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Araştırma/*Research*

EFFECT OF BACTERIAL CELLULOSE AS A FAT REPLACER ON SOME QUALITY CHARACTERISTICS OF FAT REDUCED SUCUK

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Abstract

Bacterial cellulose (BC) produced by *Gluconacetobacter* sp. A06O2 strain was used as a fat replacer in sucuk (Turkish dry fermented sausage) and effect on some quality characteristics of sucuk was investigated in the present study. Moisture and protein contents of sucuk samples increased with decreasing fat levels and increasing BC levels. While the addition of BC affected hardness value, it did not affect gumminess and chewiness values of sucuk samples. Reducing fat content caused increasing of *a* and *b* values and decreasing of *L* value ($P > 0.05$). No significant differences were observed in odour, color, texture, flavor and overall acceptability between samples. The results indicated that BC could be used as fat replacer in the production of reduced fat dry fermented sausages.

Keywords: Bacterial cellulose, sucuk, fat replacer, quality characteristic

YAĞI AZALTILMIŞ SUCUĞUN BAZI KALİTE ÖZELLİKLERİ ÜZERİNE YAĞ İKAME MADDESİ OLARAK KULLANILAN BAKTERİYEL SELÜLOZUN ETKİSİ

Özet

Bu çalışmada *Gluconacetobacter* sp. A06O2 suşundan elde edilen bakteriyel selüloz (BS) sucukta yağ ikame maddesi olarak kullanılmış ve sucuğun bazı kalite özellikleri üzerine etkisi araştırılmıştır. Yağ seviyesi azaldıkça ve BS miktarı arttıkça sucuk örneklerinin nem ve protein değerlerinin arttığı tespit edilmiştir. BS ilavesi sertlik değerine etki ederken, yapışkanlık ve çiğnenebilirdik değerlerine etki etmemiştir. Yağ içeriğindeki azalış *a* ve *b* değerlerinin artışına *L* değerinin azalışına neden olmuştur ($P > 0.05$). Tat, koku, renk, tekstür ve genel beğeni açısından örnekler arasında önemli bir farklılık tespit edilmemiştir ($P > 0.05$). Bu sonuçlar yağı azaltılmış fermente sucuk üretiminde bakteriyel selülozun yağ ikame maddesi olarak kullanılabileceğini göstermiştir.

Anahtar kelimeler: Bakteriyel selüloz, sucuk, yağ ikame maddesi, kalite özellikleri

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INTRODUCTION

Consumer awareness of the potential health risk associated with the consumption of high-fat foods has increased over the last decades. Several chronic diseases such as obesity, cardiovascular diseases, colon cancer related with dietary fat have been serious problems for consumers (1). Therefore, several health-related organizations such as American Heart Association, American Cancer Society, World Health Organization have recommended to limit total fat intake (2). In order to produce healthier meat products, the food industry has been led to develop new formulations or modify traditional food products having a reduced fat content (1).

Sucuk (Turkish dry fermented sausage) is one of the most important and widely consumed traditional Turkish meat products. It is a type of dry, uncooked, cured, fermented sausage. It consists of ground meat and sheep tail fat, and curing ingredient (nitrite or nitrate), with various spices including cumin, garlic, salt, and black and red pepper. This mixture is stuffed into a natural sucuk casing (mostly cattle small intestines), hung for fermentation (ripening period) for several weeks at ambient temperature and humidity. It has been produced and consumed around the Balkans and the Middle East for decades. It is also consumed in European countries such as Germany (3).

Sucuk which is produced from fresh meat and fat has a high fat content, and the fat globules are visible when the product is sliced. Its initial fat content is generally around 10–20 %. However, fat content reaches to 30–40 % after the ripening period (4). Therefore, some attempts about replacement of fat with the various types of oils as well as evaluation of the effect of fat levels in the sucuk production have been made. As a result of these studies, it was suggested that the use of olive oil, sunflower oil, pre-emulsified hazelnut oil and interesterified plant oils as fat replacer might give a healthier option to consumers due to higher levels of unsaturated and essential fatty acids without any significant negative sensorial characteristics (3). Increased proportions of fiber in foods are known to reduce the risk of cancer of the colon, obesity, cardio-vascular diseases and several other disorders. However, the studies on the sucuk containing dietetic fiber as fat replacer are rather scarce.

