EFFECTS OF OLIVE OIL AS PARTIAL REPLACER OF ANIMAL FAT IN SUCUK ON OXIDATION AND SOME QUALITY PROPERTIES DURING PRODUCTION

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Abstract – The objective of this study was to investigate the effects of partial animal fat replacement with olive oil on oxidation and some quality parameters of sucuk during production stages. 3 different formulations of sucuks were prepared as follows: C: control treatment formulated with 100% beef fat, O15: treatment formulated with 85% beef fat+15% olive oil, O30: treatment formulated with 70% beef fat+ 30% olive oil. While final moisture content was similar in samples, final water activity was highest in C group ($p<0.05$). The highest pH value was recorded in O30 samples compared to C and O15 samples after heat treatment ($p<0.05$). Initial and final acidity values were increased with the increased olive oil ratios ($p<0.05$). Final peroxide values of the samples were similar to each other. Increased concentrations of olive oil had a significant effect on decreasing TBA values of final products ($p<0.05$). O30 samples had the highest carbonyl content at all stages compared to C samples and heat treatment had a significant effect on carbonyl increment of all treatments ($p<0.05$). The results showed that replacing beef fat with olive oil had considerable effects on quality of heat-treated sucuk during production in terms of physical properties, lipid and protein oxidation.

Key Words – olive oil, fat replacement, fermentation, sucuk, soujouk.

I. INTRODUCTION

Sucuk (a Turkish dried fermented sausage) is one of the most popular traditional meat products in Turkey, which is mostly produced from beef, beef backfat, tail fat, salt, sugar, garlic, nitrite and various spices [1]. Generally, the fat content in the sucuk formulation has a strong impact on the quality of the final product [2]. Recently, there has been an increase in the studies of reducing and substituting of fat content of meat products. Several studies have focused on replacing animal fat with various vegetable oils in order to achieve healthier meat products. The effect of replacement fat by olive oil [3,4,5], soy oil [6] interesterified palm and cottonseed oils [7], hazelnut oil [8,9] on physical, chemical and sensory properties of fermented meat products have been extensively investigated. Olive oil is a rich source of tocopherols and phenolic substances which act as antioxidants. Thus the incorporation of olive oil in meat products may have promising functional effects.

Many reactions involving lipids, proteins and carbohydrates occur during fermentation and ripening of fermented sausages [10,11].Lipids, pigments and proteins are oxidized during processing and storage [2,12]. Oxidation of unsaturated fatty acids results in the production of lipid peroxides and carbonyl compounds, which is related to both chemical reactions and bacterial metabolism [10]. Oxidative reactions affect product quality in terms of taste and odour [12,13]

The objective of this study was to investigate the effect of replacing beef fat with olive oil on oxidation in terms of lipid and protein oxidation and some quality characteristics of heat treated sucuk during production stages.

II. MATERIALS AND METHODS

Fresh boneless lean beef, beef fat, olive oil and other additives were supplied from local market of İzmir. Beef was trimmed of visible fat and connective tissue. Lean and fat were minced through a 3 mm plate grinder (Arnica, Turkey). Three different formulations of sucuk, containing 4 kg meat each, were prepared. Each treatment was formulated to contain 20% total fat. Control (C) group was consisted of 100 % beef fat. Olive oil was replaced with beef fat at levels of 15% (O15) or 30 % (O30). The other

ingredients added to treatments were 80 g salt, 16 g saccarose, 1 g ascorbic acid, 0.6 g Na-nitrite mixture (90% salt, 10% nitrite), 110 g spices and 40 g garlic powder. After mixing all ingredients, sucuk doughs were stuffed into natural casings with a diameter of 36 mm by a hydraulic filling machine (Alpina, Switzerland). Sucuk samples were allowed to stand at 23°C and 60% relative humidity (RH) for 3 h before fermentation in a fermentation chamber (Wisd, Germany), and then, sucuks were fermented at 23°C and 87% RH until the pH reached 5.6. After fermentation, sucuks were heated (Afos, England) until core temperature reached 68°C. After heat treatment, sucuks were cooled by spraying water. Sucuk samples were then allowed to stand at 19°C and 73% RH for 2 days to drop the moisture to 50%. Samples were taken before stuffing (day 0), after heat treatment stage and at the end of the production (final product).

