Effect of cheese as a fat replacer in fermented sausage

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Abstract The effects of beef fat substitution with kashar cheese were studied in traditional Turkish fermented sausage; sucuk. Six sucuk formulations were prepared by replacing 0, 10, 20, 30, 40 and 50% of beef fat was substituted with kashar cheese. The fat substitution of fat with kashar cheese decreased fat content and increased protein content of the product that affected the chemical, physical and sensorial characteristics of products. Saturated fatty acid content increased and unsaturated, mono-unsaturated and poly-unsaturated fatty acids amount were decreased as the cheese amount increased. The formulation with 10% substitution of beef fat with cheese took the best sensory overall acceptability scores followed by 20% and control groups.

Keywords Sucuk · Kashar · Fat substitution · Cholesterol content · Fatty acid profile · Sensory quality

Introduction

Food product development is a growth area of activity to reach new consumer groups. Increasing socio-economic level of society resulted with demands increasingly more time-saving convenience foods. Food should provide the consumer with the enjoyment and satisfaction associated a pleasing visual, oral, and olfactory stimuli. Food product development involves manipulation of the chemical constituents of food and ingredients to maximize the

positive sensory perceptions by consumers of the product. Modifications on familiar and/or appreciated properties of the product by the consumers might be useful to develop new product that can affect the consumer's choice positively. Sucuk is a dry-fermented sausage which is most popular meat product in Turkey. Kashar cheese, a semi-hard cheese, is one of the most consumed cheese varieties in Turkey (Gökalp and Ockerman 1985; Erkmén and Bozkurt 2004; Aksu and Kaya 2004; Kinik et al. 2005). Sucuk and kashar are generally consumed together such as inside toasted sandwiches, baked foods or as appetizer. When sucuk and kashar are combined may very well completed each other in sensory aspect. Hence, sucuk production incorporating kashar cheese can serve as a unique appetizer increasing value addition simultaneously. Therefore, a product containing both sucuk and kashar cheese may be a production method of specification that may increase the market share. The market prices of sucuk are nearly three times of kashar prices so incorporating kashar cheese in sucuk may decrease the production cost. Additionally, this new product may be easy to prepare – time saver product for consumers. On the other hand, sucuk is a fatty product and fat content of sucuks is about 20–25% directly after manufacture, but after drying this value increases to about 40% (Kayaardı and Gök 2003). Therefore fat content of this new product should be lowered to satisfy health conscious consumer demand.

On the other hand substitution of beef fat with kashar in sucuk may cause major changes in the proximate composition and fatty acids distribution. The aims of this study was to develop a new type of low fat sucuk in which beef fat is substituted with kashar cheese and to investigate the effect of replacing beef fat with kashar cheese on the quality characteristics of sucuk.

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Materials and methods

Production technology

Fresh kashar cheese was obtained from Pilot Dairy Plant of Agriculture Faculty of Ankara University. Fresh kashar cheese was produced from raw cow's milk which was pasteurized at 65 °C for 30 min, cooled to 32 °C. Milk was coagulated with rennet for 45 min. After coagulation, curds were pressed. The cheese curds were fermented in 15±2 °C temperature with extension 12 h (night) and lather cut into small slices (about 5×10 cm). The small slices curds were hand-stretched in to the 85 °C hot water. They were put into cylindrical plastic molds. The cheeses in molds were removed. The cheeses were salted with dry salt (the amount of dry salt used was 5% of cheese weight) and kept 5 days at 15±2 °C.

