THE EFFECT OF α-TOCOPHEROL, STORAGE TIME AND STORAGE TEMPERATURE ON PEROXIDE VALUE, FREE FATTY ACIDS AND pH OF KAVURMA, A COOKED MEAT PRODUCT

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ABSTRACT

The effects of α-tocopherol, storage temperature and storage time on the peroxide value (PV), free fatty acids (FFAs) and pH of sliced, vacuum-packaged kavurma, a high-fat cooked meat product, were investigated. Kavurma was made from fresh beef meat, melted beef fat and salt as three groups: (1) control (without α-tocopherol), (2) 50 mg/kg α-tocopherol and (3) 100 mg/kg α-tocopherol. The kavurma was sliced at 3–4 cm thick, vacuum packed and stored at 4 or 10C for 90 days; and peroxide, FFA and pH values of the products were determined during storage (0, 45 and 90 days). Use of antioxidants in kavurma production resulted in a significant ($P < 0.01$*) decrease in the PV (*$P < 0.01$*), FFA (*$P < 0.01$*) and pH values (*$P < 0.01$*). Kavurma samples with antioxidant had the lowest PV, FFA and pH values. These values increased during storage (*$P < 0.01$*); the greatest increase was observed in the control group. Storage temperature had a significant effect on the PV (*$P < 0.01$*), FFA (*$P < 0.01$*) and pH values (*$P < 0.01$*). The sliced and vacuum-packaged kavurma with added α-tocopherol showed greater lipid stability at 4 or 10C for 90 days.*

PRACTICAL APPLICATIONS

Lipid oxidation is a major problem during storage and in the market place. Results of this study can be applied to prevent lipid oxidation and hydrolysis in kavurma and to improve quality/safety of kavurma during storage. Based on the results, alpha-tocopherol can be used to improve the shelf life of kavurma.

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INTRODUCTION

Kavurma is a cooked meat product made from beef or mutton meat, beef fat and salt. The meats are diced (4×5 cm) and mixed with salt, and then cooked in animal fat using a double-sided steam cauldron (Aksu and Kaya 2005). After cooking, the product is kept in almost anaerobic conditions and at low temperatures (1 or 4C) to prevent lipid oxidation and other spoilage factors. Kavurma is sold in sliced, vacuum-packaged form and has an average shelf life of 6 months when stored at a low temperature (Anon 2002; Gökalp *et al.* 2004). Because kavurma has higher moisture and fat contents (40–50% moisture, maximum of 35% fat and 2.5–4.0% salt) than other cooked meat products, and because the risk of spoilage increases with slicing, lipid oxidation is a major problem during storage. The use of antioxidants, such as butylated hydroxyanisole and α-tocopherol, in kavurma production results in a significant decrease in the lipid oxidation (Aksu and Kaya 2005), and when combined in appropriate packaging, shelf life is extended and quality properties are preserved (Kaya 1995; Kaya and Gökalp 1995; Gökalp *et al.* 2004).

Lipid hydrolysis and oxidation can significantly differ among kavurma samples, depending on the raw material, ingredient properties, temperature, pH, processing and cooking time of the meat product. In fatty products, such as kavurma, peroxide value (PV) and free fatty acids (FFAs) are very important quality criteria in determination of fat rancidity. Furthermore, the initial concentration of hydroperoxides, the primary products of autoxidation of lipids, can reduce the efficiency of the antioxidant added to meat products (Yanishlieva-Maslarova 2001).

The objective of this study was to determine the effect of α-tocopherol (0, 50, 100 mg/kg α-tocopherol), storage temperature (4 and 10C) and storage period (0, 45 and 90 days) on the PV, FFA and pH of sliced, vacuum-packaged kavurma.