Moisture % content of the samples was determined according to AOAC (2012). pH was measured from three different points by using a pH-meter (WTW pH 330i/SET, Germany) penetration probe. Weight loss was determined depending on the weight differences and expressed as percentage of the initial weight. Water activity (aw) was measured with a water activity measurement device (Testo AG 400, Lenzkirch, Germany), with a 0.001 sensitivity. Acidity was determined by a titrimetric AOAC method and expressed as lactic acid % [14]. Thiobarbituric acid (TBA) value was determined according to the method of Witte et al. [15]. For peroxide analyses, fat was extracted with chloroform and methanol according to the method of Flynn and Bramblett [16]. The peroxide value was analyzed according to AOAC [17]. The total carbonyl content of sucuk samples was analyzed by the method of Liu et al. [18]. The data was analyzed by one way ANOVA using the SPSS software version 21 [19]. Differences among the means were compared using Duncan's Multiple Range Test. A significance level of $p<0.05$ was used for all evaluations.

III. RESULTS AND DISCUSSION

Changes in moisture content of sucuk samples during production are presented in Table 1. No significant differences were recorded between treatments. During fermentation and heat treatment, moisture contents of all samples significantly decreased ($p<0.05$). According to literature, fermentation process causes the decreasing of moisture content [20,21].

Table 1 Moisture content (%) of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	63.10 ± 1.98^{X}	52.90 ± 1.23^{Y}	45.66 ± 0.28^{Z}
O15	62.74 ± 1.60^{X}	52.01 ± 2.51^{Y}	43.08 ± 0.43^{Z}
O30	59.42 ± 1.66^{X}	52.17 ± 1.56^{Y}	43.81 ± 0.78^{Z}

Data are presented as the mean values of 3 replications ± SD. Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

Water activity (aw) of sucuk samples during fermentation could be seen in Table 2. Significant differences were recorded in initial aw of the samples. Initial aw value was highest in O15 group, while it was lowest in C group ($p<0.05$). The values got closer to each other with fermentation and heat treatment. In all treatments, the changes in aw values with time were significant ($p<0.05$). At the end of fermentation, C group had the highest aw value ($p<0.05$).

Table 2 Water activity of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	$0.948\pm0.03^{c, X}$	0.912 ± 0.08^{Y}	$0.837\pm0.01^{a, Z}$
O15	$0.959\pm0.02^{a, X}$	0.919 ± 0.04^{Y}	$0.813\pm0.01^{b, Z}$
O30	$0.955\pm0.00^{b,X}$	0.913 ± 0.02^{Y}	$0.817\pm0.01^{b, Z}$

Data are presented as the mean values of 3 replications ± SD. Means within same column with different letters (a,b,c) are significantly different ($p < 0.05$). Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

pH changes in treatments during fermentation are presented at Table 3. According to [11], organic acids, mainly lactic acid, are formed in fermented sausages as a result of carbohydrate breakdown during fermentation, and pH drops. Production stages had a significant effect on pH ($p<0.05$). The results of our study showed that initial pH values of treatments were similar to each other, in accordance with studies of Kayaardı et al. [22] and Muguerza et al. [6].

After fermentation and heat treatment, pH decrement started to differ between groups, where the highest pH value was recorded in O30 samples compared to C and O15 ($p<0.05$). Vural and Javidipour [7] stated that replacing beef fat with olive oil had a significant effect in increasing the pH drop rate.

Table 3 pH values of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	5.94 ± 0.01^{X}	$5.43\pm0.02^{b, Y}$	$5.60\pm0.02^{b, Z}$
O15	5.93 ± 0.01^{X}	$5.42\pm0.02^{b, Y}$	$5.59\pm0.03^{b, Z}$
O30	5.92 ± 0.01^{X}	$5.57\pm0.03^{a, X}$	$5.70\pm0.03^{a, Y}$

Data are presented as the mean values of 3 replications ± SD. Means within same column with different letters (a,b) are significantly different ($p < 0.05$). Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

Titratable acidity values of sucuk samples are presented in Table 4. Initial acidity values were increased with the increased olive oil ratios ($p<0.05$). Heat treatment resulted in a significant increment in acidity values of all treatments ($p<0.05$). Final acidity value was highest in O30 samples ($p<0.05$). Although O30 sample had highest pH, O30 sample had the highest acidity value due to fermentation and degradation of unsaturated fatty acid of olive oil.

