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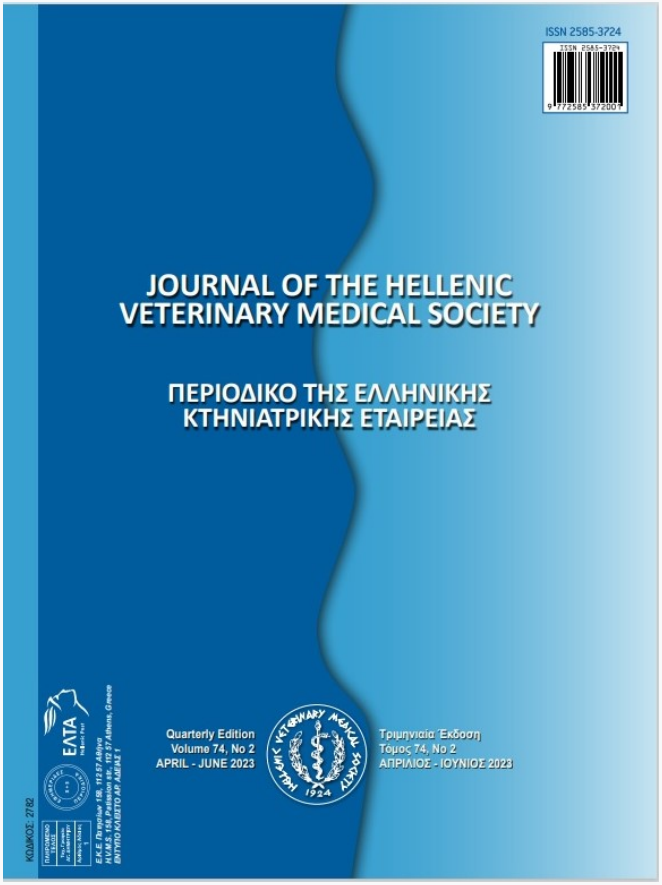

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Research article
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Effect of α-Tocopherol, Storage Temperature and Storage Time on Quality Characteristics and Oxidative Stability of Chicken Kavurma, traditional Turkish cooked meat product

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ABSTRACT: During storage of meat products, 4°C storage temperature is recommended however temperature in retails could rise to 15°C and maintaining quality of products becomes a challenge at higher temperatures. Thus, the aim of present study was determining the effects of antioxidant usage and storage temperature on some quality characteristics and lipid oxidation stability of chicken kavurma during 4-month storage at 4°C and 10°C. For this purpose, two different kavurma sample (C: without antioxidant, A:with 300 ppm α-tocopherol) were stored at 4°C and 10°C. Chemical composition, salt, texture profile analysis, color and lipid oxidation (peroxide values and TBARS values) of samples were monitored. Using α-tocopherol in formulation did not affect the chemical composition and texture of samples, all parameters were found within standards. Storage time has significant influence on pH, color and lipid oxidation of samples. Using α-tocopherol and higher storage temperature resulted higher peroxide values. During 4-month storage, lipid oxidation results significantly increased, the lowest TBARS value was found in 4A sample. Storage temperature affected only a* values while antioxidant usage affected only b* values of samples. As a result, using 300 ppm α-tocopherol can help maintaining quality and oxidative stability of chicken kavurma sold in retails.

Keywords: chicken kavurma; lipid oxidation; antioxidant; temperature; meat product

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INTRODUCTION

Kavurma is a traditional cooked meat product which generally made from beef or mutton and produced as follows: The first step of kavurma production is cutting meat or fat obtained from beef or mutton into the small pieces. Then, the diced beef or mutton and their fats are fried in cauldron. The last step of the production is filling kavurma into the casing and covering gaps and surface with fat (Kayaardi et al., 2005; Şişik Oğraş et al., 2018).

Traditionally, the main ingredient of kavurma is beef or mutton. However, consumer demand for poultry meat has been increasing since the low cost and high biological value (Efremova, 2018; Reuben et al., 2021). Thus, novel kavurma formulation by using chicken meat could be one of the alternative meat products for both industry and consumer.

