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Quality Characteristics of Retailed Sucuk (Turkish Dry-Fermented Sausage)

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Summary

Fifty sucuks (19 factory sucuks and 31 butcher's sucuks) were collected from local markets and butchers. Chemical, microbiological and overall sensory qualities of sucuks were investigated. There was a great variation in the concentrations of biogenic amines and levels of residual nitrite in them. Aerobic plate, lactic acid bacteria, and mould and yeast counts of factory sucuks varied from 5.56 to 8.39 log cfu/g, from 4.70 to 6.48 log cfu/g and from 3.15 to 4.68 log cfu/g, respectively. pH values of butcher's sucuks were higher than those of the factory ones. In general, butcher's sucuks contained higher amounts of biogenic amines and TBA values than factory sucuks. With respect to their overall sensory quality, about 63.2 % of butcher's sucuks were found to be in the acceptable range. High quality raw materials and suitable starter culture should be used in the production of sucuk.

Key words: sucuk, quality, biogenic amines

Introduction

Sucuks are produced by chance inoculation of lactic acid bacteria at the butcher's and with a starter culture mixture in factories. Sometimes, amine-positive bacteria may be used in the production of sucuk. Thus, many quality characteristics of sucuk, *i.e.* colour, flavour, odour or texture may not be developed satisfactorily; also, some toxic materials such as biogenic amines are formed during fermentation (1). Therefore, serious economical and health problems may arise due to the lack of standardized methods.

Biogenic amines are toxic substances, which can cause nausea, respiratory distress, hot flushes, sweating, heart palpitation, bright red rash, oral burning and hypotension. Putrescine is the precursor of pyrrolidine (nitrosamine), which is a carcinogenic compound (2).

To stabilise the colour, limit the oxidation and inhibit the undesired microorganisms (especially *Clostridi-*

um botulinum, *Staphylococcus aureus*, *Salmonella* spp., etc.), nitrite/nitrate are added into sucuk dough. However, nitrate and nitrite can cause toxic and carcinogenic effect (2). Therefore, their amount is limited to 300 and 150 mg/kg, respectively, by Turkish Food Codex (TFC) (3).

Lipid oxidation has been accepted as one of the major causes of the deterioration of quality in meat products (4). It changes the quality of meat and meat products, *e.g.* the colour, flavour, odour, texture and even the nutritional value (5).

The purpose of this study was to determine: (i) chemical (pH, TBA values, nitrosomyoglobin conversion, residual nitrite level and biogenic amine concentrations), microbiological (aerobic plate, lactic acid bacteria, and mould and yeast counts) and overall sensory qualities of retailled sucuks, and (ii) microbial, chemical and overall sensory quality differences of sucuks with respect to different production techniques.

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Materials and Methods

Materials

Sodium nitrate, sodium nitrite, sulfanilamide, N-(1-naphthyl)-ethylenediamine dihydrochloride (NED), HCl and glacial acetic acid were obtained from Merck (Darmstadt, Germany); 1,1,3,3-tetraethoxypropane (TEP) and 2-thiobarbituric acid (TBA) were obtained from Sigma (St. Louis, MO). β -Phenylethylamine hydrochloride, histamine dihydrochloride, serotonin hydrochloride, cadaverine dihydrochloride, spermine diphosphate, spermidine diphosphate, 1,7-diamino heptane, putrescine dihydrochloride, tryptamine hydrochloride, and tyramine hydrochloride, used as biogenic amine standards, were obtained from Sigma (St. Louis, MO); and sodium hydroxide, L-histidine, L-tyrosine and sodium bicarbonate (Merck, Darmstadt, Germany), ammonia (25 %) and acetone (Reidel DeHaen, Germany), dansyl chloride (Sigma Co, St. Louis, MO), ammonium acetate (Merck, Darmstadt, Germany) and perchloric acid (JT Baker, Holland) were used in HPLC analysis. All chemicals except acetonitrile, which was of HPLC grade, were of analytical grade (extra pure).

