SİDAS MEDYA
Akademik Gıda®
ISSN Online: 2148-015X
http://dergipark.gov.tr/akademik-gida

Akademik Gıda 18(2) (2020) 180-189, DOI: 10.24323/akademik-gida.758835

Review Paper / Derleme Makale

Functional Ice Cream Technology

Ayla Arslaner[1] ✉, Mehmet Ali Salik[2]

[1] Department of Food Engineering, Engineering Faculty, Bayburt University, 69000 Bayburt, Turkey
[2] Department of Food Engineering, Agricultural Faculty, Ataturk University, 25240 Erzurum, Turkey

Received (Geliş Tarihi): 18.11.2019, Accepted (Kabul Tarihi): 09.05.2020
✉ *Corresponding author (Yazışmalardan Sorumlu Yazar): aylaarslaner@bayburt.edu.tr (A. Arslaner)*
✆ +90 458 211 11 53 (1658) 🖷 +90 458 211 11 78

ABSTRACT

Various factors besides changes in people's lifestyle have altered the consumers understanding of dietary, health and welfare life. As a result, interest and demand for functional foods, which have been gaining momentum and importance in recent years, have increased day by day. Milk and dairy products have an important place among the functional foods considered as the foods of today and tomorrow. These products are very convenient in producing functional products due to their positive health effects in daily diet. Ice cream, which has a wide product distribution within this group, provides an advantage in the functional products market because it has a high nutritional value, its composition can be easily changed and it is a food consumed by individuals of all ages. This increases the number of studies on the functionalization of ice cream. When the studies conducted for this purpose were screened, it was determined that probiotic, prebiotic and symbiotic, antioxidant and phenolic compounds, bioactive protein-based components, whey and its products, various fatty acids like omega-3 and omega-6, some sweeteners such as stevia, honey and sugar alcohols, dietary fibers, some vitamins and minerals were used extensively in the literature. In this review, nutraceutical components commonly used in functional ice cream production technology are grouped and studies on functional ice cream are included.

Keywords: Functional food, Ice cream, Nutraceutical, Health, Nutrition

Fonksiyonel Dondurma Teknolojisi

ÖZ

İnsanların yaşam tarzlarındaki değişiklikler ile birlikte çeşitli faktörler, tüketicilerin beslenme, sağlık ve refah yaşam anlayışlarında değişime neden olmuştur. Bunun sonucunda da son yıllarda önem kazanan ve üzerinde çalışmaların hız kazandığı fonksiyonel gıdalara olan ilgi ve talep her geçen gün artmıştır. Günümüzün ve geleceğin gıdaları olarak kabul edilen fonksiyonel gıdalar arasında, süt ve süt ürünleri oldukça önemli bir yere sahiptir. Süt ve süt ürünleri, sağlık üzerine olan etkileri ve günlük diyette yer almaları nedeniyle fonksiyonel ürün eldesine oldukça elverişlidir. Bu grup içerisinde geniş bir ürün dağılımı gösteren dondurma; besin değerinin yüksek olması, bileşiminin kolaylıkla değiştirilebilmesi ve her yaştan bireyin severek tükettiği bir gıda olması nedeniyle fonksiyonel ürünler pazarında avantaj sağlamaktadır. Bu durum, dondurmanın fonksiyonel hale getirilmesi üzerine yapılan araştırmaların sayısını artırmaktadır. Bu amaçla yapılan çalışmalar incelendiğinde; daha çok probiyotik, prebiyotik ve sinbiyotiklerin, antioksidan ve fenolik bileşenlerin, biyoaktif protein bazlı bileşenlerin, peyniraltı suyu ve ürünlerinin, omega-3 ve omega-6 gibi çeşitli yağ asitlerinin, stevia, bal ve şeker alkolleri gibi çeşitli tatlandırıcıların, diyet liflerinin, bazı vitamin ve minerallerin kullanıldığı görülmüştür. Bu derlemede; fonksiyonel dondurma üretim teknolojisinde yaygın bir şekilde kullanılan nutrasötik bileşenler gruplandırılarak, fonksiyonel dondurmalar ile ilgili yapılan çalışmalara yer verilmiştir.

Anahtar Kelimeler: Fonksiyonel gıda, Dondurma, Nutrasötik, Sağlık, Beslenme

INTRODUCTION

As a result of changing lifestyles, health and dietary understanding of people, as well as their standards of living has changed [1]. "Outliving" concern has caused significant changes in behavior of food consumers over the last twenty years. On the other hand, the interest for the relationships among food-health and welfare-standard of living has increased [2]. Epidemiological and clinical studies clearly indicate the relationship between diet and health status [3]. Association of using food additives with increased health problems recently, as well as increased demand in the sector due to preferences of consumers for "natural", "organic", and "free of synthetic additives" food has directed researches to study bioactive components and their use in functional food production [4]. Moreover, the interest for functional foods has increased because of numerous critical factors, such as awareness of personal health problems, intensive lifestyle including malnutrition and insufficient physical exercises, uncontrolled drug use, briefing on dietary provided by health authorities and media, scientific developments about nutrition surveys and free and competitive food market [5].

Functional foods are defined as the foods that achieve basic nutrition and positively affect health of consumer [3, 6, 7]. One of the most important reasons that consumers prefer functional foods is that they can be consumed without changing dietary habits, regardless of dose of use and duration unlike medicines [8]. In this regard, functional foods include synthetic additive free and nutritious natural foods that are consumed with daily diet in its food form and also have positive impacts on people's health, bioactive food components, as well as various products enriched with these components [9]. Functional foods can be natural foods including a functional parameter (such as tomato-lycopene, fish-walnut-omega fatty acids, dark fruits-antioxidant-anthocyanin compounds) and obtained by adding a functional component (iodized salt, polyunsaturated fatty acids, omega-3 fatty acids, various vitamins and minerals, phenolic substances, antioxidants, dietary fibers, oligosaccharides, probiotics, prebiotics) or removing a harmful component (sodium-reduced salt). In addition, it is possible to produce functional foods by modifying some compounds (yoghurt-protein-bioactive peptide, processed tomato-lycopene) in the food [7, 9-11]. Acceptance and attitude of consumer to functional foods determines the size and success of the market. The largest functional food market consists of Japan, Korea and USA, followed by European countries. In the European Union, Spain, Finland, Holland and Sweden consume functional foods in larger amounts [12]. For functional food to be successful, it typically has to adhere to some positioning (Figure 1) [5]. Functional food consumption has important functions in many human physiologies, such as early development and growth, organization of basic metabolic processes, defense against oxidative stress, cardiovascular and gastrointestinal diseases, cognitive and mental performance, physical performance and health [12].

