ORIGINAL ARTICLE

Almond milk-based yogurt: a new perspective for athlete nutrition

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ABSTRACT

Background: Nutrition is an essential aspect of an athlete's life. This study aims to investigate alternative products and propose new perspectives. In this study, almond milk, obtained from almonds whose functional property is well-known, is enriched with egg white protein powder (EWPP) and various disaccharides. Thus a non-milk-based fermented product is produced.

Methods: To promote the viability of starter cultures, sucrose and maltose were first added to almond milk at a rate of 1.0% w/v. Afterward, sucrose and maltose milk were pasteurized at 85 °C for 20 minutes and cooled to 50-55 °C. Following the cooling, the EWPP (6% w/v) and the dry matter were adjusted to 12-13%.

Results: In this study, physicochemical, rheological, and sensory properties of fermented products, which were obtained with EWPP and different disaccharides, were determined on the 1st, 7th, 14th, and 21st days of storage. In the study, almond milk and fatty acid compositions of non-milk-based fermented products produced from this milk were determined on the first day of storage. It was determined that fermented products made by adding maltose to almond milk were more acceptable in physicochemical, sensory, and rheological aspects than sucrose-added fermented products.

Conclusion: Regarding our extensive studies, there is evidence that almond milk-based product is a sufficient alternative to cow's milk-based products. The Almond milk-based product used in this study is a nutrient that should be popularised and preferred by athletes.

Keywords: athlete nutrition, fermented products, almond milk

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INTRODUCTION

It is one of the essential activities for the human body to get the necessary nutrition. While the body produces energy, it requires specific nutrition. Especially in the case of physical activities, the body's energy needs increase. During intense physical activities such as sports, energy procurement is necessary. All sports types cause different levels of energy expenditure. In addition, the physiological features of athletes differ. Therefore, it is crucial for athletes to program their nutritional intake [1]. One of the indispensable elements in an athlete's life is proper nutrition. Nutrition is the source of energy that helps the human body to function correctly [2]. Nutrition rich in high-quality protein is essential to support skeletal muscle proteins by fixing and synthesizing [3]. Some studies indicate that after consuming milk-based proteins after training, muscle strength is likely to improve, and body composition is expected to be positively affected [4]. Comparatively, an athlete's body needs more protein than an average person's [5]. In addition, studies suggest that the protein intake should be adjusted according to the sports field and the athlete's features [6,7,8]. Athletic performance and adaptation are highly influenced by the presence of protein [9]. Protein is necessary for the body to produce essential enzymes and hormones, repair and support tissues, etc. [10]. According to Jenkins and Reaburn, the ideal protein consumption for an athlete is 1.2–2.0 g/kg of body weight each day [11].

In the last couple of decades, there has been a significant interest in plant milk as an alternative to animal milk [12]. In this process, soy and almond milk have become common choices since they contain high nutritional values [13]. Almond, in particular, has a balanced content in terms of protein and fat levels, vitamins, and minerals [14,15,16].

Almond milk has been used instead of cow's milk in pregnant women, osteoporotic individuals, and people with various illnesses because of its high level of minerals such as calcium, phosphorus, and potassium in lactose-intolerant people many years [17]. It is known that there are inconsistencies between studies on the composition of almond milk. According to Bernat et al., carbohydrate (4.9 g / 100 ml), fat (55.77 g / 100 ml), protein (22.55 g / 100 ml), fiber (6.82 g / 100 ml), and ash (3.86 g / 100 ml) levels in the compound of almond is higher than almond milk. It is reported that the levels in almond milk are , 6.6 g / 100 ml of dry matter, 93.4 g / 100 ml of water, 3.96 g / 100 ml of fat, 1.37 g / 100 ml of protein, 0.1285 g / 100 ml of carbohydrate, 0.58 g / 100 ml of fiber and 0.325 g / 100 of ash [18]. On the other hand, according to Yetunde and Ukpong, the dry matter in almond milk was 13.89 g / 100 ml, water 86.11 g / 100 ml, fat 3.40 g / 100 ml, protein 2.36 g / 100 ml, carbohydrate 4.50 g / 100 ml, fiber 1.25 g / 100 ml and ash 3.04 g / 100 ml [19]. It was determined that the compound of almond milk, calcium, was found between 13.10 mg / 100g and 156.20 mg / 100g, sodium was between 3.40 mg / 100g and 6.38 mg / 100g, and vitamin D level was 41.66 IU. It is reported that almond milk with no cholesterol and saturated fatty acids in its compound has a calorie level between 12.10 Kcal/100g and 55.40 Kcal/100g.[19,20]. Yetunde and Ukpong stated that almond milk consists of 75.20 mg / 100 ml of phosphorus, 42.05 mg / 100ml of magnesium, 65.33 mg / 100 ml of potassium, 1.40 mg / 100 ml of iron and 4.58 mg / 100 ml of zinc. Almond is an important source of high-quality proteins, and 16-22% of its dry weight is known to be protein [21]. Almonds contain a high percentage of Arginine amino acids, and their digestion rate is known to be high [22]. These differences between almonds and the milk obtained from almonds are associated with geographical conditions where the plant is grown and almond species.