Sucuk and sampling

Sucuk is widely produced in various parts of Turkey (about 66 560 t/year) (6). It is prepared from meat mixed with tail fat (18.0 %), salt (2.5 %), sugar (0.4 %), clean dry garlic (1.0 %), spices (cumin, cinnamon, allspice, clove, red pepper and black pepper) (0.033 %), NaNO_3 (0.033 %), NaNO_2 (0.005 %) and vegetable oil (olive oil). Sucuk dough is filled into natural or artificial casing. Approximate compositions of ripened sucuk according to Turkish Standards (TSI) (7) were 40 % moisture (wet bases), 33 % fat, 20 % protein, 4.0 % ash and 3.0 % salt.

The general production scheme of sucuk is given in Fig. 1. In factories, heat is applied (at 60 °C for 1 h) in the oven after the fermentation period to attain and stabilise the desired colour and aroma but heat treatment is not used at the butchers'. Starter culture is used in the production of sucuks in factories but not at the butchers'. Fifty types of sucuks, 19 factory sucuks and 31 butcher's sucuks, were collected in triplicates (each about 100 g) from local markets and the butchers', respectively, in Gaziantep region (Turkey). Microbiological, chemical and organoleptic analyses were performed. Duplicate samples of sucuks were used in the analysis.

Microbiological analysis

Surface of the casing of sucuk was sterilised using 70 % ethyl alcohol and removed under aseptic condition. The amount of 25 g of sucuk was weighed in a sterile polyethylene bag and homogenised in 225 mL of sterile peptone-water (0.1 %) in a sterile mechanical blender cup. Serial decimal dilutions were prepared using the sterile peptone-water solution. Aerobic plate counts (APC), mould and yeast counts (MYC), and lactic acid bacteria (LAB) counts were made using aerobic plate count agar (Merck, Darmstadt, Germany), potato dextrose agar (Merck, Darmstadt, Germany), and de Man, Rogosa and Sharp agar (Merck, Darmstadt, Germany), respectively, with spread plate method (8).

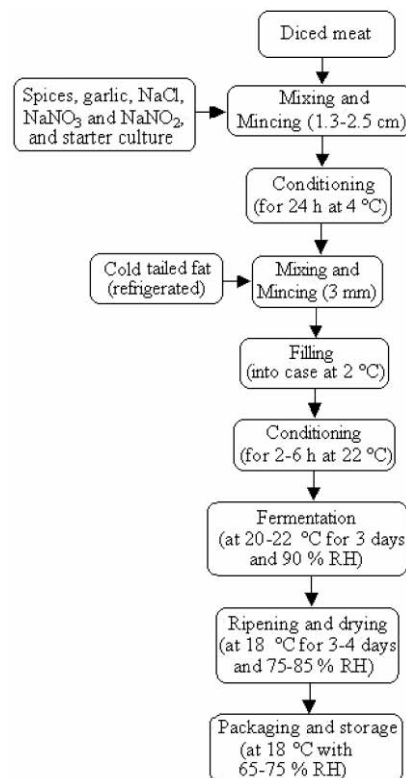


Fig. 1. General production flow-chart of sucuk

Chemical analysis

pH value was measured by homogenising 10 g of sucuk in 90 mL of distilled water using a pH meter (Jenway 3010; Jenway LTD, Essex, UK) equipped with an electrode (J95, 924001, Jenway LTD, Essex, UK). Formation of malonaldehyde was determined by TBA value. TBA (2-thiobarbituric acid) value, nitrosomyoglobin conversion (NMC) and residual nitrite level (RNL) were determined by spectrophotometric method (9–11).

Biogenic amine analysis

Biogenic amines were determined (12) and peaks were detected at 254 nm using the HPLC system with a column Spherisorb ODS2, 10 μm , 200 \times 4.60 mm (Phenomenex) and a quadratic gradient pump, which includes a Shimadzu Solvent Delivery Module (LC-10ADvp, Kyoto, Japan), Hewlett Packard UV detector, RP-18 guard column, and a computer including Borwin package program.

