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Research Article

Sensory, Chemical and Microbiological Properties of Trout Sausage (Fermented Sucuk)

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ABSTRACT

This study aimed to produce fish sucuk using rainbow trout (*Oncorhynchus mykiss*) fillet and investigate its suitability for consumption. Sensory, nutrient composition, fatty acid and amino acid composition analyses were carried out in the sucuk prepared with a commercial spice mix. Total aerobic mesophilic bacteria, total coliform, total *Enterobacteriaceae*, Lactic acid bacteria, yeast and mould counts were found to be smaller than 1 log cfu g^{-1}. It was found that the ratio of water, protein, fat, ash, total saturated FA, total mono-unsaturated FA and total poly-unsaturated FA were 48.63%, 17.27%, 22.00%, 2.52%, 50.17%, 43.23% and 6.6%, respectively. Glutamic acid (19.1 g 100 $^{g-1}$), aspartic acid (17.17 g 100g-1), leucine (9.45 g 100 g^{-1}) and lysine (8.05 g 100 g^{-1}) were the main amino acids in fish sucuk. In addition, the sensory analysis results of the sucuk produced entirely from trout meat showed that it was acceptable. This study concluded that a sucuk product suitable for consumption could be produced using trout meat entirely, with the appropriate spice mixture, heat treatment and air conditions.

Keywords: Rainbow trout, fermented products, fatty acids, amino acids

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INTRODUCTION

Aquatic products are one of the most important food sources to meet the animal protein needs in human nutrition. Fish, an aquatic product, meets the basic nutritional needs because of the essential amino acids, mineral matter, vitamins and polyunsaturated fatty acids (Pal et al., 2018; Khalili Tilami & Sampels, 2018). In addition to nutrition, aquatic products assume an effective role in strengthening immunity and treating some diseases (Kaya, Duyar, & Erdem 2004; Turan, Yalçın, & Sönmez, 2006; Cicero, Ertek, & Borghiet, 2009). Thus, it is among the important nutrients in maintaining both physiological and metabolic activities (Kaya et al., 2004). Since fish consumption is very important for human health, consumption of aquatic products ranks first in human nutrition in many countries in the world, while annual aquatic product consumption per capita in Turkey is 6.3 kg (TUIK, 2020). Aquatic product consumption in Turkey is very low per capita. Traditional consumer habits in Turkey generally tend toward consumption of fresh products. This consumption preference results from the fact that fresh products are easy to access and processed products suit people's tastes. Promotional studies on the consumption of processed seafood products in Turkey need to be increased. Thus, the consumption of aquatic products will be boosted in regions far from coastal areas and in seasons outside of hunting season.

There has always been a demand for delicatessen products in Turkey. Traditional sucuk products are among the most consumed ones. Beef sucuk produced in different ways since the Middle Ages are mainly consumed in the Balkans, Caucasia, Middle East, Central Asia, Southeast

and Northern Europe (Ercoşkun & Özkal 2011; Sarıışık & Tagmanov 2020). Sucuk is a fermented meat product prepared with a mixture containing different spices. The mixture is filled in natural or artificial dried casings, shaped in different ways (coil, baton) and ripened under certain conditions (TS 1070, 2002; TGK, 2019). While the meat of cattle, buffalo and camel is mostly used in sucuk production, sucuk is also produced using bovine sheep and goat (TGK, 2019). This study investigated whether the sucuk obtained from rainbow trout (*Oncorhynchus mykiss*), which is cultivated most in Turkey and is a fish species with high nutritional content, can be an alternative to the sucuk produced from red meat.

MATERIAL AND METHODS

Fish material

15 kg rainbow trout (*Oncorhynchus mykiss*), obtained fresh after harvest from farm conditions, was used as raw material in sucuk production. The average length of the fish was 28.25 ± 0.5 cm, and the weight was 246.2 ± 16.59 g. They were purchased from a private enterprise located in the Çanakkale region. The fish were brought to the Faculty Processing Technology Laboratory without impeding cold chain conditions.