Almond milk is usually offered for consumption as a plain beverage. However, in the literature, it is seen that there are studies that aim to increase consumption by processing non-dairy fermented products via different starter cultures. Yet, there are difficulties in processing almond milk into non-milk-based fermented products. The most significant of these difficulties is the lowness of carbohydrate level (average 0.3 g/100ml milk) in almond milk compared to cow's milk (4–5 g/100 ml) and soy milk (1.7 g/100 ml). Starter cultures used in the production of fermented milk products have multifunctional roles during the fermentation process. It is reported that low carbohydrate content in almond milk composition affects acidity development, prolongs gelling time, and produces a non-viscous product [23]. In a study conducted by Bernat, it was stated that the pH level of almond milk supplemented with starter culture was estimated to be five and above after 24 hours. Therefore, adding carbohydrates to the production of fermented products from almond milk via starter cultures is a necessity [18].

In this study, maltose and sucrose are added separately to the almond milk, whose composition is determined. In this way, the effects of different disaccharides on starter culture activity in almond milk and the effects produced by fermented products on the physicochemical, rheological, and sensory properties were determined. Pasteurized egg white protein powder (EWPP) increased dry matter.

MATERIALS AND METHODS

Materials

In our experiment, raw almonds were obtained from Tadım A.Ş (Kocaeli-Turkey), pasteurized Alfasol® brand egg white protein powder (EWPP) (Ph: 7.00; total microorganism <100 CFU / g; Coliforms <10 CFU / g, does not contain Salmonella and Aereus, humidity level 7.10%) from Kimbiotek Kimyaevi Maddeler San. Tic. A.Ş. (İstanbul-Turkey), JOINTEC VB530 lyophilized yogurt culture from CSL laboratory (Strade per Merlino, 3,26839, Italy), sucrose (57-50-1) and maltose (6363-53-7) from Sigma-Aldrich firm. Yoghurt samples were produced at Ege University, Faculty of Agriculture, Dairy Technology Department Pilot Plant.

Preparation of Bacteria Cultures

The reconstituted milk with 12% dry matter was sterilized for 10 minutes at 115 ºC and cooled to 37 ºC. To be inoculated into almond milk, classical yogurt cultures were transferred to the milk and reconstituted with 12% lean dry matter. After the milk is mixed, it is left to incubate at 37 ºC, and the incubation process is terminated when the pH of the working culture decreases to 4.6. Thus, the culture to be used in production was prepared.

Almond Milk Production

Unshelled raw almonds were mixed with water in a ratio of 1:3 for 3-4 minutes and then kept in refrigerator conditions for 48 hours. After 48 hours, the drained almonds were put into Ultra Turrax Blendera (40 sec at 1200 rpm) (IKA, Merc, Germany) with water again at a ratio of 1: 3 and homogenized for 3-5 minutes. It was then filtered through a wire mesh strainer or cheesecloth to prepare it for fermented product production.

Non-milk Based Fermented Product (FP) Production

In the study, starter culture, sucrose (1.0% w/v) and maltose (1.0% w/v) were added separately to almond milk whose dry matter is adjusted to 12-13% by adding EWPP (about 5-6% w / v). The ratio of sucrose and maltose added to almond milk before pasteurization with an amount (% 1.0 w/v) higher than the reference value determined by Bernat et al. (0.75 w/v) [18]. In preliminary trials, EWPP was added separately to almond milk in 3% (w/v) and 6% (w/v) ratios. Along with EWPP, in a 6% (w/v) ratio, dry matter of almond milk was obtained as 12-13%. For this reason, 5-6% (w/v) EWPP was used in the experiment. In the study, pasteurized EWPP was added after pasteurizing almond milk and cooling to 50-55 °C to avoid clotting of EWPP.

