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Effect of Lentil Flour Addition on Physical and Sensory Properties of Stirred Yoghurt

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ABSTRACT

The effect of lentil flour addition on the physical and sensory properties of stirred yoghurt was determined in this study. The firmness, apparent viscosity, consistency index, thixotropy and water holding capacity of yoghurts increased with an increase in the ratio of lentil flour in the formulae; however the flow behavior index and sensory scores of the stirred yoghurt samples decreased. Yoghurts with red lentil flour had lower flow behavior index and higher firmness, apparent viscosity, consistency index, thixotropy and water holding capacity than those with either green or yellow lentil flour.

Key Words: Lentil, Yoghurt, Physical properties, Sensory properties

Pıhtısı Parçalanmış Yoğurdun Fiziksel ve Duyusal Özellikleri Üzerine Mercimek Unu İlavesinin Etkisi

ÖZET

Bu çalışmanın amacı, mercimek unu tipi ve miktarının, pıhtısı parçalanmış yoğurdun fiziksel ve duyusal özelliklerini nasıl etkilediğini araştırmaktır. Mercimek unu oranı arttıkça yoğurdun sertlik, görünür viskozite, kıvam katsayısı, tiksotropi ve su tutma kapasitesi değerleri artmış, ancak akış davranış indeksi ve duyusal değerlendirme puanları azalmıştır. Kırmızı mercimek unu kullanılarak üretilen yoğurt, yeşil veya sarı mercimek unu ile üretilen yoğurda göre daha düşük akış davranış indeksine ve daha yüksek sertlik, görünür viskozite, kıvam katsayısı, tiksotropi ve su tutma kapasitesi değerlerine sahiptir.

Anahtar Kelimeler: Mercimek, Yoğurt, Fiziksel özellikler, Duyusal özellikler

INTRODUCTION

Yoghurt is a very popular dairy product all around the world mainly due to its nutritional value and healthy aspects [1, 2]. The increasing popularity of yoghurt can be attributed to consumer preference for a healthier lifestyle that includes more nutritious foods [3]. Besides health-promoting and nutritional aspects of yoghurt, its physical and sensory properties play important quality and consumer acceptance [4].

Fruits, cereals, nuts, chocolate, marmalade, honey, and various other substances were added to yoghurt milk for different nutritional and/or technical applications in yoghurt manufacture [5]. Incorporating lentil as lentil flour can enhance nutritional value of yoghurt and improve yoghurt quality [6]. Lentil is one of the oldest crops cultivated by humans and is consumed in Europe, the Middle East, Africa and South Asia [7]. Lentil is a valuable source of essential dietary components and trace elements as well as an important protein and carbohydrate source [8]. However, up to date, very little

has been done with lentil flour in yoghurt fortification. Furthermore, the effect of flour from lentil varieties on yoghurt quality has not been studied in detail. The objective of this research is to study the effect of the addition level of flour from lentil varieties on the physical and sensory properties of stirred yoghurt.

MATERIALS and METHODS

Milk Processing and Yoghurt Preparation

Low-heat skim milk powder (95.4% total solids, 35.2% protein, 1.1% fat; Izi Dairy Inc., Konya, Turkey) was reconstituted in deionised water, giving a final concentration of 12% dry matter, and then, it was kept at 4°C for 2h to allow the powder to become fully hydrated. Then, red, green and yellow lentil flours (Arom Tech Com., Izmir, Turkey) were added to skim milk heated at 55°C at levels of 1, 2, or 3% (w/w). The mixes were homogenized using an Ultra-Turrax blender (IKA T25, IKA, Staufen, Germany) at 9500 rpm until all ingredients were dissolved. For the yoghurt preparation, low-heat skim milk powder was added to the mixes to give the final total solids content of 15%. Skim milk with 15% total solids not containing any flour was used as the control. The standardized yoghurt milk was heated at 90°C for 5 min and, then, subsequently cooled to 45°C. After cooling, 0.1 g/L of frozen pellets (starter culture DI-PROX TY 973, Bioprox, France), used for the manufacture of 5 L of yoghurt for each treatment applied, were added according to the manufacture's reference. The inoculated milk was incubated at 42°C until the pH decreased to 4.60. Fermentation was stopped by rapid cooling to 4°C in an ice-water bath. Immediately after cooling, the yoghurt samples were manually stirred with a stainless-steel bored disk by up and down movements for 1 min. After setting the stirred products into 200 mL cups, they were stored at 4°C for 30 days. The physical and sensory characteristics of the samples were analyzed. All experiments were repeated two times.

