The basis of a gluten-free diet is the exclusion of all products containing gluten, which is obtained from wheat, rye, barley and oats and their derivatives. The quality of gluten-free bread is shaped by additives, including hydrocolloids, which affect its structure, improve palatability and affect the nutritional value. Gluten-free bread can be low in protein and contain more total fat and salt, compared to wheat bread. When choosing gluten-free bread, you should make a particularly careful selection of products and diversify dishes prepared with their use.

Key words: gluten-free bread, gluten-free cereals, hydrocolloids, nutritional value.

Podstawą diety bezglutenowej jest wykluczenie wszystkich produktów zawierających gluten, który otrzymywany jest z pszenicy, żyta, jęczmienia i owsa oraz z ich pochodnych. Jakość pieczywa bezglutenowego jest kształtowana przez dodatki m.in. hydrokoloidy, które wpływają na jego strukturę, poprawiają smakowitość oraz wpływają na wartość odżywczą. Pieczywo bezglutenowe może być ubogie w białko i zawierać więcej tłuszczu ogółem oraz soli, w porównaniu do pieczywa pszennego. Wybierając pieczywo bezglutenowe należy dokonywać szczególnie starannego doboru produktów i urozmaicania potraw przygotowywanych z ich udziałem.

Słowa kluczowe: pieczywo bezglutenowe, zboża bezglutenowe, hydrokoloidy, wartość odżywcza.

INTRODUCTION

Cereal products, including bread, are one of the basic ingredients of human diet. Choosing the right diet should be based on healthy and valuable products that will provide the body with all the essential nutrients needed for its development and life. It is equally important that the food consumed does not cause negative health effects on the body.

Celiac disease is a disease in which the use of an elimination diet is essential and necessary for the body of a sick person to function properly. The diet of people suffering from celiac disease is based on the exclusion of products containing gluten, which contribute to its development and aggravation of the symptoms of the disease. Gluten, which is toxic for people with celiac disease, occurs in cereal products and dishes made from wheat, rye or barley flour and oats, which itself does not contain toxic gluten, but can be contaminated during cultivation, harvesting and processing.

There are plants that do not contain gluten and can be used in the production of gluten-free food, while not reducing the nutritional and organoleptic value of the final product. By choosing the right technological ingredients, we can compose healthy and nutritious dishes. Thanks to the wide range and availability of gluten-free products, the diet of people with celiac disease can be varied and tasty.

There are many companies producing gluten-free food on the Polish market, thanks to which people on a diet have easier access to most gluten-free cereal products and get the opportunity to eat properly. Gluten substitutes used in these products improve the structure of the products, so they do not differ in quality from foods containing gluten.

The purpose of this article was to characterize technological ingredients and nutritional value of selected gluten-free breads intended for people with celiac disease.

GLUTEN – CHARACTERISTICS

Gluten proteins can be divided into two main fractions depending on their solubility in alcohol into soluble prolamines, i.e. gliadin from wheat, rye secalin, barley hordein and insoluble - glutenins.

Both fractions form a micellar network connected by non-covalent and disulfide bonds. Gluten protein is formed during the flour mixing and plays an essential role in forming the dough structure.

Gluten gives the dough cohesiveness, viscosity, elasticity, plasticity, extensibility and increases the ability to absorb water allowing the swollen starch granules and carbon dioxide bubbles, which comes from alcoholic fermentation, to remain in the new-created mesh [34, 25]. Under the influence of

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swelling gluten in the aquatic environment, a gluten mesh is formed, which traps carbon dioxide bubbles formed during fermentation. Swelling of gluten and its denaturation when baking bread results in the formation of a suitable porous and spongy structure appropriate for bread. Pure gluten is a springy, sticky mass that we get after washing out the starch and other flour ingredients from the dough obtained from the above-mentioned cereals. Gluten consists of amino acids and peptides [14]. The gluten content in flour is one of the basic parameters of its baking properties [35].

GLUTEN SUBSTITUTES

We can improve the quality of bread and gluten-free dough by adding the right amounts of starch [corn, potato, rice or wheat gluten-free], as well as hydrocolloids, which are thickening, gelling and stabilizing substances. Such an action is shown by, among others xanthan gum, guar gum, agar, acacia, modified starch, locust bean gum, carrageenan, gelatin, pectin, carboxymethyl cellulose and sodium caseinate. The quality of the dough can also be improved by adding substances that have a leavening effect and this group includes compounds such as lactone, gluten-free baking powder, sodium carbohydrate and gluconic acid.

During the production of dough, it is very important to maintain the right proportion of hydrocolloids in relation to the other ingredients, because too much thickening substance can cause buildup. Hydrocolloids, i.e. gluten substitutes, must be used in an amount of 0.1% to 1.2% of all the ingredients used. This proportion increases the water absorption of the dough, increases the bread volume, improves the crumb structure and extends the freshness of the bread [25].

Natural hydrocolloids and their derivatives are very often used in the food industry (Tab. 1). The main advantage of these substances is their increased possibility of water retention in various food products. Hydrocolloids are mainly used in manufacturing pastry, confectionery and food concentrates. We can also add them to traditional products or those that require reduced fat or sugar content as well as in the production of gluten-free products [11].

CHARACTERISTICS OF HYDROCOLLOIDS USED IN GLUTEN-FREE BREAD

Agar, E 406 – is a mixture of many polysaccharides, which we obtain as a result of extraction of marine algae. Agar is characterized by high swelling capacity; only dissolves in water above 90°C at pH 8.0–9.0. The gels it forms are thermo-reversible, clear and brittle. The addition of sugar will cause an increase in the hardness of agar gels and greater resistance to hydrolysis (Tab. 1) [1, 27].