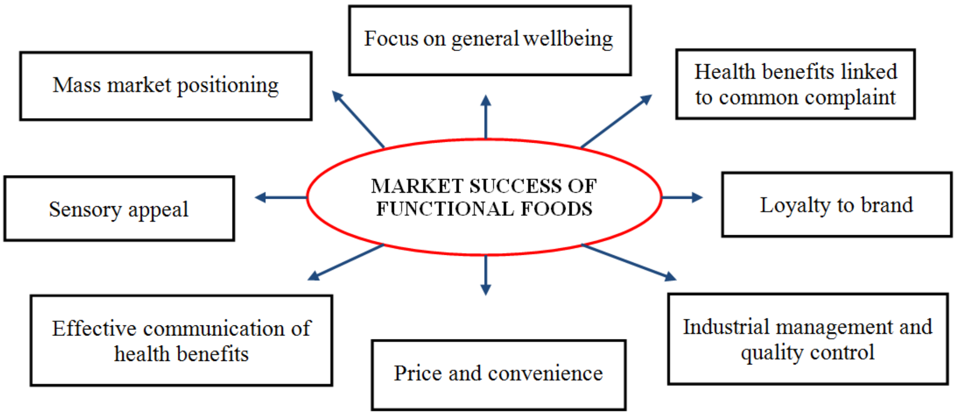

Figure 1. Strategies for functional food success in the marketplace [5]

Dairy products are important in the nourishment of Turkish public. They include various functional food components (serum proteins, peptides, essential fatty acids etc.) naturally in their structure [4] and beside those, some components like vitamins, minerals, antioxidant and phenolic are also used to enrich dairy products. Therefore, healthier and useful products are obtained for consumers by increasing functional characteristics [10]. Milk and dairy products are quite favorable for the production of functional products because of their positive effects on health and their participation in daily diet. Functional ice cream has an important place in the functional properties of dairy products [1, 8, 13].

This review groups nutraceutical components commonly used in functional ice cream production technology and presents various studies performed about functional ice cream.

FUNCTIONAL ICE CREAM PRODUCTION TECHNOLOGY

Ice cream is defined as a dairy product having a complex physiochemical system with various forms obtained by traditional and industrial methods, which includes milk, skimmed milk, cream, sugar, stabilizer, emulsifier as well as fresh and dried fruits, dietary fibers, probiotic microorganisms, prebiotic components and sweeteners based on its composition [13]. Because ice cream has a convenient structure that can be varied and also it is consumed by people fondly, the number of studies about its functionalization has increased [1].

Nowadays, ice cream production is very common all around the world and consumption amounts vary among countries [14]. It has been determined that the ice cream production in Turkey increased to 353.000 tons by approximately 4% in 2015 when compared to that impervious year [15]. As of 2015, ice cream consumption per person in Turkey increased from 1.1 liters to 4.2 liters over the last decade. Moreover, the distribution in the ice cream market, which shows a growing trend every year, consists of 70% immediate consumption, 21% home consumption and 9% catering sector [16]. It has been reported in studies that Marmara Region is responsible for 44% of total ice cream consumption while Aegean Region for 23%; 80% of ice cream consumers are aged between 6 and 25; ice cream is perceived as seasonal and it is consumed in summer with by 85% [15, 16].

In the process of improving dietary and functional properties of ice cream, various phytochemicals, vitamins, minerals, bioactive peptides, dietary fibers, probiotics, prebiotics [11, 17], whey and its products [18, 19], various fatty acids and vegetable oils [20-22], spices [23] are widely used. In addition, various components like fruits, wild fruits, vegetables, medicinal-aromatic plants, bee products (such as honey, pollen and propolis) and various sugar substitutes (vegetable sweeteners such as sugar alcohols and stevia) can also be potentially used with those components [11]. Nutraceutical components widely used in functional ice cream production technology are grouped and presented below.

Probiotics, Prebiotics and Symbiotic

Probiotic dairy products constitute one of the most important and developed sections of functional food industry [7]. Probiotics are defined as living microorganisms providing beneficial effects on the host by balancing microbial flora of intestinal system [7, 24]. To achieve desired therapeutic effect in the body, foods with probiotics should be consumed regularly and the number of probiotic microorganism in the product should be minimum around 10^6-10^8 cfu/g [25]. Lactic acid bacteria constitute the most important group of probiotic microorganisms and *Bifidobacterium and Lactobacillus* species are commonly used bacteria [7]. In addition, it has been observed that various *Saccharomyces* species have also been used as probiotics [8, 26]. Several health benefits (Figure 2) are attributed to the ingestion of probiotic containing foods, some of them have been proven scientifically [27].

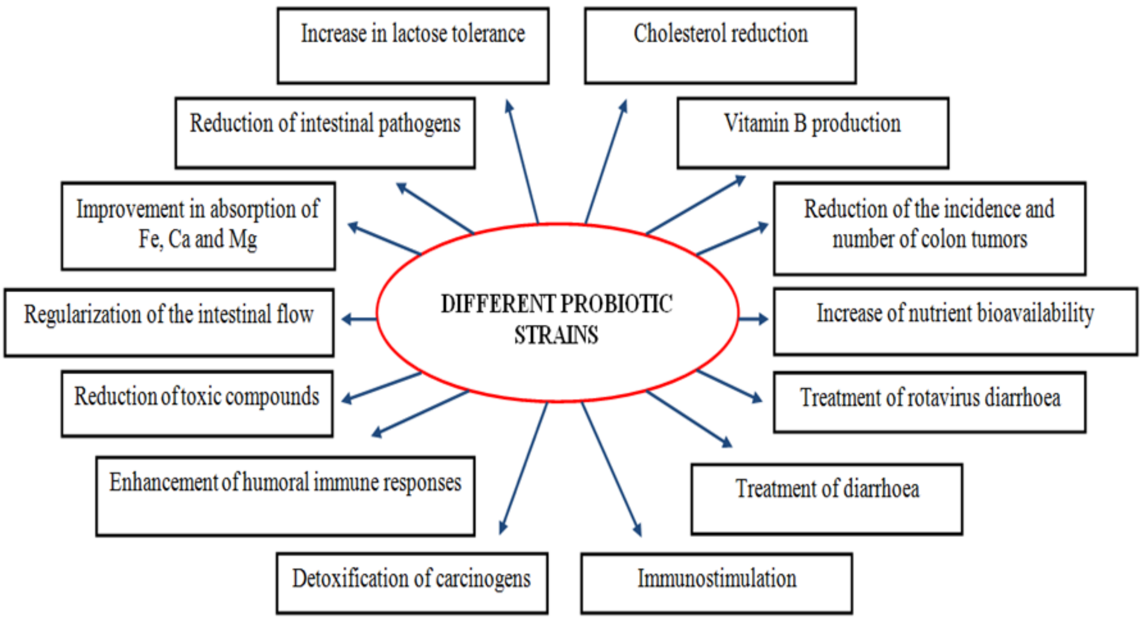

Figure 2. Physiological benefits of functional foods containing probiotics [27]