Sensory analysis

Sensory analysis (colour, odour, texture and flavour) was made by 10 panelists, who gave a score for each sample according to their perceptions of each colour, odour and flavour attributes using a hedonic scale from 1 (the worst) to 10 (the best). Texture scores were evaluated (from worst to best) by the panelists during slicing. The overall sensory qualities of sucuks were evaluated according to the following expression (13):

Overall sensory quality = (colour \times 0.10) + (odour \times 0.15) + (texture \times 0.25) + (flavour \times 0.50)

Statistical analysis

The data obtained from 3 samples were used to determine the mean value of each measurement. Procedures of variance components were carried out to estimate the effect of production place (factory and butchery), difference in variability for individual results and relationships between individual results. For this purpose one-way, two-way and Pearson's correlation coefficient analysis were carried out using SPSS 9.0 (SPSS Inc., Chicago, IL, USA) for Windows.

Results and Discussion

Microbiological analysis

APC of factory and butcher's sucuks varied from 5.75 to 7.43 log cfu/g and from 5.83 to 7.86 log cfu/g, respectively (Table 1). TSI (7) declared that APC in sucuks should not be more than 6.0 log cfu/g. About 52.6 and 64.5 % of factory and butcher's sucuks, respectively, had higher APC than 6 log cfu/g. MYC of factory and butcher's sucuks varied from 3.15 to 5.53 log cfu/g and from 3.48 to 5.80 log cfu/g, respectively (Table 1).

Table 1. Results of aerobic plate (APC), lactic acid bacteria (LAB) and mould and yeast (MYC) counts, pH, 2-thiobarbituric acid (TBA), nitrosomyoglobin conversion (NMC) and residual nitrite level (RNL) in sucuks*

