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THE NUTRITIONAL AND HEALTH VALUE OF MILK AND FERMENTED MILK DRINKS®

Wartość odżywcza i zdrowotna mleka i mlecznych napojów fermentowanych®

Key words: milk, fermented milk drinks, nutrients, health-promoting effect.

Milk and fermented milk drinks are foods rich in a range of essential nutrients. They include, among others highly digestible proteins, B vitamins, vitamins A and D, calcium, potassium and phosphorus. It is also worth noting that the use of bacterial starter cultures in the production of fermented milk drinks increases the bioavailability of some of these nutrients. The fermentation leading to the formation of such beverages therefore results in the end-products gaining not only a texture, aroma and taste different from milk, but also other properties. Increases, among others digestibility of their proteins, and as a result of the partial breakdown of lactose, they become more affordable for people with intolerance to this disaccharide. The nutritional value of milk and fermented milk drinks has a positive impact on human health. Among other things, the beneficial effect of the ingredients of these products on bone health and the ability to lower blood pressure have been proven, and the preventive role of milk in the risk of developing metabolic syndrome diseases has been confirmed.

Słowa kluczowe: mleko, mleczne napoje fermentowane, składniki, działanie prozdrowotne.

Mleko i mleczne napoje fermentowane to produkty bogate w szereg niezbędnych składników odżywczych. Należą do nich m.in. wysoce przyswajalne białka, witaminy z grupy B, witaminy A i D, wapń, potas i fosfor. Warto także zauważyć, że użycie kultur starterowych bakterii podczas produkcji mlecznych napojów fermentowanych przyczynia się do zwiększenia biodostępności niektórych z tych składników odżywczych. Fermentacja prowadząca do powstania takich napojów sprawia zatem, że końcowe produkty zyskują nie tylko odmienną od mleka teksturę, zapach i smak, ale także inne właściwości. Zwiększa się m.in. strawność ich białek, a w wyniku częściowego rozpadu laktozy, stają się one bardziej przystępne dla osób z nietolerancją tego dwucukru. Wartość odżywcza mleka i mlecznych napojów fermentowanych ma swoje przełożenie na ich pozytywny wpływ na zdrowie człowieka. Udowodniono, między innymi korzystne oddziaływanie składników zawartych w tych produktach spożywczych na zdrowie kości, zdolność obniżenia ciśnienia krwi, a także potwierdzono prewencyjną rolę mleka w przypadku ryzyka rozwoju chorób zespołu metabolicznego.

INTRODUCTION

Milk and fermented milk drinks are foods rich in a range of essential nutrients. They include, among others highly digestible proteins, B vitamins, vitamins A and D, calcium, potassium and phosphorus [36]. It is also worth noting that the use of bacterial starter cultures in the production of fermented milk drinks increases the bioavailability of some of these nutrients. The fermentation leading to the formation of such beverages therefore results in the end-products gaining not only a texture, aroma and taste different from milk, but also other properties. Increases, among others digestibility of their proteins, and as a result of the partial breakdown of lactose, they become more affordable for people with intolerance to this disaccharide [32].Therefore, the aim of this study was to analyze the articles in terms of the nutritional and health value of coffee, tea and herbal infusions.

The nutritional value of milk and fermented milk drinks has a positive impact on human health. The beneficial effect of milk components on bone health, the ability to lower blood pressure has been proven, and the preventive role of milk in the risk of developing metabolic syndrome has been confirmed [1, 43, 45]. Fermented milk drinks have an effect on the skeletal system, even more beneficial than milk, and their role in the prevention of certain malignant neoplasms has also been proven.

Due to its many health-promoting properties, fermented milk and milk drinks should be consumed every day. The latest nutritional recommendations for the consumption of milk and milk products in Poland were presented on October 17, 2020 by the National Institute of Public Health. Recommendations for healthy eating are presented graphically in the form of a healthy eating plate and in the form of 3-step instructions for

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changing eating habits. In the „eat more" category, there were low-fat dairy products with special emphasis on fermented ones, while in the „swap" category, it was proposed to change full-fat dairy products to low-fat dairy products. The same recommendation is listed as the first step in the „three steps to health". The next steps are: daily consumption of two glasses of milk, which can be replaced, for example, with kefir or yogurt, and choosing unsweetened dairy products [33]. Unfortunately, the consumption of milk by Polish consumers is much lower than recommended. The data of the Central Statistical Office also indicate persistence the downward trend in its consumption, despite the steadily increasing milk production in Poland for ten years [6].

