Received: *December 11, 2014*
Accepted: January 26, 2015

Determination of Physicochemical and Textural Properties of Different Types of Sucuk Offered for Commercial Sale*

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Abstract

Meat and meat products are important foodstuffs for adequate and balanced nutrition for the reason that they contain high quality and quantify protein, some minerals, vitamins and essential fatty acids. Possessing significant nutritional value, meat can be consumed not only as fresh but also as products obtained from application of different technological processes for the purpose of gaining various taste and flavor. Nowadays, Sucuk ranks among the meat products which are widely produced and consumed. Color, appearance and textural properties are among the most important quality parameters on preferring and purchasing meat product by consumer. In this research pH, color parameters and lactic acid values were determined for assessment of different types of Sucuk offered for commercial sale. By considering fermented and heat treated sucuks separately, which are offered for commercial sale; pH, color, lactic acid contents were determined. Besides parameters of hardness, adhesiveness, cohesiveness, springiness, gumminess, chewiness and resilience were ascertained on the purpose of finding out sucuks' textural properties. While pH values of fermented sucuk samples range between 4.92-5.37; their lactic acid quantity between 9.32-17.33 %, pH values of heat treated sucuk were detected between 4.92-5.68; their lactic acid quantity as 11.95-20.30%. Cross section *a** values of fermented sucuk samples were higher and outer *a** values of fermented sucuk samples were lower than heat treated sucuks.

Keywords: Sucuk, textural properties, color.

Ticari Olarak Satışa Sunulan Farklı Tip Sucukların Fizikokimyasal ve Tekstürel Özelliklerinin Belirlenmesi

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Özet

Et ve et ürünleri, yüksek kaliteli ve içerikli proteini, bazı mineralleri, vitaminleri ve esansiyel yağ asitlerini içermesi sebebiyle dengeli ve yeterli beslenmede önemli bir gıda maddesidir. Önemli bir besleyicilik değerine sahip olan et, hem taze olarak hem de değişik lezzet ve aroma özellikleri kazandırmak amacıyla farklı teknolojik işlemler uygulanmasıyla elde edilen ürünler şeklinde de tüketilebilmektedir. Sucuk günümüzde yaygın olarak üretilen ve tüketilen et ürünleri arasında yer almaktadır. Et ürünlerinin tüketici tarafından tercihi ve satın alınmasında en önemli kalite parametrelerinin başında renk, görünüş ve tekstürel özellikler gelmektedir. Bu çalışmada ticari olarak satışa sunulan fermente ve ısıl işlem görmüş sucuklar ayrı ayrı ele alınarak; pH, renk ve laktik asit içerikleri belirlenmiştir. Ayrıca sucukların tekstürel özelliklerini belirlemek amacıyla sertlik, yapışkanlık, elastikiyet, gamsılık, çiğnenebilirlik ve esneklik parametreleri objektif yöntemlerle tespit edilmiştir. Fermente sucuk örneklerinin pH değerleri 4.92-5.37; laktik asit miktarları %9.32-17.33 arasında değişirken, ısıl işlem görmüş örneklerin pH değerleri 4.92-5.68; laktik asit miktarları %11.95-20.30 arasında bulunmuştur. Fermente sucukların iç kesit yüzeyi *a**değerleri ısıl işlem

* It was presented at 3rd Meat Products Workshop
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görmüş sucukların iç kesit yüzeyi *a** değerlerinden genel olarak yüksek bulunmuş; sucuk dış kesit yüzeyi *a** değerleri ise düşük bulunmuştur.
Anahtar Kelimeler : Sucuk, tekstürel özellikler, renk.

1. Introduction

Along with its energizing feature, nutritiousness value of meat products bases fundamentally upon their being as sources of protein, vitamin and mineral contained with high biological [1]. Meat products are preferred more in comparison with fresh meat, because they contain less water and more protein than fresh meat due to production technologies, besides they have longer shelf life and they're given special flavour with spice and various additives [2].

Sucuk is the most produced and consumed meat product in Turkey, therefore it's among the most important meat products that are further processed. Traditional Turkish sucuk is a semi-dry fermented meat product produced by mincing meat and fat, then filling sucuk mix -prepared by adding spice and additives to mince- into natural or artificial coverings, thereafter fermenting and desiccating (ripening) it at certain temperature and in relative humidity [3].

