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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Effects of types of casing with the different materials on volatile compounds (VCs) of sausages (sucuks) during the ripening

Farklı materyallerden üretilen kılıf çeşitlerinin olgunlaşma sırasında sucukların uçucu bileşenleri üzerine etkileri

Ahmet DURSUN[1], Zehra GÜLER[1]

[1]*Mustafa Kemal University, Faculty of Agriculture, Department of Food Engineering, Antakya-Hatay, TURKEY.*

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Corresponding author: Ahmet DURSUN
✉: adursun@mku.edu.tr

Ö Z E T / A B S T R A C T

Aims: Sucuk is one of the most popular traditional dry-fermented sausages in Turkey. The most volatile compounds (VCs) formed by biochemical pathways or derived directly from spices are essential for sucuk flavor. The object of this study was to make a comparison between sucuks produced using natural casing (S-NC) or synthetic casing (S-SC), in terms of VCs.

Methods and Results: The VCs were analyzed using solid-phase-micro-extraction (SPME) technique with gas chromatography-mass spectrometry (GC-MS). The common VCs identified in sucuks were methyleugenol (14 %), 4-(1-methylethyl)-benzenmethanol (11 %), γ-terpinene (11 %), *trans*-caryophylene (10 %), cumin aldehyde (9 %), p-cymene (7 %), diallyl-disulphide (7 %), 3-hydroxy-2-butanone (4 %), eugenol (3 %), α-thujenal (2 %) and β-pinene (2 %), accounted for approximately 80 % of total VCs. Of these VCs, 4-(1-methylethyl)-benzenmethanol, cumin aldehyde, γ-terpinene, p-cymene, α-thujenal, β-pinene, eugenol, and 3-hydroxy-2-butanone were significantly influenced by the ripening period. S-NC had significantly the higher percentages of cumin aldehyde, α-thujenal and lower percentages of 4-(1-methylethyl)-benzenmethanol than those in S-SC.

Conclusions: Sucuks with synthetic or natural casing had a similar volatile compound profile but there were observed differences at the proportions of the most VCs between sucuks. The terpenes except for limonene were not influenced by the types of casing. When compared with natural casing, use of synthetic casing resulted in a decrease in total ketones, total aldehydes and total sulfur compounds, especially at the end of ripening. The synthetic casing may be used for sucuk-making at the under short-term storage conditions due to increases in the reduction products such as alcohols.

Significance and Impact of the Study: Principle component analysis based on VCs differentiated sucuks according to their ripening times and their casings. S-SC at Day 11 was completely different from the other sucuks. Furthermore, a long-term goal of this research is to determine the detailed biochemical and physical changes and also sensory characteristics during the storage.

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INTRODUCTION

Turkish fermented sausage "sucuk" is widely consumed in Turkey and Middle East Region of Asia. On the traditional sucuk production in Turkey, the batter consisting of beef meat/fat and salt, various spices such as garlic, pimento, red and black peppers mixture is stuffed into natural casing, especially bovine small intestine, and ripened/dried under the environmental conditions (Kaban and Kaya, 2009). In the past, 'natural casings' from bovine small intestine were used only for sucuk-making whereas recently 'synthetic casings' made from plastic have been widely used for this purpose due to their cheaper and stronger than natural casings. On the other hand, compared to synthetic casings, natural casings can be more permeable to air and water due to porous structure. This situation affects the various biochemical pathways such as proteolytic and lipolytic that cause the formation of volatile compounds (VCs) during the fermentation and drying process of sucuk (Sun et al., 2010; Sidira et al., 2015; Montanari et al., 2016). The VCs can also come directly from spices (Sunesen et al., 2004). Consumer's acceptance of sucuk depends mainly on its flavor, namely volatile and non-volatile compounds, and its appearance, namely texture and color. Thus, volatile compound profile of sucuk gives an idea on biochemical changes that are influenced by the raw material, type of casing, ripening process, starter cultures etc. (Montanari et al., 2016). However, it is not known that whether the type of casing used for Sucuk manufacturing can affect the VC profile during the ripening period. Therefore, the object of this study was to make a comparison between traditionally produced sucuks using synthetic casing as an alternative to natural casing, in terms of volatile compounds..

