

EFFECT OF USING SOME DIETARY FIBERS ON COLOR, TEXTURE AND SENSORY PROPERTIES OF STRAINED YOGURT

A. Kemal Seçkin, Emrah Baladura*

Celal Bayar University, Engineering Faculty, Food Engineering Department, Manisa, Turkey

Received / Geliş tarihi: 27.10.2011

Received in revised form / Düzeltılarak geliş tarihi: 30.11.2011

Accepted / Kabul tarihi: 06.12.2011

Abstract

The aim of this study was to search the effects of using some dietary fibers on color, texture and sensory properties of strained yogurts. Apple, wheat and bamboo fibers were used in the production of strained yogurt at different ratios (1%, 2% and 3%). Color, texture values and sensory evaluation scores of samples were analyzed at the 1st, 7th, 14th and 21st days of storage. Depending on storage, the most changed textural parameter is consistency in bamboo, wheat and apple fibrous strained yogurt. *L*, *a* and *b* values of apple fibrous strained yogurts were determined to be different in comparison with bamboo and wheat fibrous strained yogurts due to the structure of apple fiber. The type of dietary fiber caused statistically significant changes in color, texture values and sensory evaluation scores. Apple fibrous strained yogurts weren't preferred by panelists because of their ragged structure, dominant apple taste and strong odor. Panelists found bamboo and wheat fiber strained yogurts acceptable. Analyses were done in two replications with their parallels.

Keywords: Strained yogurt, dietary fibers, color, texture and sensory properties

BAZI DİYET LİFLERİ KULLANIMININ SÜZME YOĞURDUN RENK, TEKSTÜR VE DUYUSAL ÖZELLİKLERİ ÜZERİNE ETKİSİ

Özet

Süzme yoğurtların kimyasal özellikleri üzerine bazı diyet liflerin kullanılmasının etkisi çalışmanın amacını oluşturmaktadır. Farklı oranlarda (% 1, % 2 ve % 3) olmak üzere elma, buğday ve bambu lifleri süzme yoğurt üretiminde kullanılmıştır. Depolamanın 1., 7., 14. ve 21. günlerinde örneklerin renk ve tekstür değerleri ile duyuşsal değerlendirme puanları analiz edilmiştir. Depolamaya bağılı olarak elma, bambu ve buğday lifli süzme yoğurtlarda en çok deęişiklik gösteren tekstür parametresi kıvam olmuştur. Bambu ve buğday lifli süzme yoğurtlara göre elma lifli süzme yoğurtların *L*, *a* ve *b* deęerleri elma lifinin yapısından dolayı farklı saptanmıştır. Diyet lifi çeşidi istatistiksel olarak renk ve tekstür deęerleri ile duyuşsal değerlendirme puanlarında önemli deęişikliklere neden olmuştur. Pütürlü yapısı, baskın elma tadı ve keskin kokusu yüzünden panelistler tarafından elma lifli yoğurtlar tercih edilmemiştir. Panelistler bambu ve buğday lifli yoğurtları kabul edilebilir bulmuştur. Analizler paralelliyle beraber iki tekerrürlü yapılmıştır.

Anahtar kelimeler: Süzme yoğurt, diyet lifleri, renk, tekstür ve duyuşsal özellikler

* Yazışmalardan sorumlu yazar / *Corresponding author* ;

✉ bala_dura@hotmail.com

☎ (+90) 236 241 2144

☎ (+90) 236 241 2143

INTRODUCTION

Yogurt is a fermented milk product and is accepted all over the world with its high nutritive value and positive effects on human health. Fundamentally positive effects of yogurt in human health are based on cultures containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (1). Although it has acidic properties, yogurt shows spoilage due to its high content of water (about 85%) during storage. Separation of yogurt whey is one of most important factor for increasing shelf life of yogurts and improving its quality. In production of strained yogurt, the content of water in yogurt decreases about 70% by removing yogurt whey. Cloth bag as a traditional method and ultrafiltration and centrifugation as new methods are used for removing yogurt whey (2). Similar products consumed in different countries with different names are as Labneh in the Middle East, Skyr in Ireland, Chakka and Shirkhand in India and Ymer in Denmark (3).

In recent years, addition of dietary fibers in fermented milk products have increased the number of researches with increasing diversity in the field of functional foods. Dietary fibers are edible parts of plants and indigestible in the small intestine. They consist of remains of edible plant cells, polysaccharides, lignin and material resistant to digestion by human digestive enzymes (4). Dietary fibers are classified as water-soluble and water-insoluble. Water-insoluble dietary fibers include cellulose, lignin and hemicelluloses such as cell wall components available in mainly wheat, grain products and vegetable. Water-insoluble dietary fibers reduce transit time to intestine, increase capacity of feces and make feces softer. Water-soluble dietary fibers include pectin, gums and mucilage such as non-cellulosic polysaccharides available in fruits, oats, barley and legumes. Water-soluble fibers delay gastric emptying, reduce the absorption of glucose and lower serum cholesterol levels (5).

Most applications of dietary fiber to yogurt are related to using water-soluble dietary fibers because of water binding properties. Dietary fibers in yogurt have been used for increasing the viscosity of the product as a stabilizer, preventing syneresis and improving textural properties as creaminess. Addition of dietary fiber to yogurt is an effective tool for reducing calorie and fat (6).

