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CHEMICAL COMPOSITION, COLOUR and TEXTURAL PROPERTIES of AKÇAABAT MEATBALL: A TRADITIONAL TURKISH MEAT PRODUCT

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Abstract

In this study, chemical composition, colour and textural properties of a total of 30 samples of raw Akçaabat meatball from plants in Trabzon and Samsun were determined. The moisture, protein, fat and salt contents of meatballs from plants in Trabzon averaged 54.53%, 15.17%, 19.09% and 1.23%, while that of samples from plants in Samsun were 48.35%, 14.14%, 22.27% and 1.51%, respectively. In Akçaabat meatballs, the predominant SFA were palmitic and stearic acid and the most abundant MUFA was oleic acid. While P/S ratios of all meatballs were lower than recommended value, n-6/n-3 ratios were higher. L value of meatballs ranged from 39.10 to 45.65 and it was higher in samples from plants in Samsun ($P<0.05$). In contrast to L value, a values of the meatballs from plants in Trabzon were higher than that of the meatballs from plants in Samsun ($P<0.05$). Hardness and chewiness of samples from plant in Trabzon and Samsun were 79.05 N-10.41 N.cm and 142.46 N-17.17 N.cm, respectively and there were significant differences between hardness and chewiness of meatballs ($P<0.05$). These results show that Akçaabat meatballs are rich sources of protein and fat, but P/S and n-6/n-3 ratios has a negative impact on their nutritional value.

Keywords: Akçaabat meatball, chemical composition, fatty acids, colour, textural properties

GELENEKSEL BİR TÜRK ET ÜRÜNÜ OLAN AKÇAABAT KÖFTESİNİN KİMYASAL BİLEŞİMİ, RENK ve TEKSTÜREL ÖZELLİKLERİ

Özet

Bu çalışmada, Trabzon ve Samsun'daki işletmelerden alınan toplamda 30 adet Akçaabat köftesinin kimyasal bileşimi, renk ve tekstürel özellikleri belirlenmiştir. Samsun'daki işletmelerden alınan köfte örneklerinde ortalama değerler olarak %48.35 nem, %14.14 protein, %22.27 yağ ve %1.51 tuz belirlenirken, Trabzon'daki işletmelerden alınan örneklerde %54.53 nem, %15.17 protein, %19.09 yağ ve %1.23 tuz belirlenmiştir. Köfte örneklerinde doymuş yağ asitlerinden en yüksek miktarda palmitik ve stearik asit, tekli doymamış yağ asitlerinden ise oleik asit saptanmıştır. Köfte örneklerinin P/S oranları önerilen değerden daha düşük olurken, n-6/n-3 oranları yüksek olmuştur. Köftelerin L değerleri 39.10 ile 45.65 arasında değişmiş ve Samsun'daki işletmelerden alınan örneklerde daha yüksek bulunmuştur ($P<0.05$). L değerinin tersine, Trabzon'daki işletmelerden alınan köftelerin a değerleri, Samsun'daki işletmelerden alınanlardan daha yüksek bulunmuştur ($P<0.05$). Trabzon ve Samsun'daki işletmelerden alınan köfte örneklerinin ortalama sertlik ve çiğnenebilirlik değerleri sırasıyla 79.05 N-10.41 N.cm ve 142.46 N-17.17 N.cm olarak tespit edilmiş ve örneklerin sertlik ve çiğnenebilirlik değerleri arasında önemli farklılıklar belirlenmiştir ($P<0.05$). Bu sonuçlar Akçaabat köftesinin protein ve yağ açısından zengin bir kaynak olduğunu göstermektedir. Ancak, P/S ve n-6/n-3 oranlarının besin değeri üzerinde negatif bir etkisi vardır.

Anahtar kelimeler: Akçaabat köftesi, kimyasal bileşim, yağ asitleri, renk, tekstürel özellikler

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INTRODUCTION

Meatball (Kofte), one of the important foods of Turkish cuisine, is derived from the word "kufte" which is a Persian word and its basic raw material is ground beef. A hundred kinds of meatballs can be produced and consumed by adding various materials into the meat and using different kinds of cooking techniques (1). Turkey has about 290 types of meatballs which vary by regions of Turkey and by masters. The basic reasons of these differences are the various types of meat used in production, different materials added into the meatball mixture, technologic processes the meat goes through and the cooking techniques (2).