MATERIAL and METHOD

Sucuk production

Sucuks were produced without starter culture according to the protocol described by Çoksever and Sarıçoban (2010) with minor modification. The main constituents were beef (80 %) and beef fat (20 %). The amount of other ingredients in per kg was as follow: salt (20 g), garlic (10 g), cumin (9 g), red pepper (7 g), black pepper (5 g), pimento (2.5 g). All the ingredients except for fat were added to meat that minced about 2.5 cm and thoroughly mixed. The mixture was conditioned in sterile polyethylene at 4°C for 12 h, after that was re-minced together with the fat addition in a meat grinder (Stilevs, SGH21502, Turkey) using a 0.45 cm plate. The sucuk batter was divided into 2 equal parts, one of which was stuffed into 'natural casings' from dried-bovine small intestines (S-NC), and the other part into 'synthetic casings' from poliamid-polietilen plastic (S-SC) with a filling machine. The sucuk coils were ripened at 15-25°C and relative humidity about 75 % for 11 days. Sucuk-manufacturing trials were repeated under the same production conditions in different times. The sucuk samples were analyzed in triplet at days 0, 3, 7 and 11.

Solid phase microextraction (SPME)-gas chromatography (GC)-mass spectrometry (MS) analysis

The VCs were analyzed as described by Marco et al. (2004) with minor modification. Briefly, 3 grams of sucuk were transferred into a 20 mL headspace vial (Agilent, Palo Alto, CA, USA) and sealed using crimp-top caps with PTFE/silicone septum (Agilent, Palo Alto, CA, USA). The VCs extraction was performed in triplicate by using a 50/30 µm SPME fibre coated with divinylbenzene (DVB)/carboxen (CAR)/polydimethylsiloxane (PDMS) (Supelco, Bellefonte PA, USA). For extraction of VCs, the vials were held at 55°C for 45 min without SPME fiber and for 30 min with fiber. The VCs were separated on a HP-INNOWAX capillary column (60 m x 0.25 mm id x 0.25 µm film thickness) connected to the coupled 6890 GC and 5973 N MS (Agilent, Palo Alto, CA, USA). Helium was used as the carrier gas at a flow rate of 1 mL min^{-1}. The temperature program was initially held at 50°C for 1 min, next ramped to 230°C at 5°C min^{-1} and held for 5 min. The mass spectrometer was operated in the scan mode, with electron energy of 70eV. Identification of VCs was done by computer-matching of their mass spectra against the Wiley7n.1 and Nist 02.L GC-MS libraries. The results from VC analyses were expressed as the percentage of each compound, from its integral peak area relative to the total integration of all peaks identified.

Statistical analysis

Statistical analyses were made using a SPSS statistical program (Version 22.00, SPSS, IBM, NY, USA). Analysis of variance (one-way ANOVA) was performed on each variable (VC) for each sausage type, with the factor being ripening time. Duncan's multiple range tests were employed to determine any significant difference between ripening times. The paired comparisons of means between sucuks at each ripening day were made using the t-student test. In the General Linear Models (GLM) procedure, each replicate was evaluated as a random effect, interaction of ripening time and casing type (RxC) included as fixed terms. The differences between replicates were not significant (P>0.05). All the data on VCs were used for discriminant function analysis based on Eigenvalues. All data were expressed as triplicate determinations, and P<0.05 was considered as significantly different.

RESULTS and DISCUSSION

A total of 66 VCs were identified in the sucuk samples, including 24 terpenes, 10 alcohols, 8 phenyls and phenols, 8 aldehydes, 6 esters, 4 compounds with sulfur, 3 ketones, 2 acids and 1 alkene (Table 1). With the progression of ripening period, the number of VCs ranged from 32 to 62 for S-SC and to 65 for S-NC.