Fresh boneless beef cuts and beef fats were obtained from Ankara markets. The production of sucuk was carried out in Pilot Meat Plant of Food Engineering Department of Ankara University. Sucuk dough was prepared from beef, beef fat, salt, sugar, clean dry garlic, spices, and nitrite according to the following recipe; 90 kg beef (about 10% fat), 10 kg subcutaneous fat, 2 kg salt, 0.4 kg sucrose, 1.1 kg garlic, 0.9 kg red bell pepper, 1 kg cumin, 0.7 kg black pepper, 0.25 kg pimento and 0.005 kg NaNO₂. Additives and spices were added during mincing of the meat using a 1.3 cm plate mincer (Ari Torna, İstanbul, Turkey). The control was prepared without kashar. Each treatment was prepared to contain 90% beef and 10% total fat. Kashar cubed 0.5 cm was added to the next five treatments 10, 20, 30, 40 and 50% of fat in dough by weight and same amount of subcutaneous fat is not added. Each sausage mixture was stuffed into 40 mm collagen casing by a laboratory scale stuffer (Ari Torna, İstanbul, Turkey) to give an approximate weight of 300 g. Sausages were hung and allowed to equilibrate at 20 °C and 70 per cent relative humidity (RH) for 6–8 h. They were then placed in a ripening chamber at 25 °C and 90 per cent RH. Relative humidity decreased by 3% every day until the 5th day of fermentation, and temperature was decreased to 22 and 20 °C after 2 and 4 days, respectively. Temperature and relative humidity were constant after the 5th day until 15th day.

Sampling

The pH, dry matter, protein, fat, cholesterol and fatty acid distribution analyses of fresh kashar cheese used in study were carried out before the study. Samples from each sausage type were taken on 0 and 15th day after preparation and analyzed on that day. Two sausage rings from each sample were taken on 0 and 15th day of ripening, grinded and analyzed for pH, dry matter, total fat, and protein analyses. Samples taken on 15th day were also subjected to fatty acid distribution and

cholesterol analyses. Randomly selected four sausage rings from each group were used in sensory panel.

Proximate and chemical analyses

Dry matter content was determined by gravimetric method (105 °C hot-air oven for ~24 h). Total nitrogen was determined by the Kjeldahl method. Fat content of the samples was determined using Soxhlet method using ether as a solvent. Mohr method was used in salt analysis. Dry matter, protein, fat and salt contents were determined as per AOAC methods (2000). pH was measured in a homogenate prepared by blending 10 g of Sucuk with 90 mL of distilled water for 30 s. Readings were taken with a Cole Parmer, Model 5996-50 (USA) pH meter. Total calorie estimates (kcal) were calculated on the basis of a 100 g sample using Atwater values for fat (9 kcal g⁻¹), protein (4.02 kcal g⁻¹) and carbohydrate (3.87 kcal g⁻¹) (Mansour and Khalil 1997). Total cholesterol was determined using a spectrophotometric method described by Rudel and Moris (1973).

The fatty acid compositions of the fat extracted from sausages according to the method of Bligh and Dyer (1959) were determined on final products by converting triglycerides into their methyl esters on a Thermofinnigan TraceGC/Trace DSQ/A1300 (CA, USA) gas chromatograph with a splitless injection, equipped with a mMass Spectrophotometer (MS) and a fused capillary column (SGE BPX5, 30 m, 0.32 mm inner diameter 0.25 µm film thickness, Scientific Instrument Inc., NJ, USA). The working temperature of the injector, column, and MS detector were 240 °C, 190 °C and 240 °C respectively. Helium was used as the carrier gas at a flow rate of 1 mL/minute. Samples of 1 µL were injected into the column inlet using an automatic injector. An electron ionization system with ionization energy of 70 eV was used in MS. Fatty acid methyl esters (FAMES) were identified by comparison of their retention time and equivalent chain length with respect to standard FAMES (47885-U, Supelco, Bellefonte, Penn., USA). Samples FAMES were quantified according to their percentage area. Various ratios based on the results were computed and indices of atherogenicity (IA) and thrombogenicity (IT) were calculated according to Ulbricht and Southgate (1991).