Prebiotics, which has gained popularity after understanding the importance of probiotics, are defined as indigestible food substances that increase the activity of limited number of bacteria in colon selectively and thereby positively affect the host by improving its health [28]. The majority of prebiotics is composed of oligosaccharides and polysaccharides and it is known that some sugar alcohols, modified carbohydrates and sugar polyols show prebiotic characteristics [29, 30]. Consumption of prebiotics is beneficial in decreasing the risks of some disease formations, such as prevention of diarrhea due to intestinal infection, prevention of osteoporosis as a result of increased calcium intake, reduction of obesity risk and type-2 diabetes, reduction of colon cancer risk as a result of neutralization of toxic products, regulation of immune system and protection of ürogenital system [31]. It has been reported that prebiotics should be taken in amounts between 8 and 40 g daily to show desired physiological effects [32].

Synbiotics are defined food substances that include both probiotics and prebiotics [32, 33]. Synbiotics are known to be effective in preserving viability of probiotic microorganisms while they are passing through stomach and small intestine and thus promote selectively probiotic development and reproduction in large intestine [34].

Many functional ice cream formulations were developed by using probiotics and prebiotics separately or in combination and the products were analyzed in terms of various quality features. Turgut and Çakmakçı [35] produced probiotic ice cream samples by using *L. acidophilus* and *B. bifidum* to increase functionality and therapeutic effect and determined that the number of probiotics was at a desired level (>10^6 cfu/g) during storage for achieving therapeutic effect. In another study, symbiotic ice cream samples with *L. acidophilus* and *S. boulardii* were produced and analyzed in terms of some quality parameters. It was found out as a result of the research that the number of *S. boulardii* in the samples with *S. boulardii* was between 6.37 and 7.26 log cfu/g while the number of *L. acidophilus* in the ice cream samples with *L. acidophilus* varied between 7.05 and 8.95 log cfu/g. Moreover, it was determined that fructo-oligosaccharide (FOS) used as prebiotic component had a significant effect on viability of those probiotic microorganisms [26]. Hashemi et al. [6] prepared low-calorie probiotic, prebiotic and symbiotic functional ice creams by adding 5% inulin and lactulose into sugar and fat as a substitute. As a result of the study, they determined that the number of *B. lactis* in all samples during 90-day storage varied between 6.13 and 7.86 log cfu/g. Akalın et al. [36] determined that the number of *L. acidophilus* and *B. lactis* during storage period varied between 6.60 and 7.58 log cfu/g, and 5.15 and 7.10 log cfu/g, respectively, in probiotic ice cream samples prepared by using apple, orange, oat, wheat and bamboo fibers. In another study, it was found out that white and dark blue blueberries had prebiotic potential on *L. casei* in the functional probiotic ice cream production. The number of *L. casei* showed high viability and changed between 7.31 and 8.93 log cfu/g [37].

Antioxidant and Phenolic Compounds

Oxygen, which is vital for people's life, causes the formation of free radicals during normal metabolic phenomena. Free radicals are molecules that have one or more unpaired electrons. In living systems, free radicals are very important in numerous metabolic functions and severe oxidation occurs in biological molecules as a result of high amount of these compounds; causing various diseases such as tissue damage, cell death, early ageing, cancer, anemia, cardiovascular diseases and neurological disorders [12, 38]. Antioxidants play significant roles in preventing disorders and reactions caused by oxygen-bound free radicals in the body or absorbing active oxygen atoms. Vitamins E and C, carotenoids and phenolic compounds are prominent in terms of human health because of their antioxidant characteristics [39].

It has been found out as a result of literature review that fruits, wild fruits, vegetables, spices and medicinal aromatic herbs, which can be substituted with compounds showing antioxidant and phenolic characteristics, have been commonly used to increase the antioxidant activity in ice cream. Hwang et al. [40], in their study performed to determine the effect of grape wine deposit on rheological and antioxidant properties of ice cream, found out that grape wine deposit increased the antioxidant activity at increasing concentrations and antioxidant compounds remained stable during production. In a study carried out by Sun-Waterhouse et al. [41], green, golden and red kiwis with high amount of Vitamin C and antioxidant characteristic were used in the production of ice cream. The highest total phenolic content (in terms of gallic acid), antioxidant capacity and Vitamin C content values were determined in the ice cream sample with red kiwi while the lowest values were found in the ice cream sample with green kiwi.

Limsuwan et al. [42] studied antioxidant properties and nutritional values of sugarless, fat-reduced milk-based ice creams enriched with some selected vegetables. In the study, total phenolic content and antioxidant activity of the ice cream produced with centella extract+green tea addition were found to be higher than other samples. Çakmakçı et al. [43] used oleaster flour and crust to produce functional ice cream at different levels (1%, 2%, and 3%). They concluded that oleaster flour and crust affected quality properties of ice cream and could be used as a natural antioxidant source for food supplement. Gabbi et al. [23] used processed ginger products in various forms (ginger juice, candy, paste and powder) at different ratios to produce ice cream with functional qualities. According to the results of the study, it was determined that antioxidant activity increased with increasing ginger product concentration and DPPH (2,2-Diphenylpicrylhydrazyl) antioxidant activity varied between 4.1 and 51.9% while total phenolic contents (in terms of gallic acid) changed between 0.47 and 1.93 mg/100. In another study, it was determined that the consumption of lycopene-enriched ice cream had beneficial antioxidant effect on volunteers at both systemic and facial skin levels [44]. Mehditabar et al. [45] reported that the addition of pumpkin puree to the ice cream mix increased total phenolic content, DPPH antioxidant activity and dietary fiber (soluble and insoluble) content.