Carboxymethylcellulose, E466 – is the incomplete sodium salt of cellulose carboxymethyl ester. Slightly hygroscopic, soluble in hot and cold water, where it forms non-Newtonian solutions. Its solubility increases with a decrease in sugar and Ca2 + content, and its viscosity decreases with increasing temperature (Tab. 1) [27].

Carrageenan, E 407 – a substance that can be obtained from seaweed. It is a mixture of different types [iota, kappa, lambda, mi, ni], but the most important are lambda, iota and kappa. Only iota and kappa types have the ability to form gels (Tab. 1) [1, 27].

Guar gum, E 412 – we obtain it from the seeds of guar trees, which grow mainly in India and Pakistan. It dissolves in cold water, even in low concentration it has the ability to create stable solutions characterized by high viscosity. Due to the large number of galactose groups that hinder the formation of a spatial grid, guar does not form a gel on its own. In food, it interacts quite well with other ingredients, especially with other rubbers. During the reaction with xanthan, the viscosity of the system increases. Guar also delays the crystallization process and prevents syneresis, causes better stabilization of suspensions and emulsions (Tab. 1) [13, 27].

Hydroxypropulomethylcellulose, E 464 – is obtained from cotton or wood pulp fibers by using reagents i.e. methyl chloride and propylene oxide. It dissolves in cold water to form sticky colloidal solutions, and in hot water it precipitates, but it dissolves again when cooled. Insoluble in organic solvents and in ethanol. This substance acts as a thickener, stabilizer and emulsifier. It supports the emulsification process and creates protective layers. It is used as a thickener in the cold. It stabilizes decorative foams, creams and emulsions [sauces]. Used in the baking industry for the production of concentrates (Tab. 1) [15, 27].

Karob, E 410 – we obtain it from dry fruit of trees, mainly from Spain, Greece, Turkey and Portugal. Carob creates highly viscous solutions in hot water above 80°C with pH 4.4–10.0. This substance does not have gelling properties, but it can affect the structure and elasticity of gels that have arisen from other hydrocolloids. Gels obtained as a result of combination with agar do not show syneresis, because carob has a high ability to bind water (Tab. 1) [27, 32].

Konjak gum, E 425 (i) – is a polysaccharide obtained from the tuber of a plant naturally occurring in Asia - the weirdo Riviera (*Amorphophallus konjac*). Dispersible in both hot and cold water. It allows the formation of thermally reversible and thermally stable gels. Creates highly viscous solutions (Tab. 1) [27, 28].

Xanthan, E 415 – is a product obtained as a result of fermentation of the carbohydrate substrate by *Xanthomonas campestris* bacteria. Xanthan gains stability at pH 2.0–12.0. It dissolves quite well in cold and warm water, as well as in salt and sugar solutions and in milk. It creates stable solutions characterized by high viscosity, shows resistance to freezing and thawing (Tab. 1). Guar works more effectively in combination with gum [2, 15].

ADDITIVES USED IN GLUTEN-FREE PRODUCTS

In the composition of gluten-free products, in addition to the hydrocolloids listed above, there are also other additional substances that affect the quality of gluten-free products, among others influence many changes during the food production process, thus facilitating the manufacture of products.

The characteristics of the additives used for gluten-free cereal products discussed in the previous chapter are presented below:

Table 1. Characteristics of selected hydrocolloids used in the production of gluten-free bread
Tabela 1. Charakterystyka wybranych hydrokoloidów stosowanych w produkcji pieczywa bezglutenowego

NAME	DESCRIPTION	SOURCE OF RECEIVING	MAIN TECHNOLOGICAL FUNCTIONS
Agar	E 406	*Rhodophyta* extract	Gelling, thickening, stabilizing, clarifying, emulsifying agent
Carboxymethylcellulose	E 464	Cellulose and its derivatives	Thickener, stabilizer, emulsifier, substance to be applied to the surface, carrier
Carrageenan	E 407	*Chondrus crispus* extract	Gelling, thickening, stabilizing and clarifying substance
Guar gum	E 412	*Cyamopis tetragonoloba* seed meal	Thickening, stabilizing substance
Hydroxypropulomethylcellulose	E 466	Cellulose and its derivatives	Stabilizer, binder, carrier, bulking agent
Karob	E 410	*Ceratonia siliqua* seed meal	Thickener, stabilizer, emulsifier
Konjak gum	E 425(i)	Glucomannan obtained from tubers *Amorphophallus konjak*	Thickener, gelling agent, carrier
Xanthan	E 415	Product of fermenting the carbohydrate substrate by *Xanthomonas campestris*	Thickener, stabilizer, emulsifier, for use on the surface

Source: [25, 27]
Źródło: [25, 27]

Pectin, E 440 - occurs in the form of a powder or liquid concentrate, dissolves well in warm water, and swells in cold. Forms viscous mixtures in milk and sugar solutions. Pectin is a thickener, gelling agent, excellent carrier and stabilizer. This substance causes an increase in viscosity, however its action is less effective than other hydrocolloids [2].

Sodium bicarbonate – a fine crystalline powder or crystalline mass, odorless, white or colorless. This substance is soluble in water, but insoluble in ether and ethanol. Sodium bicarbonate is an acidity regulator, it has leavening, stabilizing and filling functions. It strengthens the smell and taste. It emits carbon dioxide in an acid environment, thanks to which it loosens the dough. Its high alkalinity affects the salty – sour taste of products. It is used for the production of baking powder [27].

Gluconic acid lactone, E 575 – a fine crystalline powder with a white color and low odor. This substance is an acidity regulator, it also has leavening properties. It strengthens the taste and smell. It works acidifying and coagulating. It is most often used for making mixtures of baking flour, desserts and jellies and baking powders [21, 27].

