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Some Chemical Characteristics of Sucuk and Salami Samples Available at Retail in Adana

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ABSTRACT

The aim of this study was to investigate some chemical characteristics and residual nitrite and nitrate levels of sucuk and salami samples collected from retail outlets of major supermarkets in Adana province. A total of 36 sucuk samples (12 brands; 7 national and 5 local producers) and 30 salami samples (10 brands; Macar salamis) were purchased from local markets. Sucuk and salami samples were analyzed for pH value, moisture content, water activity and nitrite and nitrate contents. The average pH values of sucuk samples ranged between 4.69 and 6.56 indicating a higher variation while the average pH values of salami samples ranged between 6.05 and 6.43. Likewise, the average moisture contents of sucuk samples were between 33.56% and 46.78% whereas the average moisture contents of salami samples ranged between 62.09% and 67.91% indicating a relatively lower variation. Water activity values of the sucuk samples were between 0.932 and 0.861 while the average a_w values of the salami samples ranged between 0.916 and 0.940. Among the sucuk samples analyzed in the present study mean nitrite and nitrate contents ranged from 58.65 mg/kg to 216.63 mg/kg and 34.86 mg/kg to 161.08 mg/kg, respectively. While relatively lower nitrite (14.30 mg/kg - 35.96 mg/kg) and no nitrate contents were observed in salami samples, the data indicated that a higher variation of both nitrite and nitrate contents were still present in sucuk samples in the local markets requiring more studies and inspections to lower the variation related to dietary exposure to nitrite and nitrite from these types of products.

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Introduction

Sucuk is a dry or semi-dry fermented sausage produced mostly by mixing ground beef and beef fat and/or sheep tail fat with salt, sugar, nitrite or/and nitrate (cure) and some species including black pepper, red pepper, cumin, garlic. The mixture is than stuffed into natural or synthetic casings. Sucuks are fermented either by chance inoculation (natural fermentation) or by inoculating a starter culture. Fermentation and the following drying or ripening steps take place under natural or controlled climate conditions (Erkmen et al., 2004; Gencelep et al., 2008; Coskuner et al., 2010). Traditional method of producing Turkish sucuk doesn't involve any heat treatment and generally requires at least one week of ripening period while heat treated sucuks are exposed to a heat treatment following a short period of fermentation around 12 to 24 h (Coskuner et al., 2010).

Salami is a smoked and cooked, emulsion-type sausage produced using finely chopped mixture of lean meat, fat, cure, and spices. Extraction or solubilization of salt soluble proteins (especially myosin) is required to form meat emulsions or batters. Thus salt soluble proteins are extracted by addition of salt and water during chopping to coat the fat particles. The fat particles have tendency to form the disperse phase when the proteins and water become the continuous phase in the meat emulsions. The lipophilic portions of the proteins unfold and interact with the fat while the hydrophilic portions of the proteins interact with the aqueous phase. The salt soluble proteins behave like emulsifiers and stabilize the sausage batter by forming a viscous matrix. The texture of the emulsion-type meat products is formed by thermal transitions of the fat and protein during cooking and cooling that stabilizes the structure in finished products (Pearson et al., 1996; Aberle et al., 2001; Anar, 2010).

Sodium or potassium nitrite is added into the meat products to obtain desirable meaty flavor, prevent warmed-over flavor, develop a bright reddish pink color and inhibit microbial growth, specifically out-growth of *Clostridium botulinum* spores. Meat curing also involves the use of salt, seasonings and other ingredients to give unique color, flavor and texture to the meat products. Even though sodium or potassium nitrate can be used to cure the meat, nitrate is further reduced to nitrite by the microorganisms and has limited use to cure slow-cured

products including some types of the fermented sausages (Aberle et al., 2001). In the 1970's the safety of nitrite and nitrate used for meat curing was examined since ingestion of nitrite and nitrate has potential to form carcinogenic nitrosamines in the stomach (De Gonzalez et al., 2012). However, recent researches have indicated some potential health benefits of both nitrite and nitrate due to their contribution to nitric oxide production. Nitric oxide is produced directly from nitrite and plays a significant role for cardiovascular health in the human body by controlling blood flow in the cardiac muscle (Bryan et al., 2012; De Gonzalez et al., 2012; Sindelar et al., 2012). The continuing controversy regarding human health concerns from nitrite and nitrate consumption requires periodical studies to evaluate residual nitrite and nitrate content of cured meat products. Thus, the objective of this study was to investigate some chemical characteristics and residual nitrite and nitrate levels of sucuk and salami samples collected from retail outlets of major supermarkets in Adana province and assess their safety for human consumption.