BC is a ribbon-shaped fiber and produced by *Gluconacetobacter xylinus*. The structure of BC is similar to cellulose and is regarded as an insoluble, noncaloric dietary fiber. BC showed possible application to versatile processed foods through its unique suspending, thickening, water-holding, stabilizing, bulking, and fluid properties. Feeding with BC caused a reduction in food retention in the intestine and an increased secretion of bile acids in feces of rats (5). It was also reported that the efficacy of BC in lowering serum lipids and cholesterol in hamsters was significantly higher than that of plant cellulose (6). In addition, BC has been determined to be "generally recognized as safe" (GRAS) and accepted for by the Food and Drug Administration in 1992 (7). Although several dietary fibers with plant origin have been used in various types of foods, there is only one study about the use of BC for fat reduction in the meat products. Lin & Lin (5) studied on the physicochemical, textural, and quality characteristics of Chinese-style meatball (20 % fat) containing varying levels of bacterial cellulose. They proposed that BC showed potential as a functional ingredient in Chinese-style emulsified meat products. Therefore, the aim of this study is to determine the effect of fat reduction and addition of bacterial cellulose on some quality characteristics such as the chemical, texture, color and sensory properties of reduced fat sucuk.

MATERIAL and METHODS

Bacterial Strain and Cultivation Conditions

Gluconacetobacter sp. A06O2 strain previously determined as BC producer with a high amount of BC was used in this study (8). The strain was propagated in HS medium contains glucose 20 g/ L, peptone from casein 5 g/ L, yeast extract 5 g/ L, disodium hydrogen phosphate 2.7 g/ L, citric acid 1.5 g/ L in distilled water (9).

Production and Purification of BC

The strain was inoculated to 1 L HS broth in the sterile glass tray. Incubation was performed at 28 °C for 10 days in static condition. After incubation, the pellet was boiled in 0.1 N NaOH solution for 20 min to remove bacterial cells and medium components. The cellulose pellet was then rinsed 3 times with deionized water and homogenized (10).

Formulation and Process of Sucuk

Sucuk batters with different BC and fat contents were prepared in order to determine chemical, texture, color and sensory changes in the samples. Different levels of BC (0 %, 5 %, 10 %, 15 % and 20 %) were added to sucuk batters including 20 %, 15 %, 10 %, 5 % and 0 % of fat, respectively and so four different treatments were prepared. Control group contained no BC but only 20 % fat. Their compositions are given in Table 1. Beef meat was mixed with other ingredients and this mixture was minced through a plate with 4 mm orifices, allowed to stand overnight at 4 °C (day 0), and then stuffed into 36 mm diameter collagen casings (Pabay Co., Istanbul, Turkey) using a hydraulic filling machine (Yuneka Metal Co., Bursa, Turkey). Then sucuk samples were hung on stainless steel hangers and allowed to equilibrate at 20 °C and 70 % relative humidity (RH) for 6–8 h. They were placed in a ripening chamber (Biogen Co., Ankara, Turkey) equipped with a process control system. The ripening programs were as follows: 3 days at 22 °C and RH 90 ± 2 %, 4 days at 20 °C and RH 85 ± 2 %, and 7 days at 18 ± 1 °C and RH 80 ± 2 %. The fresh air (0.2 m s-1) was circulated 4 or 5 times a day for 15 min (11, 12). Sucuk samples were dipped into K-sorbate solution (1%) to prevent surface mold growth during fermentation. At the end of day 15, pH values were in the range of 4.9-5.1 and thus the fermentation was ended. The samples were placed into the bags and vacuum packaged in a discontinuous packer (Atek, AATV 2X65, Turkey). All samples were stored at 4 °C until analysis.

Chemical Analysis

Moisture (oven air-drying), protein (Kjeldhal nitrogen) and ash (muffle furnace) contents were determined according to the Association of Official Analytical Chemists (13). Fat content was analyzed according to Soxhelet method. All determinations were performed in duplicate.

Color Analysis

Color analysis was made with a Hunter Lab colorimeter (Minolta CM-3600D, Japan) using the color space CIE lightness *L*, redness *a* and yellowness *b* system. Sucuk samples were cut and obtained three slices for each sample. Measurements were performed at four points on the central part of the cut surface at room temperature (14).

Textural Profile Analysis

The textural properties of the samples were determined using a texturometer (Lloyd TA Plus, USA). Each sample was divided into five slices having a 25 mm diameter and 10 mm high. These slices were compressed twice to 50 % of their original height with 1 mm s^{-1} crosshead speed. Some parameters such as hardness (N), gumminess (N), springiness (mm), chewiness (N mm) and cohesiveness were determined (15).