Nowadays, in modern plants, kavurma is also produced on an industrial scale and is sold in can or vacuum packaged form in supermarket retails. As a highly perishable food, poultry meat and products are prone to microbial and oxidative deteriorative reactions. To inhibit these reactions and extend shelf life, the cold chain is the most important factor during transportation, storage, and selling in retail. However, according to James et al. (2008), retail temperatures in supermarkets could rise to 15°C. Jol et al. (2005) stated that 20% of retails in United States has temperature above 10°C. González et al. (2013) mentioned that retail temperature for ready-to-eat products could increase up to 6.2°C while Margeirsson et al. (2012) reported that temperature of fish fillets could be up to 8.5°C. Similar temperature recordings were stated by Morelli et al. (2012) and Baldera Zubeldia et al. (2016). For this reason, lipid oxidation as well as microbial spoilage could be the most important problem for kavurma during storage in retails.

Lipid oxidation is the most important non-microbial change that affects quality, nutrition, safety, consumer acceptance, and color in foods during process and storage (Logan et al., 2013). The main oxidation reaction is auto-oxidation which leads to lipid degradation, develops rancid products, and damages proteins through lipid oxidation products (Estévez, 2017). Oxidation in meat products is generally affected by lipid profile, processing methods, storage condition, ingredients, and many other factors such as the presence of heme proteins, free iron, enzymes, sodium chloride, and anti or prooxidants (Min & Ahn, 2005; Amaral et al., 2018).

Control of lipid oxidation is one of the main challenges in the industry since meat is a very complex matrix and processing conditions can provoke oxidative changes. To control oxidative changes, different methods have been proposed such as decreasing fat content, using pre-emulsions, different packaging methods, using antioxidants, or a combination of these methods. However, within these proposals, using antioxidants in meat product formulation has become the major strategy for preventing lipid oxidation. (Alnoumani et al., 2017; Amaral et al., 2018; Jonušaite et al., 2021; Schevey & Brewer, 2015).

Tocopherols are one of the most commonly used natural antioxidants in the meat industry. α-tocopherol, the major group within tocopherols, has shown the highest antioxidative potential by competing with the substrate and acting as a chain-breaking donor in food systems (Georgantelis et al., 2007). Moreover, according to Frankel (2014), α-tocopherol can also retard the decomposition of hydroperoxides and prevent further oxidation of lipids. Therefore, it can reduce the risk of some diseases such as cardiovascular disease and cancer (Simopoulos, 2008; Strandberg & Albertsson, 2006). The previous studies showed the effects of α-tocopherol in animal feed (Li & Liu, 2012; Ortuño et al., 2015), meat products such as bacon (Yang et al., 2015), beef sausage (Azizkhani & Tooryan, 2014; Nacak et al., 2019), pork sausage (Georgantelis et al., 2007), pork patties (Haak et al., 2009) and beef kavurma (Aksu, 2007; Aksu & Kaya, 2005).

To the best of our knowledge, the use of α-tocopherol in chicken kavurma at different storage temperatures (4°C and 10°C) has not been studied in previous works. Thus, the aim of this study was to evaluate the effect of α-tocopherol and storage temperature on quality characteristics and oxidative stability of chicken kavurma for 4-month storage.

MATERIAL AND METHODS

Material

Chicken meat (75% chicken breast + 25% chicken thigh), beef kidney fat and refined salt (99.55% NaCl) were used in kavurma production. Chicken meat was donated by Gedik Piliç Company (Uşak, Turkey), beef kidney fat was obtained from local butcher. Salt was purchased from Yeni Aktuz Company (İzmir, Turkey), α-tocopherol was obtained from Kimbiotek (İstanbul, Turkey). All reagents were analytical grade

and were purchased from Merck (Germany).