Akçaabat meatball is a traditional meat product which has become a symbol of the province of Trabzon. First, this product is made by restaurateurs in Akçaabat during 1930 and later spread to every region of Turkey, and commercial production started. It is produced by kneading tiny pieces of beef after the addition of stale bread, garlic, fresh meat fat and some salt and mincing. In 2009, its peculiarity to Akçaabat region being confirmed, Akçaabat meatball was officially registered in terms of geographical indication by Turkish Patent Institution and it was published in the Official Gazette under date of July 22, 2009. One of the most crucial features of Akçaabat meatball is that only garlic is used as a spice in the production process. Akçaabat meatball, which is commonly baked on a charcoal grill, is served with buttermilk, haricot bean salad, grilled pepper and tomatoes and toasted Trabzon bread (2).

At the present time, Akçaabat meatball is produced mainly in Akçaabat, the town of Trabzon, and in some other cities such as Samsun, as well. In Akçaabat, nearly 60 meatball business organizations provide service and in these organizations, 3 tons of baked and 1.5 tons of raw, totally 4.5 tons of meatballs are daily sold. There are also some business organisations that are packing the meatballs they produced and serving them to the supermarkets and restaurants in other cities, as well.

There has been no specific research on the features of quality of this traditional meat product even though it is so widely produced and consumed. On that account, this study is very crucial in the sense that it is the first research to introduce the chemical composition, colour and textural properties of Akçaabat meatball and serves as a resource to the next studies.

MATERIALS and METHODS

Materials

A total of 30 samples of raw Akçaabat meatball were purchased from five different plants in Trabzon (T1, T2, T3, T4, and T5) and Samsun (S1, S2, S3, S4, and S5) provinces (Turkey) at three different periods during the year 2011. Each sample, 750 g, was transported to the laboratory in polyethylene bags and analyzed for chemical composition, colour and textural properties.

Methods

For proximate composition, all samples were ground finely in a mortar, put into glass jars to minimize moisture loss, and analyses were started. All chemical used were of analytical grade. Moisture, protein (N x 6.25), fat, ash and salt contents were determined according to AOAC procedure (3). Carbohydrate contents were calculated by difference. All the analyses were done in triplicate for each sample.

Energy values (kJ/100 g) were calculated based on 17 kJ/g for protein, 37 kJ/g for fat, and 16 kJ/g for carbohydrate. pH values were measured using a digital pH-meter (Cyberscan PC 510, Singapore) equipped with a combination pH electrode (Sensorex, S175CD Spear Tip, USA) calibrated in buffers at pH 4.01 and 7.00 (Mettler Toledo, USA) at 25 °C. The average of six measurements was used.

Total lipids were extracted by the method of Bligh and Dyer (4). Major fatty acid content of lipids was determined after methylation (5) by GC-MS (Shimadzu model of QP2010 Plus, Shimadzu Corporation, Kyoto, Japan) using a Teknokroma TR-CN 100 column (60 m x 0.25 mm I.D., 0.20 µm) (Teknokroma, Spain). The temperature of the injector port and detector was held at 250° C. The injected volume was 1.0 µL. The carrier gas was helium at a pressure of 200 kPa. The split used was 1:100. The temperature of the column was held at 90° C for 7 min, raised to 240° C at 5° C/min and finally held at 240° C for 10 min. Major fatty acids were identified by comparison of their retention times with those of authentic standards (Supelco 37 Components FAME Mixture, Cat. No. 18919-1AMP, Bellefonte PA, USA) and reported as the percentage of total fatty acids determined.

The colour of Akçaabat meatballs was measured using the Hunter Lab system with a colorimeter (Minolta CR 300), calibrated with a white tile (Minolta calibration plate, No. 21733001, Y=92.6, x=0.3136, y=0.3196) at 2° observation angle with a C illuminant. Three meatballs per group were randomly selected and three readings were taken from each meatball. Hunter L (lightness; 100=white, 0=black), *a* (redness; +, red; -, green), *b* (yellowness; +, yellow; -, blue) values were recorded.