Offered for commercial sale in our country; fermented and heat-treated sucuks are available. The distinction between these two types of sucuks is the treatments applied on the purpose of enabling product's ripening. Color, taste and flavour of fermented and heat-treated sucuks are formed depending on a set of reactions. Texture specifications are also above all desired quality parameters which are desired. Texture is a significant quality criterion expressing structural, mechanical and surface-related properties of food. Food's textural properties require to be at desired level for acceptance by consumer. Evaluation of textural properties can be carried out subjectively through sensory methods and objectively by the help of various equipments. pH, color and lactic acid contents of fermented and heat-treated sucuks were analyzed in this study by handling these two types of sucuks separately. Furthermore parameters of hardness, adhesiveness/cohesiveness, springiness, gumminess, chewiness and resilience were endeavored for analyze through objective methods.

2. Materials and Methods

2.1.Material

Fermented and heat-treated coil sucuks offered for sale in vacuumed packages by seven different companies and were used as research materials.

2.2. Method

Texture profile analyzes (TPA)

Compression tests of sucuk samples were carried out during analysis performed through usage of texture analysis device (TA-HD Plus Texture Analyser, UK) with 50 kg load cell and consequently TPA (texture analysis) profiles of the samples were determined. Slices with equal thickness were taken from every sucuk sample from each different group, texture analysis device reading was performed and results were evaluated [4]. Texture profile analyses (TPA) were carried out through usage of texture analysis device's software at 21°C room temperature. Sucuk samples were sliced at

1.5 cm height for texture analysis and analyses were performed as 3 parallel slices for each sample. Within the scope of this analysis, 50 % compression was applied to sucuks at room temperature. Results were specified under titles of hardness (N), adhesiveness (Nxmm), springiness (mm), cohesiveness, gumminess (N), chewiness (Nxmm) and recovery (resilience) [5-7].

pH determination

pH values of sucuk samples from each group were determined separately by the help of pH meter (Testo-Germany) [8].

Lactic acid determination

Lactic acid contents of sucuks were determined in terms of % lactic acid [9]. For this purpose, 10 g sucuk sample was homogenized by mixing it with 100 ml pure water in homogenizer during 60 seconds and then pH value was detected, 0.1 N NaOH was added until pH value became 8.3. NaOH amount used in milliliter was calculated as mEq and the found value was expressed as % lactic acid.

Color determination

Color measurements were carried out through usage of a chromameter (model CR-400, Konica Minolta, Osaka, Japan) with illuminant D65 (*L**, *a** and *b** values), 2° observer, 8 mm illumination range in mode Diffuse/O. Color coordinates *L** (luminance), *a** (redness, +60, red; -60, green) and *b** (yellowness, +60, yellow; -60, blue) were fixed in compliance with CIE L*a*b* color coordinate system [10]. The measurements were performed by applying 3 different readings on exterior surfaces of sucuk samples in each group on cross sections of slices taken from every sucuk sample.

Statistical analyses

Obtained data were subjected to Variance Analysis, in the form of tables drawn in accordance with experimental design by using software MINITAB release 13.0, and Duncan Multiple Comparison Test was applied in order to check whether differences between group averages were significant or not.

3. Results and Discussion

pH and lactic acid % values of fermented (F) and heat-treated sucuks provided from different companies were determined and their values are indicated in Table 3.1.

Table 1. Values belonging to pH and lactic acid (%) parameters of fermented and heat-treated sucuks

Sample Code	Fermented Sucuk (F)*		Heat-Treated Sucuk (I)*	
	pH	Lactic acid (%)	pH	Lactic acid (%)
1	5.19 ± 0.01^{bc}	1.25 ± 0.01^{abc}	4.92 ± 0.01^{f}	1.64 ± 0.14^{abc}
2	4.92 ± 0.00^{f}	1.02 ± 0.11^{c}	5.12 ± 0.01^{e}	1.97 ± 0.05^{a}
3	5.02 ± 0.01^{de}	1.73 ± 0.29^{a}	5.55 ± 0.01^{b}	1.74 ± 0.05^{ab}
4	5.11 ± 0.02^{cd}	0.93 ± 0.11^{c}	5.62 ± 0.04^{ab}	1.19 ± 0.10^{d}
5	5.20 ± 0.04^{b}	1.61 ± 0.06^{ab}	5.68 ± 0.01^{a}	1.33 ± 0.07^{cd}
6	5.37 ± 0.00^{a}	1.41 ± 0.02^{abc}	5.44 ± 0.05^{c}	2.03 ± 013^{a}
7	5.00 ± 0.04^{ef}	1.13 ± 0.19^{bc}	5.24 ± 0.01^{d}	1.46 ± 0.15^{bcd}

[a-f]The superscripts represent the statistically significant differences within the group ($p< 0.01$).