MATERIALS AND METHODS

Fresh beef meat (70%), melted beef fat (28%), NaCl (2%) and commercial preparations of α-tocopherol ([±]-α-tocopherol, Sigma-Aldrich Chemie, Steinheim, Germany) were used to process kavurma according to the manufacturing process in Fig. 1. The antioxidant was dissociated in melted kavurma fats (55–60C) and then mixed in kavurma (Aksu and Kaya 2005). The kavurma products (0 [control], 50 mg/kg α-tocopherol and 100 mg/kg α-tocopherol) were sliced (3–4 cm thick, 200–250 g) using a slicing machine at the end of the processing period. The sliced kavurma for each group was packaged (vacuum bag oriented EVOH polietilen) automatically (48 sliced kavurma samples

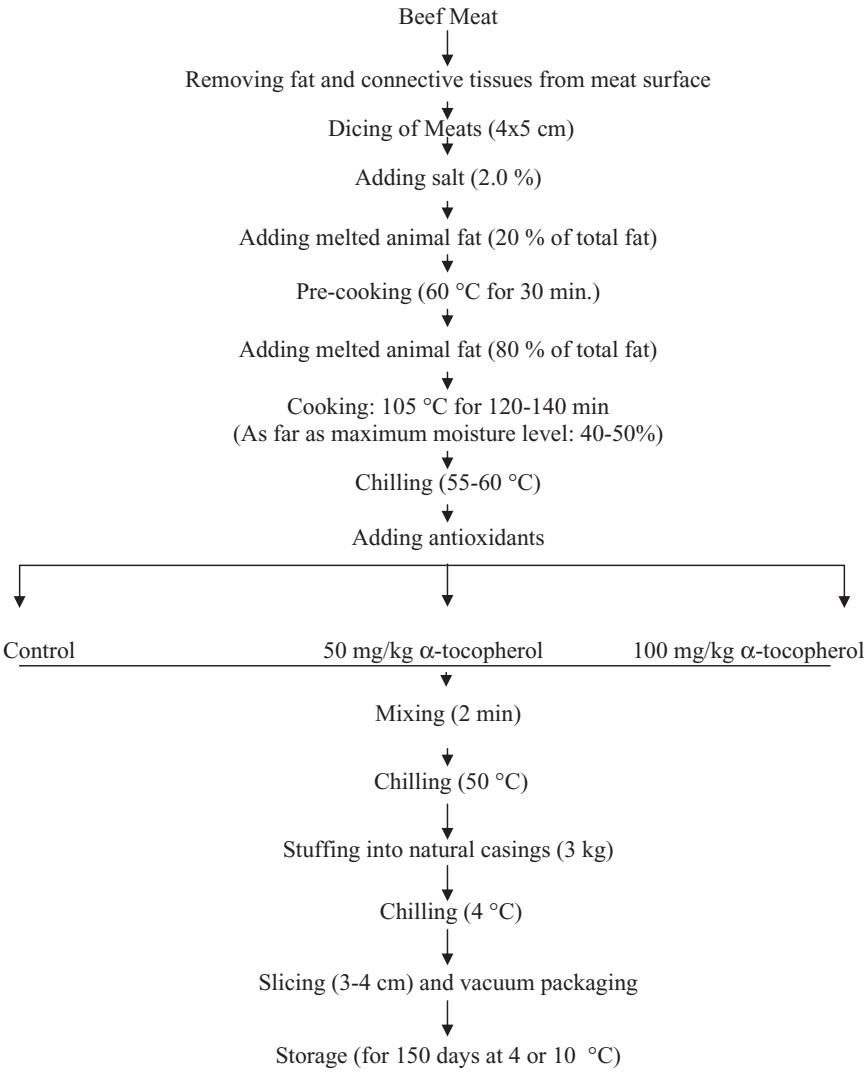


FIG. 1. THE PRODUCTION PROCESS OF KAVURMA

packaged for each treatment group: control = 48, 50 mg/kg α-tocopherol = 48 and 100 mg/kg α-tocopherol = 48; total packaged number = 144; total kavurma weight: ~36 kg, for each treatment group: ~12 kg) and thermally sealed by a Multivac packaging unit (Multivac A 300/16, Sepp Haggenmüller, Wolfertschwenden, Germany) under vacuum. The packaged kavurma samples were stored

at 4 or 10C for up to 90 days. Two trials with two replications for each treatment were conducted.