Texture profile analysis (TPA) was performed using a Texture Analyzer (TA-XT Plus, Stable Micro Systems, Survey, UK) with a maximum force of 2 kg. An adaptor, a cylinder with a diameter of 36 mm, was used. The meatballs were put in a cylindrical container with a high of 15 mm and a diameter of 30 mm. The adaptor was 20 mm above the sample, and then declining at rate of 30 mm/min. The adaptor was back up to the original position after penetrating 10 mm in depth. The movement of the adaptor was repeated once for completing the measurements. Parameters of TPA, namely hardness, springiness, adhesiveness, cohesiveness, and chewiness were determined using the software provided by the Stable Micro Systems Ltd (6).

The data were analyzed by one-way ANOVA using the SPSS statistical package program, and differences among the means of provinces were compared using Duncan's Multiple Range test (7). A significance level of 0.05 was chosen. The results of the statistical analyses were shown as mean values ± standard deviation in the tables.

RESULTS and DISCUSSION

Proximate Composition, Energy and pH Value

The moisture, protein, fat, ash, salt and carbohydrate contents of Akçaabat meatballs from different plants in Trabzon and Samsun are presented in Table 1. As can be seen, the moisture, protein, fat, ash, salt and carbohydrate contents of Akçaabat meatballs from plants in Trabzon averaged 54.53%, 15.17%, 19.09%, 1.91%, 1.23% and 10.16%, while that of Akçaabat meatballs from plants in Samsun were 48.35%, 14.14%, 22.27%, 2.09%, 1.51% and 13.16%, respectively. According to these results, all Akçaabat meatballs were found to be rich sources of protein and fat. The moisture, fat and salt contents of all meatballs (except S1 sample for salt) were within the limits of the Turkish Uncooked Meatball Standard (8). According to this standard, all meatballs are allowed up to the 65% moisture, 25% fat and 2% salt content. However, significant differences were observed between the moisture, protein, fat and carbohydrate contents of Akçaabat meatballs from plants in Trabzon and Samsun ($P<0.05$). The moisture and protein contents of Akçaabat meatballs from plants in Trabzon were higher than that of the samples from plants in Samsun, while the fat and carbohydrate contents of meatballs from plants in Samsun were higher than that of the samples from plants in Trabzon ($P<0.05$). These differences could be attributed to the amount and quality of raw materials and additives used for manufacturing the meatballs and the condition of manufacture. Similar moisture, protein and salt contents were reported by Çetin and Yücel (9) in butchery meatballs, by Yılmaz (10) in Tekirdağ meatballs and by Soyutemiz (11) in hamburger patties. However, protein contents were higher than those reported by Rakıcıoğlu et al. (12) and Huda et al. (13). While our results for fat contents were higher than those of Yılmaz (10), Rakıcıoğlu et al. (12) and Huda et al. (13), they were similar to the values determined by Çetin and Yücel (9) in butchery meatballs. These changes may also be due to the above-mentioned factors.

The energy values of Akçaabat meatballs ranged from 1058.1 to 1327.4 kJ/100 g and the energy values of meatballs from plants in Samsun were higher than that of the samples from plants in Trabzon due to the high fat content of meatballs from plants in Samsun (Table 1) ($P<0.05$). This is because fats are the most concentrated dietary energy source, providing 37 kJ/g, more than twice that supplied by proteins or carbohydrates (14). The pH values of Akçaabat meatballs ranged

Table 1. Proximate composition, energy and pH values of Akçaabat meatballs (n=3) from different plants in Trabzon and Samsun