Apple fiber is effective on hypoglycemia, rheumatism and gouty which are important for the health of the digestive system. Wheat fiber helps to prevent intestine and rectum cancer, slows down cholesterol and blood sugar transition into the blood and it is effective at hypercholesterolemia and diabetes. Bamboo fiber which is tasteless has no calorie and its capacity of absorption is high because of physical bond of water. Staffolo et al. (7) studied the effects of commercial fibers from apple, wheat, bamboo and inulin on sensory and rheological properties of yogurt. Although some rheological characteristics were modified, the supplemented yogurts were acceptable to consumers. Yogurt fortified with apple fiber had a different color compared with unfortified yogurt. Fernandez-Garcia and McGregor (8) found that fibers from rice and maize increased the apparent viscosity of yogurts, whereas soy and sugar beet did not. The addition of oat fiber allows the development of a well-fermented product, without a significant diminution in the quality of the taste, despite a slight diminution in the quality of the texture. Sendra et al. (9) studied the effect of orange fiber addition on yogurt viscoelastic properties. As a result the presence of fiber particles alters yogurt structure but when the fiber dose is high water absorption compensates the weakening effect of the fiber. Fiber pasteurization in the mix enhances its integration in the gel matrix.

The aim of this study was to evaluate the effect of the addition of apple, bamboo and wheat dietary fibers on color, texture and sensory properties of strained yogurt during cold storage. Strained yogurt samples were compared among themselves in this study.

MATERIALS AND METHODS

Apple, wheat and bamboo fibers used as dietary fibers were obtained from J. Rettenmaier and Söhne Company (Rosenberg, Germany). Table 1 presents general properties of bamboo, apple and wheat fiber used in study. Cow's milk used in this study was obtained from Bagyolu Village in Manisa, Turkey. Freeze-dried type starter culture (*St. thermophilus* and *L. bulgaricus*) used in preparation of yogurt was obtained from Clerici-Sacco Group Company (Cadorago, Italy). Strained yogurts were made in Celal Bayar University, Food Engineering Department Laboratory.

Table 1. General properties of bamboo, apple and wheat fiber used in study*

	BF	AF	WF
Color	White	Beige brown	White
Appearance	Powder	Powder	Powder
Flavor and odor	Neutral	Typically fruity, aromatic character	Neutral
Dietary fiber content	min. 97%	min. 55%	min. 97%
Bulk density	260 g/l – 330 g/l	450 g/l ± 15%	200 g/l – 240 g/l
Average fiber length	50 µm	450 µm	80 µm
Ash	max 0.3%	max 3%	max 3%
Gluten	< 10 mg/kg	< 10 mg/kg	< 10 mg/kg
pH-value (10% suspension)	6.5±1.5	4±1	6.5±1.5
Standard plate count	max. 5 x 10 ³ cfu/g	max. 10 ⁴ cfu/g	max. 5 x 10 ³ cfu/g
Yeasts and moulds	max. 2 x 10 ² cfu/g	max. 10 ³ cfu/g	max. 2 x 10 ² cfu/g
Water binding capacity	min. 3.5 g H ₂ O/g	5.0 g H ₂ O/g	4.2 g H ₂ O/g – 5.5 g H ₂ O/g
Calorific value	0.09 kcal	1.03 kcal	0.09 kcal
Loss on drying	max. 7.5%	max. 8%	max. 8%

*BF= Bamboo fiber, AF= Apple fiber and WF= Wheat fiber

Production of strained yogurts

In the production of samples, 1%, 2% and 3% apple fiber (AF₁, AF₂, AF₃), 1%, 2% and 3% wheat fiber (WF₁, WF₂, WF₃) and 1%, 2% and 3% bamboo fiber (BF₁, BF₂, BF₃) mixtures were added to the milk at 25 °C. These mixtures were pasteurized at 90 °C for 10 minutes and cooled to 43 °C. Milk was inoculated with freeze-dried starter culture (coded SACCO Lyofast®, Italy) at 43 °C. The starter culture was a 1:1 mixture of *Str thermophilus* and *L. bulgaricus*. Inoculated milk was incubated at 42±0.5 °C until pH decreased to 4.7. Samples were cooled outside until reaching to room temperature after incubation and stored 1 day at 4 °C in refrigerator. Samples were left to straining for 12 hours after they were filled to cloth bags. At the end of straining process, samples were filled to glass jars and stored at 4 °C in refrigerator. Each batch of strained yogurt was analyzed separately at the 1st, 7th, 14th and 21st days of storage.

Analytical methods

Color analyses were performed by colorimeter (Minolta, DP 310, Osaka, Japan); the *L* (lightness), *a* (red/greenness) and *b* (yellow/blueness) parameters of the Hunter scale were analyzed.

Texture profile analysis of dietary fibrous strained yogurt samples was measured using The Stable Micro Systems texture analyzer (model TA-XT-2000 plus, Vienna count, UK) according to modified method from Awad et al. (10). Texture profile analysis was carried out by a

compression test that generated plot of force (g) versus time (sec). A 50-mm-diameter cylindrical probe was used to measure textural profile of the yogurt samples. The samples were compressed to 50 mm depth and the speed of the probe was fixed at 1.0 mm sec⁻¹ during the pre-test. The force exerted on the probe was automatically recorded. Post test speed was 10 mm sec⁻¹ and trigger force was 10 g. The four different parameters that were firmness, consistency, cohesiveness, viscosity/consistency index were calculated by the software program (Texture software, Stable Micro Systems).