Microbiological enumeration

Two sucuk samples were taken for each fermentation intervals. Duplicate 10 g samples were cut aseptically from the central part of each sucuk stick (100 g) after aseptic removal of casing, and homogenized in 90 mL of 0.1% (mg l⁻¹) sterile peptone water (PW) (Merck Co, Darmstadt, Germany) for 2 min by means of Colworth Stomacher 400 (Seward, London, UK). Homogenate was serially diluted in PW, and appropriate dilutions were cultured in duplicates. Total mesophilic aerobic

Table 1 pH and chemical composition of fresh and 15 days ripened sucuk samples containing beef fat substituted with different levels of kashar cheese

Kashar Cheese			Fat substitution ratio					
			Control	10%	20%	30%	40%	50%
pH	0	6.6±0.04	5.7±0.07 ^{Aa}	5.8±0.06 ^{Ba}	5.9±0.06 ^{Ca}	5.9±0.06 ^{Da}	6.0±0.06 ^{Ea}	6.1±0.06 ^{Fa}
	15		4.8±0.06 ^{Ab}	4.8±0.06 ^{Bb}	4.9±0.06 ^{Cb}	5.0±0.06 ^{Db}	5.1±0.06 ^{Eb}	5.2±0.06 ^{Fb}
Dry Matter (%)	0	52.9±0.05	40.1±0.23 ^{Aa}	39.4±0.23 ^{Ba}	38.6±0.22 ^{Ca}	37.8±0.21 ^{Da}	37.0±0.21 ^{Ea}	36.3±0.21 ^{Fa}
	15		65.8±0.21 ^{Ab}	66.3±0.21 ^{Bb}	64.8±0.20 ^{Cb}	64.3±0.19 ^{Db}	63.8±0.22 ^{Eb}	63.9±0.06 ^{Fb}
Protein (%)	0	22.8±0.08	14.8±0.12 ^{Aa}	15.3±0.12 ^{Ba}	15.8±0.11 ^{Ca}	16.3±0.10 ^{Da}	16.7±0.11 ^{Ea}	17.2±0.13 ^{Fa}
	15		24.3±0.11 ^{Ab}	25.7±0.13 ^{Bb}	26.4±0.12 ^{Cb}	27.7±0.13 ^{Db}	28.8±0.12 ^{Eb}	30.0±0.13 ^{Fb}
Fat (%)	(% in dw)	43.1±0.11	36.9±0.18 ^A	38.8±0.21 ^B	40.8±0.23 ^C	43.0±0.19 ^D	45.2±0.22 ^E	47.4±0.18 ^F
	0	26.4±0.08	19.4±0.21 ^{Aa}	18.1±0.22 ^{Ba}	16.8±0.24 ^{Ca}	15.5±0.25 ^{Da}	14.2±0.27 ^{Ea}	12.9±0.28 ^{Fa}
	15		31.7±0.27 ^{Ab}	30.4±0.28 ^{Bb}	28.1±0.30 ^{Cb}	24.4±0.31 ^{Db}	24.5±0.32 ^{Eb}	22.5±0.34 ^{Fb}
	(% in dw)	49.8±0.12	48.2±0.37 ^A	45.9±0.39 ^B	43.4±0.39 ^C	41.1±0.32 ^D	38.4±0.42 ^E	35.5±0.35 ^F
Calori (kcal/g)	0	329.0±1.16	233.8±1.22 ^{Aa}	224.2±1.32 ^{Ba}	241.2±1.16 ^{Ca}	205.3±0.90 ^{Da}	195.4±1.42 ^{Ea}	185.1±1.35 ^{Fa}
	15		283.2±1.14 ^{Ab}	277.5±1.47 ^{Bb}	359.6±1.14 ^{Cb}	330.9±1.24 ^{Db}	336.5±1.41 ^{Eb}	322.9±1.28 ^{Fb}
Cholesterol (mg/100 g)			137.7±0.59 ^A	137.7±0.64 ^A	137.5±0.69 ^A	137.4±0.41 ^A	137.2±0.18 ^A	136.9±0.27 ^A