	Plants	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	Carbohydrate (%)	Energy value (kJ/100 g)	pH
Trabzon	T1	52.87	13.94	18.75	1.87	1.23	12.56	1131.8	5.57
		(0.82)	(0.04)	(2.68)	(0.10)	(0.16)	(3.34)	(48.6)	(0.24)
	T2	57.28	14.83	18.65	2.04	1.42	9.85	1058.1	5.58
		(3.39)	(0.72)	(1.35)	(0.41)	(0.52)	(5.43)	(41.7)	(0.14)
	T3	53.42	15.88	20.64	1.64	1.23	9.68	1168.4	5.48
		(5.72)	(1.02)	(1.46)	(0.15)	(0.24)	(5.43)	(113.8)	(0.42)
	T4	54.84	14.58	18.77	1.74	1.08	10.08	1103.6	5.63
		(2.16)	(0.84)	(2.99)	(0.08)	(0.15)	(1.84)	(89.0)	(0.20)
	T5	54.25	16.64	18.63	2.25	1.19	8.60	1103.8	5.30
		(1.63)	(0.65)	(3.44)	(0.51)	(0.14)	(2.82)	(97.2)	(0.18)
	Mean	54.53[a]	15.17[a]	19.09[b]	1.91[a]	1.23[a]	10.16[b]	1113.1[b]	5.51[a]
		(3.16)	(1.17)	(2.28)	(0.34)	(0.26)	(2.59)	(79.6)	(0.25)
Samsun	S1	48.51	13.61	20.98	2.62	2.04	14.29	1236.5	5.60
		(1.19)	(1.42)	(0.77)	(0.36)	(0.47)	(2.17)	(31.1)	(0.30)
	S2	52.28	15.08	20.20	2.12	1.53	10.32	1169.0	5.44
		(1.03)	(0.43)	(1.62)	(0.31)	(0.43)	(0.76)	(55.1)	(0.39)
	S3	48.32	14.49	24.51	1.80	1.41	10.88	1327.4	5.53
		(1.84)	(0.44)	(4.76)	(0.04)	(0.20)	(5.47)	(95.6)	(0.31)
	S4	44.65	13.81	21.38	2.13	1.43	18.02	1314.3	5.43
		(4.99)	(0.76)	(4.55)	(0.16)	(0.41)	(1.39)	(168.9)	(0.32)
	S5	47.96	13.71	24.26	1.80	1.13	12.27	1327.1	5.52
		(3.84)	(1.56)	(4.30)	(0.16)	(0.28)	(1.34)	(146.1)	(0.26)
	Mean	48.35[b]	14.14[b]	22.27[a]	2.09[a]	1.51[a]	13.16[a]	1274.8[a]	5.50[a]
		(3.57)	(1.06)	(3.56)	(0.37)	(0.44)	(3.73)	(114.9)	(0.28)

Means in the same column with different superscripts ([a-b]) are significantly different (*$P<0.05$*).
Data in parentheses represent standard deviations.

from 5.30 to 5.63 and no significant differences were observed between the pH values of meatballs from plants in Trabzon and Samsun (Table 1) (*$P>0.05$*). Similar pH values were obtained by Yılmaz (10) and Soyutemiz (11) for Tekirdağ meatballs and hamburger patties, respectively.

Major Fatty Acid Content

The fatty acid composition of muscle foods has a great impact on the nutritional value, oxidative stability and sensory properties of muscle foods. Regarding nutritional aspects, saturated fatty acids (SFA) are known to increase low density lipoproteins (LDL) and hence, blood cholesterol levels whereas unsaturated fatty acids exhibit the opposite effect (15). The major fatty acid profile of Akçaabat meatballs from different plants in Trabzon and Samsun is shown in Table 2. As can be seen, the total saturated fatty acids (ΣSFA), total monounsaturated fatty acids (ΣMUFA) and total polyunsaturated fatty acids (ΣPUFA) amounts of Akçaabat meatballs ranged from 50.90 to 56.50%, 39.86 to 45.27% and 2.57 to 3.83%, respectively and no significant differences were observed between the fatty acid profiles (except C16:1) of Akçaabat meatballs from plants in Trabzon and Samsun (*$P>0.05$*). Among the SFA, the predominant fatty acids were palmitic (C16:0) and stearic acid (C18:0), varying from 25.28 to 26.93% and 20.37 to 25.90%, respectively. Those values are close to those found by Scheeder et al. (16) in beef patties from meat of bulls fed different fats and by Bilek and Turhan (17) in beef patties with 10 and 20% fat. Concerning the MUFA, oleic acid (C18:1n-9) was the most abundant fatty acid, close to the other researchers (16, 18).