Citric acid, E 330 – white granulate or powder, odorless with a very sour tart taste. This acid is used as an antioxidant, stabilizer, acidity regulator and flavor. It is used to inhibit enzymatic processes by increasing acidity. It also has a low preservative effect. Together with salts, it creates buffer systems in food. It strengthens the action of other antioxidants. By forming complexes with metal ions, it prevents enzymatic and chemical reactions that contribute to changes in the color and appearance of products. As an acidity regulator, it is used in all branches of the food industry [24, 27].

Tartaric acid, E 334 – is a by-product formed during the production of grape wine and synthetically obtained from maleic acid. Odorless with a sour, tart, fruity taste. It plays the role of an acidity regulator, is a synergist and a flavoring substance. It has acidifying properties and enhances taste. With antioxidants, it has synergistic effects, thus preventing rancidity and cheese discoloration. It accelerates the growth of dough [27, 31].

Ascorbyl palmitate, E 304 – white or yellow powder with a lemon scent. It is difficult to dissolve in water while easily in fat and ethanol. This substance is an antioxidant, stabilizer and works synergistically with respect to other antioxidants, especially tocopherols. Compared with ascorbic acid, it has a stronger antioxidant effect on fat products that did not heat up during processing. It can also be used in low-fat products acting as a stabilizer [21, 27].

Disphosphates, E 450 – white granular powder. Used as an acidity regulator, it has stabilizing and emulsifying properties, is a leavening, acidifying, buffering and clarifying substance. It is most often used in the production of baking powder, confectionery, instant potato flour and cake concentrates [27, 31].

Mono- and diglycerides of fatty acids, E 471 – a substance soluble only in hot alcohol, insoluble in water. It acts as an emulsifier, carrier and stabilizer. Used in baking, they contribute to a stable dough characterised by tolerance to high temperature and kneading. By forming complexes with starch, they improve the quality of bread and increase its durability. They also influence the strengthening of flour gluten, thanks to which carbon dioxide is trapped and greater porosity as well as bread volume are obtained. In combination with hydrocolloids, they increase the freshness of bread and delicatessen bread [21, 27].

Mono- and diglycerides of fatty acids esterified with mono- and diacetylvinyl acid E 472 e – a thick, viscous liquid with a white-yellow color, which in a humid air undergoes the process of hydrolysis and releases tartaric acid. It acts as an emulsifier, stabilizer, carrier and is a dispersing substance. Together with starch and proteins, it helps to create systems. It strongly reacts with gluten, thanks to which it improves the baking value mainly of wheat flour. It has a positive effect on the consistency of pasta and increases the volume of bread. They are used for the production of confectionery and bakery

fats, wheat and semi-confectionery bread, creams, desserts, chocolate drinks and icing toppings [21, 27, 31].

Glycerin, E 422 – is a colorless or light yellow oily liquid, odorless and sweet taste. It acts as a carrier, stabilizer, solvent and is responsible for maintaining humidity in confectionery products and jellies. Supports texture formation with food gums and gelatin. It is most often used in food flavors. It is used, among others for the production of bread, desserts and cakes as well as icing for cakes [16, 27].

A mixture of tocopherols, E 306 – a red-brown oily liquid, colorless with a slight, mild odor. The main function of this substance is antioxidant activity. In the case of saturated fatty acids, they have a protective effect and prevent oxidation of vitamin A. They act as vitamin E, and also support oxygen transport to the muscles and heart [21, 27].

GLUTEN-FREE BREAD – NATURALLY GLUTEN-FREE CEREALS AND PSEUDO-CEREALS

Bread that is intended for people on a gluten-free diet is made of various types of flour and starch. The most commonly used is flour and starch made from corn and gluten-free wheat starch. Gluten-free oat flour [from controlled, certified crops and plants where there is no risk of gluten contamination], or rice starch and flour are also perfect for baking bread. Buckwheat flour with the addition of gluten-free wheat or corn starch is also increasingly used [23].

Due to the lack of gluten in bread dough, positive hydrocolloids are needed to improve the structure of the dough. On the market, the range of gluten-free bread is quite rich, thanks to which the gluten-free diet has become more varied.

People on a gluten-free diet must consume products that do not contain gluten, and the diet of the sick should not only be balanced and varied, but above all tasty. Pseudo-cereals and naturally gluten-free plants are available on the market, the starch of which can be used to produce gluten-free food [5]:

– buckwheat – the fruit of buckwheat is not ache, also called peanut. Its outer part is a fruit cover, and under it is a seed cover. Bielmo is the central part. Individual parts of buckwheat are characterized by a different chemical composition and different nutritional value. Hulled nuts contain approx. 12% water, proteins constitute approx. 10%, 71% are sugars, 3% fats, dietary fiber is approx. 4% and mineral substances approx. 1.7%. Buckwheat grains are rich in tocopherols, which there are more than in wheat or barley, as well as B group vitamins. Proteins contained in buckwheat grains have a high biological value and there is no α-gliadin, thanks to which buckwheat and its food processing products are used in the diet intended for people with celiac disease. Starch in buckwheat is low-energy because its fractions are resistant to the activity of amylolytic enzymes found in the digestive tract. Buckwheat is also a good source of fatty acids. The content of unsaturated fatty acids is about 80% of all fatty substances, and 40% are polyunsaturated acids. Buckwheat products prevent hypercholesterolemia because they have a beneficial effect on the content of cholesterol in the blood. Buckwheat also contains antioxidant substances such as phytosterol, flavonoids, phagopyrins and phenolic acids. Buckwheat flour has a high nutritional value (Tab. 2), which perfectly serves as a substitute for wheat flour in bakery [12].
– oats – consumption of oat-based bread is not as popular in Poland as in other countries. Complex carbohydrates, including starch, are one of the basic nutrients found in oats. The starch content fluctuates around 45–55%, which is almost 10% less comparing to other cereals. The high content of dietary fiber distinguishes it from other cereals. Soluble β-glucans are the bulk of the fiber fraction. Due to the possibility of producing colloidal solutions characterized by high viscosity, they play an important nutritional role. These solutions stimulate intestinal motility during movement in the gastrointestinal tract and absorb cholesterol. Oats are a good source of protein, and its amount is about 12–17% (Tab. 2). Proteins have a high nutritional value because they contain exogenous amino acids. The fat content is about 7%, unsaturated fatty acids such as linolenic acid are about 35–35% and oleic acid 35–50%. Saturated palmitic acid is present in an amount of about 15–20%. Oats are rich in vitamin E and B vitamins, mainly vitamin B1, PP, vitamin B6, vitamin B2, pantothenic acid and folates. Unfortunately, the amount of vitamin E can be significantly reduced when storing unprocessed beans at room temperature. The content of minerals in oats is much higher than in wheat and rye, it contains a lot of potassium, iron, zinc, copper and magnesium. Oats have antioxidant properties due to the presence of polyphenolic compounds mainly caffeic, hydroxycinnamic, phenolic acid and the presence of tetramid, whose activity is several times higher than caffeic acid. Oat sterols have antioxidant activity and contribute to reducing serum cholesterol. However, it should be noted that during the production of oat flakes sterols are destroyed. Oats and its food processing products are used in the treatment of people with diabetes, obesity or cardiovascular diseases. The presence of β-glucans largely affects its health values. They influence the reduction of the glycemic index, also contribute to the reduction of serum cholesterol by binding it in the digestive tract by the gels formed, and also increase the secretion of bile acids. Oats are mainly used for the production of flour, groats, flakes and bran [10].
– sorghum – only two varieties are grown in Poland for the purpose of being used for fodder for silage. Sorghum can be used to produce flour, groats and starch, as well as spirit and molasses. This plant can also be used to make couscous and as an addition to various pastries and tortillas. Groats that are made from sorghum do not stick after cooking and have good sensory and rheological properties. It is rich in protein, minerals and fiber. The flour we receive from sorghum is light, odorless and light. It can be perfectly used as a replacement for wheat flour for the production of pasta or pizza dough. Sorghum is a plant with high nutritional value (Tab. 2). It contains a large amount of carbohydrates approx. 75%, the protein content is approx. 11%. Sorghum grains are a rich source of dietary fiber about 6.8%, and its main fraction is hemicellulose. The fat content is 3.3%, including polyunsaturates. Minerals

are also found in large quantities, mainly potassium, iron and phosphorus. Sorghum is also a valuable source of vitamin B group. Sorghum seeds contain carotenoids and flavonoids, and anthocyanins are also present in the hulls. The presence of phytochemicals, tannins, phytosterols and phenolic acids has a positive effect on the human body due to their antioxidant properties, which are higher than in other cereals. However, sorghum bran contains more health-promoting ingredients than the whole grain. Contained sterols and polyphenols favorably affect the cardiovascular system, contributing, among others to reduce blood cholesterol. Tannins present in sorghum reduce the calorie content of food, thanks to which we can use it as one of the ingredients of a slimming diet. The sorghum also contains tannins, which destroy free radicals contributing to the immunity increase. They have also been shown to be anti-cancer because they inhibit the production of mutagenic toxins [8].