* Fermented and heat-treated sucuks were compared separately.

During pH analysis performed for the samples, values were observed between the range of 4.92 and 5.68. The difference between pH values of fermented and heat-treated sucuks were deemed as statistically significant ($p<0.01$). Among fermented sucuk samples, the sample with code F6 exhibited the highest pH value; the sample with code F2 exhibited the lowest. Among heat-treated sucuk samples, the sample with code I5 had the highest pH value; the sample with code I1 had the lowest. Ensoy [11]; reported that pH values of sucuks produced through conventional method were between the range of 5.16-5.26, pH values of heat-treated sucuks were between the range of 5.22-5.31. Ercoşkun et al. [12]; discovered in their study on different fermentation ranges' effect upon quality properties of heat-treated sucuks and of sucuks produced through conventional method that before application of heat treatment the pH value were 6.06 in the first day and 4.87 in the fifth day, following application of heat treatment the pH value were 6.18 in the first day and had increased to 5.25 in fifth day, as for sucuks produced through conventional method the pH value maintained at 5.01.

In consequence of lactic acid analysis on sucuks, values were observed between the range of 0.93-2.03 %. The difference between fermented and heat-treated sucuks was considered statistically significant ($p<0.01$) in point of acidity values. The sample with code F3 exhibited the highest acidity among fermented sucuks; as for heat-treated sucuks, the sample with code I6 exhibited the highest acidity. Franco et al. [13] reported titration acidity value of Androlla -fermented meat product- produced through conventional method in Spain was approximately 3%. Gok [14] pointed out in the study that titration acidity values of sucuks samples ranged between 0.148-0.165% at the beginning of ripening and those values increased during production period, this increase had been statistically significant and titration acidity values reached 0.735-0.758% at the end of one week-ripening.

Color parameters belonging to outer and inner sections of fermented and heat-treated sucuks provided from different companies were determined and these parameters are indicated in Table 3.2.

Table 3.2. Values belonging to color parameters of inner and outer sections on fermented and heat-treated sucuk samples

Sample Code	Fermented Sucuks (F)*			Heat-Treated Sucuks (I)*		
	Inner Section					
	*L**	*a**	*b**	*L**	*a**	*b**
1	49.72±2.13^{bc}	20.98±2.15^{bc}	19.30±1.39^{a}	54.74±1.56^{a}	21.73±1.05^{a}	15.90±0.42^{ab}
2	46.78±0.36^{cd}	23.90±0.14^{ab}	14.82±0.21^{ab}	53.33±0.50^{ab}	20.09±1.61^{ab}	16.17±1.62^{ab}
3	50.81±0.19^{b}	23.24±0.54^{abc}	16.75±1.24^{a}	54.59±1.51^{a}	17.91±0.38^{bc}	18.48±1.00^{a}
4	48.19±0.64^{bcd}	19.40±0.12^{c}	10.79±0.57^{b}	52.02±0.96^{ab}	17.22±0.25^{bc}	16.25±0.76^{ab}
5	46.44±0.79^{cd}	21.62±1.47^{abc}	15.01±2.06^{ab}	50.66±1.08^{ab}	23.16±0.12^{a}	16.86±1.15^{ab}
6	44.91±0.08^{d}	25.95±0.01^{a}	16.25±0.05^{a}	49.87±1.14^{b}	16.64±1.03^{c}	14.53±0.43^{b}
7	55.20±0.76^{a}	21.59±1.13^{bc}	14.68±1.40^{ab}	50.85±0.87^{ab}	18.04±0.38^{bc}	13.88±0.37^{b}
	Outer Section					
1	38.19±3.85^{a}	19.98±0.93^{bc}	13.94±0.11^{abc}	43.78±0.45^{a}	21.68±1.07^{ab}	18.25±1.59^{abc}
2	38.20±0.88^{a}	15.73±1.87^{c}	11.30±1.28^{c}	41.80±0.43^{ab}	25.32±0.01^{a}	21.89±0.62^{a}
3	37.09±1.57^{a}	29.21±2.39^{a}	19.26±3.27^{a}	42.76±0.86^{a}	22.20±0.27^{ab}	19.72±0.59^{ab}
4	37.46±0.73^{a}	19.78±2.26^{bc}	10.36±1.24^{c}	37.57±1.57^{bc}	18.93±0.34^{b}	13.28±1.20^{d}
5	39.40±0.02^{a}	20.70±0.20^{bc}	17.86±0.71^{ab}	42.31±0.62^{a}	26.05±1.03^{a}	14.78±0.83^{cd}
6	38.16±0.50^{a}	25.16±3.22^{ab}	15.70±0.21^{abc}	40.24±2.10^{abc}	22.28±2.62^{ab}	22.56±1.43^{a}
7	41.09±1.56^{a}	23.60±1.73^{abc}	12.59±2.14^{bc}	36.04±0.81^{c}	24.18±0.06^{a}	16.26±1.73^{bcd}