Design and production of Kavurma

Two different formulations (3 kg per each batch), one without antioxidant (C sample) and one with 300 ppm α-tocopherol (A sample), were prepared. 84% chicken meat, 15% total fat and 1% salt were used for each kavurma formulation. The chicken breast and thigh meat and beef fat were cut into pieces (2x2x2 cm). Diced chicken meat and beef fat, 300 ppm α-tocopherol (according to formulation) and salt were added to cauldron and started cooking. All the ingredients were mixed in the cauldron during cooking process. When internal temperature of kavurma reached 74-78°C, cooking process was stopped and samples were cooled to 50°C and filled into fibrous casings. After filling into casings, samples were cooled to 4°C, sliced, vacuum packaged, and samples were transferred to two different refrigerators which were set at 4°C and 10°C. Total storage time was set as 120 days which is more than shelf life of commercially available chicken kavurma (60 days). Chemical composition, salt content, and instrumental texture profile analysis were determined after production; color and lipid oxidation analyzes were performed after 0, 30, 60, 90, and 120 days of storage.

Methods

Chemical composition and salt content

Moisture, fat, protein and salt contents of the samples were determined at the end of production before storage by using Foss LAB Meat/Food Composition fast analyzer (FOSS Ltd., Denmark).

pH

pH value of samples was measured from homogenate (10 g of sample homogenized in 100 ml distilled water) by using a pH-meter (Hanna Instruments Inc., USA).

Lipid oxidation

Peroxide value

Each Kavurma group was blended individually, then 5 grams of sample was taken and homogenized with 30 ml chloroform and then filtered through Whatman No1 filter paper to flask. Filtrate was treated with 30 ml glacial acetic acid, 2 ml saturated potassium iodide then shaked for 2 mins. After shaking, flask was kept in the dark for 5 mins, then 100 ml distilled water and 1% starch solution added. 0.1 N sodium thiosulfate solution was used for titration. Results were expressed as meqO_2/kg fat (Koniecko, 1979).

$$\text{Peroxide value of sample (kg product)} = \frac{[(V - B) \times N \times 1000]}{\text{Sample weight}}$$

V: consumption of sodium thiosulfate solution in the main test, in mL,
B: consumption of sodium thiosulfate solution in the blank test, in mL,
N: normality of sodiumthiosulfate

$$\text{Peroxide value of sample (kg fat)} = \frac{\text{Peroxide value (kg product)} * 100}{\text{Fat content of sample (g/100g)}}$$

TBARS value (2-thiobarbituric acid-reactive substance)

20 grams of sample was homogenized with 50 ml cold TCA (trichloroacetic acid) solution (20%) for 2 mins, then 50 ml cold distilled water added and stirred for another 2 mins. Whatman No1 filter paper was used to filtrate sample into 100 ml flask. TCA:distilled water (1:1) was used to complete flask to 100 ml. 5 ml filtrate and 5 ml TBA solution (0.2 M) was drained into test tube and incubated at 80°C for 35 minutes in water bath. The absorbance of sample was measured at 532 nm (Biochrom Libra S70, UK) and results were expressed as mg malonaldehyde/kg sample (Witte et al., 1970).

Color

Color parameters of samples were measured triplicate on a kavurma piece (2x2x2 cm) by using a digital colorimeter (Chromameter CR400, Minolta, Japan) to obtain the color coordinates lightness (CIE L*), redness (CIE a*) and yellowness (CIE b*).

Instrumental Texture Profile Analysis (TPA)

Meat samples were prepared by cutting meat pieces to 2 cm length uniformly just after production and held at room temperature before analysis. TPA test were performed using a Brookfield CT3-4500 Texture Analyzer (Brookfield Engineering Laboratories, Inc., USA) to determine hardness, springiness, cohesiveness, gumminess, and chewiness. Test conditions were: 4500 g load cell, TA25/1000 probe, 1,50 mm/s pretest speed, 1,00 mm/s and 25% compression.