The% values indicate substitution of fat levels in kashar. Values are given as mean ± S.D. from triplicate determinations ($n=3$). Values with different capital superscripts in a row and lower case superscripts in a column differ significantly ($P<0.05$)

bacterial counts were determined by spreading on plate count agar (PCA, Merck) and incubating at 30 °C for 172 up to 96 h. Total enterobacteriaceae counts were enumerated by poured plate method in violet red bile dextrose (VRBD) agar (Merck) after overlaying with the same medium and incubating at 37 °C for 24 h. Staphylococcus and Micrococcus counts were determined by the spread plate method on Baird Parker (BP) agar (Merck) supplemented with egg yolk and potassium telluride. Petri plates were incubated at 37 °C for 72 h. Lactic acid bacteria were enumerated on de Man Rogosa Sharpe (MRS) agar (Merck) overlayed with the same medium and incubated

at 30 °C for 72 h. Moulds and yeasts were enumerated on Potato Dextrose Agar (PDA) (Merck) and incubated at 37 °C for 72 h. Microbial counts were expressed as colony-forming units per gram of sample (cfu/g) and were transformed into logarithms.

Sensory analyses

Sucuks were evaluated by a panel of ten tasters selected among the graduate students of the Food Engineering department, who were previously experienced on the sensory

Table 2 Microbiological quality (counts in log cfu/g) of fresh and 15 days ripened sucuk samples containing beef fat substituted with different levels of kashar cheese

	Ferm. Time (Day)	Kashar Cheese	Control	Fat substitution ratio				
				10%	20%	30%	40%	50%
Total total viable counts	0	5.3±0.07	5.4±0.04 ^a	5.6±0.04 ^a	5.1±0.08 ^a	5.2±0.04 ^a	5.6±0.06 ^a	5.1±0.07 ^a
	15		7.2±0.06 ^b	6.7±0.09 ^b	6.9±0.07 ^b	6.7±0.09 ^b	6.7±0.06 ^b	7.4±0.09 ^b
Lactic acid bacteria counts	0	6.1±0.09	6.1±0.09 ^a	5.7±0.09 ^a	5.6±0.11 ^a	5.6±0.10 ^a	5.8±0.09 ^a	5.7±0.09 ^a
	15		7.1±0.09 ^b	6.7±0.09 ^b	7.0±0.10 ^b	6.7±0.07 ^b	6.6±0.09 ^b	6.9±0.09 ^b
Micrococci – staphylococci	0	3.6±0.13	3.9±0.14 ^a	4.2±0.13 ^a	3.8±0.11 ^a	3.7±0.10 ^a	4.0±0.11 ^a	3.9±0.12 ^a
	15		5.1±0.09 ^b	5.1±0.10 ^b	5.4±0.09 ^b	4.9±0.11 ^b	4.9±0.13 ^b	5.4±0.11 ^b
Moulds and yeasts counts	0	4.4±0.07	4.3±0.05 ^a	4.5±0.07 ^a	4.0±0.05 ^a	4.0±0.04 ^a	4.5±0.05 ^a	4.1±0.06 ^a
	15		3.8±0.14 ^b	3.6±0.06 ^b	4.3±0.07 ^b	3.7±0.12 ^b	3.7±0.07 ^b	4.1±0.08 ^b
Enterobacteriaceae	0	<1	2.9±0.15 ^a	2.0±0.11 ^a	2.7±0.14 ^a	2.8±0.13 ^a	2.1±0.07 ^a	2.6±0.09 ^a
	15		<1 ^b	<1 ^b	<1 ^b	<1 ^b	<1 ^b	<1 ^b

The% values indicate substitution of fat levels in kashar. Values are given as mean ± S.D. from triplicate determinations ($n=3$). Values with different lower case superscripts in a column differ significantly ($P<0.05$)

assessment of sucuks. Quantitative Descriptive Analysis (QDA) was used. Two sessions per day were conducted in which panel members were served four randomized samples per session. Evaluations were performed in individually, under white fluorescent lighting. The tests were carried out between meals. Sensory evaluation is carried out with a continuous scale between 0 and 10, where 0 was worst and 10 was best. Sucuk samples sliced into 5-mm thickness were randomly served for evaluation as raw and fried. Sensory colour, consistency and appearance evaluation is carried out with raw sausages and sensory taste, smell,

flavour and hardness evaluation is carried out with fried sausages. Sensory overall acceptability evaluation is carried out with both raw and fried sausages. Unsalted bread and water were given between the samples.