[a-d]The superscripts represent the statistically significant differences within the group ($p< 0.05$).

* Fermented and heat-treated sucuks were compared separately.

It was observed that *L** values expressing luminosity were higher on inner section rather than outer section. The difference between *L** values of fermented sucuk samples was deemed as statistically insignificant ($p>0.05$). The difference between *a** values stating redness belonging to inner and outer sections of fermented and heat-treated sucuks is statistically significant ($p< 0.05$). The difference between *b** values stating yellowness of the samples was also considered as statistically significant ($p< 0.05$). It can be reflected that pH's rapid decrease has an effect upon the change of color values and upon increase of nitrosomyoglobin formation by accelerating nitrite reduction. It was also confirmed in various studies [15, 16,] large amount of nitrite was reduced concerning sucuk-type meat products in the first days of fermentation. Uren and Babayigit [17] declared sucuks' desired color values came into being until 8. day and heat treatment until 60 °C.

Hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience parameters of fermented sucuks provided from different companies were determined and their results are indicated in Table 3.3.

Table 3.3. The values of texture parameters measured on fermented sucuk samples

Sample Code	Hardness (N)	Adhesiveness (Nxs)	Springiness (mm)	Cohesiveness	Gumminess (N)	Chewiness (Nxmm)	Resilience
F1	236.49 ± 19.89^{ab}	-0.31 ± 0.02^{a}	0.75 ± 0.01^{a}	0.58 ± 0.01^{ab}	138.50 ± 12.88^{a}	104.33 ± 8.49^{a}	0.21 ± 0.00^{b}
F2	178.00 ± 24.38^{bc}	-0.60 ± 0.06^{a}	0.71 ± 0.02^{a}	0.59 ± 0.02^{ab}	106.26 ± 11.23^{ab}	75.47 ± 5.20^{b}	0.22 ± 0.02^{b}
F3	90.41 ± 5.90^{d}	-0.54 ± 0.05^{a}	0.76 ± 0.04^{a}	0.67 ± 0.02^{a}	60.57 ± 2.33^{c}	45.83 ± 0.78^{c}	0.29 ± 0.01^{a}
F4	127.95 ± 6.17^{cd}	-0.43 ± 0.11^{a}	0.68 ± 0.06^{a}	0.62 ± 0.03^{ab}	78.66 ± 0.27^{bc}	53.92 ± 5.05^{c}	0.22 ± 0.02^{b}
F5	208.50 ± 9.40^{b}	-0.49 ± 0.13^{a}	0.73 ± 0.03^{a}	0.56 ± 0.01^{bc}	117.34 ± 2.28^{a}	85.65 ± 1.62^{ab}	0.21 ± 0.00^{b}
F6	91.83 ± 18.29^{d}	-0.71 ± 0.26^{a}	0.67 ± 0.00^{a}	0.57 ± 0.04^{b}	52.96 ± 7.16^{c}	35.53 ± 4.81^{c}	0.20 ± 0.02^{b}
F7	289.91 ± 23.89^{a}	-0.36 ± 0.18^{a}	0.72 ± 0.03^{a}	0.49 ± 0.01^{c}	140.37 ± 13.98^{a}	100.73 ± 5.88^{a}	0.19 ± 0.01^{b}

[a-d]The superscripts represent the statistically significant differences within the group ($p< 0.05$).