Terpenes were the most abundant (from 29 % to 46 %) VC group, followed by aldehydes (5-46 %), phenyls and phenols (15-21 %), alcohols (2-18 %) and sulfur compounds (6-9 %), all of which accounted for approximately 99 % of total VCs identified in the sucuks (Figure 1). Similar results were obtained by Kargozari et al. (2014) and Kaban (2010) for dry-fermented sausages. The terpene abundance in sucuk is related to the use of spice for sucuk-making or the direct transfer from green herbage into meat. γ-Terpinene (10.8 %), *trans*-caryophylene (10.2 %), p-cymene (7.0 %) and β-pinene (2.0 %) were constituted the majority of terpenes (Table 2). These terpenes are the principal compounds of cumin essential oil (Li and Jiang, 2004) and black pepper (Jelen and Gracka, 2015). The major terpenes, except for p-cymene, *trans*-caryophylene and α-copaene, showed a significantly increasing tendency towards to the end of ripening, as reported by Kaban and Kaya (2009). The terpenes except for limonene were not significantly influenced by the both type of casing and the interaction between casing type and ripening time.

Methyl eugenol (MEU) and eugenol were the most abundant phenolic compounds. MEU is the principal compound of pimento and eugenol of garlic. The major phenols were not affected by the ripening period and the interaction between ripening period and casing type but were significantly (P<0.05) influenced by the type of casing at the end of ripening. On day 11, MEU and eugenol decreased in S-NC but unchanged in S-SC and also 2,6-diisopropyl anisole, p-cresol and carvacrol increased in S-SC (Data not shown). It is known that compounds such as p-cresol occur from degradation of phenylalanine amino acid.

A similar result was obtained from sucuks fermented by autochthonous starter culture (Kargozari et al., 2014). It was probable that the medium of S-SC accelerated to the accumulation of phenolic compounds, but MEU and eugenol might have been underwent peroxidative metabolism in S-NC due to its permeability to air. Alkenylbenzenes, such as MEU, with allylic hydrogen atoms are known to be susceptible to autoxidation reactions that produce organic hydroperoxides.