P/S ratio is thought to be important in relation to the nutritional value of foods for human health (19). Nutritional guidelines recommend a P/S ratio above 4 (20) and lower ratios in the diet as a whole may increase the incidence of cardiovascular disease (19). In the present study, P/S ratio of Akçaabat meatballs ranged from 0.047 to 0.075. In Akçaabat meatballs from plants in Trabzon, this ratio was higher than for samples from plants in Samsun (*$P<0.05$*). This situation could be attributed to the kind and fatty acid composition of fats used for manufacturing the meatballs, because in Akçaabat meatball production, meat

Table 2. Major fatty acid content of Akçaabat meatballs (n=3) from different plants in Trabzon and Samsun (%)

	Plants	C14:0	C16:0	C18:0	ΣSFA	C16:1	C18:1n-9	ΣMUFA	ΣPUFA	P/S	n-6/n-3
Trabzon	T1	2.75	25.97	20.37	50.90	3.54	41.07	45.27	3.83	0.075	12.97
		(0.18)	(0.41)	(0.72)	(0.47)	(0.14)	(0.64)	(0.70)	(1.03)	(0.01)	(4.20)
	T2	2.58	25.29	25.90	56.50	2.75	36.05	39.86	3.64	0.065	6.52
		(0.50)	(2.43)	(1.79)	(3.19)	(0.40)	(3.23)	(3.14)	(0.04)	(0.01)	(1.34)
	T3	2.96	26.93	21.98	53.74	3.31	38.71	43.39	2.87	0.053	12.66
		(0.35)	(1.69)	(1.36)	(3.60)	(0.26)	(3.56)	(3.72)	(0.17)	(0.01)	(5.83)
	T4	2.81	25.28	21.54	51.56	3.38	40.18	45.06	3.38	0.066	15.76
		(0.11)	(1.45)	(2.01)	(2.69)	(0.42)	(2.40)	(2.87)	(0.34)	(0.01)	(2.79)
	T5	2.77	26.14	20.62	51.42	3.53	40.15	45.05	3.53	0.068	13.96
		(0.31)	(0.18)	(3.51)	(3.74)	(0.51)	(3.82)	(4.46)	(0.76)	(0.01)	(8.36)
	Mean	2.77^{a}	25.92^{a}	22.08^{a}	52.82^{a}	3.30^{a}	39.23^{a}	43.73^{a}	3.45^{a}	0.065^{a}	12.37^{a}
		(0.30)	(1.41)	(2.72)	(3.32)	(0.43)	(2.59)	(3.46)	(0.61)	(0.01)	(5.40)
Samsun	S1	2.96	25.81	22.05	52.80	2.49	40.09	44.14	3.06	0.058	14.07
		(0.43)	(1.92)	(1.47)	(3.85)	(1.17)	(2.49)	(3.89)	(0.27)	(0.01)	(7.36)
	S2	2.84	25.91	23.83	54.68	1.87	38.54	41.65	3.67	0.067	16.86
		(0.07)	(0.81)	(0.48)	(1.18)	(0.81)	(0.50)	(1.08)	(0.34)	(0.01)	(1.39)
	S3	2.76	25.47	24.84	55.15	1.99	38.73	42.00	2.85	0.052	19.00
		(0.19)	(0.48)	(2.07)	(2.50)	(0.88)	(1.69)	(2.41)	(0.38)	(0.01)	(3.48)
	S4	3.11	26.81	23.63	54.56	2.36	38.21	42.87	2.57	0.047	16.06
		(0.30)	(1.59)	(3.11)	(0.40)	(0.75)	(1.21)	(0.54)	(0.14)	(0.01)	(3.84)
	S5	3.12	26.59	22.61	54.29	1.93	39.49	42.59	3.12	0.058	17.36
		(0.19)	(1.07)	(2.07)	(2.46)	(0.36)	(1.75)	(2.37)	(0.38)	(0.01)	(4.74)
	Mean	2.96^{a}	26.12^{a}	23.39^{a}	54.30^{a}	2.13^{b}	39.01^{a}	42.65^{a}	3.05^{a}	0.056^{b}	16.67^{b}
		(0.27)	(1.20)	(1.99)	(2.18)	(0.75)	(1.57)	(2.19)	(0.46)	(0.01)	(4.23)