Therefore, the aim of this study was to analyze the articles in terms of the nutritional and health value of milk and fermented milk drinks.

CHARACTERISTICS AND NUTRITIONAL VALUE OF MILK

In the PWN dictionary of the Polish language, milk is defined as an opaque, white liquid that is produced in the mammary glands of female animals and women, serving as food for newborn offspring [10]. However, when considering milk as a product intended for human consumption, of animal origin, you can define milk as udder discharge that has not been extracted or has any additives and is obtained from at least one milking [40]. Similarly, milk is defined by the Food and Drug Administration as a milk secretion that is almost completely colostrum-free, obtained by milking one or more healthy cows [13]. Milk is used to meet the earliest nutritional needs of the offspring, but humans are the only mammals to continue drinking the milk of other animal species after weaning [16].

The history of human consumption of milk dates back to the beginning of the Neolithic, when milk became available for consumption by adults, after the domestication of cattle, goats and sheep in southeastern Anatolia (present-day Turkey) and in the Middle East, around 10,500 years. ago. Some early Neolithic populations produced milk but probably could not digest it due to the lack of the enzyme lactase. They most likely processed the milk into cheese, yoghurt, and other lactose-reduced products that were easier for them to digest [27]. The earliest direct evidence of human consumption of milk, despite being lactose intolerant, dates back to six thousand years ago. Consumption of dairy products was confirmed by detecting milk protein (beta-lactoglobulin) in tartar in seven out of ten people living in what is then the United Kingdom [7]. Thus, the milk of farm animals, such as cows, has accompanied man for many millennia. Being the first food for newborn animals, it is an excellent source of many nutrients. Among other things, milk is a very good source of protein rich in exogenous amino acids and many other macronutrients, as well as micronutrients and vitamins necessary for humans.

Milk is a complex, colloidal mixture of fat, proteins, carbohydrates, minerals, vitamins, and other diverse ingredients dispersed in water. The composition of milk varies between species of mammals, but even within one species, the composition may vary depending on factors such as the stage of lactation, milking method, environment, the animal's feeding system and its age [37, 47]. The energy value of milk varies greatly and depends mainly on the fat content of milk, but also on the addition of non-fat milk mass or sugars. For example, whole milk (3.2% milk fat) provides about 150 kcal per cup, reduced-fat milk (2%) provides an average of 121 kcal per cup, and low-fat milk provides about 104 kcal per cup [26].

This drink provides a high concentration of nutrients in relation to the energy value. Cow's milk is considered, among other things, as an excellent source of the highest-quality protein, because it contains all the essential amino acids that the human body is unable to synthesize. Moreover, the amino acids present in milk are present in proportions relatively well suited to the needs of an adult [31]. Cow's milk proteins contain, among other things, a large amount of the essential amino acid, which is lysine, which makes milk a perfect complement to plant products, including cereals, whose proteins are poor in this amino acid [3].

Fat present in cow's milk was once considered its most valuable component, and years ago the nutritional value of milk was assessed mainly through the prism of the content of this macronutrient. Milk lipids are chemically similar to those present in other raw materials, but are distinguished by a very wide range of fatty acids. Up to 400 fatty acids have been found in them, although most of them in trace amounts [14]. Only about fifteen of them occur in the amount exceeding 1%. Among the fatty acids present in milk are lauric and myristic acids, which have an adverse effect on the cardiovascular system, as well as palmitic fatty acid, which increases the level of total cholesterol in the blood, and its LDL fraction [4]. However, the fatty acid profile of milk cannot be completely considered unfavorable, because it also comprises fatty acids valuable for human health. Some of them have an antiatherosclerotic effect or limit the development of cancer, they can also have anti-inflammatory properties and support the functioning of the intestinal epithelium. Fatty acids with such health-promoting effects are, among others, butyric acid, vaccenic acid, odd and branched fatty acids and polyunsaturated fatty acids, such as linoleic and α-linolenic acids, which are substrates for CLA [41].