Statistical evaluation

The study is carried out in triplicate and all the experiments are duplicated. All results were analyzed by analysis of variance (ANOVA) according to a two factorial design, using a split plot design with two trials. In this design, the

Table 3 Fatty acids composition of 15 days ripened sucuk samples containing beef fat substituted with different levels of kashar cheese. (% of total fat)

	Kashar Cheese	Control	Fat substitution ratio				
			10%	20%	30%	40%	50%
C4:0	2.5±0.01	0	0.1±0.01 ^B	0.2±0.01 ^C	0.3±0.01 ^D	0.4±0.02 ^E	0.6±0.02 ^F
C6:0	1.8±0.01	0	0.1±0.01 ^B	0.1±0.01 ^C	0.2±0.01 ^D	0.3±0.01 ^E	0.4±0.02 ^F
C8:0	1.3±0.01	0	0	0.1±0.00 ^C	0.1±0.00 ^D	0.2±0.01 ^E	0.3±0.01 ^F
C10:0	3.3±0.04	0	0.1±0.01 ^B	0.2±0.01 ^C	0.4±0.01 ^D	0.5±0.02 ^E	0.7±0.02 ^F
C12:0	3.4±0.05	0	0.1±0.01 ^B	0.3±0.00 ^C	0.4±0.01 ^D	0.6±0.01 ^E	0.8±0.02 ^F
C14:0	11.5±0.05	2.9±0.11 ^A	3.2±0.16 ^B	3.5±0.14 ^C	3.9±0.14 ^D	4.4±0.16 ^E	4.9±0.15 ^F
C15:0	1.1±0.01	0	0.04±0.00 ^B	0.1±0.00 ^C	0.1±0.01 ^D	0.2±0.01 ^E	0.3±0.01 ^F
C16:0	32.4±0.15	23.4±0.14 ^A	23.7±0.19 ^{AB}	24.0±0.37 ^{ABC}	24.5±0.49 ^{BC}	24.8±0.65 ^{CD}	25.4±0.69 ^D
C17:0	0.7±0.02		0	0	0.1±0.01 ^D	0.1±0.00 ^E	0.1±0.01 ^F
C18:0	11.8±0.09	18.9±0.43 ^A	18.7±0.57 ^A	18.4±0.42 ^{AB}	18.1±0.45 ^{ABC}	17.7±0.52 ^{BC}	17.3±0.60 ^C
C20:0	0.4±0.01	0.3±0.01 ^A	0.3±0.02 ^A	0.3±0.01 ^A	0.3±0.01 ^A	0.3±0.01 ^A	0.3±0.01 ^A
C14:1	0.9±0.02	1.1±0.03 ^A	1.1±0.03 ^A	1.1±0.04 ^A	1.1±0.04 ^A	1.1±0.04 ^A	1.0±0.03 ^A
C16:1	1.0±0.02	3.7±0.06 ^A	3.7±0.06 ^A	3.5±0.05 ^B	3.5±0.03 ^C	3.3±0.03 ^D	3.1±0.05 ^E
C18:1	25.0±0.21	41.7±0.63 ^A	41.2±0.72 ^{AB}	40.4±0.61 ^{BC}	39.8±0.40 ^C	38.8±0.37 ^D	37.7±0.56 ^E