The PV, FFAs and pH were determined (48 packaged samples were opened and analyzed for each storage period) at 0, 45 and 90 days of storage period. The peroxide and pH values (pH meter, SCHOTT L 6880, Lab Star pH, Germany) in the samples were determined according to the methods of Gökalp *et al.* (2000). For the PV, lipid in kavurma was dissolved in 30 mL chloroform–acetic acid mixture, treated with 0.5 mL of saturated potassium iodide (KI) solution and kept in the dark for 5 min. Thirty milliliters of distilled water was added to the mixture and shaken. One milliliter of starch solution (1.0% w/v) was added as an indicator. The PV was determined by titrating iodine liberated from the potassium iodide with sodium thiosulphate solution (Ockerman 1985). The PVs were expressed as milliequivalent O_2 per kilogram of fat. For FFA analysis, 10 g of ground sample was homogenized with 30 mL of chloroform containing 0.5 g of sodium sulfate, and was allowed to settle at room temperature (20C) for 5 min, and then filtered through Whatman No. 1 filter paper (Whatman Ltd., U.K.). The FFAs in 25 mL of the filtrate were titrated with a potassium hydroxide solution (0.01 N). Results were expressed as g of oleic acid/100 g of fat.

The results were analyzed with the completely randomized design procedure using the SPSS package with 10.01 software (SPSS 1996). Statistical model included α-tocopherol level (0 mg/kg α-tocopherol, 50 mg/kg α-tocopherol and 100 mg/kg α-tocopherol), storage temperature (4 or 10C) and storage period (0, 45 and 90 days) as main effects and their interactions. Differences between data were tested using the Duncan's multiple range test (significance $P < 0.05$). The results of the statistical analysis are shown as mean value ± SD in the tables.

RESULTS AND DISCUSSION

The PVs were used as indices to assess the level of lipid oxidation in kavurma. The α-tocopherol level had a significant effect ($P < 0.01$) on PV, and the highest PV was observed in the control group (Table 1). Storage period and storage temperature had an effect ($P < 0.01$) on the PV of sliced, vacuum-packed kavurma (Tables 2 and 3). However, α-tocopherol levels × storage period and storage temperature × storage period interactions also had an effect ($P < 0.01$) on the PV of sliced kavurma containing 50 mg/kg α-tocopherol, 100 mg/kg α-tocopherol or no added antioxidant (control). There was no significant difference ($P > 0.05$) in the PV across treatment groups at 0 days; however, there were statistically significant differences in the PV between control and α-tocopherol groups at both 45 and 90 days and between 4 and

TABLE 1.
PEROXIDE VALUE (PV), FREE FATTY ACID (FFA) AND pH VALUES OF KAVURMA WITH CONTROL (0 mg/kg α-TOCOPHEROL), 50 mg/kg α-TOCOPHEROL AND 100 mg/kg α-TOCOPHEROL

Antioxidant Level	PV†	FFA‡	pH
Control	1.59 ± 0.46a	0.30 ± 0.05a	6.29 ± 0.08a
50 mg/kg α-tocopherol	1.37 ± 0.35b	0.27 ± 0.03b	6.25 ± 0.05b
100 mg/kg α-tocopherol	1.19 ± 0.28c	0.25 ± 0.02c	6.27 ± 0.05ab
Significance	*	*	*

* $P < 0.01$.
† Milliequivalent O_2 per kilogram of fat.
‡ Gram of oleic acid/100 g of fat.
a–c, means in the same column having the same letters are not significantly different at $P > 0.05$.

TABLE 2.
PEROXIDE VALUE (PV), FREE FATTY ACID (FFA) AND pH VALUES OF KAVURMA IN 0, 45 AND 90 DAYS OF STORAGE

Storage Time (Days)	PV†	FFA‡	pH
0	1.04 ± 0.13c	0.25 ± 0.01b	6.24 ± 0.05b
45	1.39 ± 0.28b	0.29 ± 0.03a	6.25 ± 0.03b
90	1.74 ± 0.35a	0.29 ± 0.05a	6.33 ± 0.06a
Significance	*	*	*

* $P < 0.01$.
† Milliequivalent O_2 per kilogram of fat.
‡ Gram of oleic acid/100 g of fat.
a–c, means in the same column having the same letters are not significantly different at $P > 0.05$.