Sucuk mixture

After cleaning the internal organs of the rainbow trout used in the study, the fillets were removed. At the end of this process, a total of 4.984 kg fish meat was obtained. Fish fillets were minced by means of an electric meat grinder (Tefal 1800w). Two types of sucuk pastes were obtained from the minced fish using two different spice mixtures, in accordance with sucuk production technology (Table 1).

Table 1. Sucuk mixture formulation.

Traditional		Commercial	
Ingredients (g 100g^{-1})		Ingredients (g 100g^{-1})	
Fish Meat	70	Fish Meat	70
Fat (1/2 sunflower oil+1/2 beef fat)	20	Fat (1/2 sunflower oil+1/2 beef fat)	20
Starch	2.4	Food salt	
Salt	1.75	Ground red pepper	
Ginger	0.05	Ground cumin	
Cinnamon	0.05	Dried ground garlic	
Allspice	0.08	Ground black pepper	
Sweet Paprika	1.70	Stabilisers (E450, E451, E452)	10
Hot Paprika	0.09	Maltodextrin	
Garlic	1.40	Dextrosemonohydrate	
Granulated sugar	0.52	Anti-oxidant: sodium erythorbate	
Black pepper	0.30	Yeast extract	
		Spice extracts	

The first type of sucuk mixture was obtained from a mixture of minced fish and various spices. The second type of sucuk mixture was obtained by adding a spice mixture from a private company to the minced fish (Table 1). Both types of sucuk mixture were stored for 24 hours at +4°C under refrigerated conditions for fermentation.

Filling and ripening of trout sucuk

The fermented trout sucuk mixture was filled into intestinal casings that were kept in cold water (7%) with vinegar beforehand. The filled sucuk were grouped according to ripening conditions and pre-treatment conditions and left to ripen (Table 2). After the fermented sucuk were kept in the refrigerator at +4°C for one day, their sensory, physicochemical and microbiological analyses were carried out. However, analyses were not performed on the experimental groups (1, 3, 4, 5, 6, 8, 9, 11, 13, 14 and 16) that showed rancid odour and were in an inedible condition.

Sensory analysis

An academic panellist group consisting of 10 people was formed for the sensory analysis. The sensory analysis was performed using the sensory test criterion of Fernández-Fernández, Vázquez-Odériz & Romero-Rodríguez, (2002a). Appearance, colour, odour, texture and flavour parameters of sucuk were evaluated using the scoring 5=Very good, 4=Good, 3=

Table 2. Different ripening conditions of different sucuk groups.

Spice Types			
Traditional		Commercial	
Sucuk Group	Ripening Conditions	Sucuk Group	Ripening Conditions
1	1st day heat treatment * + room conditions **	9	1st day heat treatment * + room conditions **
2	room conditions **	10	room conditions **
3	1st day heat treatment * + air conditioning cabinet conditions **	11	1st day heat treatment * + air conditioning cabinet conditions ***
4	air conditioning cabinet conditions ***	12	air conditioning cabinet conditions ***
5	room conditions ** + 3rd day heat treatment *	13	room conditions ** + 3rd day heat treatment *
6	air conditioning cabinet conditions *** + 3rd day heat treatment *	14	air conditioning cabinet conditions *** + 3rd day heat treatment *

Table 2. Continue.

Spice Types			
Traditional		Commercial	
Sucuk Group	Ripening Conditions	Sucuk Group	Ripening Conditions
7	1st day heat treatment * + air conditioning cabinet conditions *** + daily heat treatment for 6 days *	15	1st day heat treatment * + air conditioning cabinet conditions *** + daily heat treatment for 6 days *
8	1st day heat treatment * + air conditioning cabinet conditions *** + 3rd day heat treatment *	16	1st day heat treatment * + air conditioning cabinet conditions *** + 3rd day heat treatment *

Note: *Heat treatment: 20 min at 70°C. **Room conditions: 18-20 °C *** Air conditioning cabinet conditions: 18-20 °C

Moderate, 2=Bad and 1=Very bad (Fernández-Fernández, Vázquez-Odériz, & Romero-Rodríguez, 2002b; Fernández-Fernández et al., 2002b).

pH analysis
Measurements were performed on ripened fish sucuk and cooked sucuk using a pH meter (HANNA / HI 2211) (Landvogt & Fischer 1991).