Materials and Methods

Sample Collection

A total of 36 sucuk samples (12 brands; 7 national and 5 local producers) and 30 salami samples (10 brands; Macar salamis) were purchased from local supermarkets in Adana province in 2014. Three samples of each brand were randomly collected from three different stores for analyzing. Sucuk and salami samples were kept at refrigerated temperature (4°C) until analyzed for pH, moisture, water activity, nitrite and nitrate contents.

pH Values

pH values of sucuk and salami samples were measured using the sample slurry method (Nielsen, 2003). The samples (approximately 10 g) were placed into a blender and 90 ml of distilled water added and blended at high speed for 30 seconds to obtain smooth slurry. An electrode of calibrated pH meter (InoLab pH Level 1, WTW GmbH & Co. KG, Weilheim, Germany) was placed in the slurry to measure the pH of the samples.

Moisture Contents

The moisture contents of sucuk and salami samples were determined by taking the initial weight of the samples (approximately 5 g) and then driving off the moisture in a temperature controlled (100°C for 18 h) drying oven. After drying, the samples then were cooled, reweighed and the moisture contents calculated as percent moisture (Nielsen, 2003).

Water Activity

Water activity (a_w) values of sucuk and salami samples were determined using a calibrated instrument of LabMASTER-aw system (Novasina, Switzerland). A sample cup was filled approximately 5 g of homogenized sample, placed in the measurement chamber and then a_w values were determined when the value becomes stable on the system.

Nitrite and Nitrate Contents

Nitrite and Nitrate contents of all samples were determined using a previously described method (Dionex Corporation, 1998) with slight modifications. Sucuk and salami samples were weighed (10.0 g) and transferred to a blender. Deionized water (90 ml) was added to the meat samples. The meat samples then were liquefied in the blender for 1 minute. The liquefied samples were transferred to Erlenmeyer flasks. A water bath (Memmert WNB22, Schwabach, Germany) was used to heat and maintain the temperature of the liquefied samples at 75ºC for 15 min. The samples were allowed to cool to the room temperature. Then the liquefied samples were transferred to centrifuge tubes and the tubes were centrifuged at 6000 rpm (4960 × g) for 10 min (Heraeus Bofuge Primo R, Germany). Finally, the supernatants were passed through 0.45 µm Teflon membrane filter, and then injected to the HPLC (Shimadzu LC-20AT, Japan) system equipped with a quaternary pump, a column temperature control oven (CTO-10AS), an auto sampler unit (SIL-20A), a degasser module (DGU-$20A_5$) and a photodiode array detector (SPD-M20A). 10 µl of supernatant was injected into the IonPac® AS11 (Dionex, 4 × 250 mm) column. The column was kept at 30°C. The mobile phase consists of deionized water (eluent A) and 0.1 N NaOH (eluent B). An isocratic elution system of 10% of eluent B and 90% of eluent A was used at a flow rate of 1.2 ml/min for 10 min. The photodiode array detector was set to 225 nm. The nitrite and nitrate were identified by comparing their UV-visible spectra and retention times with that of corresponding standards. Quantification of nitrite and nitrate contents was carried out at 225 nm using external standard method.

Statistical Analyses

Statistical analyses of data were performed with SPSS software version 20 (IBM SPSS Statistics, Armonk, NY, USA). The study replicated three times for collecting the data. Analysis of variance (One-way ANOVA) procedures were applied and Tukey multiple comparison test was used to determine the significant differences.

Results and Discussion

The data regarding the mean pH values of a total of 36 sucuk samples representing 12 different brands collected from the local supermarkets are presented in Table 1. Demeyer et al. (2002) stated that the solubilized muscle proteins coagulate and form a gel surrounding fat and meat particles following the acidification produced by fermentation in fermented sausage products. When the sausage pH reaches 5.4 the hardness increases sharply and keeps increasing gradually until pH decreases 4.9. In the present study, the average pH values of the samples ranged between 4.69 and 6.56 while the highest and lowest pH values were determined in sample 11 and sample 8, respectively ($P<0.05$). Similarly, Çon et al.