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.
P/S, polyunsaturated fatty acids/saturated fatty acids.
Means in the same column with different superscripts ($^{a-b}$) are significantly different (*P<0.05*).
Data in parentheses represent standard deviations.

fat, omentum fat and kidney fat can be used as fat source. Similar P/S ratio was obtained by Bilek and Turhan (17) in beef patties with 10 and 20% fat. However, P/S ratios of all meatballs were lower than recommended value.

The effect of the n-6/n-3 ratio is probably of more significance than the P/S ratio in term of human nutrition. A balance between n-6/n-3 ratios is of major importance in relation to coronary heart disease (19). In dietary term, in order to prevent cardiovascular disease it is recommended to reduce this ratio to less than 4 (20). While the meatballs from plants in Samsun had a n-6/n-3 ratio of 16.67, lower n-6/n-3 ratios were achieved in samples from plants in Trabzon, ranging from 6.52 to 15.76 ($P<0.05$) (Table 2). As can be seen, n-6/n-3 ratios of all meatballs were higher than recommended value. This situation could be attributed to formulation of meatball samples. These results indicate that Akçaabat meatballs should be modified with healthier lipid formulations to improving P/S and n-6/n-3 ratios.

Colour

Colour measurement is an important parameter in meat products, because consumers associate this product with a bright and characteristics pink colour. Data for colour of Akçaabat meatballs from different plants in Trabzon and Samsun are presented in Table 3. L values of Akçaabat meatballs ranged from 39.10 to 45.65 and L values of meatballs from plants in Samsun were higher than that of the samples from plants in Trabzon (*P<0.05*). In contrast to L value, a values of the meatballs from plants in Trabzon were higher than that of the meatballs from plants in Samsun (*P<0.05*). These results could be attributed to fat and carbohydrate content of meatball samples. Increasing fat and carbohydrate level resulted in dilution of the myoglobin and because of that lower a and higher L values were obtained for Akçaabat meatballs from plants in Samsun. L and a values for Akçaabat meatballs were similar to the results in Tekirdağ meatballs stored in deep freezer reported by Yılmaz (21), which ranged from 40.41-42.55 and 6.80-9.69, respectively. b

Table 3. The Hunter Lab attributes of Akçaabat meatballs (n=3) from different plants in Trabzon and Samsun

	Plants	*L* (Lightness)	*a* (redness)	*b* (yellowness)
Trabzon	T1	39.90 (0.88)	9.13 (2.49)	10.74 (0.25)
	T2	40.20 (1.10)	9.81 (1.06)	11.19 (0.13)
	T3	41.05 (2.18)	10.35 (3.13)	10.76 (0.34)
	T4	41.65 (2.44)	8.48 (2.77)	11.13 (0.93)
	T5	39.10 (0.76)	9.73 (1.84)	10.22 (0.74)
	Mean	40.38^{b} (1.66)	9.50^{a} (2.11)	10.80^{b} (0.60)
Samsun	S1	42.62 (1.86)	6.96 (0.48)	11.93 (0.56)
	S2	44.31 (2.31)	9.82 (2.12)	11.78 (1.21)
	S3	44.41 (1.34)	8.08 (0.25)	11.55 (0.40)
	S4	45.65 (1.30)	6.41 (1.10)	12.52 (0.25)
	S5	45.21 (2.42)	6.19 (1.83)	12.60 (0.81)
	Mean	44.44^{a} (1.94)	7.49^{b} (1.80)	12.08^{a} (0.75)

L=lightness (100=white, 0=black); *a*, redness (+, red; -, green); *b*, yellowness (+, yellow; -, blue). Means in the same column with different superscripts ($^{a-b}$) are significantly different (*P<0.05*).
Data in parentheses represent standard deviations.

values of Akcaabat meatballs ranged from 10.22 to 12.60 and similar to L value, b values of meatballs from plants in Samsun were higher than that of the samples from plants in Trabzon (*P<0.05*). This situation could be attributed to formulation of meatball samples. Similar b values were obtained by Turhan et al. (22) in beef patties formulated with wet okara.