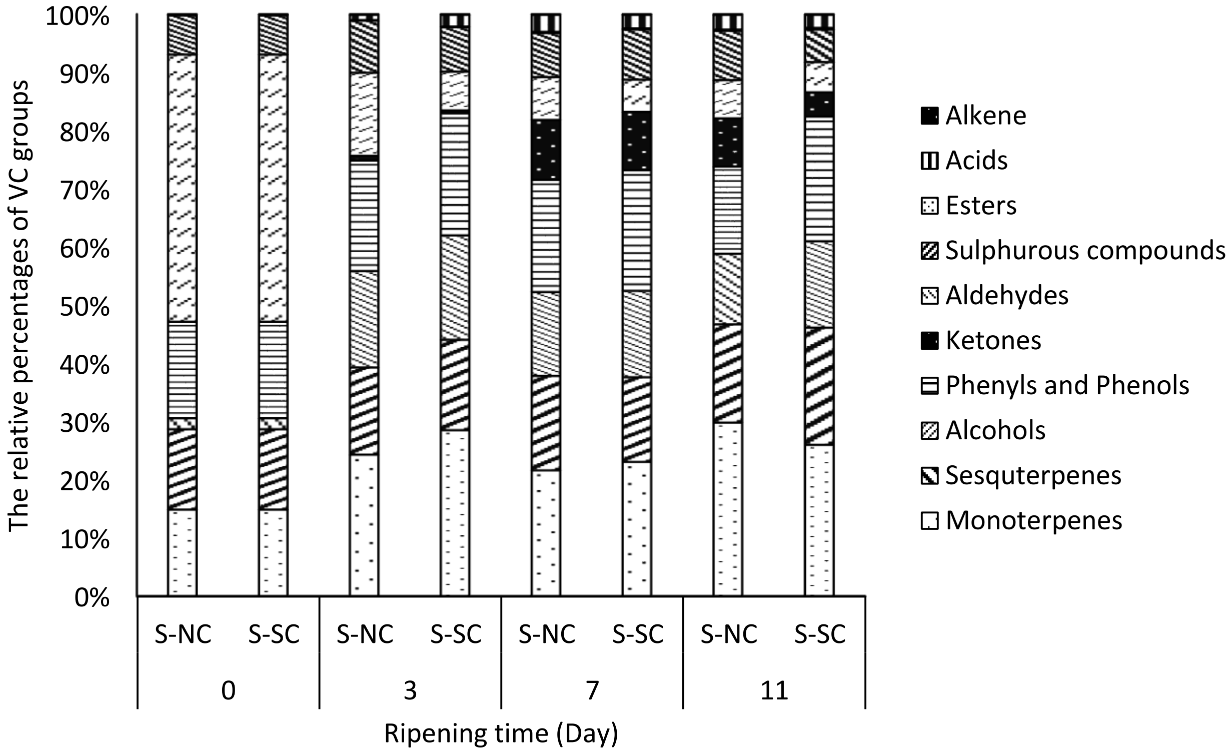

Figure 1. The mean percent values of volatile compound groups of sucuks according to chemical families

Table 1. The volatile compounds identified in sucuks during the ripening

Volatile Compounds (66)	RT	RI	Ripening time (Day)						
			0 d	3 d	7 d	11 d	3 d	7 d	11 d
			Mix	S-NC			S-SC		
Monoterpenes (11)									
β-Pinene	7.54	1010	√	√	√	√	√	√	√
Δ-3-Carene	12.3	1201			√	√		√	√
β-Phellandrene	13.02	1232		√	√	√	√	√	√
Limonene	14.36	1290	√	√	√	√	√	√	√
γ-Terpinene	15.08	1324	√	√	√	√	√	√	√
p-Cymene	17.3	1442	√	√	√	√	√	√	√
α-Terpinolene	25.18	2073	√	√	√	√	√	√	√
Camphene	29.06	>2100	√	√	√	√	√	√	√
Isoterpinolene	33.02	>2100	√	√	√	√	√	√	√
α-Terpinene	35.31	>2100		√	√	√	√	√	√
trans-Pinane	35.45	>2100				√		√	√
Sesquiterpenes (13)									
Δ-Elemene	23.28	1900	√	√	√	√	√	√	√
α-Copaene	23.93	1959	√	√	√	√	√	√	√
Isocaryophylene	26.2	>2100		√	√	√	√	√	√
β-Elemene	26.5	>2100	√	√	√	√	√	√	√
trans-Caryophylene	26.81	>2100	√	√	√	√	√	√	√
β-Farnesene	28.15	>2100	√	√	√	√	√	√	√
α-Humulene	28.6	>2100	√	√	√	√	√	√	√
2-Isopropyl-5methyl-9-methylene-Bicyclo(4.4.0)dec-1-ene	29.14	>2100	√	√	√	√	√	√	√
β-Bisabolene	29.71	>2100	√	√	√	√	√	√	√
β-Selinene	29.8	>2100	√	√	√	√	√	√	√
α-Selinene	29.89	>2100	√	√	√	√	√	√	√
cis-Calamene	32.3	>2100		√	√	√	√	√	√
Caryophylene oxide	35.72	>2100	√	√	√	√	√	√	√
Alcohols (10)									
Ethanol	4.82	864		√	√	√	√	√	
1-Octanol	25.44	2100		√		√	√		
2-Butanediol	26.32	>2100		√	√	√	√	√	√
4-Methyl-benzenemethanol	29.33	>2100		√	√	√	√	√	√
p-Cymene-8-ol	32.5	>2100		√	√	√	√	√	√
Benzenemethanol	33.22	>2100		√	√	√	√	√	√
Benzenethanol	34	>2100		√	√	√	√	√	√
Carotol	36.25	>2100	√	√	√	√	√	√	√
p-Mentha-1,4-dien-7-ol	36.8	>2100		√	√	√	√	√	√
Cuminic alcohol	37.75	>2100	√	√	√	√	√	√	√