Sucuk type	No	APC log cfu/g	LAB log cfu/g	MYC log cfu/g	pH	w(TBA) mg/kg	w(NMC) %	w(RNL) mg/kg
Produced in factories	1	5.70	5.18	4.33	5.57	0.51	84.78	5.37
	2	7.29	5.70	4.68	5.68	0.56	41.00	3.79
	3	7.21	4.70	4.00	5.39	1.85	35.25	14.91
	4	5.80	5.20	4.16	4.53	1.24	67.13	3.00
	5	5.67	5.17	5.31	4.94	2.11	70.15	6.48
	6	6.35	5.00	3.74	4.84	1.20	75.43	3.54
	7	7.39	4.70	3.93	5.04	0.74	32.75	11.27
	8	6.70	4.70	4.62	5.30	1.09	26.28	6.18
	9	7.43	5.18	4.18	5.01	1.20	32.64	3.54
	10	5.56	4.70	3.40	5.77	0.86	57.32	8.18
	11	6.23	5.48	4.53	5.57	0.59	70.48	5.36
	12	5.95	4.75	5.53	5.25	0.83	29.40	2.45
	13	5.74	5.20	3.20	5.07	0.51	69.11	18.60
	14	7.13	5.25	4.31	5.03	0.77	28.56	14.07
	15	7.06	6.43	3.98	4.87	0.81	67.18	9.80
	16	5.90	5.22	3.15	4.88	1.36	57.20	7.11
	17	5.70	5.00	4.08	4.67	1.88	41.40	9.64
	18	6.12	5.30	4.22	4.60	1.25	61.60	8.09
	19	5.92	5.35	4.04	4.90	1.57	78.65	4.50
Produced at the butchers'	1	7.56	5.48	4.00	6.09	1.22	37.38	3.95
	2	5.90	4.70	5.65	6.23	2.04	25.23	3.56
	3	6.40	5.19	4.16	5.38	3.01	87.44	19.67
	4	6.30	5.74	4.40	5.08	2.66	73.78	2.05
	5	7.86	5.98	5.30	6.07	1.92	42.94	3.08
	6	7.02	5.18	3.48	5.92	1.74	27.98	4.27
	7	5.86	4.70	3.48	6.12	1.30	31.83	2.61
	8	7.15	5.76	4.66	5.11	1.85	75.20	4.66
	9	7.04	4.70	4.23	4.83	1.55	52.64	2.13
	10	5.86	5.00	5.53	5.80	3.20	66.44	6.48
	11	6.70	5.19	5.15	4.86	2.71	41.46	7.54
	12	5.89	5.25	4.46	4.96	3.31	64.78	18.09
	13	5.88	4.12	5.11	5.48	1.05	38.32	15.36
	14	6.88	4.60	4.57	5.67	2.36	48.34	11.27
	15	5.84	4.20	3.88	5.39	3.34	24.16	7.00
	16	6.40	5.30	4.98	5.94	1.41	47.01	3.18
	17	5.92	4.25	5.40	5.58	0.98	40.55	5.72
	18	6.60	4.70	4.00	5.81	1.63	70.79	6.00
	19	7.55	5.18	5.18	5.78	2.73	47.10	8.31
20	7.27	5.40	4.54	5.64	2.08	51.61	21.99	
21	6.04	5.34	3.95	5.52	2.26	56.44	4.36	
22	6.03	5.54	4.41	5.54	2.95	85.58	4.54	
23	5.84	5.26	4.95	6.04	2.93	45.05	4.09	
24	5.88	4.70	5.32	6.62	3.18	65.74	17.26	
25	6.48	4.70	3.95	5.86	0.74	77.83	22.62	
26	7.78	4.82	5.80	6.74	1.06	84.48	4.91	
27	7.04	4.47	4.30	5.65	0.65	69.61	12.09	
28	6.23	5.18	4.66	4.90	0.72	62.51	10.27	
29	5.90	4.70	4.94	4.94	1.20	27.66	13.35	
30	5.83	4.12	5.10	6.29	0.69	66.81	7.11	
31	6.78	4.70	3.70	5.83	1.58	65.17	8.27	

* mean values of three determinations. There are statistical differences ($P < 0.05$) in the results among same type and between two different types of sucuks

TSI (7) and TFC (3) declared that MYC in sucuks should not be more than 2.0 log cfu/g. All of the sucuks had higher MYC than 2.0 log cfu/g. Higher number of APC and MYC could be due to the production of sucuks under unsanitary conditions, the use of raw materials of poor quality and differences in manufacturing techniques. LAB counts in factory and butcher's sucuks varied from 4.70 to 6.43 log cfu/g and from 4.12 to 5.98 log cfu/g, respectively (Table 1).

Chemical analysis

pH values of factory and butcher's sucuks varied from 4.53 to 5.77 and 4.83 to 6.74, respectively (Table 1). TFC (3) declared that pH value of fermented sucuks should not be higher than 5.4 and in the heat treated sucuks it should not be higher than 5.8. None of the factory sucuks had pH value higher than 5.8 while 71 % of butcher's sucuks had higher pH value than 5.4.

TBA values of factory and butcher's sucuks ranged from 0.51 to 2.11 mg/kg and from 0.65 to 3.34 mg/kg, respectively (Table 1). There are great variations ($P < 0.05$) among the TBA values of the same types and between two different types of sucuks. This may be due to the insufficient addition of antioxidants (nitrite, ascorbic acid, and tocopherols), the difference in manufacturing techniques, pH values, the starter culture type and poor quality of the raw material. Faustman *et al.* (14), Aguirrezabal *et al.* (15) and Lorenzo *et al.* (16) reported TBA values for sausages up to 1.75, 7.0 and 15.0 mg/kg respectively. Ertaş (17) reported the TBA values for sucuks sold in Ankara from 0.05 to 0.91 mg/kg. When TBA values in sausages are higher than 1.0 mg/kg, off-odours generally appear, which is considered as the beginning of the lipid oxidation (18). About 47.4 and 16.1 % of factory and butcher's sucuks had lower TBA values than 1.0 mg/kg.