Carbohydrate makes up about 5% of the nutrients in milk and consists mainly of lactose, to a lesser extent glucose and galactose, and oligosaccharides. Lactose concentration in milk ranges from 4.2% to 5%, and its low level may be caused, among others, by inflammation of the cow's udder. Lactose is a disaccharide consisting of α-D-glucose and β-D-galactose molecules [20]. Its presence makes milk a highly fermentable medium. Many species of bacteria can hydrolyze lactose to lactic acid, which lowers the pH of the milk and can cause coagulation. Unintentional fermentation spoils the milk, but controlled fermentation is the basis for the production of many dairy products, such as yoghurt and cheese [22].

Apart from calcium, the mineral fraction of milk also contains significant amounts of potassium and phosphorus. The average concentration of calcium is about 1200 mg in one liter of milk, and this amount is broken down into the micellar and water phases where it is bound to casein phosphoseryl residues or to whey proteins. Milk is also characterized by a relatively high content of B vitamins, such as vitamin B_1, B_2, B_6, B_{12} and folic acid. These vitamins are important enzyme

cofactors and are involved in many metabolic pathways such as neurotransmitter production and hormone synthesis. Although almost 90% water is present, fat-soluble vitamins are also present in milk, in particular vitamin A. Whole milk is considered a very good source of this vitamin, providing approximately 172μg/100g of it. However, in the case of non-fat milk, the vitamin A content is only about 5 μg/100 g [26, 36].

Currently, there are milk available on the market that differ in the percentage of fat, distinguished by the presence or absence of lactose, or divided according to taste.

HEALTH EFFECTS OF MILK CONSUMPTION

Currently, there are very divergent opinions on the role of milk in human nutrition and its impact on health, both in popular science and in scientific publications. It should be taken into account that the daily consumption of milk is included in the dietary recommendations of many European countries and the world. Therefore, it may be inclined to believe that the benefits of consuming milk outweigh the potential risks associated with consuming it.

Milk is one of the most important foods in the human diet to meet calcium requirements. In the average Polish diet, milk and dairy products account for more than half of the total calcium supply. The share of milk in the supply of calcium is around 21.5% [17]. The mean calcium requirement (EAR) of both women and men aged 19–50 is 800 mg/day [19]. This amount of calcium contains just over 2.5 cups of cow's milk with 2% fat. Few other foods naturally contain as much calcium as milk. Moreover, the calcium in milk also has a relatively high bioavailability. It is higher than, for example, the bioavailability of calcium found in leafy green vegetables, which also contain oxalates that limit the absorption of this element. However, milk provides not only calcium, but also other nutrients necessary for growth and development. Minerals and vitamins present in milk with particular importance for bone health are zinc, potassium, vitamin A, K, and in fortified milk also vitamin D. Many studies have confirmed the important role calcium plays in bone health [8, 48, 51]. It has been shown that diets with low dairy consumption are associated with an increased risk of osteoporosis, and that milk consumption may have a positive effect on bone mass in premenopausal women and reduce bone mineral loss [50]. A Korean study, which found data from more than 10,000 people aged 19-64, found that increased consumption of milk and dairy products is associated with a reduced risk of bone disease, and daily consumption of these foods may play an important role in maintaining optimal health bone [1]. For Caucasians, the positive effect of daily milk consumption on bone health was also confirmed. It has been proven that each additional dose of milk per day reduces the risk of hip fracture by as much as 8%, in both men and women over 50 years of age [12]. Milk is also very important for young people who use the valuable macro and micronutrients contained in it. Protein and calcium in particular are essential nutrients for bone development and maintenance at an early age, and milk is a rich source of them. In a study conducted among over 500 people aged. It has been proven that the consumption of milk promotes the development of adolescents aged 14–17, positively influencing their growth. At the same time, the influence of milk on the increase of BMI or the development of obesity was not demonstrated [35]. The lack of influence of milk consumption on the development of obesity among children and adolescents is also confirmed by previous studies. It has been proven that milk consumption can even protect against the risk of obesity. The consumption of milk and dairy products by the adults participating in the study improved body composition and aided in weight loss when they were on reduction diets. In contrast, when using normocaloric diets, milk consumption had a neutral effect on body weight [11]. Consuming milk can therefore be recommended to obese people, but also to those who, apart from abdominal obesity, also exhibit other features of the metabolic syndrome. A study involving over 130,000 people showed that the incidence of metabolic syndrome was significantly lower in people with higher milk consumption. Its higher consumption was inversely related to components of the metabolic syndrome such as elevated blood triglycerides, excessively large waistlines, and decreased levels of high-density lipoprotein (HDL cholesterol) in the blood [43]. In addition to having a lower chance of having elevated blood triglycerides and increased waistlines, they also had less frequent elevated blood pressure [18].