10C. At the end of the storage period, the lowest PV was found in the kavurma stored at 4C and produced with 100 mg/kg α-tocopherol, while the highest PV was in the kavurma produced without antioxidant stored at 4 or 10C (Table 4). The maximum peroxide level of kavurma according to the Turkish Kavurma Standard (Anon 2002) is 20 mequiv O_2/kg. Sarıgöl (1978), Güngör (2000) and Yetim *et al.* (2006) reported that the PV of kavurma during storage increased and ranged between 5 and 9 mequiv O_2/kg, and between 3.21 and 7.10 mequiv O_2/kg, respectively.

Cooking increases lipid oxidation in muscle (Tims and Watts 1958) and lipid oxidation may also decrease nutritional value by the formation of potentially toxic products during cooking and processing (Shahidi *et al.* 1992; Maillard *et al.* 1996). However, when tocopherol-supplemented meat is cooked, there is a significant increase in oxidative stability (Lynch *et al.* 1999; Galvin *et al.* 2000; Mikova 2001; Aksu and Kaya 2005). α-Tocopherol

TABLE 3.
PEROXIDE VALUE (PV), FREE FATTY ACID (FFA) AND pH VALUES OF STORED KAVURMA AT 4 AND 10C

Storage Temperature (C)	PV†	FFA‡	pH
4	1.28 ± 0.30b	0.25 ± 0.04b	6.25 ± 0.04b
10	1.48 ± 0.47a	0.28 ± 0.05a	6.29 ± 0.07a
Significance	*	*	*

* $P < 0.01$.
† Milliequivalent O_2 per kilogram of fat.
‡ Gram of oleic acid/100 g of fat.
a–b, means in the same column having the same letters are not significantly different at $P > 0.05$.

TABLE 4.
CHANGES OVER THE STORAGE PERIOD AND STORAGE TEMPERATURE IN PEROXIDE VALUE (PV), FREE FATTY ACID (FFA) AND pH VALUES OF KAVURMA WITH AND WITHOUT ANTIOXIDANT

Storage time (days)	Storage temperature (C)	Control	50 mg/kg α-tocopherol	100 mg/kg α-tocopherol	Significance
PV†					
0	4 and 10	1.10 ± 0.15	0.99 ± 0.08	0.93 ± 0.12	Ns
45	4	1.45 ± 0.21a	1.30 ± 0.12b	1.08 ± 0.10b	*
	10	1.84 ± 0.16a	1.46 ± 0.21b	1.21 ± 0.03c	**
90	4	1.80 ± 0.22a	1.50 ± 0.20b	1.31 ± 0.13b	*
	10	2.25 ± 0.29a	1.91 ± 0.12ab	1.66 ± 0.20b	*
FFA‡					
0	4 and 10	0.25 ± 0.01	0.25 ± 0.02	0.24 ± 0.01	Ns
45	4	0.30 ± 0.02a	0.27 ± 0.01b	0.26 ± 0.02b	**
	10	0.34 ± 0.02a	0.32 ± 0.01a	0.27 ± 0.02b	**
90	4	0.32 ± 0.01a	0.29 ± 0.03b	0.25 ± 0.01c	**
	10	0.36 ± 0.07a	0.24 ± 0.01b	0.27 ± 0.01b	**
pH					
0	4 and 10	6.23 ± 0.03	6.25 ± 0.06	6.26 ± 0.06	Ns
45	4	6.25 ± 0.03a	6.20 ± 0.02b	6.22 ± 0.01ab	*
	10	6.28 ± 0.01	6.24 ± 0.02	6.27 ± 0.04	Ns
90	4	6.31 ± 0.02a	6.28 ± 0.21b	6.27 ± 0.01b	**
	10	6.43 ± 0.06a	6.32 ± 0.02b	6.36 ± 0.02b	*