There should be about 60 % of nitrosomyoglobin in sausages to obtain acceptable colour (19). About 47.4 and 45.2 % of factory and butcher's sucuks had greater NMC than this value (60 %), respectively (Table 1). Nitrite is reduced to nitric oxide by the activity of microorganisms and then nitric oxide combined with meat pigment (myoglobin) produces nitrosomyoglobin, which gives the desired pink-red colour to sucuk. This colour could be stabilised with the application of heat after the fermentation period (19). Nitrosomyoglobin was decomposed to brown colour during the storage period due to the oxidation of nitrosomyoglobin (20).

RNLs in retail sucuks in Ankara were between 4.00 and 11.25 mg/kg (21). Rapid pH decline and low ripening temperature reduced nitrate in sausages (22). Nitrate and nitrite are added into sucuk dough to attain the colour and aroma, to prevent the lipid oxidation, and to inactivate the unwanted microorganisms. According to the TFC (3), RNL should be lower than 50 ppm, but in European countries this level is reduced to 15 ppm (23). All of the factory and butcher's sucuks were within the acceptable limit with respect to TFC, but 5.3 % of factory and 19.4 % of butcher's sucuks had higher RNL than the European limit (Table 1).

Biogenic amines

Statistical analysis was carried out to determine significant differences of the biogenic amine contents among the same types and between factory and butcher's sucuks. In general, statistical analysis indicated that butcher's sucuks had higher ($P < 0.05$) amount of biogenic amines than factory sucuks. This might be due to the use of starter culture and low pH level.

Nout (24) pointed out the permissible maximum of histamine contents for sausages from 50 to 100 mg/kg. About 31.6 and 32.3 % of factory and butcher's sucuks, respectively, had higher histamine concentration than 100 mg/kg (Table 2). The histamine level in sucuks obtained from local markets in Ankara was reported to be from 3.72 to 362 mg/kg (25). Variation in the histamine level of sucuks could be due to the hygienic quality of raw material, manufacturing techniques, the specific flora and the type of starter culture (natural or commercial).

Putrescine concentration varied from not detected to 383.17 mg/kg and from not detected to 918.94 mg/kg in factory and butcher's sucuks, respectively (Table 2). The putrescine level in sucuks obtained from local markets in Ankara was about 412 mg/kg (25). Putrescine was about 100 mg/kg in Belgian South sausages, 28 mg/kg in Belgian North sausages and 2 mg/kg in Italian sausages (26). This amine has not been reported to be toxic itself, but with cadaverine potentiates the toxic effect of histamine and tyramine (27). Relatively high correlation coefficients ($r = 0.66$) were found between the content of putrescine and cadaverine, and between cadaverine and histamine ($r = 0.74$) in butcher's sucuks containing cadaverin.

The maximum allowed level of tyramine in foods is 800 mg/kg (2). Tyramine concentrations of all sucuks were within the acceptable level (ranging from 1.2 to 316.6 mg/kg). Ingestion of 30–40 mg of tyramine may be responsible for skin disorders (28). Tyramine is formed from tyrosine due to the decarboxylation reaction caused by living microorganisms especially during the fermentation period (27). Tyramine level in sucuks collected from local market in Ankara varied from 208.66 to 1173.28 mg/kg (25). About 13 % of Spanish sausages had higher level of tyramine than 100 mg/kg (29). Tyramine concentration in Italian, Belgian South and Belgian North sausages was about 160, 160 and 70 mg/kg, respectively (26). Sucuks with a high content of tyramine also had a higher amount of histamine ($r = 0.97$). Tyramine content in sucuks prepared in factories was higher than in those at the butchers'. This might be due to high acid level ($\text{pH} < 5.68$) in factory sucuks.