In the research's fermented product (FP) production, almond milk was divided into three equal sections. Sucrose (1.0% w / v) was added to the first part, maltose (1.0% w / v) was added to the second part, and no ingredient was added to the third part.

After every three parts were separately pasteurized at 85 °C for 20 minutes, they were cooled to 50-55 °C, and EWPP was added to each portion with a rate of 5-6% (w / v), and they were homogenized with Ultra Turrax Blender (40 seconds at 1200 rpm) for 3-5 minutes. Then, the samples were cooled to 42-43 °C, and a 3% (w/v) starter culture was added. Thus, fermented product samples were prepared as sucrose-added almond milk fermented product (AMF_S), maltose-added almond milk fermented product (AMF_M), and plain almond milk fermented product (AMF=K). Samples were divided into plastic containers (200 g) and left to incubate (42-43 ° C), and incubation was stopped at pH 4.60. Physicochemical, rheological, and sensory analyses were performed on samples stored at 4 ° C ± 1 for 21 days on days 1, 7, 14, and 21.

Analysis of Almond Milk and Fermented Products

Physico-chemical Analysis

Dry matter (%): Dry weight was made by a gravimetric method in milk and yoghurt samples [24].

Fat (%): Fat values of milk and yoghurt samples were determined according to Gerber method [24].

pH value: The pH value of milk and yoghurt samples was determined by the brand pH meter of SS-3 Zeromatic (Beckman Instruments Inc., California, USA) [24].

Titration acidity (% LA): Titration acidity of milk and yoghurt samples was determined according to AOAC 2000 [24].

Protein value (%): Protein value was obtained by the Kjeldahl method [24].

Viscosity (cP): Viscosity values in yoghurt samples were estimated with Brookfield's Digital Viscometer (Model DV-II+PRO, USA) (180 rpm, 10°C), in milk and yoghurt samples with LV2 spindle (23.47 g), between 13% and 42%] as cP.

Syneresis (g): Syneresis in yoghurt samples was determined in g by weighing the amount of 25 g of yoghurt sample at 4 ± 1 °C filtered through coarse filter paper in 120 minutes [25].

Texture Profile Analysis (TPA): TPA values of yoghurt samples were determined by Texture Analyzer (Brookfield CT3 4500 model, USA / Shape Cylinder; Target 10 mm; Test speed 1 mm / sec).

Sensory tests: On the 1st, 7th, 10th, 14th, and 21st days of storage, the sensory analyses on the yoghurt samples were performed according to Meilgaard et al. 1999 [26].

Ash (%): Ash was made by a gravimetric method in milk and yoghurt samples [24].

Carbohydrate level (g): Carbohydrate value was measured with Atago Polax x 2L (Japanese) model polarimeter [27].

Statistical Analysis

Yoghurt samples were examined with three parallel analyses and two recurrence analyses. For this purpose, the SPSS version 15 (IBM SPSS Statistics) statistical analysis package program was used. According to Duncan's Multiple Comparison Test, important data obtained from variance analysis ANOVA were tested at $p<0.05$.

Determination of Fatty Acid Composition in Almond Milk and Fermented Samples

Each homogenized sample was extracted according to Gerber method to obtain oil (ISO 11870: 2009 - ID 152: 2009) [28], and fatty acid methyl esters were prepared according to AOCS (2009) [29] and examined in gas chromatography (GC). [Chromatography; Supelco SP-2380 is a fused silica capillary column (60m0.25mm i.d., 0.2mm film thickness; Supelco Inc., Bellefonte, PA, USA) and flame ionized detector Hewlett-Packard GC (model 6890). The injection volume is 1μl, and the GC oven temperature is programmed at a rate of 4 °C/min from 100 °C to 220 °C. The injector and detector temperature is 300 °C, the carrier gas is Helium, and the flow rate is 1ml/min. Fatty acid methyl esters were detected on the day the 1st of storage in almond milk and fermented samples.

RESULTS AND DISCUSSION

Physicochemical Properties

The physicochemical properties of non-milk-based fermented samples are given in Table 1.