– millet – the nutritional value of millet is as high as that of other cereals (Tab. 2). The carbohydrate content in this grain is high, and starch dominates. Its amount is in the range of 56–63%. Carbohydrates present in millet are characterized by high bioavailability – 98%. Starch, thanks to its organized and homogeneous structure, absorbs large amounts of water and forms gels. The fiber content is lower compared to wheat or rye, which is why it is a more absorbable plant. The dominant fiber fraction is pentosans 6.6%, cellulose 1.6% and lignin 0.3%. Millet is a very good source of protein (Tab. 2), and its quantity is mainly influenced by genetic factors and environmental conditions. The amount of protein in millet is similar to that in wheat, but the millet protein has more essential amino acids, including lysine. The protein's bioavailability is also high, around 85%. The fat content is 4% and its bioavailability reaches 90%. Sterols, fatty acids and triglycerides are also present in millet. The amount of polyunsaturated acids is 40%. Millet is rich in minerals, mainly magnesium, potassium and iron. The distinguishing feature from other cereals is the base-forming effect of millet and the presence of silica, which is rarely found in cereal products. Vitamins found in millet are mainly B group vitamins. The yellow-pale variety of millet is rich in β-carotene, which is transformed into vitamin A. Millet groat can be obtained from millet. It is an easily digestible product with high nutritional value (Table 2), which we can perfectly be used as an addition to various dishes. Millet is also suitable for making flour. Gluten-free flour can be used for baking bread and various cakes. Its swelling ability, smell, color and nutritional value [tab. 6], as well as consistency mean that we can replace flour made of wheat for millet flour [9].
– Amarantus – also known as amaranth, only one variety is cultivated in Poland, with high nutritional value. Amaranth seeds consist of 64% starch, 17% fiber, 15% protein, 7% fat, and 3% ash. Comparing the nutritional value of amaranth with other cereals, they have more potassium, magnesium, calcium, phosphorus and iron (Tab. 2). Amarantus is also a valuable source of B vitamins, vitamins A, E and C. Proteins found in this plant have a lot of amino acids that contain sulfur and other essential amino acids necessary for the proper development of the body. Starch present in amaranth is even 2–4 times more bioavailable than starch present in millet. The fats contained in amaranth mostly consist of unsaturated fatty acids, among others linoleic and oleic, and in smaller quantities from peanut and linolenic acid. Amarantus also has biologically active substances that are recommended in diets used by people with heart disease and atherosclerosis, as well as in rejuvenating, gluten-free and high-protein diets. A very important nutrient and health-promoting component of this plant is squalene, which has many health-promoting properties, among others antioxidant. Amarantus can be used for the production of groats, cereals, muesli, gruel, popcorn and flour, which is suitable for making bread, biscuits and cakes and pasta. Amarantus is perfect for bakery products intended for people with allergies, celiac disease and atherosclerosis. We can get flour from amaranth, which acts as a natural bread improver. It increases its nutritional value and replaces synthetic additives. The addition of this flour can help improve the rheological properties of the dough, thanks to which it becomes more flexible and spongier. It also increases the bread volume and also shortens the dough fermentation process [3].
– quinoa – a plant originating in South America, is a very good source of protein, which is characterized by a large amount of exogenous amino acids. These proteins are characterized by high digestibility, which is about 80–90%. Quinoa also contains a large amount of carbohydrates (Table 2). Starch has the largest quantity among them (55–65%). Disaccharides are found in a small amount of 2–3%, while pentosans 3–4%. The prevailing fraction of quinoa is amylopectin, and the amount of amylose ranges from 25–27%. A similar quantity of these fractions also occurs in corn and wheat starch. The fat found in quinoa seeds is within 7–8%. The fatty acid content is similar to that in maize. There are more minerals present in quinoa than in traditional bread cereals. Potassium and phosphorus predominate here. The amount of calcium, magnesium and copper is also quite large. A distinctive feature is also a large amount of vitamins (Tab. 2), mainly A, C, E, as well as carotenoids. B vitamins are found in smaller amounts, primarily niacin and thiamine. Quinoa mainly provides seeds that are used in the baking industry and for the production of food concentrates [4].
– rice – is the basic cereal that makes the food of people in East and South Asia. Rice is an excellent addition to various dishes, it is also used for the production of flakes, flour, pasta and rice starch [18]. The energy value of flour is varied and depends on the rice variety (Tab. 2). Brown rice is considered to be more valuable, and this is mainly due to the fact that in the technological process brown rice retains a fruit-seed coat. The protein content is also higher in brown rice. Rice is a valuable source of carbohydrates, their total content in white rice is 79%, and in brown rice about 77%. This plant is also rich in dietary fiber, and its content is quite diverse. The fats found in rice are in small amounts, white rice contains 0.7%, and brown rice 1.9%. The majority of fatty acids is 30% linoleic acid. Rice is also a good source of vitamins, especially from group B, among others B1, B2 and niacin, as well as vitamin E [36].

Table 2. Nutritional value of selected gluten-free cereals and pseudo-cereals, Sources [20,33]
Tabela 2. Wartość odżywcza wybranych bezglutenowych zbóż i pseudozbóż, Źródła [20,33]

Nutrient Ingredient	Units	Flour											
		Wheat type 500	Rye type 580	Barley	Buckwheat	Oat	Millet	Sorgo	Amaranth	Quinoa	Rice	Corn	Teff
Energy value	kJ/kcal	1436 /343	1410 /337	1443 /345	1519 /363	1549 /370	1540 /368	1410 /337	1645 /393	1539 /368	1452 /347	1457 /348	1603 /383
Protein	g	10,10	5,10	10,50	13,10	14,00	11,60	5,90	15,90	14,12	7,20	5,90	13,30
Fat	g	1,20	1,50	1,60	2,70	8,00	2,90	3,00	7,40	6,07	0,70	3,00	2,40
Saturated fatty acids	g	0,31	0,36	0,34	0,64	1,60	0,70	0,53	2,10	0,71	0,15	0,38	0,40
Monounsaturated fatty acids	g	0,15	0,26	0,21	1,03	2,87	2,62	0,94	1,69	1,61	0,18	0,68	0,60
Polyunsaturated fatty acids	g	0,74	0,89	0,77	1,10	3,33	0,00	1,40	2,78	3,29	0,26	0,18	1,07
carbohydrates	g	74,00	78,50	74,50	68,60	55,00	75,90	78,00	60,10	64,16	76,90	70,50	73,10
Starch	g	70,50	68,40	63,62	60,50	57,80	69,88	68,00	57,30	52,22	74,90	68,30	36,56
Dietary fiber	g	2,30	5,60	10,10	5,90	11,00	3,20	7,60	11,40	7,00	2,30	7,50	8,00
Calcium	mg	18,00	19,00	32,00	40,00	55,00	13,00	7,00	186,00	47,00	10,00	7,00	180,00
Magnesium	mg	10,00	21,00	96,00	219,00	144,00	213,00	40,00	266,00	197,00	36,00	40,00	184,00
Potassium	mg	340,00	155,00	296,00	521,00	371,00	340,00	193,00	527,00	563,00	117,00	193,00	427,00
Iron	mg	1,10	1,10	2,68	4,00	4,00	4,30	3,00	7,20	4,75	1,10	3,00	7,60
Zinc	mg	0,08	1,04	2,00	3,75	3,20	3,66	0,84	2,87	3,10	0,80	0,84	3,63
Copper	mg	67,00	0,09	0,34	0,60	0,44	0,78	0,10	0,53	0,59	0,20	0,10	0,81
Phosphorus	mg	67,00	91,00	309,00	441,00	452,00	397,00	127,00	557,00	457,00	90,00	127,00	429,00
Manganese	mg	0,25	0,70	1,03	1,89	4,02	1,61	0,35	3,33	2,03	0,60	0,37	9,24
Vitamin E	mg	0,40	0,12	0,57	0,30	0,70	0,10	0,30	1,19	2,44	0,00	0,30	0,08
Vitamin B1	mg	0,11	0,15	0,37	0,58	0,69	0,20	0,37	0,12	0,36	0,08	0,37	0,40
Vitamin B2	mg	0,05	0,07	0,11	0,11	0,13	0,12	0,10	0,20	0,32	1,90	1,00	3,40
Vitamin PP	mg	0,93	0,57	6,27	4,72	1,47	5,63	1,32	0,92	1,52	10,00	1,32	0,94
Vitamin B6	mg	0,02	0,10	0,40	0,67	0,13	0,37	0,33	0,59	0,49	0,20	0,33	0,48