Physicochemical Measurements

Proximate analysis of lentil flours including moisture, protein, fat, crude fiber and ash measurement were done using standard AOAC methods [9]. The firmness of the stirred yoghurt was determined by a TA-XT Plus Texture Analyzer (Stable Micro System, Godalming, UK) in accordance with the method of Sodini et al. [10]. Apparent viscosity was measured using a Brookfield DVII+Pro viscosimeter (Brookfield, Middleboro, MA, USA) with a Helipath (T spindle, type D) following the method described by Rasmussen et al. [11]. Rheological properties of the first day yoghurt samples were measured on a Brookfield R/S plus rheometer (Brookfield, Middleboro, MA, USA) using double gap concentric cylinder geometry (DG 3) with a Brookfield temperature control (TC-502) at constant temperature of 10°C. The sample was sheared by linearly increasing shear rate from 0.5 to 300 s^{-1} for 5 min (upward curve) and reducing back to 0.5 s^{-1} in the next 5 min (downward curve). Obtained shear rate-stress data were fitted by the power law model using Rheo3000 software (Rheotec Messtechnik GmbH, Berlin, Germany) to determine the rheological properties of the samples. Water holding capacity of the day 1 samples was determined in accordance with the method from Michael et al. [12].

Sensory Analysis

Sensory analysis was conducted by a group of seven trained panelists (staff and graduate students from the Department of Food Engineering, Akdeniz University). The panelists were asked to judge the product using a modified methodology of Bodyfelt et al. [13].

Statistical analysis

All statistical calculations were analyzed using SAS Statistical Software (released for Windows, SAS Institute Inc., Cary, NC, USA). Duncan's multiple range test was conducted to detect differences among the treatment means.

RESULTS and DISCUSSION

The proximate compositions of the lentil flours are given in Table 1. Yellow lentil flour was characterized with its higher content of moisture, while red lentil flour was higher in protein and fat, and green lentil flour was higher in crude fiber. Ash contents of the lentil flours were similar.

Table 1. Proximate composition of lentil flours (g/100g)[1]

Lentil Flour Type	Moisture	Protein	Fat	Crude Fiber	Ash
Green	7.2±0.2	27.1±0.0	0.9±0.0	4.2±0.2	2.5±0.0
Red	6.2±0.0	30.5±0.1	1.7±0.0	1.3±0.1	2.4±0.0
Yellow	7.8±0.0	29.6±0.1	1.3±0.0	1.3±0.1	2.6±0.0

[1]: Values are means ± standard deviation

Rheological parameters of the yoghurt samples described by power law model are shown in Table 2. Determination coefficient (R^2) for the model was above 0.90 showing satisfactory fit of flow curves. The consistency indices and thixotropy values of the day 1 yoghurt samples ranged from 9.2 to 24.1 $Pa.s^n$ and from 1876 to 3164 $Pa.s^{-1}$, respectively. The consistency index (K) and thixotropy of the samples increased significantly ($P<0.01$) when the ratio of lentil flours was increased. Yoghurt containing 3% red lentil flour had the highest consistency index, while the lowest consistency index was exhibited by yoghurts containing 1% lentil flour, 2% green lentil flour and the control sample. At level of 2 or 3% lentil flour supplementation, the consistency index of yoghurt containing red lentil flour was significantly ($P<0.05$) higher than that of yoghurt containing yellow or

green lentil flour. The yoghurt sample containing red lentil flour at level of 3% had the highest thixotropy, with the difference in the thixotropy of samples containing 3% lentil flour not being significant (P>*0.05*). The control sample had the lowest thixotropy, followed by yoghurts contained 1% yellow lentil flour, 1% green lentil flour and 2% green lentil flour, respectively, which were significantly lower (P<0.05) than the sample containing 1% red lentil flour. Flow behavior indices varied from 0.26 to 0.43. The flow behavior index (*n*) decreased significantly (P<0.01) when the amount of lentil flours had been increased. The flow behavior index of the yoghurt containing 3% red lentil flour was significantly lower than all other samples. At level of 2 or 3% lentil flour supplementation, the sample containing red lentil flour had the lowest flow behavior index, followed by yoghurts contained yellow lentil flour and green lentil flour, respectively. However, the highest flow behavior index was exhibited by yoghurts containing 1% lentil flour, 2% green lentil flour and the control sample.