Table 1. Continued

Volatile Compounds (66)	RT	RI	Ripening time (Day)						
			0 d	3 d	7 d	11 d	3 d	7 d	11 d
			Mix	S-NC			S-SC		
Phenyls and Phenols (8)									
Naphthalene	30.51	>2100	√	√	√	√	√	√	√
2,6-Diisopropyl anisole	34.34	>2100		√	√	√	√	√	√
p-Creosol	34.94	>2100		√	√	√	√	√	√
Methyl eugenol	35.94	>2100	√	√	√	√	√	√	√
Eugenol	39.08	>2100	√	√	√	√	√	√	√
Isomethyl eugenol	39.24	>2100		√	√	√	√	√	√
Carvacrol	39.76	>2100	√	√	√	√	√	√	√
p-Cumenol	39.94	>2100	√	√	√	√	√	√	√
Aldehydes (8)									
Nonanal	21.12	1709		√		√	√		√
Benzaldehyde	25.07	2063	√	√	√	√	√	√	√
2-Decanal	27.85	>2100			√	√		√	
Cuminaldehyde	31.34	>2100	√	√	√	√	√	√	√
α-Thujenal	31.61	>2100	√	√	√	√	√	√	√
2,4-Decadienal	31.79	>2100	√			√			
Tetradecanal	37.21	>2100				√		√	√
Pentadecanal	38.19	>2100		√	√	√	√	√	√
Esters (6)									
Ethyl octanoate	22.2	1802				√			√
Ethyl decanoate	27.49	>2100		√	√	√	√	√	√
2-Hydroxymethyl benzoate	31.23	>2100		√		√	√	√	√
Cuminyl acetate	35.09	>2100		√	√	√	√	√	√
Ethyl tetradecanoate	36.41	>2100				√		√	√
Ethyl hexadecanoate	40.28	>2100			√	√		√	√
Sulphurous compounds (4)									
Allyl methyl disulfide	17.76	1470	√	√	√	√	√	√	√
Diallyl disulphide	23.74	1942	√	√	√	√	√	√	√
Imidazole-2-thiol	34.73	>2100		√	√	√	√	√	√
2,3,5-Trimethylthiophene	39.45	>2100		√	√		√	√	
Ketones (3)									
3-Hydroxy-2-butanone	17.93	1480		√	√	√	√	√	√
Carvone	30.21	>2100		√	√	√	√	√	√
2(5H)-Thiophenone	38.97	>2100			√	√		√	√
Acids (2)									
Acetic acid	22.79	1852		√	√	√	√	√	√
Decanoic acid	40.63	>2100	√	√	√	√	√	√	√
Alkene (1)									
3,7,11,15-Tetramethyl-2-hexadecene	32.59	>2100		√	√	√	√	√	√

$^{\delta}$Sucuks in a natural casing or synthetic casing were coded as S-NC and S-SC, respectively. RI, retention index based on the identified VCs retention time (RT) and calculated from a linear equation between each pair of straight alkanes (C5-C25).

Table 2. The relative percentages of major VCs identified in sucuks with natural and synthetic casings