Defined as maximum power that is exerted in order to press the samples, hardness values were determined between the range of 289.91-90.41 N. This difference between the samples is statistically significant ($p<0.05$). The fermented sucuk sample with code F7 has the highest hardness value; the samples with codes F3 and F6 have the lowest hardness value. Herrero et al. [7] discovered hardness values of sausage samples between 100-272 N in their study on the purpose of observing textural properties of some dry fermented sausages (chorizo, salchichon, salami, fuet and mini fuet) and determining their breaking strength. Cabeza et al. [18] found out hardness value of Salchichon as 116.5 N and the Chorizo's as 43.8 N in the study on irradiation's effect upon product safety and quality by applying irradiation to dry fermented sausages (salchichon and chorizo). Yetim et al. [19] measured sucuk's textural specification through Warner-Bratzler Method and pointed out that sucuk's unsatisfactory texture came into being due to poor quality raw material, misapplication of fermentation and high rates of humidity, fat amounts, pH values.

Adhesiveness parameter of fermented sucuks was determined between -0.31 and -0.71 (Nxs) and the difference between these samples were considered as statistically insignificant ($p>0.05$). Herroro et al. [7] discovered adhesiveness values of sausage samples between the range of -0.6 and -1.3 Nxs in their study on the purpose of determining textural properties of some dry fermented sausages (chorizo, salchichon, salami, fuet and mini fuet). Hoz et al. [20] determined adhesiveness values between -1.12 Nxs and 0.01 Nxs in their study on the purpose of enriching Salchichon –dry

fermented Spanish sausage- with poly unsaturated fatty acids n-3 and tocopherol α. Cabeza et al. [18] determined adhesiveness values of salchichon as -0.61 (Nxs) and of chorizo as -0.35 (Nxs) in their study on irradiation's effect upon product safety and quality by applying irradiation to dry fermented sausages (salchichon and chorizo).

Springiness is defined as sample's ability to regain its original form after deformation power has been taken away from the sample applied [7, 21-23]. Springiness values of fermented sucuks were determined between the range of 0.67 and 0.76 mm and this change is not statistically significant ($p>0.05$). Gimeno et al. [24] discovered springiness values of sausages provided from market between 0.51-0.61 mm.

Cohesiveness expressed as breaking strength was determined between 0.49 and 0.67 considering fermented sucuk samples. This difference is statistically significant ($p<0.05$). The highest cohesiveness value belonged to the sample with code F3; the sample with code F7 exhibited the lowest cohesiveness value. Hoz et al. [20]; detected cohesiveness values between 0.46-0.52 in their study on the purpose of enriching "Salchichon" -dry fermented Spanish sausage- with poly unsaturated fatty acids n-3 and tocopherol α. Casquete et al. [25]; found out cohesiveness values between 0.6-0.8 in their study on starter cultures' effects upon salchichon –traditional dry fermented Iberian sausage- during different ripening durations.

Gumminess is expressed as multiplication of hardness and cohesiveness. The difference between gumminess values of fermented sucuk samples were deemed as statistically significant ($p<0.05$) in this study. It was determined that gumminess values of fermented sucuks ranged between 52.96 and 138.50 N. Whereas the samples with codes F1, F5, F7 had the highest gumminess value; the sample with code F3 exhibited the lowest. Hoz et al. [20] detected gumminess values between 70.73 N and 77.00 N in their study on dry fermented Spanish sausage.

Chewiness values of fermented sucuks were detected between the range of 35.53 and 104.33 (Nxmm). This difference is statically significant ($p<0.05$). It was determined the samples with codes F1 and F7 had the highest chewiness values. Crehan et al. [5] discovered chewiness values of frankfurters, to which they were added 5%, 12%, 30% fat contents, between the range of 119.9-190.9 (Nxmm). Likewise Crehan et al. [5] found out chewiness values of frankfurters, which were added maltodextrin and had 5%, 12%, 30% fat contents, between the ranges of 101.3-149.9 (Nxmm).

Resilience values of fermented sucuk samples were determined between the range of 0.19 and 0.29. This change ensued as statically significant ($p<0.05$). The sample with code F3 exhibited the most resilience. Gadiyaram and Kannan [26] studied on determining textural specifications of sucuks containing low percentage of fat, produced from pork and cattle meat, and resilience value of the samples were determined between 0.10-0.13 in this research.

Hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience parameters of heat-treated sucuks provided from different companies were determined and these parameters are indicated in Table 3.4.