Statistical analysis

Statistical analysis of data was performed using SPSS package program (IBM, version 21.0, USA). Analysis of variance (ANOVA) was performed to determine the treatment effects. A significance level of $p<0.01$ and $p<0.05$ was used for evaluations. pH, color and lipid oxidation values data were collect-

ed and analyzed by two-factor factorial analysis in a completely randomized design. The factors were: (1) antioxidant addition; (2) the two different storage temperature (4°C and 10°C); and (3) the storage time for each parameter. When significant treatment effects were found, their means were separated by Duncan's test.

RESULTS AND DISCUSSION

Chemical Composition and salt content

Chemical composition and salt contents of samples are shown in Table 1. Moisture, protein, fat and salt contents of samples were found between 44.40% - 44.60%, 27.58% - 28.24%, 26.70% - 27.20%, and 1.58% - 1.68%, respectively. Chemical composition and salt contents of samples are determined after production and only variation was α-tocopherol addition between A and C samples. However, α-tocopherol addition to formulation did not show any significant changes in chemical composition of samples and moisture, fat, protein, and salt contents of samples were found similar ($p>0.05$).

Moisture, fat, and salt contents of kavurma is regulated by Turkish Legislation which should be at most 45%, 30%, and 3%, respectively (Anon, 2019). In this perspective, all samples are found within legislation standards.

In a previous study, similar to the present study, moisture content of chicken kavurma samples was ranged between 44.35%-44.70% and fat contents of samples were found 29.04%-29.94% (Dikici et al., 2022). Şişik Oğraş et al. (2018) determined moisture and fat contents of beef kavurma between 30.76% - 40.85%, 27.01% - 34.44%, respectively. According to Aksu and Kaya (2005), moisture content of beef kavurma was ranged between 37.91% - 39.80%. Sağır and Turhan (2013) determined 40.75 − 42.87% moisture, 23.63 − 25.66% protein, 25.39 − 28.62% fat in beef kavurma samples.

pH

The effects of variances on pH and pH values of samples are given in Table 2 and Table 3, respectively. pH of samples were highly influenced by storage time and the combined effects of factors ($p<0.01$). The highest pH values (6.51 - 6.52) were found at the beginning of storage ($p<0.05$) and all samples had similar initial pH values ($p>0.05$). In previous reports, initial pH values of beef kavurma was found 6.17 - 6.28 (Aksu & Kaya, 2005), 5.98 - 6.04 (Sağır & Turhan, 2013), and 6.27 - 6.29 (Aksu, 2007). In the present study, pH values were found higher than beef kavurma studies due to changes in raw material.

Storage period had significant effect on pH values

Table 1. Chemical composition of chicken kavurma

Sample	Moisture (%)	Protein (%)	Fat (%)	Salt (%)
C	44.60±0.06	27.58±0.04	27.20±0.11	1.58±0.15
A	44.40±0.17	28.24±0.69	26.70±0.27	1.68±0.20

All values are means ± SD of three replicates.

Table 2. Analysis of variance on the effect of antioxidant, storage temperature and storage time on physico-chemical parameters and lipid oxidation values of chicken kavurma samples (F-values of independent variables and interactions).

	Source of variances						
Parameter	A	B	C	AxB	AxC	BxC	AxBxC
pH	6,695*	6,695*	207,834**	13,016**	4,742**	3,680**	10,652**
Lipid oxidation							
Peroxide value	18,030**	16,057**	140,980**	1,792ns	7,844**	3,861**	0,526ns
TBARS	201,340**	13,135**	54,054**	4,486*	11,072**	20,087**	1,329ns
Color							
L*	0,041ns	0,086ns	61,095**	0,082ns	0,584ns	1,497ns	1,875ns
a*	0,762ns	6,532*	20,188**	0,226ns	0,577ns	1,154ns	0,060ns
b*	5,060*	2,781ns	59,175**	0,018ns	1,241ns	2,109ns	0,181ns

A: antioxidant, B: storage temperature, C: storage time, AxB: antioxidant x storage temperature, AxC: antioxidant x storage time, BxC: storage temperature x storage time, AxBxC: antioxidant x storage temperature x storage time
*$p < 0.05$
** $p<0.01$
ns: not significant $P>0.05$