Sensorial Analysis

Ten experienced panelists, staff members of the department of food engineering in Ankara University were chosen and informed about sensorial evaluation of sucuk. A test was carried out using hedonic scales in which the panelists evaluated different attributes: odour, color, texture,

Table 1. Formulation of sucuk samples
Çizelge 1. Sucuk örneklerinin formülasyonu

Ingredients	Samples				
	Control 20% fat, 0% BC	G1 15% fat, 5% BC	G2 10% fat, 10% BC	G3 5% fat, 15% BC	G4 0% fat, 20% BC
Beef meat (g)	2000	2000	2000	2000	2000
Fat (g)	400	300	200	100	0
Bacterial cellulose (g)	0	100	200	300	400
Salt (2 %)	48	48	48	48	48
Sugar (0.2 %)	4	4	4	4	4
Garlic (1.2 %)	29	29	29	29	29
Red pepper (0.9 %)	22	22	22	22	22
Balck Pepper (0.5%)	12	12	12	12	12
Cummin (0.6 %)	15	15	15	15	15
Na-Nitrite (0.05 %)	1.2	1.2	1.2	1.2	1.2
Starter culture (0.27 %)	0.65	0.65	0.65	0.65	0.65

flavor and overall acceptability (0 = very unpleasant and 10 = very pleasant). The averages of scores were calculated and then the samples were sorted for preferences of panelists.

Statistical Analysis

An analysis of variance was used to evaluate the effects of different concentrations of BC and fat on the overall attributes of sucuk. The differences were tested by Duncan's Multiple Range Test at a confidence level of 5 % ($P < 0.05$) using the SPSS statistical package (SPSS Inc., Chicago, IL, USA).

RESULTS and DISCUSSION

Chemical Analysis

Some chemical properties of the sucuk samples are given in Table 2. Reduction of fat content and addition of BC in different rates had a significant effect ($P < 0.05$) on all chemical properties. Moisture contents of the sucuk samples varied between 33.78 % and 39.91 %. The treatments with reduced fat had higher in moisture content than that of the treatment with control. This is probably due to the water holding capacity of BC. Similar results were reported for other fat replacers such as β–glucan, starch and commercial fat replacers at different researches (16-19). Addition of BC also caused an important increase in ash content ($P < 0.05$). As expected, it was also determined an increase in protein contents ($P < 0.05$), because fat replaced with lean meat in the original formula. The final fat content of the control was 19.02 %, which was similar to traditional fermented sausages (4, 20). Conversely, the G1, G2, G3 and G4 treatments had final fat contents of 17.98 %, 11.70 %, 10.70 % and 5.17 %, representing an approximately 2 %, 40 %, 50 % and 70 % reduction in the fat content, respectively. Although the fat contents of the groups showed a relative decrease, the data were not correlated with added fat into the batter. These results could be attributed to the differences in fat distribution within the sucuk mass.

Texture Profile Analysis

Texture profile (hardness, springiness, cohesiveness, gumminess, chewiness) of sucuk samples were compared with each other and results were given in Table 3. The treatment with control had significantly higher hardness value than the treatments with reduced fat, which demonstrate that the addition of BC has effect on this parameter. This may be explained by water holding capacity of BC which provided high moisture. Some researchers showed similar results in their studies about using diet fiber to reducing fat content (21, 22). As gumminess and chewiness increased, pasty gummy sucuk were formed and sucuk became tougher during the ripening period (23). In the present study gumminess and chewiness values was not increased with addition of BC and this result is desirable in terms of quality of structure. Cohesiveness values of G3 and G4 samples are different from the control sample. It is showed that increase of BC content has an effect on cohesiveness value of sucuk. Springiness values

Table 2. Chemical properties of the sucuk samples after ripening period
Çizelge 2. Sucuk örneklerinin olgunlaştırma sonrası kimyasal özellikleri

	Control	G1	G2	G3	G4
Moisture (%)	33.78 ± 2.69^{b}	36.16 ± 1.51^{ab}	37.52 ± 3.41^{ab}	39.28 ± 0.09^{ab}	39.91 ± 0.29^{a}
Protein (%)	33.36 ± 1.43^{c}	32,75 ± 1.19^{c}	33.75 ± 0.33^{bc}	35.77 ± 0.37^{b}	39.58 ± 0.22^{a}
Fat (%)	19.02 ± 0.77^{a}	17.98 ± 0.69^{a}	11.70 ± 1.23^{b}	10.70 ± 1.36^{b}	5.17 ± 0.54^{c}
Ash (%)	4.06 ± 0.80^{c}	5.21 ± 0.41^{bc}	5.85 ± 0.40^{ab}	6.21 ± 0.24^{ab}	6.79 ± 0.60^{a}

$^{a-c}$ Values with the different superscript letters in the same line show significant differences ($p < 0.05$)

Table 3. Textural properties of the sucuk samples after ripening period
Çizelge 3. Sucuk örneklerinin olgunlaştırma sonrası tekstürel özellikleri