Table 2. Rheological properties of yoghurts containing different amounts of flour from lentil varieties according to the power law model[1]

Lentil Flour Type	Ratio (%)	Thixotropy ($Pa.s^{-1}$)	Consistency index (K, $Pa.s^n$)	Flow behavior index (n)	R^2
Control	0	1876±64f	9.3±0.6e	0.40±0.01ab	0.95
Green	1	2178±147def	9.2±0.5e	0.43±0.00a	0.95
	2	2300±155def	10.6±1.1de	0.40±0.02ab	0.95
	3	2790±88abc	13.3±1.2cd	0.37±0.01bc	0.94
Red	1	2402±359cde	9.4±1.2e	0.42±0.01a	0.94
	2	2887±564ab	19.8±2.8b	0.29±0.04d	0.94
	3	3164±258a	24.1±5.1a	0.26±0.04e	0.93
Yellow	1	2010±22ef	9.6±0.3e	0.42±0.01a	0.96
	2	2509±24bcd	14.0±0.2cd	0.36±0.02c	0.95
	3	3141±166a	16.5±1.9bc	0.33±0.01d	0.92

[1]: Values are means ± standard deviation, and different letters within a column indicate significant differences according to the Duncan's multiple range test (P<0.05)

The firmness and apparent viscosity values of all yoghurts with or without lentil flour are given in Table 3. The firmness increased as the level of lentil flour was increased. The firmness of yoghurts containing lentil flours was higher than that of the control yoghurt. The yoghurt containing 3% red lentil flour was the most firm, approximately 2 times firmer than that of the control yoghurt during storage. The results showed that the yoghurt contained red lentil flour had the highest firmness at an equal concentration, followed by yoghurts contained yellow lentil flour and green lentil flour, respectively. During cold storage, the firmness of the yoghurts increased significantly (P<0.05). According to the results, yoghurts with lentil flour provided for a higher apparent viscosity than that measured in the control yoghurt. As the ratio of lentil flour was increased, the apparent viscosity values increased significantly (P<0.05) for all the yoghurt samples. The highest apparent viscosity value was exhibited by yoghurt containing 3% red lentil flour. The apparent viscosity values of the samples increased significantly (P<0.05) as the storage time was increased.

Table 3. Firmness and apparent viscosity values of yoghurts containing different ratios of flour from lentil varieties during storage[1]

Yoghurt Type		Firmness (g)			Apparent viscosity (Pa.s)		
Storage time (day)		1	15	30	1	15	30
Control (No lentil flour)		47.4±0.5	51.3±1.5	57.6±1.4	30.4±1.1	46.4±2.3	50.4±2.4
Yoghurt with green lentil flour	1%	47.7±1.1	55.5±2.0	62.6±0.9	31.3±1.0	51.4±3.7	67.0±2.0
	2%	52.4±0.2	66.3±1.2	72.8±1.3	45.0±2.0	56.0±1.1	82.6±0.8
	3%	58.8±0.1	74.5±2.0	84.5±2.7	51.4±0.3	71.0±2.0	90.2±0.3
Yoghurt with red lentil flour	1%	49.4±0.0	65.0±0.2	75.3±2.5	46.2±3.1	67.0±2.0	79.4±2.5
	2%	75.4±0.3	91.3±0.9	107.5±1.9	53.8±2.6	83.8±3.1	103.2±2.8
	3%	85.5±0.1	122.7±0.8	129.5±1.4	76.8±3.3	111.2±2.8	129.8±3.7
Yoghurt with yellow lentil flour	1%	48.4±0.4	57.4±0.5	63.0±0.4	35.6±1.7	51.4±3.7	56.0±2.8
	2%	60.8±0.9	74.7±0.5	82.2±1.7	48.8±1.7	68.0±2.9	76.8±0.4
	3%	71.2±0.4	84.6±3.1	95.2±2.5	61.6±1.9	76.0±2.8	91.0±2.8

[1]: Values are means ± standard deviation.

The water holding capacity values of the day 1 yoghurt samples are presented in Figure 1. Lentil flour increased water holding capacity of the yoghurt samples. This result was similar to that reported for yoghurt by Zare et al. [6]. The water holding capacity of yoghurts containing lentil flours was higher than that of the control yoghurt. The highest water holding capacity (42.1%) was observed in yoghurt containing 3% red lentil flour, presenting increase of 53% in relation to the control sample. At level of 2 or 3% lentil flour supplementation, the sample containing red lentil flour had the highest water holding capacity, followed by yoghurts contained green lentil flour and yellow lentil flour, respectively. There were insignificant differences (P>0.05) among the

water holding capacity values between the yoghurts containing 1% green lentil flour and red lentil flour, which were significantly higher ($P<0.05$) than the yoghurt containing 1% yellow lentil flour.