(1998) reported that pH values of 51 sucuk samples obtained from the market in ten different cities in Turkey were ranged from 4.10 to 6.31. In another study related to surveying sucuk samples from local markets and butchers in Gaziantep region, Erkmen et al. (2004) reported that pH values of 50 sucuk samples varied from 4.53 to 6.74. Gencelep et al. (2008) also reported that pH values of 30 sucuk samples obtained from retail markets and butchers in several cities were between 4.53 and 6.29. Furthermore, Siriken et al. (2009) reported that pH values of a total of 100 Turkish sucuk samples purchased from local butcher shops and retail markets in Afyon province were ranged from 4.84 to 6.50. The previous studies and the present study indicated that pH values are highly variable among sucuk products that were available in local markets in different regions of Turkey. In addition, Table 2 presents the data regarding the mean pH values of a total of 30 salami samples representing 10 different brands collected from the local supermarkets. The average pH values of the samples ranged between 6.05 and 6.43 indicating a relatively lower variation among the pH values of the salami samples. Of the salami samples surveyed within the scope of the study, the lowest pH value was measured in sample 4 (6.05) while the multiple comparison tests indicated that the highest pH values were held by sample 2 (6.31), sample 3 (6.32), sample 7 (6.37), sample 10 (6.41), sample 5 (6.43) and sample 1 (6.43). The most of the samples were in agreement with Turkish Standard for Salami which states that salami should have a pH value of less than 6.4 (Anonymous, 2002).

Mean moisture values of sucuk samples are shown in Table 1. Sucuk samples had significantly different moisture contents ($P<0.05$). The average moisture values ranged between 33.56% and 46.78%. Among the sucuk samples surveyed within the scope of the study, the highest moisture value was measured in sample 11 (46.78%) while the multiple comparison tests indicated that the lowest moisture values were held by sample 10 (33.56%), sample 1 (34.73%), sample 3 (35.42%), and sample 4 (35.81%). Çon et al. (1998) stated that moisture contents of 51 sucuk samples obtained from the market in ten different cities in Turkey were ranged from 20.96% to 50.49. Similarly, Atasever et al. (1998) studied some quality characteristics of 30 sucuk samples collected from retails in Konya. It was reported that moisture values of the sucuk samples were highly variable ranging from 7 to 48.2%. Likewise, Siriken et al. (2009) stated that moisture contents of 100 sucuk samples randomly purchased from local butcher shops and retail markets in Afyon province varied from 29.80% to 47.60%. Table 2 shows mean moisture values of salami samples studied in the current study. Even though salami samples had significantly different moisture contents ($P<0.05$), the average moisture contents ranged between 62.09% and 67.91% indicating a relatively lower variation among the moisture values of salami samples. Among the salami samples surveyed within the scope of the study, the lowest moisture values were measured in sample 3 (62.09%), sample 1 (63.17%), sample 9 (64.04%) and sample 10 (64.44%) while the highest moisture values were determined in sample 4 (66.93%), sample 5 (67.01%), sample 8 (67.58%), sample 2(67.70%), sample 6 (67.91%) and sample 7 (68.40%). Five samples were not in agreement with Turkish Standard for Salami which states that salami should have a moisture content of less than 65% (Anonymous, 2002).

Table 1 provides the mean water activity (a_w) values of the sucuk samples studied in the present study. Among all sucuk samples, sample 11 had the highest a_w value of 0.932 ($P<0.05$) while sample 10 and sample 3 had the lowest a_w values of 0.861 and 0.869, respectively ($P<0.05$). Gencelep et al. (2008) determined that a_w values of 30 sucuk samples collected from retail markets and butchers in several cities ranged from 0.761 and 0.960. Similarly, Ozturk et al. (2014) reported that a_w values of 35 sucuk samples obtained from sucuk producers ranged from 0.710 to 0.930. In another study, Kesmen et al. (2014) indicated that a_w values of sucuk samples collected from 8 local producers in triplicate in Kayseri were between 0.752 and 0.854. Likewise, Table 2 provides a_w values of the salami samples. Even though salami samples had significantly different a_w values ($P<0.05$), the average a_w values ranged between 0.916 and 0.940 indicating a relatively lower variation among a_w values of the salami samples.