	Control	G1	G2	G3	G4
Hardness, N	28.83 ± 1.62^{b}	24.00 ± 1.64^{b}	23.78 ± 1.32^{b}	16.13 ± 0.93^{c}	40.64 ± 1.17^{a}
Gumminess, N	13.19 ± 0.59	12.22 ± 2.43	11.69 ± 1.82	9.65 ± 0.74	9.97 ± 4.19
Springiness, mm	14.03 ± 0.01^{a}	14.03 ± 0.01^{a}	10.98 ± 4.29^{ab}	14.03 ± 0.02^{a}	7.49 ± 1.38^{b}
Chewiness, N mm	185.02 ± 8.16^{a}	171.43 ± 34.18a	124.48 ± 30.17^{ab}	135.36 ± 10.57^{a}	71.76 ± 17.60^{b}
Cohesiveness	0.46 ± 0.01^{b}	0.51 ± 0.07^{bc}	0.49 ± 0.05^{bc}	0.60 ± 0.01^{a}	0.24 ± 0.10^{c}

$^{a-c}$ Values with the different superscript letters in the same line show significant differences ($p < 0.05$)

of samples are not significantly different from each other except G4 sample. Springiness was significantly related to moisture content of sucuk and also affected to the elastic properties of sucuk. Decreasing the springiness value indicates that elasticity of sucuk is lost possibly due to the removal of water (23). In the present study, springiness values were not changed since BC prevented to removal water.

Color Analysis

The changes of Hunter *L*, *a*, *b* values in sucuk samples are given in Table 4. In the present study, the control sample showed higher *L* value compared to treatments with reduced fat content. In general manner, the fat reduction yield a decrease in lightness related to the lack of the lower brilliant aspect associated with the presence of fat (24). Papadima and Bloukas (25) also reported that increasing fat levels resulted in higher *L* values. However this decrease in lightness was not observed significantly ($P > 0.05$). While the increase of *b* values of samples was not found important significantly ($p > 0.05$), variation of *a* value was observed significantly ($P < 0.05$). Differences in a value can be ignored since the values are so close to each other. Dos Santos et al. (14) also indicated that 50 % reduction in fat and the addition of 3 %, 6 % or 9 % fructooligosaccharides did not change the *a* and *b* values at the end of production. Similarly, Muguerza et al. (26) detected no difference in colour between control fermented sausages and sausages in which pre-emulsified olive oil replaced 30% of the pork fat. These results are to say, no significant effect of addition of BC on sucuk color parameters was observed in the current study.

Sensory Analysis

Fat reduction can affect the acceptability of the products since fat contributes to the sensory properties of sausages (4). The effect of BC on the sensory properties of sucuk samples is shown in Table 5. G4 treatment without fat had lower texture and overall acceptability value. This may be attributed to the increased hardness observed in the texture profile analysis. G4 treatment also exhibited differences as in texture analysis. This showed that addition of 20 % BC showed negative impact of texture and sensory properties of sucuk. However, in general terms, there were no differences in the odour, color, flavour, texture between the controls and the G1, G2, G3, G4 treatments ($P > 0.05$). It was reported that the sensory properties of sausage decreases with decreasing fat content (27, 28). Contrary to this, sensory properties of sucuk samples were not affected with decreasing fat content in the present study.

CONCLUSIONS

These results showed that the substitution of fat content by BC can be accomplished without a loss of product quality, enabling the production of sucuk reduced fat levels 15 %, 10 %, 5 %. Thus, the use of BC has been provided to be a good alternative for the development of healthier products for the consumer. However, in order to obtain more clear results, changes of physicochemical, texture, and sensory properties during storage period should be searched in the further studies.

Table 4. Colour attributes (Hunter L, a, b) of the sucuk samples after ripening period
Çizelge 4. Sucuk örneklerinin olgunlaştırma sonrası renk özellikleri (Hunter L, a, b)

Hunter colour	Control	G1	G2	G3	G4
L	41.72 ± 3.83	40.99 ± 1.10	39.25 ± 3.33	44.25 ± 2.27	38.58 ± 3.18
a	15.77 ± 0.62^{ab}	16.34 ± 0.14^{b}	16.49 ± 0.19^{b}	15.25 ± 0.54^{a}	16.00 ± 0.04^{ab}
b	15.21 ± 1.13	16.32 ± 0.48	14.24 ± 1.43	15.84 ± 0.69	15.50 ± 0.64

$^{a-b}$ Values with the different superscript letters in the same line show significant differences ($p < 0.05$)

Table 5. Sensory properties of the sucuk samples after ripening period
Çizelge 5. Sucuk örneklerinin olgunlaştırma sonrası duyusal özellikleri

	Control	G1	G2	G3	G4
Odour	6.3	5.9	6.4	7.1	6.5
Color	6.4	6.4	7.1	7.8	6.8
Flavor	7.0	6.0	6.4	7.3	6.0
Texture	6.3	6.1	6.0	6.9	6.0
Overall acceptability	6.1	6.5	7.1	7.5	5.8

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