Bioactive Proteins, Peptides and Amino Acids

It is known that protein, peptide and amino acids provide energy and basic foods in nutrition and also have various biological functions such as growth, antihypertensive, antimicrobial and antioxidant. For example, milk proteins like lactoferrin, lactoperoxidase and immunoglobulin are known to have antibacterial, antiviral, antiparasitic and antifungal characteristics and they have important functions on people's immune system [46]. Serum proteins, which are important for nutrition physiology, as well as peptide fractions obtained as a result of the hydrolysis of these proteins, are commonly used to increase nutritional values of foods and improve their structural properties and give functionality to foods [4].

Shaviklo et al. [47] used fish protein powder at different levels (10%, 20%, and 30%) to enrich ice cream in terms of protein. Researchers concluded that this practice was effective in nutritious and functional ice cream production. In another study, the effect of using soya protein isolate and hydrolysate on physicochemical and melting properties of ice cream was determined [48].

Whey and Its Products

Whey, which is the most important side product of cheese technology, is a rich and nutritious food in terms of serum proteins, lactose, fat, mineral substances and water-soluble vitamins (particularly riboflavin) [1, 49]. Today, by means of various techniques (such as ultrafiltration, microfiltration, reverse osmosis, ion exchange), whey powder, whey protein concentrations, whey protein isolates, whey with low lactose, demineralized whey and hydrolyzed whey can be commercially obtained [49, 50]. Whey proteins, which have the highest food quality among all food proteins, are optimal source for functional food components [4, 51].

Whey and its products are used in ice cream to provide dry matter standardization, enhance flavor and aroma, increase protein amount and improve textural properties. Innocente et al. [52] determined an increase in emulsion capacity in ice cream samples produced with the addition of proteose-peptone whey fraction. Patel et al. [53] reported that the addition of whey protein concentration milk protein concentration into ice cream mix at different ratios increased the protein amount and improved textural properties of ice cream. Puangmanee et al. [54], in ice cream samples produced with the addition of glycated whey protein isolate, determined that this protein isolate had significant effects on quality properties and antioxidant activity of the ice cream. Tsuchiya et al. [19] aimed to produce reduced-lactose ice cream enriched with whey powder. To achieve that purpose, they used β-galactosidase enzyme for the hydrolysis of lactose. It was determined as a result of the study that lactose hydrolysis changed between 86.59 and 97.97% and the product with lactose content decreased by 91% could be consumed by individuals with lactose intolerance.

Bioactive Lipids

Besides providing flavor to foods, fats provide a significant portion of the energy taken from the diet, it is the carrier for fat-soluble vitamins and important source for essential oils. The digestion products of fats, along with endogenously synthesized lipids, provide a diverse group of molecules that play a critical role in multiple metabolic processes [55].

Milk fat is an important nutrient in terms of nutrition physiology because it has fatty acids with high physiological values; its digestion capability is high and it includes various vitamins (A, D, E, and K) [4]. In the composition of milk fat, there are short- or medium-chain fatty acids with high functional properties such as phospholipids, polyunsaturated fatty acids, cholesterol, gangliocytes and glycolipids [4, 56]. Of polyunsaturated fatty acids, which are very important in term of nutrition physiology, linoleic [C18:2 (n-6 omega)], linolenic [C18:3 (n-3 omega)] and arachidonic fatty acids [C20:4 (n-6 omega)] are essential fatty acids that cannot be synthesized by human organism. Therefore, these fundamental fatty acids should be taken with foods [4, 57]. In addition to these fatty acids, other polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) [C20:5 (n-3 omega)], docosahexaenoic acid (DHA) [C22:6 (n-3 omega)] and conjugated linoleic acid (KLA) are crucial for people [4, 46]. It was reported in some studies that omega-3 fatty acids are abundant in marine species such as fish, mussels, clams and shrimp while omega-6 fatty acids are present in various herbal sources such as nuts, walnuts, sesame seeds, flaxseeds, soybeans, canola and olives [58]. In epidemiological studies, essential fatty acids play key roles in prevent many diseases such as heart attack, cardiovascular diseases, depression, migraine, joint rheumatism, diabetes, high cholesterol, blood pressure, allergy and cancer [59]. Lipophilic, functional, nutraceutical components and potential health benefits are given in Table 1 [46].

Table 1. Lipophilic functional nutraceutical components [46]

Name	Types	Potential nutritional benefits
Fatty acids	ω - 3 fatty acids, Conjugated linoleic acid, Butyric acid	Coronary heart disease, Bone health, Immune response disorders, Weight gain, Stroke prevention, Mental health, Cancer, and Visual acuity
Carotenoids	β-Carotene, Lycopene, Lutein, and Zeaxanthin	Cancer, Coronary heart disease, Macular degeneration, and Cataracts
Antioxidants	Tocopherols, Flavonoids, Polyphenols	Coronary heart disease, Cancer, and urinary tract disease
Phytosterols	Stigmasterol, β-Sitosterol, and Campesterol	Coronary heart disease

It has been observed that some marine species and oilseeds have been commonly used to enrich ice cream with various fatty acids, primarily omega-3 and omega-6. Corradini et al. [20] used the milk obtained from cows fed by palm oil and coconut oil for the production of ice cream enriched with omega-3 fatty acids. Analysis results showed that milk-obtained from cows fed by palm oil-included higher amount of omega-3 fatty acid compared to that fed by coconut oil; and this was also observed in ice cream samples. Nadeem et al. [21] reported that milk fat fractions with low melting point could be used in functional ice cream formulation. Ullah et al. [22] determined that the addition of chia oil olein fraction at different concentrations (5%, 10%, 15%, and 20%) significantly affected the concentration of omega-3 fatty acids in ice cream samples and increased total phenolic, and flavonoid contents and DPPH free radical scavenging activity. In another study, micro-encapsulated silver carp oil was used in the production of ice cream flavored with vanilla and cacao [60]. Sorio and Albina [61] used three different ratios (5%, 10%, and 15%) of oyster (*Crassostrea iredalei*) puree to increase the nutritional value of ice cream. As a result of the study, the highest general acceptability score in terms of sensory evaluation was found in the sample with 10% oyster puree.

Sweeteners

Increase in the interest for low-calorie foods recently has made the products with alternative sweeteners more popular. It was reported in some studies that the possibility of incidence of metabolic diseases like diabetes, cardiovascular diseases, obesity increased, depending on excessive sugar consumption [62]. Ice cream is a dairy product with high amount of sugar. Thus, researchers have begun using various sweeteners to improve functional properties of ice cream and decrease its calorific value [63]. Various sweeteners can be used in ice cream production: sucrose, glucose, fructose, maltose, lactose, invert sugar, high fructose corn syrup, high maltose corn syrup, brown sugar, honey, sugar alcohols (such as sorbitol, maltitol, mannitol, lactitol and xylitol) and high-intensity sweeteners (aspartame, acesulfame K, saccharin and stevia) [14].