Table 3.4. The values of texture parameters measured on heat-treated sucuk samples

Sample Code	Hardness (N)	Adhesiveness (Nxs)	Springiness (mm)	Cohesiveness	Gumminess (N)	Chewiness (Nxmm)	Resilience
I1	253.92±15.50^{ab}	-1.34±0.30^{a}	0.67±0.01^{a}	0.51±0.04^{bcd}	129.40±2.13^{ab}	86.81±2.79^{ab}	0.15±0.02^{cd}
I2	251.49±15.35^{ab}	-1.30±0.23^{a}	0.58±0.08^{a}	0.41±0.05^{d}	102.28±6.04^{b}	59.35±11.54^{b}	0.11±0.02^{d}
I3	226.76±39.76^{ab}	-0.78±0.06^{ab}	0.59±0.03^{a}	0.44±0.02^{cd}	100.30±13.03^{b}	59.13±4.55^{b}	0.14±0.01^{cd}
I4	275.25±1.08^{ab}	-0.96±0.01^{ab}	0.69±0.10^{a}	0.48±0.01^{bcd}	131.99±4.03^{ab}	91.03±16.63^{ab}	0.14±0.00^{cd}
I5	237.86±34.51^{ab}	-0.54±0.24^{b}	0.76±0.00^{a}	0.57±0.01^{ab}	134.79±17.22^{ab}	101.73±12.53^{ab}	0.20±0.01^{b}
I6	341.46±12.99^{a}	-1.06±0.07^{ab}	0.74±0.08^{a}	0.53±0.02^{abc}	179.65±1.19^{a}	133.58±12.63^{a}	0.17±0.01^{bc}
I7	176.01±53.48^{b}	-0.32±0.20^{b}	0.78±0.01^{a}	0.64±0.04^{a}	111.70±27.91^{b}	87.45±20.33^{ab}	0.28±0.01^{a}

$^{a-d}$The superscripts represent the statistically significant differences within the group ($p< 0.05$).

Hardness values of heat-treated sucuk samples were determined between the ranges of 176.01-341.46 N. This difference between the samples was found statistically significant ($p<0.05$). The sample with code I6 had the highest hardness value; whereas the sample with code I7 owned the lowest hardness value. In a different research on textural study of sucuk [27] which handled sucuks produced by different applying different heat treatment, it was determined that hardness value had been 6.29 before heat treatment, hardness value of sucuks applied heat treatment at 60 °C had been 16.22 N and the hardness value of sucuks applied heat treatment at 70 °C had been 19.17 N. It was pointed out application of heat treatment causes increase of sucuk's hardness degree and hardness degree of sucuks produced through conventional methods is lower. Hoz et al. [20] discovered hardness values between 135.2-168.8 N in their study on the purpose of enriching Salchichon –dry fermented Spanish sausage- with poly unsaturated fatty acids n-3 and tocopherol α.

Adhesiveness parameter of heat-treated sucuks were detected between the range of -0.32 and -1.34 (Nxs) and statistical significance of this difference between the samples ($p<0.05$) was confirmed. Toptanci [27] researched different heat treatment temperatures' effect upon color and texture of sucuks. In this study done, adhesiveness value of sucuks were discovered as 0.13 (Nxmm) before application of heat treatment, this value was detected as 0.15 (Nxmm) considering sucuks applied heat treatment at 60 °C, 0.31 (Nxmm) at 65 °C and 0.47 (Nxmm) as for 70 °C. Adhesiveness values showed increase, as long as application temperature of heat treatment increased.

Springiness values of heat-treated sucuks were detected between 0.58 and 0.78 mm, this change is not statistically significant ($p>0.05$). Toptanci [27] found out springiness value of sucuks as 8.18 mm before application of heat treatment, this value was determined as 8.12 mm for sucuks applied heat treatment at 60 °C, 8.30 mm at 65 °C and 8.57 mm at 70 °C in the study on different heat treatment temperatures' effect upon color and texture of sucuks.