Table 4 Acidity (lactic acid %) of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	$0.24\pm0.03^{c, Z}$	$1.06\pm0.04^{b, X}$	$0.48\pm0.03^{c, Y}$
O15	$0.62\pm0.01^{b, Y}$	$1.39\pm0.04^{a, X}$	$0.54\pm0.01^{b, Z}$
O30	$0.67\pm0.01^{a, Z}$	$1.10\pm0.03^{b, X}$	$0.75\pm0.05^{a, Y}$

Data are presented as the mean values of 3 replications ± SD. Means within same column with different letters (a,b,c) are significantly different ($p < 0.05$). Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

Peroxide values of samples were given in Table 5. While no differences were recorded in the initial peroxide values of the samples, peroxide values of the samples showed significant alterations during fermentation and heat treatment ($p<0.05$). At the end of the production, peroxide values of all samples were close to each other. Similar to our study, fluctuations in the lipid oxidation values were reported during production of Cantonese-type sausages [23].

Table 5 Peroxide value of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	18.54 ± 0.89^{Y}	$36.84\pm0.68^{b, X}$	35.04 ± 1.19^{X}
O15	18.64 ± 0.10^{Z}	$55.13\pm1.07^{a, X}$	34.81 ± 0.46^{Y}
O30	18.79 ± 0.31^{Y}	$19.01\pm0.17^{c, Y}$	36.25 ± 1.16^{X}

Data are presented as the mean values of 3 replications ± SD. Means within same column with different letters (a,b,c) are significantly different ($p < 0.05$). Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

TBA values of the treatments are given in Table 6. The highest initial TBA value was recorded in C samples ($p<0.05$), while increased amounts of olive oil did not have a considerable effect on TBA. TBA values of all samples were significantly increased with the fermentation and heat treatment process ($p<0.05$). Final values showed that increased concentrations of olive oil had a significant effect on decreasing TBA values ($p<0.05$), which could be probably due to antioxidant compounds present in olive oil. Our results were similar to the study of Bloukas et al. [3].

Table 6 TBA value of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	$0.58\pm0.08^{a,Z}$	$1.29\pm0.07^{a,X}$	$1.17\pm0.13^{a,Y}$
O15	$0.49\pm0.49^{b,Z}$	$1.13\pm0.03^{b,X}$	$0.90\pm0.09^{b,Y}$
O30	$0.45\pm0.45^{b,Z}$	$0.76\pm0.07^{c,X}$	$0.51\pm0.02^{c,Y}$

Data are presented as the mean values of 3 replications ± SD. Means within same column with different letters (a,b,c) are significantly different ($p < 0.05$). Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

One of the indexes of protein oxidation, total carbonyl content results were given in Table 7. The addition of olive oil caused significant changes in carbonyl content of the samples ($p<0.05$). Olive oil contains high amount of unsaturated fatty acid, so it's more sensitive to oxidation. For this reason O30 samples had the highest values at all stages compared to C samples ($p<0.05$). During the production, carbonyl content of samples were significantly increased ($p<0.05$). The results showed that heat treatment had a significant effect on carbonyl increment of all treatments ($p<0.05$). Similarly, Dalmış [20] reported that heat treatment and drying process caused the increment in the carbonyl content of sucuk samples.

Table 7 Carbonyl content of sucuk treatments during production

Groups	Initial	Heat treated	Final
C	$1.55\pm0.39^{b, Y}$	$2.69\pm0.11^{b, X}$	$2.61\pm0.13^{b, X}$
O15	$2.05\pm0.25^{ab, Y}$	$2.94\pm0.11^{ab, X}$	$2.83\pm0.22^{ab, X}$
O30	$2.38\pm0.01^{a, Y}$	$3.59\pm0.08^{a, X}$	$3.53\pm0.13^{a, X}$

Data are presented as the mean values of 3 replications ± SD. Means within same column with different letters (a,b,c) are significantly different ($p < 0.05$). Means within same row with different letters (X,Y,Z) are significantly different ($p < 0.05$).

IV. CONCLUSION

The results of the study showed that partial replacement of beef fat with olive oil resulted in considerable changes in physical and chemical quality attributes during production of heat treated sucuk. Further research should be performed with various vegetable oils and variable production parameters.

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