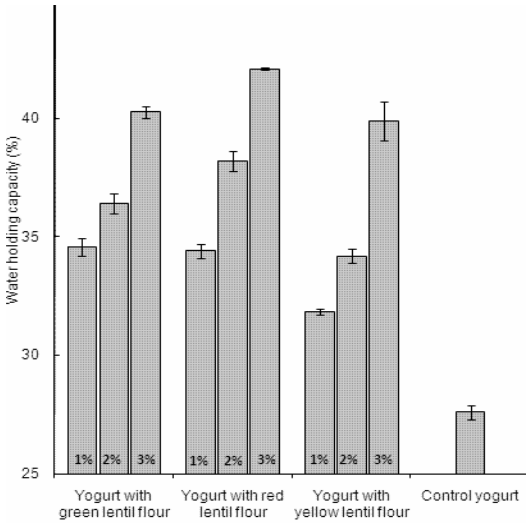

Figure 1. The effect of lentil flour addition on the water holding capacity of the yoghurts. The error bars represent standard deviations.

The sensory properties of the stirred yoghurt samples are shown in Table 4. The mean scores of the sensory assessment of the control sample was higher than all other samples, with the difference in the mean sensory panel scores of the control sample and the sample containing 1% yellow lentil flour not being significant ($P>0.05$). According to the sensory evaluation results, the scores for aroma, structure and appearance decreased as the level of lentil flour was increased. The results showed that the yoghurt contained yellow lentil flour showed the highest scores at an equal concentration, followed by yoghurts contained red lentil flour and green lentil flour, respectively, in terms of structure and appearance.

Regarding aroma scores, the yoghurt contained yellow lentil flour had the highest scores at an equal concentration, followed by yoghurts contained green lentil flour and red lentil flour, respectively. In general, the sensory quality of yoghurts decreased after 30 days of storage, while the highest scores were obtained with yoghurts after 1 day storage. Based upon the sensory evaluation, 1% yellow lentil flour supplemented yoghurt among the lentil flour supplemented yoghurt samples was more preferred by the panelists.

Table 4. Sensory properties of yoghurts containing different amounts of flour from lentil varieties during storage[1]

Properties / Scores	Storage time (day)	Control (No lentil flour)	Yoghurt with green lentil flour			Yoghurt with red lentil flour			Yoghurt with yellow lentil flour		
			1%	2%	3%	1%	2%	3%	1%	2%	3%
Aroma (full score:10)	1	9.8±0.3	9.4±0.2	9.0±0.3	8.7±0.3	9.3±0.3	8.8±0.8	8.8±0.3	9.5±0.4	9.1±0.2	8.9±0.2
	15	9.6±0.7	8.7±0.8	8.5±0.6	8.3±0.5	8.3±0.2	8.2±0.3	8.1±0.4	9.3±0.8	8.8±0.7	8.3±0.8
	30	9.3±0.4	8.2±0.8	8.1±0.9	7.8±0.8	8.0±0.0	8.0±0.0	7.8±0.3	8.7±0.6	8.4±0.6	8.1±1.0
Structure (full score:5)	1	4.9±0.1	4.7±0.1	4.7±0.2	4.5±0.2	4.8±0.2	4.8±0.3	4.6±0.3	4.9±0.1	4.8±0.1	4.7±0.2
	15	4.9±0.1	4.7±0.1	4.6±0.2	4.6±0.2	4.8±0.0	4.8±0.2	4.6±0.2	4.9±0.1	4.8±0.1	4.7±0.2
	30	4.8±0.1	4.3±0.3	4.2±0.3	4.2±0.3	4.6±0.2	4.4±0.2	4.4±0.2	4.6±0.2	4.4±0.4	4.4±0.4
Appearance (full score:5)	1	5.0±0.0	4.4±0.1	4.1±0.4	3.8±0.4	4.8±0.3	4.7±0.3	4.4±0.3	5.0±0.0	4.8±0.3	4.6±0.3
	15	4.9±0.1	3.9±0.5	3.8±0.7	3.7±0.5	4.6±0.5	4.2±0.1	3.9±0.1	4.7±0.2	4.7±0.2	4.5±0.4
	30	4.9±0.1	3.9±0.5	3.7±0.7	3.6±0.6	4.6±0.5	4.2±0.1	3.9±0.1	4.7±0.2	4.6±0.5	4.5±0.4

[1] Values (means±standard deviation) of aroma, structure and appearance scores of the non-fat stirred yoghurt

CONCLUSION

This study has shown that the physical and sensory properties of non-fat stirred yoghurt are influenced by the addition of different types and ratios of lentil flour to varying degrees. Lentil flour addition to yoghurt milk resulted in an improved physical properties of the yoghurt. Among the lentil flour-contained samples, yoghurt samples contained red lentil flour had the highest firmness, apparent viscosity, consistency index, thixotropy, water holding capacity and the lowest flow behavior index at an equal concentration. An increase in the levels of lentil flour negatively affected the sensory scores of the samples. However, there were no significant differences in the sensory scores between the control yoghurt and the yoghurt containing 1% yellow lentil flour. The results of this study revealed that lentil flour could be potentially considered as a source of ingredient for yoghurt supplementation.

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