Volatile Compounds	Sucuk	Ripening time (Day)				Ripening	RxC
		0	3	7	11		
γ-Terpinene	S-NC	7.1±0.05^{c}	10.3±0.74^{b}	9.8±0.09^{b}	13.7±0.51^{a}	***	NS
	S-SC	7.1±0.05^{b}	12.4±1.67^{a}	9.8±1.26^{ab}	12.5±0.31^{a}	*	
	$^{\#}P$		NS	NS	NS		
p-Cymene	S-NC	5.6±0.06	6.5±0.99	6.4±0.11	8.7±0.26	NS	NS
	S-SC	5.6±0.06	7.4±1.04	6.5±0.34	7.8±0.33	NS	
	P		NS	NS	NS		
β-Pinene	S-NC	0.3±0.09^{b}	3.1±0.67^{a}	1.6±0.64^{ab}	2.7±0.42^{a}	*	NS
	S-SC	0.3±0.09^{c}	3.2±0.28^{a}	1.2±0.59^{bc}	2.1±0.43^{ab}	*	
	P		NS	NS	NS		
Limonene	S-NC	0.6±0.00^{c}	1.0±0.10^{b}	0.8±0.09^{bc}	1.4±0.09^{a}	**	**
	S-SC	0.6±0.00	1.6±0.29	2.1±0.49	0.5±0.09	*	
	P		NS	*	*		
trans-Caryophylene	S-NC	9.3±0.09	9.4±0.46	10.0±0.70	10.5±0.09	NS	NS
	S-SC	9.3±0.09	10.3±0.36	9.2±1.18	12.7±0.74	NS	
	P		NS	NS	NS		
α-Copaene	S-NC	1.1±0.01	1.1±0.09	1.0±0.17	1.3±0.01	NS	NS
	S-SC	1.1±0.01	1.1±0.07	1.0±0.03	1.4±0.14	NS	
	P		NS	NS	NS		
Cuminic alcohol	S-NC	1.5±0.13^{c}	12.7±0.36^{a}	12.0±0.49^{a}	9.7±0.16^{b}	***	NS
(4-Isopropylbenzyl alcohol)	S-SC	1.5±0.13^{b}	14.7±1.26^{a}	12.6±0.45^{a}	12.0±0.65^{a}	***	
	P		NS	NS	NS		
2,6-Diisopropyl anisole	S-NC	ND	0.6±0.07	0.6±0.04	0.6±0.08	**	**
	S-SC	ND	0.9±0.08	1.1±0.03	1.1±0.09	**	
	P		NS	*	*		
Methyl eugenol	S-NC	13.2±1.17	13.6±1.03	14.0±0.64	10.4±0.28	NS	NS
	S-SC	13.2±1.17	15.0±2.78	14.6±0.44	14.9±1.09	NS	
	P		NS	NS	*		
Eugenol	S-NC	2.5±0.27	3.4±0.08	3.3±0.11	2.6±0.05	NS	NS
	S-SC	2.5±0.27	3.6±0.55	3.6±0.12	3.5±0.19	NS	
	P		NS	NS	*		
3-Hydroxy-2-butanone	S-NC	ND	0.6±0.05^{b}	9.6±0.65^{a}	7.8±1.18^{a}	***	NS
	S-SC	ND	0.2±0.02^{c}	9.6±1.51^{a}	3.7±0.48^{b}	***	
	P		**	NS	*		
Cuminaldehyde	S-NC	38.7±1.76^{a}	10.0±0.29^{b}	4.0±0.18^{c}	3.4±0.11^{c}	***	**
(4-(1-methylethyl)-benzaldehyde)	S-SC	38.7±1.76^{a}	3.7±0.34^{b}	2.4±0.49^{b}	1.3±0.08^{b}	***	
	P		***	*	**		
α-Thujenal	S-NC	6.5±0.27^{a}	3.2±0.11^{b}	1.9±0.09^{c}	1.3±0.03^{d}	***	**
	S-SC	6.5±0.27^{a}	1.5±0.12^{b}	1.1±0.24^{bc}	0.4±0.07^{c}	***	
	P		**	*	**		
Pentadecanal	S-NC	ND	0.4±0.03^{b}	1.0±0.03^{a}	0.9±0.00^{a}	*	**
	S-SC	ND	0.9±0.29^{b}	1.5±0.04^{b}	2.5±0.44^{a}	**	
	P		NS	***	***		
Diallyl disulphide	S-NC	6.4±0.27	7.4±0.49	6.7±0.25	7.7±0.18	NS	*
	S-SC	6.4±0.27	7.0±0.89	7.6±0.27	5.1±0.41	NS	
	P		NS	NS	*		

All data were expressed as mean ± standard error. RxC indicates the significant of the interaction between casing type and ripening time. $^{\#}P$ indicates the differences between casing type at the same ripening time. Different lower case superscript letters at the same row indicate the effects of ripening time. NS: not significant, ND: not detected, *P<0.05, **P<0.01, ***P<0.001.