Spermine concentrations had variable ($P < 0.05$) changes among the same types and between two different types of sucuks (Table 2). This difference in variability probably reflects the naturally occurring spermine in meat and considerable environmental effects (pH, temperature) on bacterial amine production (30). Another most abundant amine found in both types of sucuks was tryptamine. Concentrations of tryptamine ranged from not detected to 46.53 mg/kg and from not detected to 126.91 mg/kg in factory and butcher's sucuks, respectively. Lower amounts of tryptamine in factory sucuks

might be due to the use of lactic acid bacteria and low pH level. β -Phenyl ethylamine in factory and butcher's sucuks ranged from not detected to 21.19 mg/kg and from not detected to 31.90 mg/kg, respectively (Table 2). Cadaverine was detected in 22.6 % of butcher's

sucuks but it was not detected in factory sucuks. Serotonin in factory and butcher's sucuks ranged from not detected to 7.78 mg/kg and from not detected to 12.43 mg/kg, respectively (Table 2).

Table 2. Mass fraction of biogenic amines in sucuks*

Sucuk type	No	<i>w</i> /(mg/kg)							
		TA	PA	PUT	CD	HA	SER	TYR	SM
Produced in factories	1	27.6±2.1	4.7±0.7	nd	nd	15.5±1.4	2.6±0.1	8.6±1.3	3.2±0.1
	2	15.2±1.8	nd	nd	nd	14.0±1.2	3.1±0.2	7.6±0.6	0.07±0.0
	3	17.9±1.5	nd	9.5±1.0	nd	12.2±0.9	1.6±0.1	9.9±0.9	2.9±0.2
	4	31.7±2.5	5.4±0.8	nd	nd	17.9±1.6	2.9±0.1	9.8±1.1	3.7±0.3
	5	17.5±2.4	nd	nd	nd	16.0±1.5	4.2±0.3	8.7±1.3	0.1±0.0
	6	46.5±4.3	21.2±2.6	nd	nd	12.9±1.2	6.4±0.4	16.3±1.7	0.1±0.0
	7	nd	4.4±0.8	12.6±1.4	nd	14.8±1.7	2.9±0.2	71.6±4.5	12.6±1.3
	8	2.6±0.1	nd	126.2±13.6	nd	138.4±12.5	nd	188.6±8.9	50.0±0.7
	9	2.6±0.1	8.7±1.3	4.6±0.4	nd	9.5±1.1	7.7±0.8	3.5±0.2	24.3±2.5
	10	nd	5.0±0.2	14.5±1.5	nd	17.0±1.8	3.3±0.2	82.3±3.4	14.5±1.7
	11	nd	18.5±2.7	nd	nd	3.9±0.2	7.8±0.6	2.1±0.1	22.1±1.8
	12	9.5±0.7	1.7±0.1	351.1±23.5	nd	202.7±9.6	nd	177.2±7.1	9.1±1.6
	13	nd	6.8±0.4	12.7±1.2	nd	12.0±1.2	2.9±0.1	11.3±0.7	41.2±3.8
	14	1.2±0.1	3.5±0.2	177.2±14.6	nd	122.2±10.3	4.4±0.3	130.9±7.8	13.2±1.2
	15	nd	nd	37.4±2.1	nd	19.4±1.8	1.4±0.1	1.2±0.1	24.9±2.3
	16	13.0±0.4	4.0±0.1	383.2±20.8	nd	255.2±16.8	2.1±0.1	179.4±10.6	9.4±0.9