Table 3. pH values of chicken kavurma samples

Sample	day	30. day	60. day	90. day	120. day
4C	$6.52\pm0.01^{a,X}$	$6.39\pm0.02^{a,Y}$	$6.27\pm0.02^{b,Z}$	$6.29\pm0.04^{a,Z}$	$6.33\pm0.02^{a,Z}$
4A	$6.51\pm0.02^{a,X}$	$6.40\pm0.03^{a,Y}$	$6.26\pm0.01^{b,Z}$	$6.26\pm0.04^{ab,Z}$	$6.19\pm0.08^{c,Z}$
10C	$6.52\pm0.01^{a,X}$	$6.33\pm0.01^{b,Y}$	$6.31\pm0.01^{a,Y}$	$6.23\pm0.02^{b,Z}$	$6.22\pm0.05^{b,Z}$
10A	$6.51\pm0.02^{a,X}$	$6.36\pm0.05^{ab,Y}$	$6.27\pm0.01^{b,Z}$	$6.25\pm0.04^{ab,Z}$	$6.26\pm0.01^{ab,Z}$

All values are means ± SD of three replicates.
For each analysis, means within the same column with different superscripts (a,b,c) are significantly different
For each analysis, means within the same row with different superscripts (X,Y,Z) are significantly different

of samples ($p<0.01$). With respect to storage time increment, pH values of samples decreased significantly until 60th day. After 60th day, storage time did not affect the pH values of samples except 10C sample ($p>0.05$). At the end of storage, the lowest pH value was found in 4A (6.19), while the highest was observed in 4C (6.33). Similar effects of using α-tocopherol and different temperatures on pH values of beef kavurma was observed by Aksu (2007). In a previous study, pH values of beef kavurma was decreased until 90th day significantly, however no significant effect was observed between 90 - 180 days of storage (Sağır & Turhan, 2013).

Lipid Oxidation

Peroxide value

Peroxide value (PV) is the measurement of hydroperoxides formed during initial stages of lipid oxidation (Kavuşan et al., 2020). As seen in Table 2, the PV of samples were highly influenced by antioxidant addition, storage temperature and storage time ($p<0.01$). Similar initial PV was found 3.78 meqO_2/kg fat and 3.47 meqO_2/kg fat in C and A samples respectively. During storage significant increment was observed in all samples and at the end of storage PV were found between 8.39 - 15.37 meqO_2/kg fat.

Temperature is one of the main parameter that affects lipid oxidation (Śmiecińska et al., 2015). As expected, higher storage temperature resulted higher PV in samples ($p<0.01$). At the end of storage, samples stored at 4°C had lower PV compared to samples at 10°C.

α-tocopherol is an effective antioxidant to prolong shelf life of meat products and inhibits PV production (Aksu 2007; Aksu and Kaya 2005; Azizkhani and Tooryan 2014; Nacak et al. 2019). In contrast to this knowledge, samples with 300 ppm α-tocopherol resulted higher PV than samples with no antioxidant. As previously said that, one of the antioxidative mechanism of α-tocopherol is delaying hydroperoxide decomposition (Frankel, 2014). Therefore, α-tocopherol addition could retard hydroperoxide decomposition and inhibits seconder lipid oxidation product formation. During storage the highest PV was found 10A (15.37 meqO_2/kg fat) at the end of storage. Nevertheless, this result was found lower than 20 meqO_2/kg fat which is the maximum value according to Kavurma standard (Anon, 2002).

TBARS

The level of malondialdehyde is served as a reliable biomarker of lipid peroxidation (Acaroz et al., 2018; Singh et al., 2014). Thus, measurement of malonaldehydes is the major parameter to observe oxidative changes in meat products during storage. As shown in Table 2, TBARS values of samples were highly affected by the addition of antioxidant, storage temperature and storage time ($p<0.01$). In contrast to PV results, antioxidant addition significantly decreased TBARS values ($p<0.01$).