* $P < 0.05$; ** $P < 0.01$.
† Milliequivalent O_2 per kilogram of fat.
‡ Gram of oleic acid/100 g of fat.
a–c, means in the same line having the same letters in the same sections are not significantly different at $P > 0.05$.
Ns, Non-significant.

protects highly oxidizable polyunsaturated fatty acids from peroxidation by reactive oxygen species produced by adjacent membrane-bound enzymes (McCay and King 1980). α-Tocopherol can interrupt lipid autoxidation by interfering with either the chain propagation or the decomposition processes; however, at high concentrations, α-tocopherol inhibits hydroperoxide decomposition and promotes hydroperoxide formation. The inhibition of hydroperoxide decomposition by antioxidants may be critical in preserving food quality by reducing rancidity due to aldehyde formation. So, α-tocopherol has been associated with retarding the decomposition of hydroperoxides (Frankel 1996).

On the other hand, storage temperature has a significant effect on the effectiveness of α-tocopherol. In the present study, PVs in the kavurma samples stored at 4C were lower than in those stored at 10C (Tables 3 and 4).

The FFA values were significantly affected by antioxidant treatment, storage period and storage temperature ($P < 0.01$). There was a significant ($P < 0.01$) difference in the FFA content in kavurma between the control group and 50 and 100 mg/kg α-tocopherol groups (Table 1), and this value decreased in α-tocopherol-added groups. There was no difference between 45 and 90 days of storage period (Table 2). Also, α-tocopherol levels × storage period and storage temperature × storage period interactions had an effect ($P < 0.01$) on the amount of FFA in the sliced kavurma with and without antioxidant. The FFA amount of the control samples increased during storage, but the FFA amount of added-antioxidant groups decreased after 45 days. However, there were statistically significant differences in FFAs between the control and antioxidant groups at both 45 and 90 days at 4 and 10C (Table 4).

The amount of FFAs in fat depends on the hydrolytic activity of the lipases, the microbial metabolic processes and the oxidative reactions that work on the FFAs released in the lipolysis. These reactions are directly related to both the raw material used to prepare kavurma and the production process. Furthermore, lipids and phospholipids are hydrolyzed by lipase and phospholipase yielding FFAs, which are oxidized to peroxides (Toldra 1994). Güngör (2000) found that the FFA value of kavurma stored at 4C for 180 days was between 0.67 and 1.18 mg KOH/g fat, with an increase during storage. Additionally Kowale *et al.* (1996) reported that cooking of meat significantly increased the amount of FFAs.

The lowest pH was found in 50 mg/kg α-tocopherol groups (Table 1). Also, storage period and storage temperature had an effect ($P < 0.01$) on the pH values, and the highest pH was determined in the end of the storage period (Table 2) at 10C (Table 3). However, there were no significant differences in pH among treatment groups at 0 days of storage period at both 4 and 10C ($P > 0.05$), but there was a higher difference among treatment groups at 45 and 90 days except for 45 days at 10C (Table 4). The pH of meat products to which antioxidant is added is very important in terms of antioxidant effectiveness and

product shelf life. According to the kavurma standard (Anon 2002), the pH of kavurma should be between 4.5 and 6.4. Determined results in the present study are compatible with the kavurma standard (Anon 2002). Also, the pH determined in this study is similar to some research results (Vural and Öztan 1989a,b; Tiryakioğlu and Yücel 1995; Cetin 2000). In a study on the use of tocopherol as an antioxidant, Aksu and Kaya (2005) reported that the pH values in the kavurma made with 0, 50 and 100 mg/kg α-tocopherol at 4C for 300 days increased during storage.

CONCLUSION

The changes observed in the PV and FFAs suggested oxidation and hydrolysis in kavurma fat during storage (4 and 10C for 90 days), but the stability of kavurma fat was maintained by the addition of antioxidants.

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