In the research, dry matter in almond milk (AM) was determined as 6.84%, fat 3.52%, protein 1.28%, titration acidity (°SH) 0.133%, pH 6.54, ash 0.6% and viscosity 3.49 cP (20 °C). During storage, the pH value of yoghurt samples decreased, and the percentage of lactic acid (LA%) increased. During storage, the relationship between acidity increase and sugar addiction/variety was significant ($p <0.05$). In the study, the increase in acidity in AMFS and AMFM samples was higher than in AMF (K), and it was associated with maltose and sucrose content added to almond milk at a 1% (w/v) level. In the literature, it has been reported that lactic acid bacteria develop better in the presence of glucose and some other sugars (sucrose, maltose) and cause acidity to increase [30].

Fat decreased in all samples during storage, and the highest decrease was detected in AMF (K), followed by AMFS and AMFM, respectively. During storage, the fat levels determined in AMFS and AMFM were higher than in AMF.

	Storage time	AMF (K)	AMF_S	AMF_M
Dry matter (%)	Day 1	6.73 (1.23)^{aA}	12.78 (0.56)^{aB}	12.81 (1.49)^{aA}
	Day 7	5.68 (0.02)^{aA}	12.14 (0.14)^{aB}	12.44 (0.23)^{aC}
	Day 14	5.54 (0.03)^{aA}	11.46 (0.91)^{aB}	11.65 (1.67)^{aC}
	Day 21	4.85 (0.06^{aA}	11.12 (0.47)^{aB}	11.36 (0.29)^{aC}
Viscosity (cP)	Day 1	648 (0.06)^{aA}	915 (0.01)^{aB}	1159 (0.59)^{aC}
	Day 7	636 (0.14)^{bA}	1145 (1.27)^{bB}	1192 (0.42)^{aC}
	Day 14	621 (0.08)^{bA}	1444 (1.64)^{bB}	2356 (0.73)^{bC}
	Day 21	609 (0.19)^{bA}	1856 (0.37)^{bB}	2841 (0.47)^{bC}
Syneresis (g)	Day 1	11.42 (0.09)^{aA}	6.41 (0.73)^{aB}	5.24 (1.47)^{aC}
	Day 7	15.06 (0.06)^{aA}	9.24 (0.64)^{AB}	5.74 (1.68)^{aC}
	Day 14	17.76 (0.07)^{aA}	11.27 (0.11)^{aB}	8.13 (1.71)^{aC}
	Day 21	20.88 (0.04)^{aA}	12.89 (0.06)^{aB}	9.47 (1.91)^{aC}
pH	Day 1	5.21 (0.49)^{aA}	4.55 (0.26)^{aB}	4.54 (0.88)^{aC}
	Day 7	5.21 (0.75)^{aA}	4.39 (1.71)^{aB}	4.37 (0.61)^{bC}
	Day 14	5.20 (0.64)^{aA}	4.27 (1.39)^{aB}	4.23 (1.22)^{bC}
	Day 21	5.20 (0.67)^{bA}	4.18 (2.51)^{bB}	4.15 (0.67)^{bC}
Titration acidity (%LA)	Day 1	0.522 (0.06)^{aA}	0.925 (0.27)^{aB}	0.941 (0.33)^{aC}
	Day 7	0.524 (0.07)^{aA}	1.035 (0.46)^{aB}	1.074 (0.08)^{bC}
	Day 14	0.524 (0.26)^{bA}	1.046 (0.31)^{bB}	1.119 (0.66)^{bC}
	Day 21	0.524 (0.74)^{bA}	1.116 (0.30)^{bB}	1.142 (1.42)^{bC}
Fat (%)	Day 1	3.48 (0.14)^{aA}	3.50 (0.06)^{aA}	3.50 (0.06)^{aA}
	Day 7	2.91 (0.56)^{aA}	3.41 (0.01)^{aA}	3.42 (0.09)^{aA}
	Day 14	2.06 (0.87)^{aA}	3.25 (0.33)^{aA}	3.37 (0.47)^{aA}
	Day 21	1.42 (0.91)^{aA}	3.18 (0.57)^{aA}	3.21 (0.36)^{aA}