Proximate composition
Nutrient composition analyses were performed in three parallel procedures. Moisture, protein and ash analysis were carried out to AOAC standards (AOAC, 2005). Crude protein (factor: 6.38) was determined by the Kjeldahl method. Crude fat was determined by the methanol–chloroform extraction method (Folch, Lees, & Sladane-Stanley, 1957).

Fatty acid methyl ester analysis (FAME)
Lipid extraction of sucuk samples was carried out according to Folch et al. (1957). For fatty acid analysis, 0.1 g sample was treated with 10 mL of n-hexane and 0.5 mL of 2N methanolic KOH solution was added (I.U.P.A.C., 1987). Gas chromatograph analysis was performed on a Shimadzu GCMS QP 2010 ULTRA instrument equipped with a RTX-2300 capillar column (60 m; 0.25 mm; 0.2 μm). Each fatty acid peak was determined by comparing the retention times in a mixture of known standard fatty acids United States Pharmacopeia (USP) Fame Mix Reference Standard (US Pharmacopeia, Maryland, USA) run under the same operating conditions. Fatty acids were presented as a percentage of total methylated fatty acids.

Amino acid composition
For amino acid analysis, 0.5 grams of sucuk sample was weighed and burned with 20 mL of HCl at 110°C for 18-24 hours. 20 mL of distilled water was added and dried in an evaporator at 70°C. The volumetric flask was set to 25 mL with pure water. Amino acid samples were analysed on a Shimadzu LC-MS/MS 8040 and determined using a Zorbax Eclipse AAA column (4.6 X 150 mm, 3.5 µm). Mobile phase consisted of 1‰ formic acid in ultrapure water (eluent A) and 1‰ formic acid in methanol (v/v) (eluent B). The column temperature was set at 40 °C, the injected sample volume was 0.2 µL and the flow rate was 1 mL min^{-1}.

Microbiological analysis
10 g of sucuk samples were taken for microbiological analysis. The samples were homogenised for three minutes in 90 mL of peptone water using a blender (Seward Stomacher 400). In the total viable count of sucuk samples, Tryptic Soy Agar medium (TSA at 36 °C for 48 h) (Merck 1.05458), (FDA, 2001); for lactobacillus count, DeMan, Rogosa and Sharpe (MRS at 36 °C for 120 h) Agar (Merck 1.10660) medium (Jokovic et al., 2008); for coliform group microorganisms count, MacConkey (MAC at 36 °C for 48 h) Agar (Merck 1.05465); for enterobacteria count, Violet Red Bile Dextrose (VRBD at 36 °C for 48 h) Agar (Merck 1.10275) medium; for yeasts and moulds count, Potato Dextrose Agar (PDA at 22°C for 120 h) (Merck, 1.10130) were used.

Statistical analysis
Statistical analyses of the data obtained as a result of the study were performed using the SPSS package program. SPSS 17.0 package program was used for statistical evaluation. In order to detect differences in the study, Oneway analysis of variance (ANOVA) and Tukey tests were run on the data. Differences were evaluated at the 0.05 significance level.