Özdemir et al. [62] investigated the possibilities of using stevia in ice cream production as a natural sweetener and determined that stevia improved some quality properties such as viscosity, overrun rate and melting rate of ice cream and it could be used in ice cream production for diabetic patients. Fuangpaiboon and Kijroongrojana [64] produced low-glycemic coconut oil ice creams by using low-glycemic sweeteners (xylitol, erythritol, inulin and fructose) as an alternative to sucrose. They determined that the mixture including 4% erythritol, 7% inulin and 2.15% fructose could be used as a sugar source in low-glycemic coconut oil ice cream production as an alternative to 12% sucrose. Moriano and Alamprese [63] investigated various quality properties of ice cream samples produced by using honey, trehalose and erythritol as an alternative to sugar and indicated that these sweeteners could be used as an alternative to sugar. Moreover, it was reported in the study that trehalose and erythritol should be used with other sweeteners in ice cream to adjust hardness and melting behaviors. In another study, low calorie ice cream was produced by using dried mulberry powder as a substitute for sucrose and walnut paste as a substitute for milk fat. It was determined as a result of the study that the addition of these substitution substances had positive effects on physiochemical and sensory properties of ice cream. It was also reported that an alternative ice cream formulation was developed for consumer who prefer natural and low-calorie products for healthy nutrition [13]. Kalicka et al. [65] investigated the effect of some polyols (xylitol, erythritol, maltitol and isomalt) on physical and sensory properties of probiotic ice cream and survival of *Bifidobacterium* BB-12.

Dietary Fibers

Dietary fibers are defined as food components, which are commonly available in herbal sources, primarily, cereals, fruits and vegetables, very resistant against digestion enzymes, cannot be digested in intestine but totally or partially fermented in large intestine [66]. Dietary fibers can be classified in many different ways including biological origins, molecular structures, physicochemical properties and physiological effects [46]. They are usually classified into two classes in terms of simulated intestinal solubility, as water-soluble (various non-digestible oligosaccharides such as pectin, mucilage, loosely bound hemicelluloses, beta-glucans and inulin) and water-insoluble (cellulose, lignin and tightly bonded celluloses) [66]. Dietary fibers contribute to modify and improve textural, sensory properties and shelf life by being used in food formulations because of their numerous functional properties such as water binding capacity, gel formation ability, oil substitution, texture formation and thickening [67]. Moreover, these components constitute the basic component of low energy-dietary products, which have been increasingly consumed recently and also, they are widely used in functional foods because of their many positive effects on health [1, 46, 66]. Some epidemiological studies have revealed that there is a direct relationship between the consumption of high-fiber foods and the risk reduction of some chronic diseases such as colorectal cancer, cardiovascular disease, obesity, diabetes, constipation [66]. In addition, these components have fundamental bioactive functions like cholesterol-lowering, bioavailability of calcium and strengthening of immunological system [67]. It has been reported in studies that recommended daily intake amount of total fiber is 38 g for adult men and 25 g for adult women [66, 67].

There have been various studies about functional ice creams produced by using herbal dietary fibers and fruits and vegetables substituted with these components. Soukoulis et al. [67] investigated rheological and thermal properties of ice cream samples produced by using various dietary fibers (oat, wheat, apple and inulin) at different ratios (2% and 4%). They concluded that fiber addition increased viscosity values of ice cream mixtures and using 2% fiber was more effective on the melting point of the mixture. Crizel et al. [68] used orange fiber as an oil substitution in lemon ice cream production and reported that orange fiber could be used to decrease oil amount and increase the content of various bioactive components (fiber and carotenoids). Salem et al. [18] used whey protein, modified starch, oat and wheat fiber at 1% and 2% ratios as an oil substitute to produce functional ice creams. It was concluded as a result of the study that an increase in fiber amount increased viscosity and the highest viscosity value was found in the ice cream sample with modified starch. It was indicated in another study that the addition of peach fiber could be used as an optimum natural source in ice cream production to increase nutritional value and the sample produced by using 1% peach pulp fiber was the most liked one in terms of sensory [69].

Vitamins and Minerals

Vitamins and minerals, which are grouped in micronutrients, are one of food components essential for the body in small amounts [70]. Because the majority of vitamins cannot be synthesized in the body, they should be taken with foods. Vitamins are basically examined under two groups, namely fat soluble (A, D, E, and K) and water soluble (group B and C) [71]. Minerals, which are abundant in nature, are crucial nutritional elements that play key roles for the growth, and development of organism and protection of its health. They are classified as macro (Ca, Mg, K, Na, Cl, P, and S) and micro (I, Zn, Se, Fe, Mn, Cu, Co, Mo, F, Cr, and B) [70]. Dairy products, which are included in daily diet, are rich in Ca and P; moreover, they are significant sources for many nutritional elements, primarily for Mg, vitamins A, B_1, B_2, B_3, B_{12}, D, E, and K [70]. It is recommended that these products be consumed in all age groups, especially children [11]. It has been seen in the literature that usually herbal sources, particularly fruits, were used to enrich ice cream with vitamins and minerals. Çakmakçı et al. [72] determined that the amounts of vitamin C, Mg and K increase in ice cream samples with the addition of kumquat (*Fortunella margarita*) fruit. It was determined in another study that the amount of vitamin C increased with the addition of oleaster flour and crust [43]. Akın and Dasnik [73] determined in symbiotic ice cream samples produced by using ascorbic acid and glucose oxidase that the addition of ascorbic acid positively affected the growth of *L. acidophilus* and *Bifidobacterium* BB-12. Kavaz Yüksel et al. [74] determined in ice cream samples produced by using green tea powder at different concentrations (1% and 2%) that the amounts of Ca, Cu, Mg, K, Zn, and Na minerals increased. Góral et al. [75] used lactic acid bacteria enriched with Mg ions as carrier for probiotic ice cream production. For this purpose, *Lactobacillus rhamnosus* B442, *Lactobacillus rhamnosus* 1937 and *Lactococcus lactis* JBB500 strains were used and prepared cultures were enriched with Mg ions through pulsed electric field. After this treatment, probiotic strains were directly used in ice cream production. It was reported as a result of the study that the strains used were potentially good carriers for Mg.