Six panelists consisting of students and staff of the university were recruited and performed sensory evaluation of dietary fibrous strained yogurts. All samples were marked with 3-digit codes and the presentation of samples was randomized for each panelists. Yogurt samples were examined according to the method modified from Turkish Yogurt Standard (2001) using a 5-point hedonic scale all of for appearance, consistency (with spoon), consistency (with mouth), odor and flavor (11).

Statistical analysis

The results of researches were estimated by using Completely Random Design and GLM Procedure of SAS Statistic Analysis Program (12). LSD test was used for mean comparison. Analyses are the averages of production which had two replications and made as parallel. Only results of dietary fibrous yogurts were evaluated in this study.

RESULTS AND DISCUSSION

Color plays an important role in food choice of consumers. *L* (whiteness) values of samples changed between 72.9 and 109.4 (Table 2). The storage time had effect on *L* values of AF₁, AF₂ and AF₃ (*P*<0.05). Dietary fiber types were effective (*P*<0.05) on *L* values. *L* values of AF₂ and AF₃ were lower than those of other samples on the 1st and 7th day of storage (*P*<0.05). *L* values of AF₁, AF₂ and AF₃ were significantly lower (*P*<0.05) than those of other samples at the end of storage. The highest *L* values were registered for BF₁, BF₂, AF₂, AF₃, and all of WF samples on the 1st day of storage. Sensory evaluation scores supported this conclusion. Thus AF group samples were given the lowest scores in sensory evaluation. The *a* (red/greenness) values of samples ranged from 0.4 to 8.9 (Table 2). The storage time didn't have an effect (*P*>0.05) on *a* values of all samples. Dietary fiber types were effective (*P*<0.05) on *a* values. The *a* values of AF₁, AF₂ and AF₃ were significantly lower (*P*<0.05) than these of other samples during the storage time. The highest *a* values were registered for BF₂, BF₃, AF₂ and all of WF samples on the 1st day of storage. Similar results were reported for yogurts fortified with date fiber (13), orange fiber (14), and asparagus fiber (15). The *b* values of samples changed between 15.2 and 23.7 (Table 2). The storage had effect on *b* values of AF₁ (*P*<0.05). Dietary

fiber types were effective on *b* values (*P*<0.05). The *b* values of AF₁ were higher (*P*<0.05) than *b* values of other samples on the 14th and 21st days of storage. The highest *b* values were registered for BF₁, BF₂, BF₃, AF₂, AF₃ and WF₂ samples on the 1st day of storage. Hashim et al. (13) reported that *L* values changed between 75.4 and 89.3, *a* values changed between 0.8 and 5.0 and *b* values changed between 9.7 and 12.4 for yogurt fortified with date fiber. Similarly, Sanz et al. (15) determined that *L* values changed between 78.3 and 81.2, *a* values changed between 0.64 and 1.01 and *b* values changed between 15.97 and 18.22 for yogurt enriched with functional asparagus fiber.

Firmness, consistency, cohesiveness and viscosity/consistency index were determined (Table 3). The storage time affected (*P*<0.05) only firmness values of WF1. Dietary fiber types affected (*P*<0.05) firmness values of samples. Firmness values of WF1 were significantly higher than those of other samples on the 21st day of storage (*P*<0.05). Generally, firmness values increased with storage time. This situation may be attributed to increased water holding capacity of milk proteins with time storage. Another reason could be that increased water holding capacity of dietary fibers during containing bamboo fibrous samples had high firmness values which had the highest water holding capacity. Akin (16) determined that firmness values of strained yogurt were between 64 and 68 g. Hashim et al.