– Maize – initially it was grown only in America, and then spread to the African and Asian countries, it came to Poland later than to neighboring countries [19]. Corn is a good source of carbohydrates (Tab.2), but it contains far fewer than traditional bread cereals. Potassium, phosphorus and magnesium dominate among the minerals. Corn is also rich in B vitamins, mainly thiamine, riboflavin, niacin, as well as vitamin A and dietary fiber. Corn is a versatile plant. You can get flour, groats, cereals, oil and sugar from it, it can also be consumed immediately after cooking the flask [18]. Corn flour obtained during milling is yellow and its texture is granular or fine. It is mainly used for the production of bread raised by baking powder instead of yeast. The bread is light and fluffy. The structure of the dough has small pores and the color of the bread is golden. Comparing its nutritional value with other flours, it can be stated that it has the most carbohydrates, while mineral compounds, dietary fiber and vitamins are present in smaller amounts than in other flours [17].
– teff – Abyssinian love is cereal from Africa. The flour obtained from teff is very well suited for making sourdough bread. During the fermentation of the dough, numerous gas bubbles are formed that give a better quality of the final product. Abyssinian malka is a naturally gluten-free plant, its composition is similar to that of millet (Tab. 2). However, the amount of amino acids in teff is much higher than in other cereals. This plant is also a valuable source of calcium, magnesium and iron. The distinguishing feature of this grain from others is the high content of folic acid. Teffu grains are very stable, because they do not go rancid during storage [19].

Wheat, rye and barley flour, compared to flours obtained from the above-mentioned cereals and pseudo-cereals, has a nutritional value that is comparable to other flours (Tab. 2). It is not distinguished by a higher quantity of protein in total, but differs in its amino acid composition and technological quality as well as the impact on the structure of the final

product. Gluten-free bread contains less protein compared to rye or wheat bread. However, the calorific value, fat and carbohydrate content are comparable [7].

NUTRITIONAL VALUE OF SELECTED GLUTEN-FREE BREADS

Table 3 presents the nutritional value of 85 selected bakery products from the bread assortment from 4 producers who offer their products in Poland. The nutritional value for individual products was obtained from the websites of their producers.

The analysis of selected products showed a large diversity of bread on the Polish market. The offer includes, for example, products that are obtained on the basis of sourdough, with the addition of whole-grain flour and/or grains of various gluten-free cereals, because it affects their nutritional value and organoleptic characteristics.

The energy value of bread varied within a fairly wide range of 179-432 kcal/100 g of product (Tab. 3). The protein content is much lower compared to wheat bread. In addition, attention should be paid to the protein content of gluten-free flours used for baking bread – it was comparable to levels in wheat mat (Tab. 2). The differences that are observed for gluten-free and wheat bread are due, among others the technological quality of flour that does not contain gluten. In the production of gluten-free bread [12, 17], it is necessary to use other gluten replacement ingredients, including hydrocolloids, legume proteins and dietary fiber [31], which will improve the technological and organoleptic quality of the products obtained. The use of the above ingredients, however, significantly affects the nutritional value of the final product, including the reduction of the protein content.

Gluten-free bread is characterized by a much higher total fat content, which ranged from 1.8 to 11 g/100g of bread, on average 5.35 g in 100 g of product. Fat has an impact on the textural, structural and sensory characteristics of the final product. Variations in fat and protein amount can significantly influence the delicate and spongy structure of the breads, which as a result will have a higher acceptance among consumers [29].

The salt content of bread was varied. A slice of wheat bread weighing 25 g provides the body with about 1.6% of the recommended daily salt intake. Bread is one of the main sources of salt in the diet of Poles. In addition, it should be noted that bread is rarely consumed without additives, e.g. spreadable fat, cheese or sausages, which are also a source of salt. This is of great epidemiological importance, as excessive intake of salt is associated with an increased risk of hypertension, cardiovascular disease and stomach cancer [6, 22].

The content of dietary fiber in gluten-free products under analysis was quite high, e.g. three slices of bread with sunflower seeds or whole-grain breads provided up to 30 g of fiber. This is important for patients with celiac disease, as some of them may have problems with regeneration and intestinal motility immediately after diagnosis [26]. In such cases, doctors and dietitians recommend periodic use of an easily digestible diet rich in water-soluble fiber, rather than water-insoluble fiber dominant in bread. In addition, it should be noted that gluten-free products are high energy and for some patients it is important to provide dietary fiber with diet, which helps regulate and/or reduce weight [30].

SUMMARY AND CONCLUSIONS

Celiac disease is an autoimmune disease that is characterized by gluten intolerance. As a result of the action of gluten on the gastrointestinal mucosa, intestinal villi in the small intestine disappears, which are responsible for the absorption of nutrients. **Celiac disease can appear at any age. If you do not use the gluten-free diet, you may have serious health problems related to, among others anemia, osteoporosis, mental disorders, problems with pregnancy and the risk of gastrointestinal cancers increases significantly.** The only treatment method for celiac disease is to follow a gluten-free diet throughout your life.

Gluten is a protein that is made from gliadin (or sekalin, hordein) and glutenin during dough kneading. It performs many technological functions, such as affecting the elasticity, viscosity, elasticity and plasticity of the dough. It allows the proper increase of dough volume during fermentation, and also increases the porosity of the bread and affects its rise.