Cohesiveness of heat-treated sucuk samples was determined between 0.41 and 0.64. This difference is statistically significant ($p<0.05$). The sample with code I7 owned the highest cohesiveness value; whereas the sample with code I2 exhibited the lowest cohesiveness value. Toptanci [27] detected cohesiveness value as 0.35 for all sucuks applied heat treatment at 60 °C, 65 °C and 70 °C in the study related to color and texture of sucuks. It was reported that heat treatment application's and heat treatment temperature's effect was insignificant upon cohesiveness values of sucuks ($p>0.01$).
Gumminess values of heat-treated sucuks were determined between 100.30-179.65 N. This determinated value is statistically significant ($p<0.05$). The sample with code I6 exhibited the highest gumminess value; the samples with codes I2, I3 and I7 owned the lowest value. Herranz et al. [28] stated gumminess values of fermented sausages specified in three diverse groups as 53.6, 75.0 and 82.1 N in their study on effect of adding free amino acid to dry fermented sausages.

Chewiness values of heat-treated sucuks; were detected that they varied between 59.13 and 133.58 (Nxmm). This difference was found significant in point of statistic ($p<0.05$). The sample with code I6 possessed the highest chewiness value and the samples with codes I2 and I3 exhibited the lowest chewiness values. Uz [29] found out chewiness value of sucuks added bran at different rates as 26.53 (Nxmm) in control group of his study, while he determined chewiness values of sucuks added 3%, 6% and 9% bran as respectively 26.65, 30.66 and 36.70 (Nxmm).

Resilience values of heat-treated sucuk samples were determined between the range of 0.11 and 0.28. This change was considered statistically significant ($p<0.05$). The sample with code I7 exhibited the most resilience; whereas the sample with code I2 owned the lowest resilience value.

4. Conclusions

The results showed that the sample coded as F7 exhibited the highest properties of hardness, gumminess, chewiness and the highest L^* value. As for the sample with code F3, it had the highest acidity; this group also exhibited the highest properties of cohesiveness and resilience.

Among heat-treated sucuks, the sample with code I1 had the lowest pH value; the samples with codes I6 and I2 exhibited the highest acidity values. As to the samples with codes I1 and I5, they demonstrated the highest a^* values. The sample with code I6 had the highest properties of hardness, chewiness and gumminess. The sample demonstrating the highest properties of cohesiveness and resilience is the one with code I7.

It's considered that raw materials used during production of fermented and heat-treated sucuks (used meat, fat, spices, additives etc.), applied treatments during production process (applied temperature, ripening duration, environment temperature etc.) and conditions within period elapsing after production until consumption may be the reasons of the difference between textural and physicochemical properties of the sucuks provided from different companies.

5. References

[1] Muguerza E, Ansorena D, Gimeno O. Astiasara´n I (2004). New formulations for healthier dry fermented sausages: A review. *Trends in Food Sci. & Techn*, 15, 452–457.

[2] Öksüztepe G, İncili GK, Gül SB, Güran HŞ (2011). Elazığ'da tüketime sunulan fermente sucukların mikrobiyolojik ve kimyasal kalitesi. Fırat *Üniversitesi Sağlık Bilim Veterinerlik Dergisi*, 25(3), 107 – 114.

[3] Ertaş AH. (1985). Et ürünlerinin üretim teknikleri ve mikroorganizmalar. Kükem, 8(2), 131-134.

[4] Anonymous (2010). Gıdalarda Tekstür Analizi. www.forumfood.org/zyr/dosyalar/3d404e36ac.doc.

[5] Crehan CM, Hughes E, Troy DJ. Buckley DJ (2000). Effects of fat level and maltodextrin on the functional properties of frankfurters formulated with 5, 12 and 30% fat. *Meat Science*, 55, 463-469.

[6] Bozkurt H, Bayram M (2006). Color and texturel attributes of sucuk during ripening. *Meat Science*, 73, 344-350.

[7] Herrero AM, Ordónez JA, Romero de Avila , Herranz , B., de la Hoz L, Cambero MI (2007). Breaking strength of dry fermented sausages and their correlation with texture profile analysis (TPA) and physico-chemical characteristics. *Meat Science*, 77, 331-338.