Table 1 Means and standard deviations for pH, moisture, water activity, nitrite and nitrate values of sucuk samples

Sucuk*	pH	Moisture (%)	a_w	Nitrite (mg/kg)	Nitrate (mg/kg)
1	$4.97^{fg} \pm 0.01$	$34.73^{e} \pm 0.48$	$0.886^{e} \pm 0.005$	$58.65^{g} \pm 12.87$	$161.08^{a} \pm 3.06$
2	$5.49^{cd} \pm 0.45$	$40.58^{cd} \pm 3.79$	$0.889^{de} \pm 0.001$	$110.73^{c} \pm 19.06$	$57.88^{ef} \pm 7.60$
3	$5.56^{c} \pm 0.08$	$35.42^{e} \pm 2.66$	$0.869^{fg} \pm 0.010$	$77.12^{fg} \pm 5.21$	$34.86^{h} \pm 1.39$
4	$6.18^{b} \pm 0.02$	$35.81^{e} \pm 1.31$	$0.874^{f} \pm 0.004$	$80.11^{ef} \pm 13.97$	$41.43^{gh} \pm 8.54$
5	$4.98^{fg} \pm 0.02$	$42.24^{bcd} \pm 0.38$	$0.898^{cd} \pm 0.002$	$105.22^{cd} \pm 3.47$	$48.88^{fg} \pm 0.39$
6	$4.95^{fg} \pm 0.06$	$44.28^{ab} \pm 3.19$	$0.897^{cd} \pm 0.001$	$100.13^{cde} \pm 3.72$	$71.87^{cd} \pm 5.21$
7	$5.67^{c} \pm 0.02$	$44.17^{abc} \pm 1.73$	$0.911^{b} \pm 0.009$	$100.38^{cde} \pm 4.70$	$59.78^{e} \pm 2.29$
8	$4.69^{g} \pm 0.02$	$43.55^{abc} \pm 1.03$	$0.916^{b} \pm 0.004$	$106.30^{c} \pm 3.18$	$95.91^{b} \pm 1.26$
9	$5.13^{ef} \pm 0.03$	$43.88^{abc} \pm 0.97$	$0.907^{bc} \pm 0.008$	$84.00^{def} \pm 0.33$	$62.29^{de} \pm 6.69$
10	$5.26^{de} \pm 0.23$	$33.56^{e} \pm 1.23$	$0.861^{g} \pm 0.003$	$134.08^{b} \pm 28.01$	$80.24^{c} \pm 12.29$
11	$6.56^{a} \pm 0.02$	$46.78^{a} \pm 1.01$	$0.932^{a} \pm 0.006$	$108.76^{c} \pm 5.82$	$71.40^{cd} \pm 4.83$
12	$4.87^{fg} \pm 0.03$	$39.78^{d} \pm 0.59$	$0.914^{b} \pm 0.006$	$216.63^{a} \pm 3.01$	$96.30^{b} \pm 1.63$

*Means in the same column with different superscript letters are significantly different ($P<0.05$).

Table 2 Means and standard deviations for pH, moisture, water activity, nitrite and nitrate values of salami samples

Salami*	pH	Moisture (%)	a_w	Nitrite (mg/kg)	Nitrate (mg/kg)
1	6.43 ^{a} ± 0.03	63.17 ^{c} ± 2.14	0.934 ^{ab} ± 0.010	23.86 ^{bcd} ± 0.30	ND$^{\delta}$
2	6.31 ^{ab} ± 0.02	67.70 ^{a} ± 0.40	0.923 ^{abc} ± 0.015	19.14 ^{de} ± 1.27	ND
3	6.32 ^{ab} ± 0.01	62.09 ^{c} ± 0.33	0.931 ^{abc} ± 0.017	25.92 ^{bcd} ± 0.43	ND
4	6.05 ^{d} ± 0.04	66.93 ^{ab} ± 0.60	0.923 ^{abc} ± 0.000	25.22 ^{bcd} ± 8.76	ND
5	6.43 ^{a} ± 0.01	67.01 ^{ab} ± 0.80	0.920 ^{bc} ± 0.010	35.96 ^{a} ± 2.69	ND
6	6.05 ^{d} ± 0.01	67.91 ^{a} ± 0.13	0.920 ^{bc} ± 0.002	29.69 ^{abc} ± 2.74	ND
7	6.37 ^{a} ± 0.02	68.40 ^{a} ± 0.38	0.940 ^{a} ± 0.000	14.30 ^{e} ± 4.36	ND
8	6.23 ^{bc} ± 0.02	67.58 ^{a} ± 1.32	0.916 ^{c} ± 0.007	20.81 ^{cde} ± 0.11	ND
9	6.15 ^{cd} ± 0.16	64.04 ^{bc} ± 4.42	0.940 ^{a} ± 0.001	31.03 ^{ab} ± 10.83	ND
10	6.41 ^{a} ± 0.12	64.44 ^{bc} ± 0.39	0.935 ^{ab} ± 0.005	17.87 ^{de} ± 1.14	ND

*Means in the same column with different superscript letters are significantly different (P<0.05)., $^{\delta}$ND: Not Detected