Table 2. Color values of dietary fibrous strained yogurt*

Parameter	Day	BF ₁	BF ₂	BF ₃	AF ₁	AF ₂	AF ₃	WF ₁	WF ₂	WF ₃
		Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD
<i>L</i>	1	99.6±3.0 ^{aA}	109.4±0.8 ^{aA}	99.7±3.1 ^{aA}	77.0±4.4 ^{bB}	81.1±4 ^{bB}	74.4±5.8 ^{bB}	109.1±4.5 ^{aA}	100.5±6.8 ^{aA}	103.5±1.4 ^{aA}
	7	95.4±3.1 ^{aA}	94.2±5.7 ^{aA}	93.7±5.1 ^{aA}	82.5±1.7 ^{bB}	72.9±3 ^{bB}	67.8±0.9 ^{bB}	106.4±4.9 ^{aA}	95.3±2.7 ^{aA}	100.0±9.4 ^{aA}
	14	88.5±1.7 ^{aA}	98.2±2.1 ^{aA}	97.0±7.7 ^{aA}	98.1±7.6 ^{bB}	75.4±1 ^{bB}	67.8±1.5 ^{bB}	95.8±2.1 ^{aA}	94.5±3.8 ^{aA}	101.7±9.7 ^{aA}
	21	98.1±8.3 ^{aA}	101.3±1.0 ^{aA}	100.0±3.9 ^{aA}	76.8±5.1 ^{bB}	73.4±1 ^{bB}	68.2±2.4 ^{bB}	106.2±0.9 ^{aA}	100.2±9.7 ^{aA}	92.6±5.1 ^{aA}
<i>a</i> (-)	1	7.4±1.2 ^{aA}	8.3±0.2 ^{aA}	7.9±0.2 ^{aA}	0.9±0.7 ^{bB}	2.4±0.2 ^{bB}	2.6±0.5 ^{bB}	8.9±2.0 ^{aA}	7.6±0.1 ^{aA}	7.2±0.6 ^{aA}
	7	7.5±0.6 ^{aA}	7.7±0.3 ^{aA}	7.7±0.2 ^{aA}	1.8±1.4 ^{bB}	2.0±0.1 ^{bB}	2.5±0.7 ^{bB}	4.6±3.9 ^{aA}	7.4±0.1 ^{aA}	7.0±0.4 ^{aA}
	14	7.4±0.4 ^{aA}	7.6±0.3 ^{aA}	7.7±0.2 ^{aA}	1.7±2.0 ^{bB}	1.9±0.9 ^{bB}	2.8±1.2 ^{bB}	7.0±0.1 ^{aA}	7.2±0.2 ^{aA}	7.1±0.5 ^{aA}
	21	7.7±0.6 ^{aA}	7.7±0.3 ^{aA}	7.8±0.1 ^{aA}	0.4±0.2 ^{bB}	1.6±0.7 ^{bB}	2.5±0.4 ^{bB}	7.5±0.4 ^{aA}	7.2±0.6 ^{aA}	6.8±0.1 ^{aA}
<i>b</i>	1	16.9±0.3 ^{aA}	20.0±2.8 ^{aA}	20.3±6.4 ^{aA}	18.3±1.1 ^{aA}	23.7±2.4 ^{aA}	23.3±0.4 ^{aA}	17.0±1.5 ^{aA}	18.9±5.2 ^{aA}	17.3±2.0 ^{aA}
	7	15.2±0.5 ^{aA}	19.3±1.3 ^{aA}	19.5±7.1 ^{aA}	19.4±0.2 ^{aA}	22.5±1.9 ^{aA}	21.8±1.0 ^{aA}	17.9±3.3 ^{aA}	18.4±3.1 ^{aA}	17.3±0.2 ^{aA}
	14	15.9±1.8 ^{aA}	18.6±3.6 ^{aA}	19.4±7.1 ^{aA}	20.7±1.2 ^{bB}	22.0±3.2 ^{aA}	22.3±2.6 ^{aA}	15.7±0.3 ^{aA}	18.0±3.9 ^{aA}	18.0±0.6 ^{aA}
	21	16.2±0.4 ^{aA}	18.2±3.7 ^{aA}	20.2±7.3 ^{aA}	19.9±0.3 ^{bB}	21.6±1.5 ^{aA}	21.8±1.7 ^{aA}	17.5±0.2 ^{aA}	18.8±2.7 ^{aA}	16.5±0.7 ^{aA}

*BF₁, BF₂ and BF₃ = 1%; 2% and 3% bamboo fibrous strained yogurt respectively; AF₁, AF₂ and AF₃ = 1%; 2% and 3% apple fibrous strained yogurt respectively; WF₁, WF₂ and WF₃ = 1%; 2% and 3% wheat fibrous strained yogurt respectively; SD=Standard deviation; Avr.=Average; ^{A,B,C(-), a,b,c(-)} The difference between averages having the same or common letters is statistically significant (*P*<0.05); Analyses are the averages of production which had two replications and made as parallel

(13) determined that firmness values of yogurt fortified with date fiber ranged from 36.5 to 57.0 g. The storage time affected ($P<0.05$) consistency values of WF₁. The most variable parameter was determined to be consistency during storage time. Dietary fiber type was effective on consistency values ($P<0.05$). The storage was effective ($P<0.05$) on cohesiveness values of AF₁. Dietary fiber types were effective ($P<0.05$) on cohesiveness values. The cohesiveness values of AF₁ were lower than these of other samples except for the 1st day of storage ($P<0.05$). Hashim et al. (13) reported that cohesiveness values of yogurt fortified with date fiber changed between 20.9 and 30.4 g. It was observed that cohesiveness was the least varied parameter during storage. Storage time was ineffective on cohesiveness values ($P>0.05$). Dietary fiber types were effective on viscosity/consistency index values ($P<0.05$). The storage wasn't effective ($P>0.05$) on viscosity/consistency index values of all samples. Variations in cohesiveness, consistency and viscosity/consistency index values were found not to follow any particular pattern during storage which can be explained by physical, biochemical and chemical reactions occurring during the storage.