[8] Lambooij E, Potgieter CM, Britz CM, Nortje GL, Pieterse C (1999). Effects of electrical and mechanical stunning methods on meat quality in Ostriches. *Meat Science*, 52, 331-337.
[9] Keller JE, Skelley GC, Acton CJ (1974). Effect of meat particle size and casing diameter on summer sausage properties during drying. *J. Milk Food Technol*, 37(2), 101-103.
[10] CIE (1976). International Commission on Illumination, Colorimetry: official recommendations of the International Commission on Illumination. Publication CIE No.15 (E-1.3.1) Paris, France: *Bureau Central de la CIE*.
[11] Ensoy Ü, Kolsarıcı N (2004). Fermente et ürünlerinde flavor oluşumu. *Standard*, 43(507), 81-93.
[12] Ercoşkun H, Tağı Ş, Ertaş AH (2010). The effect of different fermentation intervals on the quality characteristics of heat treated and traditional sucuks. *Meat Sci*, 85,174-181.
[13] Franco I, Prieto B, Cruz JM, Lopez M, Carballo J (2002). Study of the biochemical changes during the processing of androlla, a spanish dry-cured pork sausage. *Food Chemistry*, 78, 339-345.
[14] Gök V (2006). Antioksidan Kullanımının Fermente Sucukların Bazı Kalite Özellikleri Üzerine Etkileri. (Ph. D Thesis), *Ankara Üniversitesi, Gıda Mühendisliği Bölümü*, Ankara, 136.
[15] Bozkurt H, Erkmen O (2004). Effect of nitrate/nitrite on the quality of sausage (sucuk) during ripening and storage. *J Sci Food Agric*, 84, 279-286.
[16] Pérez-Alvarez JA, Sayas-Barberá ME, Férnandez-López J, Aranda-Catala V (1999). Physicochemical characteristics of Spanish-type dry-cured sausage. *Food Research International*, 32, 599-607.
[17] Üren A, Babayigit D (1997). Colour parameters of Turkish-type fermented sausage during fermentation and ripening. *Meat Science*, 45(4), 539–549.
[18] Cabeza MC, Hoz L, Velasco R, Cambero MI, Ordóñez (2009). Safety and quality of ready-to-eat dry fermented sausages subjected to E-beam radiation, *Meat Science*, 83, 320-327.
[19] Yetim H, Gökalp HY, Kaya M, Yanar M, Ockerman HW (1992). Physical, chemical and organoleptic characteristics of Turkish style frankfurters made with an emulsion containing soy flour. *Meat Science*, 31, 43-56.
[20] Hoz L, D'Arrigo M, Cambero I, Ordóñez, JA (2004) Development of an n-3 fatty acid and a-tocopherol enriched dry fermented sausage. *Meat Science*, 67, 485-495.
[21] Bruna J M, Fernández M, Hierro EM, Ordóñez JA, Hoz L (2000). Combine duse of a protease (Pronase E) and a fungal extract (*Penicillium aurantiogriseum*) to improve the sensory characteristics of dry fermented sausages. Meat Science, 54, 135–145.
[22] Andres SC, Garcia ME, Zaritzky NE, Califano AN (2006). Storage stability of low-fat chicken sausages. *Journal of Food Engineering*, 72, 311-319.
[23] Spaziani M, Del Torre M, Stecchini ML (2009). Changes of physicochemical, microbiological, and textural properties during ripening of Italian low-acid sausages. Proteolysis, sensory and volatile profiles. *Meat Science*, 81, 77-85.
[24] Gimeno, O, Ansorena, D, Astiasaran, I, Bello, J (2000). Characterization of chorizo de Pamplona: Instrumental measurements of colour and texture. *Food Chem*., 69, 195–200.
[25] Casquete R, Benito MJ, Martín A, Ruiz-Moyana S, Hernández A, Córdoba MG (2011). Effect of auto chthonous starter cultures in the production of "salchichón", a traditional Iberian dry-fermented sausage, with differen tripening processes. *Meat Science*, 44, 1562-1571.
[26] Gadiyaram KM, Kannan G (2004). Comparison of textural properties of low-fat chevon, beef, pork and mixed-meat sausages. *South African Journal of Animal Science*, 34 (Supplement 1).
[27] Toptancı İ (2007). Sucuğun Renk ve Tekstürüne Farklı Isıl İşlem Sıcaklıklarının Etkisi. Yüksek Lisans Tezi. Ankara Üniversitesi, *Fen Bilimleri Enstitüsü,* Ankara.
[28] Herranz B, Hoz L, Hierro E, Fernández M, Ordóñez JA (2005). Improvement of the sensory properties of dry-fermented sausages by the addition of free amino acids. *Meat Science*, 91, 673-682.

[29] Uz A (2008). Az Yağlı Sucuğun Renk ve Tekstürüne Buğday Kepeği İlavesinin Etkisi. Yüksek Lisans Tezi. Ankara Üniversitesi, *Fen Bilimleri Enstitüsü*, Ankara.