The percentages of alcohol in both S-NC and S-SC were the highest at day 3 (16.7 % and 17.8 %, respectively), and markedly decreased towards the end of ripening. Cuminic alcohol, a reduction product of cumin aldehyde (originates from cumin), was identified as principal alcohol in the both casing types, as reported by Yalınkılıç et al. (2015). At all the stages of ripening, S-SC had slightly higher percentage of cuminic alcohol (10.2 %) than that (9.0 %) in the S-NC. With progressive of ripening time, cuminic alcohol increased but cuminic aldehyde significantly (P<0.001) decreased. The rate in decrease was the higher in S-SC compared to S-NC. Use of synthetic casing may have accelerated to the reduction of cumin aldehyde to cumin alcohol. Cuminic aldehyde [benzaldehyde, 4-(1-methylethyl)] was identified in initial sucuk batter (day 0) as the major volatile compound (Table 2). In previous studies (Kaban and Kaya, 2009; Kaban, 2010), although cuminic alcohol was routinely identified in sucuks, its precursor aldehyde did not. This may be due to the analyse technique used such as the extraction of volatile compounds and gas chromatographic conditions. Of volatile compounds, aldehydes and esters only were significantly influenced by the type of casing, the ripening period and the interaction of casing type and ripening period.

Acetoin, a product of fermentation and synthesized from pyruvate, was the major ketone identified in sucuks. The level of acetoin was significantly (P<0.001) influenced by the ripening time. It was not found to be in the initial mixture, but ranged from 0.58 % on day 3 to 9.6 % on day 7 and significantly (P<0.05) decreased in S-SC on day 11. Acetoin is converted into 2,3-butanediol by the 2,3-butanediol dehydrogenase in microorganisms. This may indicate an increase in non-starter lactic acid bacteria (NSLAB) for S-SC. However, unlike acetic acid the high proportion of acetoin may reflect the internal pH value and the availability of Enterococcus in S-NC, as reported by Latorre-Moratalla et al. (2011).

Of sulfur compounds, diallyl disulfide was the most abundant sulfur in the sucuks. The ripening period did not affect diallyl disulfide but its level decreased significantly (P<0.05) in S-SC at the end of ripening. Garlic used in sucuk formulation is an important source of sulfur compounds (Toldra et al., 2001).

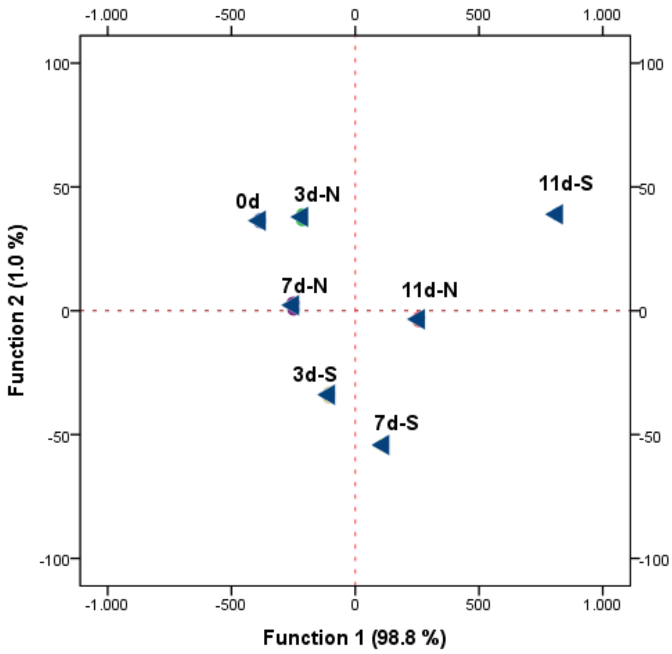

Figure 2. Discriminant analysis of the percentage of VCs in sucuk produced with natural (N) and synthetic (S) casing during the ripening day (d).