RESULTS AND DISCUSSION

Microbiological results
Table 3 presents the microbiological analysis findings of the sucuk mixture and different sucuk groups. Microbiological analyses were not performed on the experimental groups that showed rancid odour and were in an inedible condition. When the production was completed, the yeast-mould counts of group 7, group 2 and group 10 sucuk exceeded the limit (2 log cfu/g) specified in the Communiqué on Turkish Food Codex Meat and Meat Products (TGK, 2010). This study aimed to produce Turkish-type "fish sucuk" suitable for consumption by using fish meat entirely instead of red meat. 16 groups of sucuk were produced under different ripening conditions, including traditional spice mixture and commercial spice mixture. Sucuk that was not suitable for consumption due to rancid odour and sucuk that failed to meet the microbiological limits as per the Communiqué on Turkish Food Codex Meat and Meat Products (TGK, 2010) was excluded from the analysis. For this reason, among 16 different sucuk groups, Group 15 was found to be suitable for consumption in terms of microbiology, and other analyses were performed on this group.

Total aerobic mesophilic bacteria (TAMB), lactic acid bacteria (LAB), total coliform counts (TC), total *Enterobacteriaceae* counts

(TE) and yeast and mould counts (YM) of sucuk mixture prepared for both spice mixtures were found to be similar to the previous shark sucuk study (Kahraman, 2010). While TC was 2 log cfu/g and YM 3.81 log cfu/g on the first day in carp sucuk, it was reported as TC < 1 log cfu/g and YM 4.23 log cfu/g in the ripened sucuk (7th day) (Arslan, Dinçoğlu, & Gönülalan, 2001a). While TC was 0 log cfu/g on day 7 in silverside sucuk, YM was found to be 4.55 log cfu/g (Arslan, Dinçoğlu, & Gönülalan, 2001b).

Kılınç & Çaklı (2021) kept the traditional spice-mixed sucuk they produced using trout and sea bass fillets in the refrigerator, and as of the 10th day for trout sucuk and 30th day for sea bass sucuk, YM limit value was exceeded (2 log cfu/g). Similarly, in our study, YM exceeded the limit value after fermentation in traditional spice blended groups. In addition, On the other hand, this study determined that trout sucuk can be made suitable for consumption in cases where a commercial spice mixture is used and suitable air conditioning conditions are provided.

Sensory properties and pH values

Table 4 presents the sensory analysis findings in raw and cooked sucuk samples. The general like rate of the sucuk sample, which was evaluated out of five, was found to be 4.4 in raw sucuk and 4.54 in cooked sucuk. While the pH value of raw sucuk was 5.6, it was found to be 5.8 in cooked sucuk. In all sensory analysis results of trout sucuk, it was seen that the panellists liked the sucuk produced from fish meat. Similar results were obtained in sucuk produced before using only fish fillets. For example, it has been reported that the overall tastes of sucuk produced entirely with fish meat using carp (Arslan et al., 2001a), mullet (Berik & Kahraman, 2010) and shark (Kahraman, 2010) fillets were good or very good. While determining the quality of fish and similar products, pH measurement is also carried out during production and subsequent stages. Among the control parameters, the pH value plays an important role. As per the "Communiqué on Turkish Food Codex Meat and Meat Products" in the Turkish Food Codex, it is stated that the pH value of sucuk should be 5.4 at the highest (TGK, 2019). In TS 1070/T4, the Turkish Standards Institute reported the pH value of Turkish sucuk to be at most 5.8 and at least 5.4 (TSE, 2019). In our study, it was observed that the pH findings were also in parallel with the literature. In grey mullet sucuk, while the pH value was 5.34 in ripened raw sucuk, it was determined to be 5.30 in cooked sucuk (Berik & Kahraman 2010). pH was reported to be 5.48 in ripened raw carp sucuk (Arslan et al., 2001a) and 5.96 in silverside fish sucuk (Arslan et al., 2001b).

Table 3. Microbiological analysis findings of sucuk mixture.