Protein (%)	Day 1	1.27 (0.02)^{aA}	1.26 (0.11)^{aA}	1.26 (0.01)^{aB}
	Day 7	1.21 (0.03)^{aA}	1.18 (0.24)^{aA}	1.17 (0.07)^{aB}
	Day 14	1.12 (0.09)^{bA}	1.08 (0.16)^{aA}	1.08 (1.11)^{aB}
	Day 21	1.02 (0.22)^{bA}	1.05 (0.79)^{bA}	1.04 (1.14)^{bB}
Carbohydrate (%)	Day 1	0.17 (0.05)^{aA}	1.14 (1.12)^{aA}	1.12 (0.07)^{aB}
	Day 7	0.11 (0.14)^{aA}	1.09 (2.10)^{aA}	1.05 (1.18)^{aB}
	Day 14	0.06 (1.10)^{aA}	1.01 (0.05)^{aA}	0.97 (1.23)^{aB}
	Day 21	0.03 (0.09)^{aA}	0.8 (1.21)^{aA}	0.82 (1.36)^{aB}
Ash (%)	Day 1	0.60 (0.21)^{aA}	0.62 (0.15)^{aA}	0.62 (0.13)^{aA}
	Day 7	0.28 (0.18)^{aA}	0.44 (0.27)^{aA}	0.45 (0.17)^{aA}
	Day 14	0.19 (0.34)^{aA}	0.31 (0.49)^{aA}	0.31 (0.26)^{aA}
	Day 21	0.18 (0.17)^{aA}	0.27 (0.52)^{aA}	0.28 (0.12)^{aA}

Table 1. Physicochemical Properties of Non-milk-based Fermented Samples (n = 3).

^{a,b,c} The difference between values with different expressions in the same column is statistically significant ($p < 0.05$)

^{A,B,C} The difference between values with different expressions in the same row is statistically significant ($p < 0.05$).

Increased sugar levels increased the activity of starter cultures; thus, acidity and viscosity increased, and syneresis decreased. Our results are consistent with the studies indicating that the symbiotic relationship between the increase of syneresis and microorganisms is impaired, and the pH development slows down or stops [31].

Rheological Properties

Texture analysis results are given in Table 2. One of the quality criteria of yoghurt, which is a fermented milk product, is clot stability. Many factors influence the consistency (clot stability = hardness), syneresis, and viscosity, known as the rheological properties of the clot. Among these factors, especially pH value, dry matter, and protein content [32], denatured serum protein content, β-lactoglobulin, and k-casein interactions are essential [33].

In the study, the consistency values of the samples were found to be significant in terms of sugar type × time interaction ($p < 0.05$). Therefore, in terms of consistency values, the difference between non-milk-based fermented samples was significant ($p < 0.05$). During storage, consistency (penetrometer) values of AMFM and AMFS samples decreased, and clot stability (hardness) increased. In AMF samples, the opposite was determined. The effect of storage on consistency values was significant (p <0.05).

	Storage Time	AMF	AMF_S	AMF_M
Hardness(g)	Day 1	12.09 (0.02)^{aA}	15.12 (1.14)^{aA}	15.28 (1.06)^{aA}
	Day 7	11.03 (0.06)^{aA}	15.63 (1.86)^{aA}	15.85(1.66)^{aA}
	Day 14	9.05 (0.08)^{aA}	15.75(1.13)^{aA}	16.34 (1.24)^{aA}
	Day 21	8.65 (0.12)^{aA}	15.92 (1.26)^{aA}	16.41 (1.63)^{aA}
Viscidity	Day 1	0.03 (0.36)^{aA}	0.04 (0.25)^{aA}	0.10 (0.88)^{aA}
	Day 7	0.01 (0.11)^{aA}	0.06 (0.74)^{aA}	0.15 (1.12)^{aA}
	Day 14	0.01 (0.06)^{aA}	0.11 (0.22)^{aA}	0.17 (0.14)^{aA}
	Day 21	0.01 (0.56)^{aA}	0.15 (0.24)^{aA}	0.22 (0.41)^{aA}
Flexibility(mm)	Day 1	2.00 (1.24)^{aA}	3.11 (1.12)^{aA}	4.42 (0.01)^{aA}
	Day 7	2.06 (1.89)^{aA}	3.22 (1.23)^{aA}	4.39 (0.33)^{aA}
	Day 14	2.16 (1.74)^{aA}	3.64 (1.56)^{aA}	4.88 (0.74)^{aA}
	Day 21	2.18 (1.71)^{aA}	3.74 (1.87)^{aA}	5.02 (0.89)^{aA}
Gumminess(g)	Day 1	21.10 (1.06)^{aA}	66.33 (1.45)^{aA}	77.51 (1.23)^{aA}
	Day 7	21.12 (1.14)^{aA}	64.42 (1.63)^{aA}	71.21 (1.48)^{aA}
	Day 14	22.00 (1.89)^{aA}	52.03 (1.71)^{aA}	69.24 (1.91)^{aA}
	Day 21	22.03 (1.43)^{aA}	49.21(1.96)^{aA}	64.41 (1.80)^{aA}
Chewiness (mJ)	Day 1	0.02 (0.18)^{aA}	0.31 (0.06)^{aA}	1.55 (0.33)^{aA}
	Day 7	0.09 (0.61)^{aA}	0.36 (0.16)^{aA}	2.07 (0.16)^{aA}
	Day 14	0.11 (0.23)^{aA}	0.42 (0.37)^{aA}	2.68 (0.74)^{aA}
	Day 21	0.11 (0.75)^{aA}	0.55 (0.74)^{aA}	3.24 (0.90)^{aA}