Sensory evaluation is widely used for food quality control and product development. Table 4 presents sensory evaluation scores of strained yogurt samples. Appearance, consistency (with spoon and with mouth), odor and flavor were determined. Appearance scores of BF₁, BF₂, BF₃, AF₁, AF₂, AF₃, WF₁, WF₂ and WF₃ were respectively 4.34, 4.33, 4.27, 2.46, 1.62, 1.38, 4.39, 4.27, 3.75 on 1st day of storage and these scores changed to 3.4, 4.4, 3.78, 2.35, 2.18, 1.87, 4.05, 3.71, 3.6 on 21st day of storage. WF₁ had the highest appearance score (4.39) and AF₃ had the lowest with 1.38 on 1st day of storage. At the end of storage WF₁ had the highest (4.05) and AF₃ had the lowest (1.87). Appearance scores of BF₁, BF₃, AF₁, WF₁, WF₂ and WF₃ decreased with increased storage time. Dietary fiber types were effective ($P<0.05$) on appearance scores. Appearance scores of AF₁, AF₂ and AF₃ were significantly lower than those of other samples ($P<0.05$). Dietary fiber types were effective ($P<0.05$) on consistency (with spoon) scores. Consistency (with spoon) scores of AF₃ were significantly lower than those of other samples ($P<0.05$). Consistency (with spoon) scores of BF₂, BF₃, WF₁, WF₂ and WF₃ were increased and scores of AF₂ were decreased at the end of storage. Generally,

Table 3. Texture values of dietary fibrous strained yogurt*

Parameter	Day	BF ₁	BF ₂	BF ₃	AF ₁	AF ₂	AF ₃	WF ₁	WF ₂	WF ₃
		Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD
Firmness (g)	1	1515±8 ^{aA}	945±1.2 ^{aA}	925±4.3 ^{aA}	670±2.1 ^{aA}	655±65.9 ^{aA}	619±4.1 ^{aA}	1374±4.7 ^{aA}	1525±5.8 ^{aA}	1475±6.7 ^{aA}
	7	1975±1.7 ^{aA}	1389±4.0 ^{aA}	1806±3.9 ^{aA}	981±5.2 ^{aA}	504±37.2 ^{aA}	917±5.7 ^{aA}	2086±5.5 ^{aA}	1783±5.5 ^{aA}	1403±6.4 ^{aA}
	14	2096±1.1 ^{aA}	1321±1.9 ^{aA}	1873±4.4 ^{aA}	1717±4.2 ^{aA}	641±57.0 ^{aA}	1401±3.4 ^{aA}	1944±5.3 ^{aA}	2227±6.7 ^{aA}	1608±2.6 ^{aA}
	21	2154±5.8 ^{aA}	1371±2.7 ^{aA}	2163±4.8 ^{aA}	1072±1.9 ^{aA}	724±52.2 ^{aA}	1485±7.0 ^{aA}	2768±2.4 ^{bB}	1974±7.1 ^{aA}	1213±4.0 ^{aA}
Consistency (gs)	1	33196±6.9 ^{aA}	20447±1.1 ^{aA}	20296±1.4 ^{aA}	16999±4.9 ^{aA}	16217±12.5 ^{aA}	15426±8.6 ^{aA}	31845±1.2 ^{aA}	34737±7.4 ^{aA}	34142±1.9 ^{aA}
	7	40716±6.7 ^{aA}	31740±1.2 ^{aA}	43032±1.5 ^{aA}	24165±4.4 ^{aA}	12888±94.4 ^{aA}	22082±3.7 ^{aA}	39386±7.5 ^{aA}	42404±1.5 ^{aA}	31936±5.7 ^{aA}
	14	38123±5.7 ^{aA}	30351±5.5 ^{aA}	39419±2.8 ^{aA}	31690±9.8 ^{aA}	16055±40.9 ^{aA}	33342±2.6 ^{aA}	42228±1.4 ^{aA}	47329±4.7 ^{aA}	38436±1.4 ^{aA}
	21	44423±9.3 ^{aA}	30938±3.5 ^{aA}	35817±9.4 ^{aA}	33345±1.3 ^{aA}	17489±27.7 ^{aA}	33541±1.4 ^{aA}	57393±7.3 ^{bB}	39562±6.6 ^{aA}	38679±5.2 ^{aA}
Cohesiveness (g)	1	1162±3.4 ^{aA}	944±7.9 ^{aA}	976±3.7 ^{aA}	815±2.9 ^{bB}	720±50.7 ^{aA}	623±3.7 ^{aA}	1314±5.4 ^{aA}	926±5.4 ^{aA}	1007±1.7 ^{aA}
	7	1135±7.2 ^{aA}	1233±2.5 ^{aA}	1498±9.6 ^{aA}	1049±6.5 ^{aA}	574±47.2 ^{aA}	876±5.7 ^{aA}	1294±5.2 ^{aA}	1746±5.9 ^{aA}	1135±2.7 ^{aA}
	14	1043±1.8 ^{aA}	1222±5.5 ^{aA}	1635±3.0 ^{aA}	1737±7.2 ^{aA}	655±59.9 ^{aA}	1399±5.6 ^{aA}	1305±7.6 ^{aA}	1356±6.3 ^{aA}	1355±1.3 ^{aA}
	21	1195±3.3 ^{aA}	1110±6.8 ^{aA}	1819±3.2 ^{aA}	992±2.9 ^{aA}	830±65.2 ^{aA}	1432±9.7 ^{aA}	1644±3.1 ^{aA}	1280±1.3 ^{aA}	1425±8.4 ^{aA}
Index of viscosity/ consistency (gs)	1	1853±6.7 ^{aA}	1194±3.4 ^{aA}	1626±6.9 ^{aA}	1516±1.7 ^{aA}	1317±19.5 ^{aA}	1220±7.5 ^{aA}	2088±3.9 ^{aA}	1963±1.0 ^{bB}	1141±4.9 ^{aA}
	7	1957±4.6 ^{aA}	1675±7.5 ^{aA}	1900±3.3 ^{aA}	1556±7.8 ^{aA}	1273±11.4 ^{aA}	1775±3.3 ^{aA}	2316±7.2 ^{aA}	1403±7.5 ^{aA}	1952±4.4 ^{aA}
	14	1838±1.3 ^{aA}	2343±4.6 ^{aA}	1409±7.4 ^{aA}	2262±5.3 ^{aA}	1284±11.5 ^{aA}	2460±3.8 ^{aA}	1608±7.2 ^{aA}	1353±7.4 ^{aA}	2191±2.5 ^{aA}
	21	1569±7.4 ^{aA}	1684±1.3 ^{aA}	1876±8.9 ^{aA}	1931±4.4 ^{aA}	1783±46.8 ^{aA}	3055±1.8 ^{aA}	1948±5.0 ^{aA}	1838±7.3 ^{aA}	2813±7.4 ^{aA}