C20:1	0.4±0.01	0.6±0.02 ^A	0.6±0.03 ^A	0.6±0.02 ^A	0.6±0.02 ^A	0.6±0.04 ^A	0.6±0.01 ^A
C18:2w6	1.5±0.02	3.5±0.05 ^A	3.5±0.09 ^{AB}	3.4±0.04 ^{BC}	3.3±0.02 ^C	3.2±0.03 ^D	3.1±0.06 ^E
C18:3w6	0	0.4±0.01 ^A	0.4±0.01 ^A	0.4±0.01 ^B	0.4±0.01 ^C	0.3±0.01 ^D	0.3±0.01 ^E
C20:2w6	0.1±0.01	0.2±0.01 ^A	0.2±0.01 ^{AB}	0.2±0.01 ^A	0.2±0.01 ^{ABC}	0.2±0.01 ^{BC}	0.0±0.02 ^C
C20:3w6	0	0.7±0.02 ^A	0.6±0.01 ^{AB}	0.6±0.01 ^{BC}	0.6±0.02 ^C	0.5±0.02 ^D	0.5±0.02 ^D
C20:4w6	0	0.2±0.01 ^A	0.2±0.01 ^B	0.2±0.01 ^B	0.2±0.01 ^C	0.7±0.01 ^D	0.1±0.00 ^D
C18:3w3	0	0.6±0.01 ^A	0.6±0.01 ^B	0.6±0.01 ^C	0.6±0.01 ^D	0.5±0.01 ^E	0.5±0.01 ^F
C20:5w3	0	0	0	0	0	0	0
SFA	70.2±0.25	45.6±0.47 ^A	46.4±0.79 ^A	47.3±0.45 ^B	48.5±0.28 ^{AB}	49.6±0.41 ^D	51.1±0.22 ^E
UFA	28.9±0.05	52.9±0.65 ^A	52.2±0.70 ^A	51.0±0.66 ^B	50.2±0.41 ^B	48.8±0.28 ^C	47.2±0.48 ^D
PUFA	1.6±0.04	5.7±0.05 ^A	5.6±0.08 ^B	5.4±0.05 ^C	5.2±0.07 ^D	5.0±0.07 ^E	4.8±0.10 ^F
MUFA	27.3±0.15	47.2±0.70 ^A	46.6±0.78 ^{AB}	45.6±0.69 ^{BC}	45.0±0.43 ^C	43.8±0.35 ^D	42.4±0.58 ^E
SFA/UFA	2.4±0.01	0.9±0.02 ^A	0.9±0.03 ^A	0.9±0.02 ^B	1.0±0.01 ^C	1.0±0.01 ^D	1.1±0.02 ^E
PUFA/SFA	0.02	0.1±0.01 ^A	0.1±0.01 ^B	0.1±0.01 ^C	0.1±0.01 ^C	0.1±0.00 ^D	0.1±0.00 ^E
w3	0	0.7±0.01 ^A	0.6±0.01 ^B	0.6±0.01 ^B	0.6±0.01 ^C	0.5±0.01 ^D	0.5±0.01 ^E
w6	1.4±0.02	5.0±0.06 ^A	4.9±0.08 ^A	4.8±0.06 ^B	4.7±0.06 ^C	4.5±0.06 ^D	4.3±0.09 ^E
w6/w3	0	7.7±0.23 ^A	7.8±0.27 ^{AB}	7.8±0.23 ^{ABC}	8.0±0.10 ^{BC}	8.2±0.03 ^{CD}	8.4±0.08 ^D
IT	2.2±0.02	0.7±0.02 ^A	0.7±0.02 ^A	0.7±0.02 ^B	0.8±0.02 ^C	0.9±0.03 ^D	1.0±0.04 ^E
AI	2.0±0.02	1.1±0.02 ^A	1.2±0.02 ^B	1.2±0.02 ^C	1.3±0.01 ^D	1.3±0.01 ^E	1.4±0.01 ^F