For people with celiac disease, it is forbidden to consume products containing the above-mentioned cereals. These cereals can be replaced with other plants that do not form gluten and are suitable for the production of various products, among others for baking bread, making pasta or making cakes and cookies.

The nutritional value of the gluten-free bread assortment varies. It contains less protein than wheat bread that affects its nutritional value as well as technological quality, which results in the need to replace the structure-forming role of gluten.

PODSUMOWANIE I WNIOSKI

Celiakia to choroba o podłożu autoimmunizacyjnym, charakteryzująca się nietolerancją glutenu. W wyniku działania glutenu na śluzówkę przewodu pokarmowego, w jelicie cienkim dochodzi do zaniku kosmków jelitowych, które odpowiadają za wchłanianie składników pokarmowych. Celiakia może ujawnić się w każdym wieku. **W przypadku nie zastosowania leczenia dietą bezglutenową, może dojść do poważnych problemów zdrowotnych związanych m. in. niedokrwistością, osteoporozą, zaburzeniami psychicznymi, problemami z zajściem w ciążę oraz istotnie rośnie ryzyko wystąpienia nowotworów układu pokarmowego.** Jedyną metodą leczenia celiakii jest ścisłe przestrzeganie diety bezglutenowej przez całe życie.

Gluten jest białkiem, które powstaje z gliadyny (lub sekaliny, hordeiny) i gluteniny podczas miesienia ciasta. Pełni on wiele funkcji technologicznych, takich jak wpływ na elastyczność, lepkość, sprężystość i plastyczność ciasta. Umożliwia prawidłowy wzrost objętości ciasta podczas fermentacji, a także zwiększa porowatość pieczywa i wpływa na stopień jego wyrośnięcia.

W przypadku osób chorych na celiakię spożywanie produktów zawierających wyżej wymienione zboża jest zabronione. Zboża te należy zastąpić innymi roślinami, które nie tworzą glutenu i nadają się do wyrobu różnych produktów m.

in. do wypieku chleba, wyrobu makaronu czy produkcji ciast i ciasteczek.

Wartość odżywcza asortymentu pieczywa bezglutenowego jest zróżnicowana. Zawiera ono mniej białka niż pieczywo pszenne, co wpływa na jego wartość odżywczą oraz jakość technologiczną, co jest związane z koniecznością zastąpienie strukturotwórczej roli glutenu.

Table 3. Nutritional value of selected gluten-free bread available on the Polish market, Sources [38,39,40]

Tabela 3. Wartość odżywcza wybranego pieczywa bezglutenowego dostępnego na polskim rynku, Źródła [38,39,40]

Product name	Energy value		Fat	Staturated fatty acids	Carbohydrates	Sugars	Dietary fiber	Protein	Salt
	kJ	kcal	g						
Producer - Glutenex									
Buckweat bread	1266	299	3,7	0,5	65	4,6	ND*	1,1	1,4
Bread roll with sunflower seeds	1202	285	6,4	0,9	53	5,3	ND	2	1,6
Butter bread	329	10	4,6	58	12	1,2	ND	1	BD
Butter rolls	1826	432	8	6,6	87	14	ND	1,7	1,5
Dark bread	1240	293	4	1,5	63	7,3	ND	0,7	1,8
Dark kaiser roll	1111	263	3,9	0,7	55	5,3	ND	0,5	1,6
Dark vital bread with seeds	923	219	5,1	1,2	38	5,4	2,9	2,7	1,4
Gluten-free rolls	1111	263	4	0,7	55	5,5	ND	0,5	1,7
Kaiser roll	1118	265	4	0,7	55	5,5	ND	0,5	1,6
Light vital bread	859	204	3	0,7	40	2,9	5	2	1,5
Loaf braed	985	233	3,5	0,6	49	4,6	ND	0,4	1,5
Milk bread	1116	264	4,4	1	54	5,5	ND	1,2	1,2
Multigrain bread	1298	308	8,6	1,8	52	3,5	ND	4	1,5
Multigrain dark loaf	1152	274	7	1,7	48	4,8	ND	2,3	1,4
Multigrain light loaf	1159	257	7	1,7	49	4,9	ND	2,2	1,5
Poznan circular wedding bread	1271	302	9,3	2,6	49	5,4	1,1	3,1	5,7
Poznanska roll	1111	263	4	0,7	55	5,5	ND	0,5	1,7
Sandwich bread	1157	274	4,2	0,7	57	5,4	ND	0,5	1,7
Toast bread	1163	275	4,5	0,3	56	5,8	ND	1,6	1,5
Producer - Balviten									
Multigrain bread	1544	373	2,8	2,6	16	1,1	9,6	1	1,6
Bread "Chlebus"	1300	312	6,3	0,5	60	3,7	2,9	1,98	1,55
Bread with chia seeds	940	223	42	0,44	40	2,1	5,5	4,1	1,3
Bread with no added sugar	1019	241	2,9	0,22	50	0,6	2,8	2,8	1,2
Bread with sunflower seeds	1100	261	7,5	0,6	46	1	1,5	1,5	1,09
Ciabatta	792	188	2,8	0,2	34	1	5,3	3,6	1
Cumin Bread	906	215	3,7	0,3	38	BD	4,8	4,7	1,3
Daily bread	1062	252	4,8	0,5	50	2,9	3,7	0,8	1,2
Dark farmhouse bread	950	225	3,8	0,3	40	2	6,1	4,6	1,1
Dark sandwich bread	792	188	2,8	0,2	34	1	5,3	3,6	1
Dark supreme royal bread with grains	999	237	3,6	0,3	44	5,4	5,8	4,6	1,3
Galician bread	990	235	3,9	0,4	47	4,1	4,4	0,7	0,9
Home-made bread	993	237	4,2	0,3	48	4,1	2,2	0,53	0,95
Kaiser rolls	1250	300	5,8	0,4	58	3,3	3,5	1,4	1,2
Light bread	792	188	2,8	0,2	34	1	5,3	3,6	1
Light bread	752	179	5,5	0,38	31	3,6	1,2	0,84	1,2
Light farmhouse bread	950	225	3,8	0,3	40	2	6,1	4,6	1,1