*BF₁, BF₂ and BF₃ = 1%; 2% and 3% bamboo fibrous strained yogurt respectively ; AF₁, AF₂ and AF₃ = 1%; 2% and 3% apple fibrous strained yogurt respectively ; WF₁, WF₂ and WF₃ = 1%; 2% and 3% wheat fibrous strained yogurt respectively ; SD=Standard deviation ; Avr.=Average ; ^{A, B, C (i), a, b, c (-)} The difference between averages having the same or common letters is statistically significant ($P<0.05$); Analyses are the averages of production which had two replications and made as parallel.

consistency (with mouth) scores of samples decreased, but scores of WF₁ and WF₃ samples increased during storage. Dietary fiber types did not affect ($P>0.05$) consistency (with mouth) scores of samples. Odor scores of BF₃, BF₁ and WF₂ were increased at the end of storage. Dietary fiber types were effective on odor scores ($P<0.05$). Odor scores of AF₁ and AF₂ were lower ($P<0.05$) than these of other samples on the 7th, 14th and 21st day of storage. The highest odor scores of WF₂ (4.06) were observed on the first day but WF₃ sample reached the highest odor score on 21st day. Odor scores of BF₂, WF₁ and WF₂ samples were determined notably close to each other at the end of storage. Storage affected ($P<0.05$) odor scores of AF₂. During storage, flavor scores of BF₁, BF₃, AF₁, AF₂, AF₃, WF₁, WF₂ and WF₃ were decreased ($P<0.05$). Dietary fiber types had effect on flavor scores of all samples ($P<0.05$). WF₁ had the highest flavor scores on the first and last days. Flavor scores of AF₂ were lower than those of other samples ($P<0.05$). The storage wasn't effective on appearance, consistency (with spoon), consistency (with mouth) and flavor scores ($P>0.05$).

Fernandez-Garcia et al. (17) reported that fiber addition to unsweetened yogurt improved the body and texture and decreased the quality overall flavor. Garcia-Perez et al. (14) determined that flavor scores were changed between 4.58 and 5.31 and odor scores were changed between 2.76 and 4.38 on yogurt fortified with orange fiber. Hashim et al. (13) stated that flavor scores and appearance scores of yogurt fortified with date fiber were ranged from 3.3 to 6.1 and 6 to 6.4 respectively.

In our study, sensory scores were found to be low for apple fibrous strained yogurts. But sensory results of bamboo and wheat fibrous strained yogurts were high and acceptable ratings. Based on sensory scores, WF₁ was the best sample.

CONCLUSION

When apple fiber was used in strained yogurt, significant differences in texture, color and sensory values were observed. Apple fibrous strained yogurts weren't preferred by panelists