	17	nd	7.1±0.6	5.0±0.6	nd	79.0±11.5	nd	37.8±2.7	5.5±0.4
	18	nd	7.4±0.8	49.6±8.1	nd	127.3±17.9	3.3±0.1	81.2±3.1	7.7±0.7
	19	22.1±1.8	2.3±0.1	235.0±18.3	nd	218.6±19.2	nd	147.5±8.4	0.1±0.0
Produced at the butchers'	1	48.7±5.2	2.3±0.1	nd	nd	7.1±0.7	5.5±0.6	72.1±3.9	0.1±0.0
	2	23.5±2.4	nd	65.9±4.6	nd	8.8±0.9	7.7±0.9	12.8±1.1	0.1±0.0
	3	19.1±2.5	nd	70.3±13.5	nd	7.9±0.7	1.1±0.1	7.8±0.7	0.2±0.0
	4	27.7±3.6	9.6±1.2	nd	nd	13.0±1.0	1.3±0.1	5.0±0.7	1.3±0.1
	5	19.7±3.6	nd	9.6±1.0	nd	11.8±1.3	2.0±0.1	9.4±0.8	2.6±0.1
	6	28.3±4.9	25.0±1.6	nd	nd	105.4±8.7	6.0±0.4	68.1±2.9	0.11±0.0
	7	53.5±6.7	nd	20.3±1.8	nd	12.6±0.9	10.8±0.8	22.3±1.3	2.3±0.1
	8	nd	0.8±0.1	14.8±1.9	1.5±0.1	16.9±1.2	2.9±0.1	8.0±0.8	1.7±0.1
	9	nd	nd	8.3±0.7	4.0±0.1	5.4±0.6	3.1±0.1	14.1±0.9	8.4±0.5
	10	nd	22.6±3.5	nd	nd	5.0±0.5	4.5±0.3	3.1±0.3	7.5±0.3
	11	56.0±5.7	2.6±0.1	nd	nd	8.1±0.8	6.3±0.8	82.9±2.5	0.1±0.0
	12	31.6±6.4	18.8±2.4	17.5±2.5	4.6±0.3	1.5±0.1	5.0±0.5	100.9±6.2	3.7±0.4
	13	22.0±3.8	nd	80.8±8.7	nd	9.1±0.8	1.3±0.1	9.0±1.9	0.1±0.0
	14	31.8±4.8	11.0±1.5	nd	nd	15.0±1.3	1.5±0.1	5.7±0.6	1.5±0.2
	15	22.4±4.2	nd	11.0±1.4	nd	113.6±6.1	2.3±0.1	110.8±4.1	2.9±0.1
	16	61.6±7.8	nd	23.3±2.8	nd	14.5±1.8	12.4±0.8	25.6±1.6	2.6±0.1
	17	16.4±1.5	nd	479.7±28.7	nd	429.8±14.6	11.4±1.2	212.5±12.4	8.1±0.6
	18	9.1±0.9	2.6±0.1	112.0±11.2	nd	267.0±15.2	9.9±1.0	193.0±6.3	9.3±0.4
	19	2.3±0.1	7.6±0.6	4.0±0.2	nd	8.3±1.1	6.7±0.4	3.0±0.2	21.1±2.1
	20	nd	13.3±1.2	5.6±0.4	nd	2.9±0.2	3.5±0.1	2.4±0.1	17.5±1.7
	21	nd	10.8±1.1	2.1±0.1	nd	109.2±1.4	3.3±0.2	93.4±2.5	20.7±2.1
	22	26.5±3.2	nd	26.4±1.9	nd	1.5±0.1	nd	5.5±0.3	18.8±1.6
	23	1.1±0.1	3.1±0.1	154.1±12.4	nd	19.3±2.1	3.8±0.3	113.9±4.9	11.5±0.9
	24	110.4±8.7	nd	799.1±24.7	nd	478.2±21.5	3.2±0.1	275.0±12.1	8.1±0.7
	25	10.5±1.2	3.0±0.2	128.8±13.6	nd	307.1±16.8	1.5±0.8	222.0±11.0	10.7±0.6
	26	nd	15.3±2.3	25.8±2.4	6.4±0.3	3.4±0.1	4.1±0.3	2.8±0.1	20.2±0.8
	27	3.0±0.1	nd	605.1±21.9	nd	451.5±16.5	nd	216.9±11.9	5.7±0.3
	28	30.4±4.7	nd	30.4±3.8	3.0±0.1	1.8±0.1	nd	6.3±0.5	21.6±1.4
	29	nd	nd	112.3±11.7	6.7±0.4	122.3±3.1	nd	140.4±12.8	15.7±1.8
	30	126.9±12.3	nd	918.9±18.9	nd	349.9±12.9	3.6±0.2	316.3±13.9	9.3±0.9
	31	nd	31.9±5.7	10.2±1.2	1.0±0.1	2.3±0.1	nd	12.0±0.7	41.5±3.2