	TAMB	TC	TE	LAB	YM
Traditional Sucuk Mixture	4.6	2.5	2.0	1.9	1.3
Commercial Sucuk Mixture	4.6	3.1	3.0	2.7	1.2
Group 15	<1	<1	<1	<1	<1
Group 7	3.7	<1	<1	<1	2.3
Group 2	4.3	<1	<1	4.1	4.0
Group 10	4.6	2.0	2.0	5.2	3.3
Other Groups*	-	-	-	-	-

Note: * Microbiological parameters were not analysed because other sucuk groups showed a high level of rancid odour. CFU: Colony forming unit, TAMB: Total aerobic mesophilic bacteria, TC: total coliform counts, TE: Total *Enterobacteriaceae* counts, LAB: Lactic acid bacteria, YM: Yeast and mould counts

Proximate composition

For the trout sucuk (Group 15), water was determined as 48.63%, protein as 17.27%, fat as 22.00% and ash as 2.52% (Table 5). In accordance with the Communiqué on Turkish Food Codex Meat and Meat Products (TGK, 2019), the total meat protein value of sucuk produced using trout meat was found to be at least 14% by mass, the ratio of moisture content to total meat protein was found to be below 3.6 and the ratio of fat to total meat protein was found to be below 2.5. Previous studies show that the water, protein, fat and ash were between 50.35% to 37.62%, 20.05% to 45.21%, 11.52 to 31.47% and 3.64 to 5.33% respectively, in Turkish type sucuk produced using carp (Arslan et al., 2001a; Çiltaş, 2009), silverside (Arslan et al., 2001b), sea bass (Çiltaş, 2009), mullet (Berik & Kahraman 2010) and shark (Kahraman, 2010). These different results might be associated with differences in fish species, mixture formulation, heat treatment and/or air conditioning conditions.

Fatty acid composition

In rainbow trout sucuk (Table 2), a high oleic acid (C18:1) concentration was found, which was 38.68% of total fatty acids, followed by palmitic acid (C16:0; 27.18%), stearic acid (C18:0; 14.32%), myristic acid (C14:0; 5.30%), linoleic acid (C18:2; 3.95%), palmitoleic acid (C16:1; 4.50%), margaric acid (C17:0; 1.74%) and doco-

Table 5. Proximate compositions of rainbow trout sucuk.

	Mean ± SD
Moisture (%)	48.63±0.08
Crude Protein (%)	17.27±0.09
Crude Fat (%)	22.00±0.17
Crude Ash (%)	2.52±0.26

Table 4. Sensory properties of fish sucuk.

	Appearance	Colour	Texture	Odour	Flavour	Overall acceptability	pH
Raw Sucuk	4.6	4.1	4.6	4.3	-	4.40	5.6
Cooked Sucuk	4.7	4.2	4.7	4.5	4.6	4.54	5.8

Note: The assessment test is 1–5 indicator value levels. 5 = Very good, 4 = Good, 3 = Fair, 2 = Bad, 1 = Very bad

Table 6. Fatty acid composition (%) of the rainbow trout sucuk.

Fatty acid	
Saturated fatty acids	**Mean**
C8:0	0.01
C10:0	0.38
C12:0	0.95
C13:0	0.05
C14:0	5.30
C16:0	27.18
C17:0	1.74
C18:0	14.32
C20:0	0.18
C21:0	0.02
C22:0	0.04
Mono-unsaturated fatty acids	
C16:1	4.50
C18:1	38.68
C20:1	0.01
C24:1	0.04
Poly-unsaturated fatty acids	
C18:3 (n-3)	0.9
C18:2 (n-6)	3.95
C20:4 (n-6)	0.08
C20:3 (n-3)	0.03
C20:5 (n-3)	0.08
C21:5 (n-3)	0.14
C22:5 (n-3)	0.4
C22:6 (n-3)	1.02
Total saturated FA (SFA)	50.17
Total mono-unsaturated FA (MUFA)	43.23
Total poly-unsaturated FA (PUFA)	6.6
(n-6) / (n-3)	1.57

Table 7. Amino acid composition of the rainbow trout sucuk (g/100g protein).