Table 4. Sensory evaluation scores of dietary fibrous strained yogurt*

Parameter	Day	BF ₁	BF ₂	BF ₃	AF ₁	AF ₂	AF ₃	WF ₁	WF ₂	WF ₃
		Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD	Avr.±SD
Appearance	1	4.34±0.8 ^{aA}	4.33±0.7 ^{aA}	4.27±0.3 ^{aA}	2.46±0.5 ^{bB}	1.62±0.1 ^{bB}	1.38±0.8 ^{aA}	4.39±0.1 ^{aA}	4.27±0.2 ^{aA}	3.75±0.2 ^{aA}
	7	4.27±0.1 ^{aA}	4.52±0.6 ^{aA}	4.10±0.6 ^{aA}	2.32±0.2 ^{bB}	1.67±0.2 ^{bB}	2.05±0.7 ^{aA}	4.15±0.2 ^{aA}	4.05±0.7 ^{aA}	3.83±0.1 ^{aA}
	14	3.81±0.2 ^{aA}	3.71±0.1 ^{aA}	3.68±0.4 ^{aA}	2.07±0.1 ^{bB}	1.75±0.6 ^{bB}	1.80±0.1 ^{aA}	4.12±0.2 ^{aA}	3.64±0.2 ^{aA}	4.12±0.5 ^{aA}
	21	3.40±0.2 ^{aA}	4.40±0.1 ^{aA}	3.78±0.7 ^{aA}	2.35±0.5 ^{bB}	2.18±0.8 ^{bB}	1.87±0.2 ^{aA}	4.05±0.3 ^{aA}	3.71±0.3 ^{aA}	3.60±0.3 ^{aA}
Consistency (with spoon)	1	3.95±0.7 ^{aA}	3.78±0.1 ^{aA}	3.61±0.1 ^{aA}	2.83±1.0 ^{aA}	2.40±0.4 ^{aA}	1.72±0.3 ^{bB}	3.93±0.3 ^{aA}	3.67±0.1 ^{aA}	3.37±0.3 ^{aA}
	7	3.19±0.1 ^{aA}	3.65±0.7 ^{aA}	3.17±0.3 ^{aA}	3.07±0.9 ^{aA}	2.95±0.3 ^{aA}	2.47±0.1 ^{bB}	3.95±0.7 ^{aA}	3.68±0.3 ^{aA}	3.46±0.1 ^{aA}
	14	3.41±0.6 ^{aA}	3.60±0.2 ^{aA}	3.12±0.3 ^{aA}	3.14±0.2 ^{aA}	2.50±0.3 ^{aA}	1.98±0.1 ^{bB}	3.43±0.3 ^{aA}	2.98±0.3 ^{aA}	2.92±0.3 ^{aA}
	21	3.60±0.8 ^{aA}	3.90±0.4 ^{aA}	3.77±0.6 ^{aA}	3.15±0.5 ^{aA}	2.19±0.2 ^{aA}	1.80±0.2 ^{bB}	3.72±0.2 ^{aA}	3.50±0.7 ^{aA}	3.76±0.5 ^{aA}
Consistency (with mouth)	1	3.73±0.2 ^{aA}	3.95±0.1 ^{aA}	3.77±0.3 ^{aA}	3.14±0.9 ^{aA}	2.71±0.4 ^{aA}	2.46±0.1 ^{aA}	3.71±0.4 ^{aA}	3.82±0.2 ^{aA}	3.77±0.3 ^{aA}
	7	3.74±0.6 ^{aA}	3.46±0.1 ^{aA}	3.80±0.4 ^{aA}	3.05±0.7 ^{aA}	2.85±0.2 ^{aA}	2.32±0.1 ^{aA}	3.76±0.5 ^{aA}	3.61±0.3 ^{aA}	3.85±0.2 ^{aA}
	14	3.35±0.2 ^{aA}	3.72±0.3 ^{aA}	3.30±0.5 ^{aA}	3.14±0.2 ^{aA}	2.78±0.5 ^{aA}	1.71±0.2 ^{aA}	3.65±0.4 ^{aA}	3.20±0.3 ^{aA}	3.65±0.7 ^{aA}
	21	3.30±0.4 ^{aA}	3.66±0.1 ^{aA}	3.35±0.6 ^{aA}	3.05±0.6 ^{aA}	2.65±0.3 ^{aA}	1.93±0.8 ^{aA}	3.91±0.3 ^{aA}	3.36±0.2 ^{aA}	3.90±0.4 ^{aA}
Odor	1	3.90±0.4 ^{aA}	4.05±0.1 ^{aA}	3.55±0.4 ^{aA}	2.82±1.0 ^{aA}	2.76±0.7 ^{aA}	1.63±0.5 ^{aA}	3.83±0.2 ^{aA}	4.06±0.1 ^{aA}	3.97±0.6 ^{aA}
	7	4.20±0.3 ^{aA}	3.81±0.5 ^{ab}	3.55±0.3 ^{aA}	2.77±0.8 ^{bB}	2.63±0.1 ^{bB}	2.57±0.1 ^{aA}	4.00±0.3 ^{aA}	3.83±0.2 ^{aA}	3.44±0.3 ^{aA}
	14	3.55±0.7 ^{aA}	4.18±0.8 ^{aA}	3.12±0.3 ^{aA}	2.69±0.6 ^{bB}	2.36±0.7 ^{bB}	2.27±0.1 ^{aA}	4.05±0.7 ^{aA}	3.81±0.8 ^{aA}	4.12±0.5 ^{aA}
	21	3.62±0.3 ^{aA}	3.95±0.7 ^{aA}	3.44±0.5 ^{aA}	2.60±0.1 ^{bB}	2.25±0.5 ^{bB}	1.80±0.2 ^{aA}	3.98±0.4 ^{aA}	3.96±0.4 ^{aA}	3.13±0.2 ^{aA}
Flavor	1	3.97±0.2 ^{aA}	3.78±0.8 ^{aA}	3.67±0.3 ^{aA}	2.88±1.0 ^{aA}	2.37±0.6 ^{bB}	1.66±0.1 ^{aA}	4.00±0.2 ^{aA}	3.90±0.3 ^{aA}	3.35±0.6 ^{aA}
	7	3.75±0.6 ^{aA}	3.65±0.7 ^{aA}	3.27±0.4 ^{aA}	2.62±0.3 ^{aA}	2.81±0.1 ^{bB}	2.30±0.3 ^{aA}	4.25±0.4 ^{aA}	3.83±0.1 ^{aA}	3.29±0.7 ^{aA}
	14	3.41±0.6 ^{aA}	3.95±0.6 ^{aA}	3.12±0.3 ^{aA}	2.85±0.2 ^{aA}	2.15±0.7 ^{bB}	2.06±0.8 ^{aA}	4.01±0.3 ^{aA}	3.16±0.2 ^{aA}	3.90±0.7 ^{aA}
	21	2.80±0.6 ^{aA}	3.86±0.2 ^{aA}	2.98±0.6 ^{aA}	2.35±1.0 ^{aA}	2.00±0.1 ^{bB}	1.80±0.2 ^{aA}	4.04±0.5 ^{aA}	3.71±0.3 ^{aA}	3.17±0.3 ^{aA}