* mean values ± standard deviations of three determinations. There are statistical differences ($P < 0.05$) in the results among same type and between two different types of sucuks.

Abbreviations: TA – tryptamine, PA – β -phenyl ethylamine, PUT – putrescine, CD – cadaverine, HA – histamine, SER – serotonin, TYR – tyramine, SM – spermine, nd – not detected

Sensory quality of sucuks

Overall sensory quality was monitored based on the scores for flavour, colour, odour and texture, which varied from 3.41 to 8.40 and from 2.75 to 8.93 mg/kg for factory and butcher's sucuk, respectively. About 63.2 and 87.1 % of factory and butcher's sucuks were found to be in the acceptable range (overall sensory quality higher than 5.00). Lipid oxidation (TBA value) in sucuks may have significant influence on the quality of colour, flavour, texture and nutritional value (26). Wu *et al.* (31) concluded that when TBA values in sausages are higher than 1.0 mg/kg, off-odours generally appear. TBA values were about 0.48 mg/kg (25), 1.63 mg/kg (32) and 0.85 mg/kg (33) in fermented sausages. These changes increased overall sensory quality of sucuks. The use of starter culture (in factory sucuks) enhanced the formation of flavour and desired colour (NMC) and cutting scores.

Conclusions

All sucuks had higher MYC than the allowed level according to TFC (5). Considering the known toxicological effects of biogenic amines, it is important for meat industry to produce fermented products with high degree of safety. There was a great variation in the biogenic amine concentrations and RNL of sucuks ($P < 0.05$) produced in factory and at the butcher's. In general, biogenic amine levels in factory sucuks were lower than in butcher's sucuks. This could be due to the use of starter culture, low pH level and heat treatment. The results indicated that manufacturing steps and conditions (hygienic rules, temperature and relative humidity, % RH) should be adjusted and controlled carefully. High quality raw materials and suitable starter culture should be used.

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Kakvoća sudžuka u maloprodaji (turska suho fermentirana kobasica)

Sažetak

Pedeset uzoraka sudžuka (19 proizvedenih u tvornici i 31 iz mesnice) uzeto je na mjesnoj tržnici i od mesara. Ispitana su kemijska, mikrobiološka i senzorska svojstva sudžuka. Uočene su velike razlike u koncentracijama biogenih amina i ostatka nitrita u sudžuku. Vrijednosti mikroorganizama dobivene uzgojem u Petrijevoj posudici bile su od 5,56 do 8,39 log cfu/g, količina bakterija mliječne kiseline iznosila je od 4,70 do 6,48 log cfu/g, a plijesni i kvasaca od 3,15 do 4,68 log cfu/g. pH-vrijednosti sudžuka dobivenih iz mesnice bile su veće od tvorničkih proizvoda. Općenito su sudžuci dobiveni iz mesnice sadržavali veću količinu biogenih amina i više TBA-vrijednosti od tvorničkih. Ukupne, senzorskim metodama utvrđene, vrijednosti pokazale su da približno 63,2 % sudžuka iz mesnica zadovoljava kakvoćom. Za proizvodnju sudžuka potrebno je koristiti sirovine dobre kakvoće i odgovarajuću starter kulturu.