Table 2. Texture Change During Storage in Non-Milk Based Fermented Products (n=3)

^{a,b,c} The difference between values with different expressions in the same column is statistically significant (p <0.05)

^{A,B,C} The difference between values with different expressions in the same row is statistically significant (p <0.05).

In non-milk-based fermented samples, the relationship between the viscosity values and the type of sugar used is meaningful. In addition, the relationship between viscosity and acidity increase, storage time, dry matter, and oil were also significant ($p < 0.05$). In the related studies, it is reported that there is a linear relationship between dry matter [32] and oil content [34] and between viscosity and hardness.

In the study, clot stability (hardness) increased during storage, and the effect of storage was significant ($p < 0.05$]. The hardness determined in the AMFM during storage was higher than in the other samples. Hardness was associated with syneresis; increases in dry matter, protein, lactose, viscosity, acidity, and fruit concentrate were significant ($p < 0.05$]. Syneresis, an increase in dry value, protein, lactose, density, sharpness, and fruit concentrate were signed in AMFM during storage was low. Syneresis, an increase in dry matter, protein, lactose, viscosity, acidity, and fruit concentrates were signed, and dry matter reduction in AMFS samples was lower than in AMF samples. In the study, the relationship between increased acidity and syneresis, dry matter, protein, lactose, viscosity, sharpness, and fruit concentrate was significant ($p < 0.05$). The relationship between thickness, sugar type, and acidity increase was meaningful ($p < 0.05$). During storage, viscosity was increased in AMFM and AMFS samples and decreased in AMF samples, respectively. Increased acidity in yoghurt and prolonged storage in the cold has been reported to increase viscosity [35]. The highest acidity rise between days 1 and 14 was determined in AMF_M samples. In the same samples, the viscosity value was 2356 cP on day 14 and 2841 cP on day 21. Rheological properties of a clot in fermented products, such as yoghurt, develop depending on milk composition, applied temperature, pH, soluble Ca ++ ratio, and other factors [36]. An increase in acidity causes the interaction between proteins to increase, hardness to decrease, calcium to become more soluble, and thus viscosity to increase [37]. During storage, rhetological properties found in AMF_M were reported to be better than AMF_S.

Fatty Acid Composition in Almond Milk and Fermented Products

The ratio of saturated fatty acids in almond milk was stated as 4.02 g / 100 g. The percentage of unsaturated fatty acids in the fatty acid composition of almond milk was determined as 90%. Among these fatty acids, monounsaturated fatty acid levels were 38.7 g / 100 g, and polyunsaturated fatty acids were 2.7 g / 100 g.

The approximate proportions of unsaturated fatty acids in almond milk were determined as follows: Oleic acid (C18: 1) 57%, linoleic acid (C18: 2) 22%, palmitic acid (C16: 0) 7%, Stearic acid (C18: 0) Palmitoleic acid (C16: 1), myristic acid (C14: 0) and arachidic acid (C20: 0). In the research, it was determined that the fatty acid profile of fermented products made by adding different types of sugar to almond milk were quite close to the almond milk fat profile.

Sensory Properties

During the sensory evaluation during storage, AMFM and AMFS samples were simulated in fermented milk product yoghurt in terms of textural properties (structure consistency, appearance, color, etc.) and were appreciated. In general, AMFM scored more in structure consistency than AMFS during storage.