*BF₁, BF₂ and BF₃ = 1%; 2% and 3% bamboo fibrous strained yogurt respectively ; AF₁, AF₂ and AF₃ = 1%; 2% and 3% apple fibrous strained yogurt respectively ; WF₁, WF₂ and WF₃ = 1%; 2% and 3% wheat fibrous strained yogurt respectively ; SD=Standard deviation; Avr.=Average ; ^{A, B, C (i), a, b, c (-)} The difference between averages having the same or common letters is statistically significant ($P<0.05$); Analyses are the averages of production which had two replications and made as parallel

because of their ragged structure, dominant apple taste and strong odor. No difference between wheat and bamboo fiber addition was detected by sensory panel. Panelists found bamboo and wheat fiber strained yogurts acceptable.

During storage, the most variable textural parameter was consistency index in bamboo, wheat and apple fibrous strained yogurt. *L*, *a* and *b* values of apple fibrous strained yogurts were determined to be different in comparison with bamboo and wheat fibrous strained yogurts due to the structure of apple fiber.

KAYNAKLAR

1. Tamime Y, Robinson RK. 1985. The nutrient value of yogurt. *Yogurt Science and Technology*, Pergamon Press, New York, 365-373.
2. Tamime AY, Kalab M, Davies G, Mahdi HA. 1991. Microstructure and firmness of labneh (high solid yogurt) made from cow's, goat's and sheep's milks by a traditional method or by ultrafiltration. *Food Struct*, 10, 37-44.
3. Tamime AY, Robinson RK. 1988. Fermented milks and their future trends. Part II. Technological aspects. *J Dairy Res*, 55, 281-307.
4. Gordon DT. 1999. Defining dietary fiber. *Cereal Foods World*. 44(5), 336.
5. Cho S, Dreher M. 2001. *Handbook of dietary fiber*. CRC, New York, 082-4789-601.
6. Nilüfer D, Boyacıoğlu D. 2003. Süt ürünlerinde diyet liflerinin ingredyen olarak kullanımı. Süt Endüstrisinde Yeni Eğilimler Sempozyumu, 22-23 Mayıs, İzmir, Türkiye, 58-65.
7. Staffolo MD, Bertola N, Martino M, Bevilacqua YA. 2004. Influence of dietary fiber addition on sensory and rheological properties of yogurt. *Int Dairy J*, 14 (3), 263-268.
8. Fernandez-Garcia E, McGregor JU. 1997. Fortification of sweetened plain yogurt with insoluble dietary fiber. *Z Lebensm Unters Forsch A*, 204, 433-437.
9. Sendra E, Kuri V, Fernandez-Lopez J, Sayas-Barbera E, Navarro C, Perez-Alvarez JA. 2010. Viscoelastic properties of orange fiber enriched yogurt as a function of fiber dose, size and thermal treatment. *LWT Food Sci Technol*, 43, 708-714.
10. Awad R A, Abdel-Hamid LB, El-Shabrawy SA, Singh RK. 2002. Texture and microstructure of block type processed cheese with formulated emulsifying salt mixtures. *LWT Food Sci Technol*, 35, 54-61.
11. Anonymous, 2001. Yoğurt Standardı. TS 1330. Türk Standartları Enstitüsü, Ankara.
12. SAS. 2001. SAS/STAT User Guide (8.02). SAS Institute Inc., Cary, NC, USA.
13. Hashim IB, Khalil AH, Afifi HS. 2009. Quality characteristics and consumer acceptance of yogurt fortified with date fiber. *J Dairy Sci*, 92(11), 5403-5407.
14. Garcia-Perez FJ, Lario Y, Fernandez-Lopez J, Sayas E, Perez-Alvarez JA, Sendra E. 2005. Effect of orange fiber addition on yogurt color during fermentation and cold storage. *Color Res Appl*, 30, 457-463.
15. Sanz T, Salvador A, Jimenez S, Fiszman S. 2008. Yogurt enrichment with functional asparagus fibre: Effect of fibre extraction method on rheological properties, colour, and sensory acceptance. *Eur Food Res Technol*, 227(5), 1515-1521.
16. Akin N. 1999. İnek ve koyun sütünden üretilen bazı konsantre fermente süt ürünlerinin sertliği ve duyuusal özellikleri. *Türk J Vet Anim Sci*, 23, 583-590.
17. Fernandez-Garcia E, McGregor JU, Traylor S. 1998. The addition of oat fiber and natural alternative sweeteners in the manufacture of plain yogurt. *J Dairy Sci*, 81, 655-663.