The data regarding the mean nitrite and nitrate values of sucuk samples collected from the local supermarkets are presented in Table 1. There were significant differences (P<0.05) among average nitrite and nitrate contents of the sucuk samples ranging from 58.65 mg/kg to 216.63 mg/kg and 34.86 mg/kg to 161.08 mg/kg, respectively. Of the sucuk samples analyzed in the present study, sample 12 that was produced by a local producer in Adana province, had the highest mean nitrite content of 216.63 mg/kg (P<0.05) while the second highest nitrite content was detected in sample 10 (134.08 mg/kg). The difference between these two samples indicated that sample 12 contained more than 82.55 mg/kg residual nitrite when compared to other samples surveyed in the present study. Conversely, the lowest mean nitrite content of 58.65 mg/kg was found in sample 1 which was manufactured by a national producer. In contrast to the nitrite contents, the highest nitrate value was determined in sample 1 (161.08 mg/kg). Of all sucuk samples, the lowest nitrate value was found in sample 3 (34.86 mg/kg). In a previous study, Soyutemiz et al. (1996) studied the nitrite and nitrate contents of processed meats including 25 sucuk samples obtained from local markets in Bursa. They reported that nitrite and nitrate values of sucuk samples were between 1.55 and 18.75 mg/kg and 0 and 618.86 mg/kg, respectively. Similarly, Sancak et al. (2008) reported that nitrite and nitrate contents of 40 sucuk samples obtained from the local market in Van ranged from 0.80 to 82.13 mg/kg and 1.56 to 553.18 mg/kg, respectively. Likewise, Buyukunal et al. (2016) indicated that nitrite values of 132 sucuk samples collected from producers and retailers in several cities ranged from 6.41 to 90.02 mg/kg and 28.10 to 174.62 mg/kg. In another study, Doğu et al. (2002) also stated that nitrite values of 30 sucuk samples collected from 5 high capacity meat plants in Afyon were between 41.80 and 631.03 mg/kg. In addition, Table 2 presents the data regarding the mean nitrite values of salami samples collected from the local supermarkets. There were significant differences (P<0.05) among average nitrite values of the salami samples ranging from 14.30 mg/kg to 35.96 mg/kg indicating a relatively low variation among to the samples when compared to that of the variation among the sucuk samples (58.65 mg/kg to 216.63 mg/kg). Of the salami samples analyzed within the scope of the study, sample 5 (35.96 mg/kg), sample 9 (31.03 mg/kg) and sample 6 (29.69 mg/kg) had the highest nitrite levels (P<0.05) while the lowest mean nitrite values of 14.30 mg/kg, 17.87 mg/kg, 19.14 mg/kg, and 20.81 mg/kg were found in sample 7, sample 10, sample 2 and sample 8, respectively. Among the all salami samples analyzed in the present study, nitrate residue was not detected in any of the samples. Conversely, Soyutemiz et al. (1996) reported that a relatively higher variation for both nitrite and nitrate values of 15 salami samples obtained from the local market ranging from 8.01 to 157.91 mg/kg and from 7.44 to 349.95 mg/kg, respectively. In another study, Işıklı (2001) reported that nitrite values of 70 salami samples obtained from several producers were between 3.46 and 676.97 mg/kg. Furthermore, Sezer et al. (2013) reported that nitrite and nitrate values of 15 salami samples purchased from local markets were ranged from 163 to 532 mg/kg and 98 to 293 mg/kg, respectively. Comminuted products including sucuk and salami are allowed a maximum ingoing concentration of 150 mg/kg of sodium or potassium nitrite or nitrate during the production (Türk Gıda Kodeksi, 2013) in Turkey. Although relatively lower nitrite and no nitrate contents were observed in the salami samples, previous studies and the present study indicated that both nitrite and nitrate contents are still highly variable among the sucuk products that are available in local markets in different regions of Turkey.

Conclusion

The present study and some previous studies indicated that some chemical characteristics including pH (4.69 – 6.56), moisture (33.56% and 46.78%), a_w (0.932 - 0.861), nitrite (58.65 mg/kg - 216.63 mg/kg) and nitrate (34.86 mg/kg to 161.08 mg/kg) contents of the sucuks are highly variable in local markets in Turkey. In contrast to previous studies, the salami samples studied in this study showed less variation mainly for the nitrite and nitrate contents indicating improved standardized procedures in producing these types of products in the recent years. However, the higher variation of both nitrite and nitrate contents observed particularly in sucuk samples in the local markets requires more studies and inspections to lower the variation related to dietary exposure to nitrite and nitrite from these types of products.

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