This was associated with increased viscosity, hardness, and reduced syneresis during storage. The relationship between the increase in storage time and structure consistency was significant ($p < 0.05$). In the study, two different sugar additions were found closer in taste and smell in yoghurt made from cow milk with prolonged storage time in AMFM and AMFS samples. On the first day of storage, there was no significant difference in taste and smell between sugar-added samples. However, it was found that yoghurt taste and odor in AMFM samples were more prominent than in AMFS samples in the following days. However, with the increase in storage time, it was found that the almond flavour started to dominate the yoghurt taste. This became particularly noticeable on the 14th day of storage. The Almond aroma has become more pronounced, especially in AMFS samples. The smell was found to be more favourable by the panelists than the regular yoghurt. Fat levels in sugar-added samples during storage were also thought to affect the taste. However, with the addition of two different sugars in almond milk, no color change was detected in AMFM and AMFS samples, and it was regarded as acceptable by the panelists.

CONCLUSION

In the study, it was determined that with the addition of maltose and sucrose to almond milk at a rate of 1% (w/v), it is possible to make non-milk-based products similar to cow's milk in terms of physicochemical, sensory, and rheological properties. In summary, the almond milk-based product is an innovative and effective nutrient for sports nutrition. Regarding our extensive studies, there is evidence that almond milk-based product is a sufficient alternative to cow's milk-based products. It is imperative to emphasize this product is similar to cow's milk in several aspects. As sports nutrition is one of the significant concerns of athletes, the almond milk-based product is quite promising. For this reason, it is the statement of this study that the almond milk-based product used in this study is a nutrient that should be popularised and preferred, particularly by athletes.

Authors' Contributions

Kavas N. and Oral O. designed the study; data were collected and analyzed by Kavas N., Kavas G., and Oral O. Data interpretation and manuscript preparation was undertaken by Kavas N., Kavas, G., and Oral, O. All authors approved the final version of the paper.

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Conflict Of Interest

The author certifies that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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REFERENCES

1. Jeukendrup A, Gleeson, M. In: Sports Nutrition: An introduction to energy production and performance. Ed.Human Kinetics. 2004.

2. Thomas DT, Burke LM, Erdman KA. Nutrition and athletic performance. Medicine and Science 2016;48:543-568.

3. Tipton KD, Elliott TA, Cree MG, Aarsland AA, Sanford AP, Wolfe RR. The synthesis of net muscle protein is stimulated by whey protein ingestion before and after exercise. American Journal of Physiology. Endocrinology and Metabolism 2007;292(1):E71–76

4. Josse AR, Atkinson SA, Tarnopolsky MA, Phillips SM. Increased consumption of dairy foods and protein during diet- and exercise-induced weight loss promotes fat mass loss and lean mass gain in overweight and obese premenopausal women. The Journal of Nutrition 2011;141(9):1626–1634.

5. Campbell B, Kreider RB, Ziegenfuss T, La Bounty P, Roberts M, Burke D, et al. International society of sports nutrition position stand. Protein and exercise. Journal of International Society Sports Nutrition 2007;4:8.

6. Phillips SM. Protein requirements and supplementation in strength. Sports Nutrition 2004;20(7):689–95.

7. Slater G, Phillips SM. Nutrition guidelines for strength sports: sprinting, weightlifting, throwing events, and bodybuilding. Journal of Sports Science 2011;29:S67–77.

8. Stellingwerff T, Maughan RJ, Burke LM. Nutrition for power sports. Middle-distance running, track cycling, rowing, canoeing/kayaking, and swimming. Journal of Sports Science 2011;29:S79–89

9. Tipton KD, Wolfe RR. Protein and amino acids for athletes. Journal of Sports Science 2004;22(1):65–79

10. Cotugna N, Vickery CE, McBee S.' Sports nutrition for young athletes', The Journal of School Nursing 2005;21(6): pp. 323–328.

11. Jenkins D, Reaburn P. Guiding the young athlete. St. Leonards, Australia Allen & Unwin p. 2000;146-147

12. Donkor OA, Henriksson T, Vasiljevic and NP Shah, "Galactosidase and proteolytic activities of selected probiotic and dairy cultures in fermented soymilk," Food Chemistry 2007;104: 10–20

13. Watkins C. The world of nuts.International News on Fats, Oils and Related Materials16:200-201

14. Jenkins DJA, Kendall CWC, Marchie A, Parker TL, Connelly PW, Qian W. "Dose response of almonds on coronary heart disease risk factors – blood lipids, oxidized LDL, Lp(a), homocysteine

and pulmonary nitric oxide: A randomized controlled cross-over trial," Circulation 2002;106:1327–1332

15. Hasan N. Almond milk production and study of quality characteristics. Journal of Academia 2012; Vol 2:1-8.

16. Spiller GA, Miller A. "Effects of plant-based diets high in raw or roasted almonds or roasted almond butter on serum lipoproteins in humans," Journal of the American College of Nutrition 2003;22:195–200.