Consumption of milk is certainly associated with health benefits and a reduced risk of many diseases, but it is not an ideal drink and appropriate for all population groups. The health effects of milk can also be negative. For example, a paradox has been observed that hip fracture rates are higher in developed countries where calcium intake is high than in developing countries where calcium intake is low. Such a phenomenon has been proven, among others in a Swedish cohort study in which high milk consumption was associated with a higher incidence of fractures in women and higher mortality in both men and women [30]. FAO (Food and Agriculture Organization of the United Nations) and WHO (World Health Organization) experts concluded that the "calcium paradox" may be a more complex problem and may concern different amounts of protein, sodium and vitamin D intake in different countries [50].

Research describing the influence of milk consumption on the incidence of cancer is also controversial. A cancer that is often associated with the consumption of cow's milk by the public is breast cancer. This is because milk may contain relatively high levels of estrogen and progesterone metabolites and insulin-like growth factor (IGF-I), substances that may increase the risk of breast cancer. A study in over 30,000 women found that long-term high-volume unfermented milk consumption (two or more than two servings a day) was associated with an increased risk of breast cancer with positive estrogen and progesterone receptors (ER+/PR+). Such a relationship was observed especially in women with a BMI below 25 kg/m^2 [21]. Although the authors of the cohort study conducted on over 90,000 women also point to IGF-I and hormone metabolites as potentially carcinogenic substances, their test results are different. The study found that milk consumption by women 50 years of age and younger was associated with a reduced risk of breast cancer compared with those who consumed milk very infrequently (less than

a serving per week) [44]. The question of the influence of milk consumption on the development of cancer, especially breast cancer, remains unclear. However, many researchers and nutritionists argue about the superiority of the health-promoting properties of milk, and the recommendation for its consumption is still valid. Despite this, however, milk consumption in Poland is decreasing, and diets excluding milk and dairy products are becoming more and more popular. Nowadays, an exaggerated concentration on the food consumed is often noticeable, and people, especially in rich societies, are more and more often characterized by orthorectic inclinations. Such people often give up dairy products because they consider cow's milk to be a product that is difficult to digest, causes allergies and has a negative impact on the immune system [5]. Meanwhile, the currently available scientific literature suggests that the consumption of milk and its derivatives in accordance with the current recommendations may be beneficial for all age groups. The only exceptions are people suffering from specific diseases, such as allergy to milk proteins or lactose intolerance [29, 49].