According to discriminant analysis based on Eigenvalues, VCs could be used to discriminate and characterize sucuks through ripening time (Figure 2). The function 1 (98.8 % explanation) was associated primarily with time of ripening; sucuks up to day 7 were located at the left side of the graphic, going to the right side with the increase in ripening time. At the end of ripening, S-SC was completely distinguished from the other sucuks. This may be due to the high proportions of *trans*-caryophylene, isomethyl eugonel, p-cresol, ethyl decanoate, ethyl tetradecanoate, ethy hexanoate, tetradecanal and pentadecanal. Regardless of ripening

time, sucuk with synthetic casing was different from sucuk with natural casing due to the high percentages of phenol, phenyl and alcohols, and the low percentages of aldehydes. Although sucuks were produced under the identical conditions, it was probable that the differences in air and water permeability of casings affected the microbiota that varied the relative percentages of VCs. The analysis of VCs during sucuk ripening seemed to be a useful tool for discriminating of ripening stages and casings used.

ÖZET

Amaç: Sucuk, ülkemizde en yaygın üretilen geleneksel kuru fermente et ürünlerinden biridir. Sucuk üretiminde kullanılan baharatlar ve olgunlaşma sırasında meydana gelen biyokimyasal reaksiyonlardan oluşan uçucu bileşenler sucuk aroması için önemlidir. Çalışmada, hem doğal bağırsak (S-DK) hem de sentetik kılıf (S-SK) kullanılarak üretilen sucukların uçucu bileşenlerinin karşılaştırılması amaçlanmıştır.

Yöntem ve Bulgular: Uçucu bileşenler, katı-faz mikro-ekstraksiyon tekniği (KFME) kullanılarak gaz kromatografisi-kütle spektrofotometresinde (GK-KS) analiz edilmiştir. Sucuklarda en fazla oranda belirlenen uçucu bileşenler metilöjenol (% 14), 4-(1-metiletil)-benzenmetanol (% 11), γ-terpinen (% 11), *trans*-karyofilen (% 10), kumin aldehit (% 9), p-simen (% 7), diallildisülfit (% 7), 3-hidroksi-2-bütanon (% 4), öjenol (% 3), α-tujenal (% 2) ve β-pinen (% 2) olup; toplam uçucu bileşenlerin yaklaşık % 80'ini oluşturmuşlardır. Anılan bileşenler arasında, 4-(1-metilletil)-benzenmetanol, kumin aldehit, γ-terpinen, p-simen, α-tujenal, β-pinen, öjenol, and 3-hidroksi-2-bütanon oranları olgunlaşma süresi boyunca önemli farklılıklar göstermiştir. S-SK ile karşılaştırıldığında, S-DK istatistiksel olarak daha yüksek oranda kumin aldeit, α-tujenal; daha düşük oranda 4-(1-metilletil)-benzenmetanol içermiştir.

Genel Yorum: Doğal bağırsak ya da sentetik kılıf ile üretilen sucuklar, benzer uçucu bileşen profili göstermesine rağmen sucuklar arasında çoğu uçucu bileşenlerin oranlarında farklılıklar gözlemlenmiştir. Kullanılan kılıflar limonen hariç diğer terpen bileşenlerinin oranlarını etkilememişlerdir. Ancak doğal kılıf ile karşılaştırıldığında, sentetik kılıf sucuklarda keton, aldehit ve sülfür bileşenlerinde özellikle olgunlaşmanın sonunda önemli bir azalmaya neden olmuştur. Sentetik kılıf ise, alkoller gibi indirgenme ürünlerinde bir artış meydana getirmesi nedeniyle kısa süreli depolanan sucukların üretiminde kullanılabilir.

Çalışmanın Önemi ve Etkisi: Uçucu bileşenler ile gerçekleştirilen temel bileşen analizinde, sucuklar olgunlaşma dönemi ve kılıflara göre ayrılmıştır. Sentetik kılıflarda üretilen sucukların olgunlaşmanın 11. gününde diğer sucuklardan tamamen ayrıldığı belirlenmiştir. Bu çalışmanın uzun dönemdeki diğer bir amacı da, sucuğun depolanma süresince daha detaylı biyokimyasal ve fiziksel aynı zamanda duyusal niteliklerindeki değişimlerin belirlenmesidir.

Anahtar Kelimeler: Sucuk, uçucu bileşenler, sentetik ve doğal kılıf, olgunlaşma dönemi.

CONFLICT OF INTEREST DECLARATION

The authors declared no potential conflicts of interest to declare.

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