Product name	Energy value		Fat	Staturated fatty acids	Carbohydrates	Sugars	Dietary fiber	Protein	Salt
	kJ	kcal	g						
Light supreme royal bread with grains	950	225	3,8	0,3	40	2	6,1	4,6	1,1
Mini baguette	792	188	2,8	0,2	34	1	5,3	3,6	1
Multigrain bread	908	216	5,9	0,5	33	1,5	6,7	4,8	0,94
Multigrain bread	1086	258	7,3	0,6	46	2,4	1,4	1,6	1,1
Our favourite bread	792	188	2,8	0,22	34	1	15,3	3,6	1
Rustic baguette	1109	264	8,4	1	38	4,4	5,9	5,5	1,4
Sunflower seed bread	1171	278	8,2	0,9	47	2,5	4,4	2,1	1,2
Supreme royal bread with grains	1102	263	8,3	0,7	38	5,5	7,6	5,2	0,9
Supreme royal rolls	1040	248	2,97	0,2	50	2,7	4,9	2,8	1,2
Toast bread	1036	246	4,7	0,4	48	4,6	3,7	0,7	0,8
Vbread with quinoa flour	1009	239	4,1	0,33	45	3	4	3,7	1,5
Producer - Bezgluten									
Mini baguette	1148	272	5,6	0,6	49	3,4	5,4	3,5	1,12
Bread with no added sugar	985	235	6,7	0,6	35	1,3	6,3	5,4	1,54
Ciabatta	1143	271	5,6	0,6	49	3,4	5,4	3,5	1,12
Daily bread	1099	262	6,6	0,8	43	4,6	9,1	3	1,4
Daily rolls	1065	253	5,4	0,9	45	5,5	6,6	2,8	1,1
Dark bread with pumpkin seeds and cranberries	1079	257	6	0,8	39	4,9	7,5	8,1	1,3
Hamburger rolls	1176	279	7,8	0,9	48	3,2	ND	4,2	1,07
Kaiser rolls	1143	271	5,6	0,6	49	3,4	5,4	3,5	1,12
Light loaf with black cumin	1059	254	10	1,1	30	3,7	13	4,4	0,9
Miltigrain bread with chia seeds	1109	264	7,6	0,8	41	2,6	9,7	3	1,1
Multigrain bread	1157	275	8	0,8	44	2,5	6,5	3,6	1,15
Multigrain bread	902	215	5,4	0,6	35	2,2	7,4	2,8	1,3
Noble brown bread	1080	257	7,2	1	39	4,5	9,1	4,6	1,1
Noble white bread	1008	239	4,8	0,6	41	3	6,5	4,8	1,03
Plain bread	976	232	4,3	0,4	43	1,6	6,5	2,1	1,25
Plain bread with sunflower seed	1078	257	7,9	0,8	40	1,9	6,2	3,3	1,1
Plain rolls	1148	272	5,6	0,6	49	3,4	5,4	3,5	1,12
Rolls with poppy seeds	1131	268	6,3	0,7	49	3,4	ND	3,8	1,1
Rosette rolls	1162	276	5,6	0,6	49	3,4	7,8	3,5	1,12
Sunflower seed bread	1135	270	7,6	0,8	43	4,2	10	2,5	1,3
Toast bread	1006	239	4	0,1	44	6	6,5	3,7	1,08
White bread	1068	253	5,1	0,6	47	2,5	5,1	2,3	1,3
White bread	1052	250	4,6	0,5	46	3,1	7,7	2,2	1,2
White bread	1008	240	5,7	0,6	42	1,1	6,4	1,9	0,88
Producer - Shär									
Ciabatta Rustica	1150	274	8,1	1	40	3,7	8,9	5,8	1
Bon matin	1236	293	7,3	3,9	51	14	3	3,4	0,75
Ciabatta	900	213	1,8	0,3	41	2,7	8,8	4,1	1
Focaccia Con Rosmarino	1064	253	6,1	0,8	42	4,1	3,8	BD	1,3
Maestro cereale	1042	248	6,2	0,9	40	2,8	7,4	4,3	0,85

Product name	Energy value		Fat	Staturated fatty acids	Carbohydrates	Sugars	Dietary fiber	Protein	Salt
	kJ	kcal	g						
Maestro classic	1009	239	3,4	0,5	45	3,3	7,3	3,5	1
Maestro vital	1099	262	9,2	1,1	36	0,9	8,8	4,5	1
Mehrkornbrotchen	1241	296	11	1,3	38	2,3	8	7,3	0,75
Pain campagnard	967	229	3,5	0,5	43	3	5,7	3,5	1,3
Pan blanco	889	211	2,7	0,4	41	7,9	ND	2,4	1,3
Pan multigrano	989	235	4,9	0,6	40	7	8	3,6	1,1
Pan rustico	954	239	2,4	0,4	44	6,3	6,7	3,8	1
Panini rolls	993	235	2,9	0,5	45	4,9	7,2	3,7	1
Vollkornbrot	990	236	7	0,8	31	2	9	7	0,83
Producer - Putka									
Wheat bread	1160	276	1,5	0,3	49	1,9	4,3	7,6	1,6
ND* - *no data*									

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