Texture Profile Analysis

Hardness, springiness, adhesiveness, cohesiveness and chewiness of Akçaabat meatballs from different plants are shown in Table 4. As can be seen, while there were significant differences between hardness and chewiness of Akçaabat meatballs from plants in Trabzon and Samsun (*P<0.05*), there were no significant differences between springiness, adhesiveness and cohesiveness (*P>0.05*). Compared to Akçaabat meatballs from plants in Trabzon, meatballs from plants in Samsun presented significantly higher values for hardness and chewiness (P<0.05). The degree of extraction of myofibrillar proteins, stromal protein content, degree of comminuting and type and level of non-meat additives such as fat and starch are factors responsible for textural properties in comminuted meat proteins (13, 23). The higher hardness and chewiness values of meatball samples from plants in Samsun could be attributed to their higher carbohydrate content (Table 1). Huda et al. (13) and Huang et al. (24) also reported that the increase of the hardness and chewiness is due to the increase of the carbohydrate content. Despite these differences, texture profile properties of Akçaabat meatballs were generally similar to the values found by various researchers (13, 25-27).

CONCLUSION

This study indicate that proximate composition, P/S and n-6/n-3 ratios, colour properties, hardness and chewiness values of Akçaabat meatballs from plants in Trabzon and Samsun were different. Akçaabat meatballs were found to be rich sources of protein, fat and energy. The moisture, fat and salt contents of meatballs were generally within the limits of the Turkish Uncooked Meatball Standard. While P/S ratios of meatballs were lower than recommended value, n-6/n-3 ratios were higher. Therefore, Akçaabat meatballs should

Table 4. Texture profile analysis of Akçaabat meatballs (n=3) from different plants in Trabzon and Samsun

	Plants	Hardness (N)	Springiness (cm)	Adhesiveness (N.s)	Cohesiveness	Chewiness (N.cm)
Trabzon	T1	77.66	0.73	4.08	0.23	12.04
		(32.29)	(0.22)	(1.29)	(0.06)	(4.43)
	T2	72.48	0.68	3.34	0.22	10.87
		(26.84)	(0.09)	(1.28)	(0.05)	(5.20)
	T3	74.03	0.62	3.31	0.19	9.18
		(19.02)	(0.09)	(0.68)	(0.02)	(3.19)
	T4	80.81	0.51	2.62	0.18	10.54
		(14.24)	(0.07)	(0.24)	(0.01)	(7.82)
	T5	100.09	0.56	3.33	0.17	9.42
		(16.26)	(0.13)	(0.47)	(0.02)	(2.52)
	Mean	79.05^{a}	0.62^{a}	3.34^{a}	0.20^{a}	10.41^{b}
		(24.51)	(0.14)	(0.90)	(0.04)	(4.35)
Samsun	S1	176.16	0.78	4.05	0.18	23.94
		(34.66)	(0.09)	(0.79)	(0.02)	(2.25)
	S2	101.57	0.73	3.92	0.19	13.95
		(3.54)	(0.03)	(0.38)	(0.03)	(2.67)
	S3	121.01	0.49	3.17	0.24	10.48
		(27.92)	(0.11)	(1.36)	(0.06)	(4.48)
	S4	187.42	0.59	5.67	0.21	23.25
		(43.11)	(0.24)	(2.69)	(0.04)	(12.89)
	S5	126.16	0.62	3.97	0.17	14.25
		(31.85)	(0.20)	(1.12)	(0.01)	(8.71)
	Mean	142.46^{a}	0.64^{a}	4.15^{a}	0.20^{a}	17.17^{a}
		(43.42)	(0.17)	(1.52)	(0.04)	(8.40)

Means in the same column with different superscripts ($^{a-b}$) are significantly different (*P<0.05*).
Data in parentheses represent standard deviations.

be modified with healthier lipid formulations. The differences in the quality characteristics of Akçaabat meatballs were mainly due to the difference in the formulation.

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