CONCLUSION AND RECOMMENDATIONS

In recent years, changes in people's lifestyle and various factors (awareness of people, explanations of health authorities on nutrition, scientific developments and doubts about synthetic food additives etc.) have increased the interest for functional food sector due to the increase in demand for healthy and natural foods. When examining the related studies, it has been observed that the "functionality" concept has been well understood in Turkey and Europe and the number of studies on the functionalization of ice cream by integrating this concept have increased day by day. The studies performed on functional ice cream in Turkey have remained at academic level and varieties of functional ice cream have been limited in the market because studies could not be transferred to the industry. It is necessary to increase functional ice cream variety in the market with new practices to be introduced to milk technology. To make functional ice cream producible in industrial facilities by increasing its variety, it is necessary to increase the number of projects to be performed with university-industry cooperation. In R&D (Research & Development) units to be formed by means of these projects, effective coordination of specialist academics working on functional ice cream, nutrition and health professionals, marketers and ice cream producers may be possible. Therefore, the market share in functional product market will be globally increased and functional, healthy, nutritious and high commercial value original products will be introduced as a result of the development of functional ice creams, their transfer to the industry and marketing. Considering the fact that ice cream consumption per capita and number of modern enterprises producing ice cream in Turkey have gradually increased, it is expected that studies to be conducted in this field will gather momentum and cooperation will be provided.

REFERENCES

[1] Türkmen, N., Gürsoy, A. (2017). Functional ice cream. *Akademik Gıda*, 15(4), 386-395.

[2] Xavier, A.A.O., Mercadante, A.Z. (2019). The bioaccessibility of carotenoids impacts the design of functional foods. *Current Opinion in Food Science*, 26, 1-8.

[3] Shahidi, F. (2004). Functional foods: Their role in health promotion and disease prevention. *Journal of Food Science*, 69(5), 146-149.

[4] Arslaner, A., Salık, M.A. (2019). Functional bioactive components of milk. *Erzincan University Journal of Science and Technology*, 12(1), 124-135.

[5] Granato, D., Branco, G.F., Nazzaro, F., Cruz, A.G., Faria, J.A.F. (2010). Functional foods and nondairy probiotic food development: Trends, concepts and products. *Comprehensive Reviews in Food Science and Food Safety*, 9(3), 292-302.

[6] Hashemi, M., Arı, H.R.G., Shekarforoush, S. (2015). Preparation and evaluation of low-calorie functional ice cream containing inulin, lactulose and *Bifidobacterium lactis*. *International Journal of Dairy Technology*, 68(2), 183-189.

[7] Mahmoudi, R., Fakhri, O., Farhoodi, A., Kaboudari, A., Pir-Mahalleh Rahimi, S.F., Tahapour, K., Khayyati, M., Chegini, R. (2015). A review on probiotic dairy products as functional foods reported from Iran. *International Journal of Food Nutrition and Safety*, 6(1), 1-12.

[8] Salık, M.A. (2019). Some quality properties of probiotic (*Saccharomyces boulardii*) ice cream

produced with Cimin grape (*Vitis vinifera* L.) and Kemah walnut (*Juglans regia* L.) paste (Saruç). MS Thesis, Bayburt University, Turkey.
[9] Roberfroid, M.B. (2000). A European consensus of scientific concepts of functional foods. *Nutrition*, 16(7/8), 689-691.
[10] Dayısoylu, K.S., Gezginç, Y., Cingöz, A. (2014). Functional food or functional component? Functionality in foods. *Food*, 39(1), 57-62.
[11] Arslaner, A., Salık, M.A. (2019b). Functional ice cream technology and nutraceutical components used in production. *3rd International Conference on Advanced Engineering Technologies*, September, 19-21, 2019, Bayburt, Turkey.
[12] Tur, J.A., Bibiloni, M.M. (2016). Functional foods. *Encyclopedia of Food and Health*, 157-161.
[13] Arslaner, A., Salık, M.A. (2017). Determination of some quality properties of low-calorie ice-cream produced with walnut paste and dried mulberry powder. *Atatürk University Journal of the Agricultural Faculty*, 48(1), 57-64.
[14] Goff, H.D., Hartel, R.W. (2013). Ice Cream. 7th Edition Springer New York Heidelberg Dordrecht London.
[15] Anonymous. (2018). World ice cream consumption. https://www.dunya.com/dunya-gida/dondurma-tuketimi-son-10-yilda-4-kat-artti-haberi-376170 [Date of access: 24 October 2018].
[16] TOB. (2016). Ministry of agriculture and forestry ice cream foreign market work. https://www.tarimorman.gov.tr/ABDGM/Belgeler/%C4%B0DAR%C4%B0%20%C4%B0%C5%9ELER/D%C4%B1%C5%9F%20Pazar%20Stratejileri/Dondurma%20Sekt%C3%B6r%20Raporu_07102016.pdf [Date of access: 28 December 2018].
[17] Tsevdou, M., Aprea, E., Betta, E., Khomenko, I., Molitor, D., Biasioli, F., Gaiani, C., Gasperi, F., Taoukis, P., Soukoulis, C. (2019). Rheological, textural, physicochemical and sensory profiling of a novel functional ice cream enriched with Muscat de Hamburg (*Vitis vinifera* L.) grape pulp and skins. *Food and Bioprocess Technology*, 12(4), 665-680.
[18] Salem, S.A., Hamad, E.M., Ashoush, I.S. (2016). Effect of partial fat replacement by whey protein, oat, wheat germ and modified starch on sensory properties, viscosity and antioxidant activity of reduced fat ice cream. *Food and Nutrition Sciences*, 7, 397-404.
[19] Tsuchiya, A.C., Silva, A.G.M., Brandt, D., Kalschne, D.L., Drunkler, D.A., Colla, E. (2017). Lactose-reduced ice cream enriched with whey powder. *Semina: Ciências Agrárias Londrina*, 38(2), 749-758.
[20] Corradini, S.A.S., Madrona, G.S., Visentainer, J.V., Bonafe, E.G., Carvalho, C.B., Roche, P.M., Prado, I.N. (2014). Sensorial and fatty acid profile of ice cream manufactured with milk of crossbred cows fed palm oil and coconut fat. *Journal of Dairy Science*, 97(11), 6745-6753.
[21] Nadeem, M., Situ, C., Abdullah, M. (2015). Effect of olein fractions of milk fat on oxidative stability of ice cream. *International Journal of Food Properties*, 18(4), 735-745.
[22] Ullah, R., Nadeem, M., Imran, M. (2017). Omega-3 fatty acids and oxidative stability of ice cream supplemented with olein fraction of chia (*Salvia hispanica* L.) oil. *Lipids in Health and Disease*, 16(34), 1-8.
[23] Gabbi, D.K., Bajwa, U., Goraya, R.K. (2018). Physicochemical, melting and sensory properties of ice cream incorporating processed ginger (*Zingiber officinale*). *International Journal of Dairy Technology*, 71(1), 190-197.
[24] FAO/WHO. (2002). Joint FAO/WHO (Food and Agriculture Organization/World Health Organization) working group report on drafting guidelines for the evaluation of probiotics in food. London/Ontario, Canada: FAO/WHO.
[25] Kailasapathy, K., Harmstorf, I., Phillips, M. (2008). Survival of *Lactobacillus acidophilus* and *Bifidobacterium animalis* ssp. *lactis* in stirred fruit yogurts. *LWT-Food Science and Technology*, 41, 1317-1322.
[26] Pandiyan, C., Annal Villi, R., Kumaresan, G., Murugan, B., Gopalakrishnamurthy, T.R. (2012). Development of symbiotic ice cream incorporating *Lactobacillus acidophilus* and *Saccharomyces boulardii*. *International Food Research Journal*, 19(3), 1233-1239.
[27] Granato, D., Branco, G.F., Cruz, A. G., Faria, J.A.F., Shah, N.P. (2010). Probiotic dairy products as functional foods. *Comprehensive Reviews in Food Science and Food Safety*, 9(5), 455-470.
[28] Gibson, G.R., Roberfroid, M.B. (1995). Dietary modulation of the human colonic microbiota: Introducing the concept of prebiotics. *Journal of Nutrition*, 125, 1401-1412.
[29] Gibson, G.R. (2004). Fibre and effects on probiotics (the prebiotic concept). *Clinical Nutrition Supplements*, 1(2), 25-31.
[30] Al-Sherajia, S.H., Ismail, A., Manap, M.Y., Mustafa, S., Yusof, R.M., Hassan, F.A. (2013). Prebiotics as functional foods: A review. *Journal of Functional Foods*, 5, 1542-1553.
[31] Oliveira, R.P.Z., Perego, P., Oliveira, M.N., Converti, A. (2011). Effect of inulin as prebiotic and synbiotic interactions between probiotics to improve fermented milk firmness. *Journal of Food Engineering*, 107(1), 36-40.
[32] Sezen, A.G. (2013). Effects of prebiotics, probiotics and synbiotics upon human and animal health. *Atatürk University Journal of Veterinary Sciences*, 8(3), 248-258.
[33] Douglas, L.C., Sanders, M.E. (2008). Probiotics and prebiotics in dietetics practice. *Journal of the American Dietetic Association*, 108, 510-521.
[34] Schrezenmeir, J., Vrese, M. (2001). Probiotics, prebiotics and synbiotics-approaching a definition. *The American Journal of Clinical Nutrition*, 73(2), 361-364.
[35] Turgut, T., Çakmakçı, S. (2009). Investigation of the possible use of probiotics in ice cream manufacture. *International Journal of Dairy Technology*, 62(3), 444-451.
[36] Akalın, A.S., Kesenkaş, H., Dinkci, N., Ünal, G., Özer, E., Kınık, O. (2017). Enrichment of probiotic ice cream with different dietary fibers: Structural