The % values indicate substitution of fat levels in kashar. Values are given as mean ± S.D. from triplicate determinations ($n=3$). Different capital superscripts in the same row indicate significant differences for the same fatty acid between sausage type ($P<0.05$)

factors were the kashar (control, 10%, 20%, 30%, 40% and 50% of fat substitution with kashar) and the ripening time (days) for a specific parameter. If required, Duncan multiple comparison test was performed to investigate which means that the results of analysis significantly differed from each other. Minitab (Minitab, State College, PA) software (ver. 13.0 for Windows) was used for statistical analysis.

Results and discussion

Changes of pH and dry matter, protein, fat, salt, cholesterol and energy contents of samples are shown in Table 1. The initial pH values of control, 10%K, 20%K, 30%K, 40%K and 50%K products were 5.75, 5.80, 5.86, 5.94, 6.02 and 6.11 and the final pH values were 4.76, 4.84, 4.92, 5.02, 5.11 and 5.17 respectively. The increased substitution level of fat with kashar significantly increased the pH values at the starting and the end of ripening. The pH values of sucuks were significantly decreased during the ripening ($P<0.05$). The main protein component of the kashar cheese is casein that acts as emulsifier (Kinik et al. 2005). Emulsifier role of kashar cheese could not observe since cheese was diced into 5 mm cubes. Casein might buffer the system during the pH analysis and that may affect the results of pH analysis. The Turkish Standard Institute states that quality ripened sausages should have pH values between 4.7 and 5.4 in Turkish Sucuk Standard and the pH values of all Sucuk samples were between in this range. The decline in the pH value during the first days of ripening (fermentation) is very important for the production of safe and high quality sausages due to the inhibition of undesired bacteria, conversion and stabilization of colour, and formation of desired flavour (Incze 1992; Rai et al. 2010; Thomas et al. 2010; Surehkumar et al. 2010).

The initial dry matter contents of control, 10%K, 20%K, 30%K, 40%K and 50%K products were 40.13, 39.36, 38.60, 37.84, 37.04 and 36.27 and the final dry matter

contents were 65.80, 66.28, 64.80, 64.30, 63.77 and 63.28, respectively. The increased substitution level of fat with kashar cheese significantly decreased the dry matter contents at the 0 and 15th day of production ($P<0.05$). The dry matter contents of all sucuk groups significantly increased during the fermentation time ($P<0.05$). Kashar cheese used in the study contained more dry matter than control sucuk dough; consequently the protein and fat contents were also more than control sucuk dough. The protein contents of sucuks significantly increased ($P<0.05$) and the fat content of sucuks significantly decreased with the increased substitution ratio ($P<0.05$). Increment in protein content, and decrement in fat content clearly observed in dry weight basis (Table 1). The dry matter, protein and fat contents of the samples were increased during the ripening significantly ($P<0.05$). Proximate composition of Turkish Standards for first class sucuk are; 40% for maximum moisture, 35 per cent for maximum fat and 22 per cent for minimum protein. All samples had moisture, protein and fat contents within the limits stated in the standard at the end of the fermentation. As the fat substitution ratio increased, the total calorie estimates were decreased in the sausage dough samples and in the final products ($P<0.05$) because of mainly decrement in fat amount. Cholesterol is present in both meat and cheese. The cholesterol content of sucuks is depicted in Table 1. The cholesterol contents of the samples were not affected by substitution of fat with kashar. Cholesterol content of 115 mg/100 g and 84.26–127.15 mg/100 g has been reported for sucuk and fresh kashar cheeses, respectively (Kayaardı and Gök 2003; Kinik et al. 2005).

The microbial changes during ripening are shown in Table 2. The initial microbial counts of sausages were between 5.14 and 5.65 log cfu/g for total viable, 5.60–6.09 log cfu/g for lactic, 3.75–4.02 log cfu/g for micrococci–staphylococci bacteria, 4.06–4.31 for yeasts and moulds and 2.07–2.95 log cfu/g for enterobacteriaceae. The final counts were between 6.67 and 7.44 log cfu/g for total viable, 6.59–7.12 log cfu/g for lactic, 4.90–5.41 log cfu/g

Table 4 Sensory quality attributes of sucuk samples containing beef fat substituted with different levels of kashar cheese