	Rainbow trout sucuk	Preschool Childs* (2 to 5 years)	Adult*
Amino acid			
Leucine	9.45	6.6	1.9
Lysine	8.05	5.8	1.6
Histidine	2.61	1.9	1.6
Isoleucine	3.07		
Methionine	3.51	2.8	1.3
Phenylalanine	2.48		
Threonine	3.47	3.4	0.9
Valine	3.53	3.5	1.3
Arginine	3.3		
Tryptophan[2]	n.d	1.1	0.5
Total essential amino acids	39.47		
Cysteine	0.70		
Glutamine	1.11		
Glutamic Acid	19.1		
Proline	1.67		
Alanine	5.49		
Serine	5.24		
Trosine	3.88		
Aspartic Acid	17.17		
Total non-essential amino acids	54.36		
Total amino acids	93.83		
Methionine + Cysteine	4.21	2.5	1.7
Phenylalanine + Trosine	6.36	6.3	1.9

Note: * Expert Consultations, 1985. (Amino acid requirements) [2]n.d. – no determined

sahexaenoic acid (C22:6; 1.02%). There is a limited number of studies on the fatty acid composition of fish sucuk in the literature. Only one study reported that the fatty acids in shark sucuk were C18:1>C16:0>C22:6>C18:0>C18:2>C22:5>C14:0 from the highest concentration to the lowest (Kahraman, 2010). This order was found to be C18:1>C16:0>C18:0>C14:0> C18:2>C16:1> C17:0> C22:6 in rainbow trout. Differences between studies may result from factors such as fish species, habitat and diet. The (n-6)/(n-3) ratio we obtained for trout sucuk is 1.57. This rate was reported to be 6.22 for beef and 2.95 for camel meat in Turkish-type sucuk produced using different types of meat (Kargozari et al., 2014). In our study, we determined the PUFA concentration to be 6.6%. In different studies, PUFA concentrations were reported to be 0.6% (Yıldız-Turp & Serdaroğlu 2008a), 2.6% (Yıldız-Turp & Serdaroğlu 2008b) for beef and 4.38% (Kargozari et al., 2014) and 2.76% for camel meat (Kargozari et al., 2014). Omega-3 (ω-3) polyunsaturated fatty acids (PUFAs) obtained from fish and fish oils are considered to have a protective effect against coronary heart disease (Cicero et al., 2009; Abdelhamid et al., 2018; Ajith & Jayakumar 2019). Compared to Turkish type sucuk produced using red meat, the lower (n-6)/(n-3) ratio, higher PUFA concentration and nutritional and health benefits of the sucuk produced from trout meat increase the value of the product.

Amino acid composition

Amino acid composition of the rainbow trout sucuk is given in Table 7. In this study, it was determined that among the fish sucuk aspartic acid, glutamic acid, leucine, and lysine were in higher concentrations. In the literature, only one study (Kahraman, 2010) reported the amino acid composition of Turkish type fish sucuk. Present findings are similar to the results of Kahraman (2010), who found that the main amino acids for spiny dogfish sucuk were glutamic acid, aspartic acid, lysine and leucine. In addition, a similar amino acid composition was also reported in sausages made from tilapia fillet scraps (Oliveira Filho, Maria Netto, Ramos, Trindade, & Viegas, 2010) and

sausages produced using silver carp roe protein hydrolysate (Hajfathalian, Jorjani & Ghelichiet, 2020). Moreover, it was observed that fish sucuk contains a balanced ratio of essential amino acids except for tryptophan, and it meets the amino acid requirement standards (Expert Consultations, 1985) for both adults and especially children aged 2-5.

CONCLUSION

This study concluded that when the appropriate spice mix, heat treatment and air conditioning conditions are provided, sucuk suitable for consumption can be produced using trout meat. The low (n-6)/(n-3) ratio and high PUFA concentration in the sucuk produced using fish meat increased the product's value in the healthy food category. From now on, studies should be carried out to increase the shelf life of fish sucuk, which is produced as a qualified and safe food.

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