characteristics and culture viability. *Journal Dairy Science*, 101, 37-46.

[37] Öztürk, H.İ., Demirci, T., Akın, N. (2018). Production of functional probiotic ice creams with white and dark blue fruits of *Myrtus communis*: The Comparison of the prebiotic potentials on *Lactobacillus casei* 431 and functional characteristics. *LWT-Food Science and Technology*, 90, 339-345.

[38] Ratnam, D.V., Ankola, D.D., Bhardwaj, V., Sahana, D.K., Ravi Kumar, M.N.V. (2006). Role of antioxidants in prophylaxis and therapy: A pharmaceutical perspective. *Journal of Controlled Release*, 113(3), 189-207.

[39] Baublis, A.J., Lu, C., Clydesdale, F.M., Decker, E.A. (2002). Potential of wheat-based breakfast cereals as a source of dietary antioxidants. *Journal of the American College of Nutrition*, 19(3), 308-311.

[40] Hwang, J.Y., Shyu, Y.S., Hsu, C. K. (2009). Grape wine lees improve the rheological and adds antioxidant properties to ice cream. *Food Science and Technology*, 42, 312-318.

[41] Sun-Waterhouse, D., Edmonds, L., Wadhwa, S.S., Wibisono, R. (2013). Producing ice cream using a substantial amount of juice from kiwi fruit with green, gold or red flesh. *Food Research International*, 50, 647-656.

[42] Limsuwan, T., Paekul, N., Thongtan, J., Tangkanakul, P. (2014). Total phenolic compounds, antioxidant activity and nutritional values of sugar-free and reduced-fat milk-based ice cream enriched with selected herb ingredients. *KKU Research Journal*, 19(4), 515-525.

[43] Çakmakçı, S., Topdaş, E.F., Kalın, P., Han H., Şekerci, P., Köse, L.P., Gülçin, İ. (2015). Antioxidant capacity and functionality of oleaster (*Elaeagnus angustifolia* L.) flour and crust in a new kind of fruity ice cream. *International Journal of Food Science and Technology*, 50, 472-481.

[44] Chernyshova, M.P, Pristenskiy, D.V., Lozbiakova, M.V., Chalyk, N.E., Bandaletova, T.Y. Petyaev, I.M. (2019). Systemic and skin-targeting beneficial effects of lycopene-enriched ice cream: A pilot study. *Journal Dairy Science*, 102, 14-25.

[45] Mehditabar, H., Razavi, S.M.A., Javidi, F. (2019). Influence of pumpkin puree and guar gum on the bioactive, rheological, thermal and sensory properties of ice cream. *International Dairy Technology*, 1-12.

[46] McClements, D.J., Decker, E.A., Park, Y., Weiss, J. (2009). Structural design principles for delivery of bioactive components in nutra-ceuticals and functional foods. *Critical Reviews in Food Science and Nutrition*, 49, 577-606.

[47] Shaviklo, G.R., Thorkelsson, G., Sveinsdottir, K., Rafipour, F. (2011). Chemical properties and sensory quality of ice cream fortified with fish protein. *Journal Science Food Agriculture*, 91, 1199-1204.

[48] Chen, W., Liang, G., Li, X., He, Z., Zeng, M., Gao, D., Qin, F., Goff, H.D., Chen, J. (2019). Effects of soy proteins and hydrolysates on fat globule coalescence and meltdown properties of ice cream. *Food Hydrocolloids*, 94, 279-286.