CHARACTERISTICS AND NUTRITIONAL VALUE OF FERMENTED MILK DRINKS

Most fermented foods contain naturally occurring organic acids, ethanol, or other antibacterial compounds that inhibit the growth of spoilage organisms. Therefore, thanks to the possibility of preservation, fermented foods have been present in the human diet for many millennia. The microorganisms used to produce fermented milk products are lactic acid bacteria of the genera *Lactobacillus, Streptococcus and Leuconostoc* [24]. In the case of fermented milk drinks, the microorganisms used in their production must be viable, active and abundant in the product until the end of its shelf-life [25]. Lactic fermentation in milk begins with the hydrolysis of lactose into a glucose molecule and a galactose molecule, and then, thanks to lactic bacteria, lactic acid and energy are formed from the glucose molecule. The lactic acid produced in this process causes the coagulation of milk proteins, thanks to which it changes its taste and structure. Fermented milk drinks not only gain a different texture, smell and taste, but also other properties. For example, they are easier to digest due to a change in the structure of proteins and a greater amount of free amino acids. However, as a result of the partial breakdown of lactose and the formation of β-galactosidase, which facilitates the breakdown of lactose in the small intestine, these products become more affordable for people intolerant to this disaccharide. As a result of fermentation, the bioavailability of calcium, phosphorus and iron also increases, and the content of folic acid and cobalamin increases [32, 46].Fermented milk drinks are a very diverse group. Milk is used to make yogurt, kefir and other drinks, such as koumiss, buttermilk, curdled milk, acidophilic or bifidus milk. A particularly popular fermented milk drink is yoghurt, both natural and flavored. The etymology of the word yogurt is derived from the Turkish verb "yoğurmak", meaning thickening and kneading. This concentration in the Turkish name occurs precisely at the moment of coagulation during fermentation, as a result of lowering the pH level. A symbiotic mixture of *Lactobacillus delbrueckii subsp*. Strains is most often used as a starter culture. bulgaricus and *Streptococcus thermophilus*. These microorganisms are responsible for creating yoghurt's typical flavor and texture [52]. A special fermented milk drink is kefir, the production process of which involves not only lactic fermentation, but also alcoholic fermentation. It is made from kefir grains, or so-called kefir mushrooms, which consist of bacteria that produce lactic acid and acetic acid, as well as lactose-fermenting yeast and non-fermenting yeast that live in symbiosis. At the end of kefir production, in the cooling stage, alcoholic fermentation leads to the accumulation of CO_2, ethanol, as well as B vitamins [39].

Although it may seem that the composition of fermented milk drinks should remain almost identical to that of milk, some differences are noticeable. It has been shown that fermentation with lactobacilli improves the nutritional value of food products by increasing the digestibility, bioavailability, but also the amount of certain nutrients. Fermentation has been found to increase the folic acid content of yogurt and bifidus milk, and also to increase the niacin and riboflavin content of yogurt [23]. Based on the data contained in the tables of the composition and nutritional value of food [26], it can also be noticed that the highest increase in the content of B vitamins compared to natural milk occurs in the case of both flavored and natural yoghurt. However, in the case of kefir and buttermilk, the content of most minerals and vitamins is lower than in milk or yoghurt.

HEALTH EFFECTS OF FERMENTED MILK DRINKS CONSUMPTION

Milk consumption is positively related to bone mineral density. However, scientific evidence is emerging that fermented milk products have a particularly beneficial effect on skeletal health. Fermented milk drinks, such as milk, contain valuable nutrients such as protein and calcium to help increase bone mass. However, in dairy products that are fermented, the pH changes to a lower one because of the lactic acid produced. From the initial value of 6.7, characteristic of milk, the pH of the yogurt drops to 4.7 [28]. Such an acidified environment promotes better bioavailability of many nutrients. For example, to be able to absorb calcium, it must be dissolved in the stomach into its ionic form. In the case of weaker secretion of HCl acid and an increase in the pH level in the stomach, calcium may have a much lower bioavailability, and its absorption in the intestines may be difficult [2]. Therefore, the low pH of fermented milk-based beverages may contribute to a greater absorption of calcium and therefore a very beneficial effect of these products on bone health. Among other things, it has been shown that high yogurt consumption is associated with a reduction in the risk of hip fractures in postmenopausal women compared to little or no consumption of this drink [34]. Consumption of fermented milk products also positively affects bone growth and homeostasis. The presence of nutrients such as calcium, phosphorus and protein is crucial. In addition to influencing age-related bone loss, fermented milk drinks also affect calcium balance by preventing secondary hyperparathyroidism [38].

Many of the health-promoting properties of fermented milk beverages are not only related to the health of the skeletal system. They also show a beneficial effect in the case of malignant neoplasms, incl. colon and breast. Consumption

of fermented milk drinks has been shown to affect the gut microbiota, may stimulate gut-related immune cells, and have beneficial effects in inflammatory bowel disease and colon cancer. A diet rich in fermented milk products may also inhibit the growth of breast cancer [15]. Kefir has been shown to induce cell apoptosis, arrest the cell cycle, and reduce tumor growth in breast cancer. Kefir has an anti-cancer effect and induces cell apoptosis not only in breast cancer, but also in colorectal cancer and lung cancer. In addition, it is used in the prevention and treatment of various other diseases, such as allergies, hypertension and diseases of the digestive system [42].