17. Bernat N, Chafer M, Chiralt A, Gonzalez-Martinez C. Probiotic fermented almond \milk" as an alternative to cow-milk yoghurt. International Journal of Food Studies 2015;4: 201-21

18. Bernat N, Chafer M, Chiralt A, Gonzalez-Martinez C. Development of a non-dairy probiotic fermented product based on almond milk and inulin. Food Science and Technology International 2014;21(6): 440–453.

19. Yetunde AE, Ukpong US. Nutritional and sensory properties of almond (Prunus amygdalu Var. Dulcis) seed milk. World Journal of Dairy & Food Sciences 2015;10 (2): 117-121.

20. Somanchi M, Pehrsson P. Lactose Intolerance: Comparison of the nutritive value of milk substitutes to milk. US Dept. of Agriculture, ARS, Beltsville Human Nutrition Research Center, Beltsville, MD 20705. Abstract. 2015.

21. Sze-Tao KWC, Sathe SK. Functional properties and in vitro digestibility of almond (Prunus dulcis L.) protein isolate. Food Chemistry 2000;69: 153-160.

22. He S, Hekmat S. Sensory Evaluation of non-dairy probiotic beverages. Journal of Food Research. 2015;4 (1): 186-192

23. Chang CY, Stone MB. Effect of total soymilk solids on acid production by selected lactobacilli. Journal of Food Science 1990;55 (6): 1643–1646.

24. AOAC (Association of Official Analytical Chemists). Official methods of analysis. Association of Official Analytical Chemists International, Association of Official Analytical Chemists (publisher), Washington, DC 20044, USA, 2000;1018p.

25. Farooq H, Haque ZU. Effect of sugar esters on the textural properties of nonfat low-calorie yoghurt. Journal of Dairy Science 1992;75: 2676–2680.

26. Meilgaard M, Civille GV, Carr BT. Descriptive analysis techniques. Sensory evaluation Techniques. 3rd Edition. CRC Press, Boca Raton,FL.1999;161-170.

27. Horwitz W. Official methods of analysis of the association of official agricultural chemists. 10th ed., p. 224, Publishing by the association official agricultural chemists. Benjamin Franklin Station, Washington DC 20044. 1965.

28. ISO 11870.2009 (IDF 152.2009). Milk and milk products- Determination of fat content-General guidance on the use of butyrometric methods.

29. AOCS, AOCS Official Method Ce 2-66. Preparation of Methyl Esters of Fatty Acids. 2009.

30. Shirai K, Guerrero I, Huerta S, Saucedo G, Castillo A, Gonzalez, RO, et al. effect of initial glucose concentration and inoculation level of lactic acid bacteria in shrimp waste ensilation. Enzyme and Microbial Technology 2001;28: 446–452.

31. Tamime AY, Robinson RK. Yoghurt: science and technology. Oxford, UK: Pergamon Press. 1985.

32. Torre L, Tamime YA, Muir DO. Rheology and sensory profiling of set-type fermented milk made with different commercial probiotic and yoghurt starter cultures. International Journal of Dairy Technology 2003;56(3): 163-170.

33. Puvanenthiran A, Williams RPW, Augustin MA. Structure and viscoelastic properties of set yoghurt with altered casein to whey protein ratios. International Dairy Journal 2002;12(4): 383-391.

34. Brauss MS, Linforth RST, Cayeux I, Harvey B, Taylor AJ. Altering the fat content affects flavor release in a model yoghurt system. Journal agriculture food chemistry 1999;47: 2055-2059.

35. Beal C, Skokanova J, Latrille E, Martin N, Corrieu G. Combined effects of culture conditions and storage time on acidification and viscosity of stirred yoghurt. Journal of Dairy Science 1999;82: 673-681.

36. Anema SG, Klostmeyer H. δ Potentials of casein micelles from reconstitued skim milk heated at 120ºC. International Dairy Journal 1996;6: 673-687.

37. Anema SG, Lowe EK, Li Y. Effect of pH on The viscosity of heated reconstituted skim milk. International Dairy Journal 2004;14: 541-548.

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