[49] Yerlikaya, O., Kınık, Ö., Akbulut, N. (2010). Functional properties of whey and new generation dairy products manufactured with whey. *Food*, 35(4), 289-296.

[50] Marshall, K. (2004). Therapeutic applications of whey protein. *Alternative Medicine Review*, 9(2), 136-156.

[51] Dullius, A., Goettertb, M.I., de Souzaa, C.V.F. (2018). Whey protein hydrolysates as a source of bioactive peptides for functional foods-biotechnological facilitation of industrial scale-up. *Journal of Functional Foods*, 42, 58-74.

[52] Innocente, N., Comparin, D., Corradini, C. (2002). Proteose-peptone whey fraction as emulsifier in ice-cream preparation. *International Dairy Journal*, 12, 69-74.

[53] Patel, M.R., Baer, R.J., Acharya, M.R. (2006). Increasing the protein content of ice cream. *Journal of Dairy Science*, 89(5), 1400-1406.

[54] Puangmanee, S., Hayakawa, S., Sun, Y., Ogawa, M. (2008). Application of whey protein isolate glycated with rare sugars to ice cream. *Food Science Technology Research*, 14(5), 457-466.

[55] Parodi, P.W. (2007). Nutritional Significance of Milk Lipids. In: Advanced Dairy Chemistry, Volume 2: Lipids, 3rd edition. Edited by P. F. Fox and P. L. H. McSweeney, Springer, New York.

[56] Park, Y.W. (2009). Overview of Bioactive Components in Milk and Dairy Products. In: Bioactive Components in Milk and Dairy Products, Edited by Y.W. Park, Wiley-Blackwell Publishers, Ames, Iowa 50014-8300, USA, 440p.

[57] Benito, P., Caballero, J., Moreno, J., Alcantara, C.G., Munoz, C., Rojo, G., Garcia, S., Soriguer, F. C. (2006). Effects of milk enriched with ω-3 fatty acid, oleic acid and folic acid in patients with metabolic syndrome. *Clinical Nutrition*, 25, 581-587.

[58] Çakmakçı, S., Tahmas Kahyaoğlu, D. (2012). Effects of fatty acids on health and nutrition. *Turkish Journal of Scientific Reviews*, 5(2), 133-137.

[59] Wassell, P., Bonwick, G., Smith, C.J., Almiron-Roig, E., Young, N.V.G. (2010). Towards a multidisciplinary approach to structuring in reduced saturated fat-based systems-a review. *International Journal Food Science Technology*, 45(4), 642-655.

[60] Nawas, T., Yousuf, N.B., Azam, Md. S., Ramadhan, A.H., Xu, Y., Xia, W. (2017). Physiochemical properties and sensory attributes of ice cream fortified with microencapsulated silver carp (*Hypophthalmichthys molitrix*) oil. *American Journal of Food Science and Nutrition Research*, 4(3), 79-86.

[61] Sorio, J. C., Albina, M.B. (2019). Microbial and sensorial quality of ice cream fortified with oyster (*Crassostrea iredalei*) puree. *Current Research in Nutrition and Food Science*, 7(1), 295-299.

[62] Özdemir, C., Arslaner, A., Özdemir, S., Allahyari, M. (2015). The production of ice cream using stevia as a sweetener. *Journal of Food Science Technology*, 52 (11), 7545-7548.

[63] Moriano, M. E., Alamprese, C. (2017). Honey, trehalose and erythritol as sucrose alternative sweeteners for artisanal ice cream a pilot study. *LWT-Food Science and Technology*, 75, 329-334.
[64] Fuangpaiboon, N., Kijroongrojana, K. (2015). Qualities and sensory characteristics of coconut milk ice cream containing different low glycemic index (GI) sweetener blends. *International Food Research Journal*, 22(3), 1138-1147.
[65] Kalicka, D., Znamirowska, A., Pawlos, M., Buniowska, M., Szajnar, K. (2019). Physical and sensory characteristics and probiotic survival in ice cream sweetened with various polyols. *International Journal of Dairy Technology*, 72(3), 456-465.
[66] Ramirez-Santiago, C., Ramos-Solis, L., Lobato-Calleros, C., Peña-Valdivia, C., Vernon-Carter, E. J., Alvarez-Ramírez, J. (2010). Enrichment of stirred yogurt with soluble dietary fiber from *Pachyrhizus erosus* L. urban: Effect on syneresis, microstructure and rheological properties. *Journal of Food Engineering*, 101, 229-235.
[67] Soukoulis, C., Lebesi, D., Tzia, C. (2009). Enrichment of ice cream with dietary fibre: Effects on rheological properties, ice crystallization and glass transition phenomena. *Food Chemistry*, 115, 665-671.
[68] Crizel, T.M., Araujo, R.R., Rios, A.O., Rech, R., Flôres, S.H. (2014). Orange fiber as a novel fat replacer in lemon ice cream. *Food Science and Technology (Campinas)*, 34(2), 332-340.
[69] Yangılar, F. (2016). Production and evaluation of mineral and nutrient contents, chemical composition and sensory properties of ice creams fortified with laboratory-prepared peach fibre. *Food and Nutrition Research*, 60, 1-9.
[70] Gharibzahedi, S.M.T., Jafari, S.M. (2017). The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. *Trends in Food Science and Technology*, 62, 119-132.
[71] Combs, G.F., McClung, J. P. (2017). The Vitamins: Fundamental Aspects in Nutrition and Health. London; San Diego; Cambridge, MA; Oxford: Academic Press, Hardcover.
[72] Çakmakçı, S., Toptaş, E. F., Çakır, Y., Kalın, P. (2016). Functionality of kumquat (*Fortunella margarita*) in the production of fruity ice cream. *Journal Science Food Agriculture*, 96, 1451-1458.
[73] Akın, M.B., Dasnik, F. (2015). Effects of ascorbic acid and glucose oxidase levels on the viability of probiotic bacteria and the physical and sensory characteristics in symbiotic ice-cream. *Mljekarstvo*, 65(2), 121-129.
[74] Kavaz Yüksel, A., Yüksel, M., Şat, İ.G. (2017). Determination of certain physicochemical characteristics and sensory properties of green tea powder (matcha) added ice creams and detection of their organic acid and mineral contents. *Food*, 42(2), 116-126.
[75] Góral, M., Kozlowicz, K., Pankiewicz, U., Góral, D. (2018). Magnesium enriched lactic acid bacteria as a carrier for probiotic ice cream production. *Food Chemistry*, 239, 1151-1159.