It is the health-promoting properties of fermented milk drinks that are particularly important in the case of the digestive system. Lactic acid formed during fermentation has an acidifying effect in the environment and thus prevents the development of putrefying bacteria in the intestines. It also has the ability to accelerate intestinal peristalsis, while preventing diarrhea [32]. Many yoghurts and kefirs may also contain probiotic bacteria, which have a beneficial effect on changes in the intestinal microflora. The gut microbiota is a population of microbes that live in the gut, especially in the colon. The bacteria found in the intestines include, among others *Bifidobacterium*, *Lactobacillus* and *Streptococcus*. These bacteria are important for the production of short-chain fatty acids, the maintenance of immune activity, the extraction of energy from food, and even brain activity [9]. The fermented milk drink, which additionally contains probiotic bacteria, which have the ability to modulate the intestinal microflora, therefore gains many health-promoting properties. These bacteria help to regulate the work of the intestines and colonize them, preventing the multiplication of pathogenic bacteria and their penetration through the mucous membranes in the intestines.

CONLUSIONS

The properties of milk are a frequently discussed topic, both in the media space and in scientific communities around the world. Although this drink has a group of opponents and it is certainly not favored by people with lactose intolerance, it cannot be denied that it has many health-promoting properties. Milk is appreciated by people from many social groups. Children consume them for proper growth and development, young people are recommended them as a prophylaxis in order to reduce the risk of bone diseases. It is also recommended for obese people on reduction diets, as well as for people with symptoms characteristic of the metabolic syndrome. Milk in its composition contains B vitamins, vitamins A and D, calcium, phosphorus, potassium, but also the highest quality protein, providing all the necessary amino acids. Products that are made from it by fermentation also gain, among others, preventive properties in the case of some malignant neoplasms, and are able to positively affect the intestinal microflora and counteract digestive system ailments. However, despite the numerous benefits of consuming milk and fermented milk drinks, the trend of their consumption in Poland has been declining for many years. Therefore, it seems justified to conduct research on the impact of drinking milk and fermented milk drinks on human health depending on the frequency of consumption, but also on the type of selected product in different age groups.

PODSUMOWANIE

Właściwości mleka to często poruszany temat, zarówno w przestrzeni medialnej, jak i w środowiskach naukowych na całym świecie. Choć napój ten ma pewne grono przeciwników i z pewnością nie są mu przychylne osoby z nietolerancją laktozy, to nie sposób odmówić mu wielu prozdrowotnych właściwości. Mleko doceniane jest przez ludzi z wielu grup społecznych. Dzieci spożywają je w celu prawidłowego wzrostu i rozwoju, osobom młodym zaleca się je w ramach profilaktyki, w celu zmniejszenia ryzyka chorób kości. Polecane jest także osobom otyłym stosującym diety redukcyjne, jak i osobom z objawami charakterystycznymi dla zespołu metabolicznego. Mleko w swoim składzie zawiera witaminy z grupy B, A, D, wapń, fosfor, potas, ale i najwyższej jakości białko, dostarczające wszystkich niezbędnych aminokwasów. Produkty, które powstają z niego na drodze fermentacji zyskują ponadto m.in. właściwości prewencyjne w przypadku niektórych nowotworów złośliwych, a także są w stanie wpływać pozytywnie na mikroflorę jelit i przeciwdziałać dolegliwościom ze strony układu pokarmowego. Pomimo licznych korzyści płynących ze spożywania mleka i mlecznych napojów fermentowanych, tendencja ich spożycia w Polsce jest od wielu lat spadkowa. Dlatego zasadne wydaje się prowadzenie badań nad wpływem spożycia mleka i mlecznych napojów fermentowanych na zdrowie człowieka w zależności od częstotliwości ich spożycia, ale także od rodzaju wybieranego produktu w różnych grupach wiekowych.

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