	Fat substitution ratio					
	Control	10%*	20%*	30%*	40%*	50%*
Colour	8.3±0.20 ^a	7.5±0.06 ^b	7.3±0.25 ^b	6.7±0.20 ^c	5.2±0.20 ^d	4.8±0.25 ^e
Consistency	6.6±0.46 ^{ab}	7.2±0.15 ^a	6.5±0.10 ^{ab}	6.2±0.36 ^b	5.8±0.42 ^{bc}	5.3±0.67 ^c
Appearance	7.3±0.26 ^a	6.9±0.35 ^a	6.9±0.12 ^a	6.7±0.40 ^{ab}	6.0±0.47 ^{bc}	5.3±0.67 ^c
Taste	6.3±0.42 ^a	7.0±0.64 ^a	6.8±0.36 ^a	6.3±0.90 ^a	5.8±0.80 ^{ab}	4.8±0.60 ^b
Smell	8.4±0.20 ^a	7.5±0.15 ^b	7.2±0.50 ^b	6.3±0.66 ^c	5.2±0.46 ^d	4.5±0.20 ^d
Flavour	8.2±0.35 ^a	6.6±0.12 ^b	5.9±0.52 ^b	6.2±0.95 ^b	6.3±0.75 ^b	5.7±0.74 ^b
Hardness	8.5±0.17 ^a	7.6±0.17 ^b	6.7±0.17 ^c	6.5±0.15 ^c	5.5±0.15 ^d	5.4±0.74 ^d
Acceptance	6.2±0.35 ^{bc}	7.1±0.21 ^a	6.6±0.17 ^{ab}	5.8±0.46 ^c	4.8±0.30 ^d	3.9±0.68 ^e

* The% values indicate substitution of fat levels in kashar. Values are given as mean ± S.D. from triplicate determinations ($n=10$). Values with different lower case superscripts in a row differ significantly ($P<0.05$)

for micrococci–staphylococci bacteria, 3.71–4.13 for yeasts and moulds and <1 log cfu/g for enterobacteriaceae. There is no significant affect of added kashar levels on the microbial counts of the sausages ($P>0.05$) but ripening time significantly affected the microbial loads ($P<0.05$).

The fatty acid distributions of sucuks are shown in Table 3. Butyric ($C_4:0$), caproic ($C_6:0$), caprylic ($C_8:0$), capric ($C_{10:0}$), lauric ($C_{12:0}$) and pentadecanoic acid ($C_{15:0}$) were found in only kashar added sucuks. Butyric ($C_4:0$), caproic ($C_6:0$), caprylic ($C_8:0$), capric ($C_{10:0}$), lauric ($C_{12:0}$), myristic ($C_{14:0}$), pentadecanoic acid ($C_{15:0}$), palmitic ($C_{16:0}$), heptadecanic ($C_{17:0}$) and arachidic ($C_{20:0}$) were increased with increasing kashar levels ($P>0.05$) while stearic ($C_{18:0}$), myristoleic ($C_{14:1}$), palmitoleic ($C_{16:1}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$, ω -6), γ -linolenic ($C_{18:3}$, ω -6), eicosadienoic ($C_{20:2}$, ω -6), eicosatrienoic ($C_{20:3}$, ω -6), arachidonic ($C_{20:4}$, ω -6), α -linolenic ($C_{18:3}$, ω -6) and eicosapentaenoic acids were decreased ($P>0.05$). As a summary of fatty acids distributions of sucuk samples, saturated fatty acids (SFAs), ω -6/ ω -3 ratio, index of thrombogenicity (IT) and atherogenicity index (AT) were increased while the amounts of monosaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), unsaturated fatty acids (UFA), ω -6, ω -3 were decreased. The substitution of fat with kashar did not result with healthier fatty acids distribution.

The sensory quality attributes of sucuk samples are depicted in the form of bar chart in Table 4. The best sensory scores for color, appearance, odor, flavor and hardness were seen in control samples. The best scores for taste, consistency and overall acceptability was associated with 10 per cent of fat substitution with kashar cheese. These results suggest that a 10% fat substitution with kashar cheese could result in a product with better consumer acceptability.

Conclusion

The results indicate that it is possible to partially substitute the animal fat with kashar which can be preferable by the consumers. The results of the study indicated that 10% of animal fat can be substituted with kashar cheese in sucuk but unsaturated, monounsaturated and poli unsatu-

rated fatty acids contents decreased with the increased fat substitution ratio of the sucuks and the cholesterol contents of sucuks did not affected with the fat substitution.

The study showed that replacing beef fat with kashar may be a useful application for developing new type of sucuks and further studies should be considered to determine changes of quality attributes during storage.

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