Initial TBARS values of samples were found 0.22 - 0.29 mgMA/kg in A and C samples, respectively. During storage, samples with α-tocopherol showed lower TBARS compared to control samples in different temperatures and found 0.23 and 0.36 in 4A and 10A samples at the end of storage, respectively ($p<0.05$). Similar to the previous study (Bozkurt & Belibağlı, 2009), antioxidant addition significantly decreased TBARS values of kavurma. Haak et al. (2009) stated that, using α-tocopherol in pork patties decreased TBARS values of samples. Similar to this, Leskovec et al. (2018) and Mazur-Kuśnirek et al. (2019) showed that α-tocopherol addition to chicken fed resulted significant decrement in TBARS values.

According to Bayrak Kul et al. (2021), storage time has influence on TBARS values of kavurma. In the present study, during 120 day of storage, significant increment in TBARS values was observed ($p<0.05$). The highest TBARS value was observed in

10C (0.56 mgMA/kg) while the lowest TBARS were found in 4A (0.23 mgMA/kg). Moreover, 4C samples had similar TBARS values at the end of storage to the beginning ($p>0.05$). This proves the synergistic effect of low temperature storage and antioxidant usage on oxidative stability of samples. Wazir et al. (2019) stated that, higher storage temperature resulted higher TBARS values in meat products. According to Aksu and Kaya (2005), 100 ppm α-tocopherol could improve oxidative stability of beef kavurma samples during 300-day cold storage and significant lower TBARS results were observed in this samples compared to samples with no antioxidant. Similarly, Nacak et al. (2019) found that 200 ppm α-tocopherol addition to beef sausage formulation could retard lipid oxidation during 3 month storage. In another study, use of 200 ppm α-tocopherol in chicken diet resulted lower TBARS values during 11 day storage of raw chicken breast (Saleh et al., 2017). In addition, Basanta et al. (2018) stated that use of plum peel microparticles (contains 298 mg/kg α-tocopherol) in chicken breast patties inhibits lipid oxidation during cold storage.

Color

One of the important parameters that affects consumer's buying decision is color of product. Color parameters of samples are given in Table 5. in terms of lightness (L*), redness (a*) and yellowness (b*). In Table 2., it is seen that storage time significantly

Table 4. Lipid oxidation of chicken kavurma samples

Sample	0.day	30. day	60. day	90. day	120. day
Peroxide value (meqO,/kg fat)					
4C	$3.78\pm1.13^{a,Z}$	$8.30\pm1.30^{a,Y}$	$5.27\pm0.37^{bc,Z}$	$11.65\pm1.70^{a,X}$	$8.39\pm0.81^{c,Y}$
4A	$3.47\pm0.69^{a,Z}$	$7.75\pm0.94^{a,Y}$	$6.32\pm0.96^{b,Y}$	$11.72\pm1.97^{a,X}$	$12.20\pm1.50^{b,X}$
10C	$3.78\pm1.13^{a,Z}$	$8.17\pm1.04^{a,Y}$	$4.93\pm0.68^{c,Z}$	$12.73\pm1.28^{a,X}$	$11.53\pm0.99^{b,X}$
10A	$3.47\pm0.69^{a,Z}$	$8.70\pm0.84^{a,Y}$	$8.15\pm0.76^{a,Y}$	$13.26\pm0.95^{a,X}$	$15.37\pm2.88^{a,X}$
TBARS (mgMA/kg)					
4C	$0.29\pm0.01^{a,Z}$	$0.34\pm0.04^{a,Y}$	$0.32\pm0.03^{a,YZ}$	$0.27\pm0.05^{a,Z}$	$0.41\pm0.04^{b,X}$
4A	$0.22\pm0.01^{b,X}$	$0.18\pm0.02^{b,Y}$	$0.22\pm0.01^{b,X}$	$0.21\pm0.02^{b,X}$	$0.23\pm0.01^{c,X}$
10C	$0.29\pm0.01^{a,Y}$	$0.29\pm0.03^{a,Y}$	$0.29\pm0.01^{a,Y}$	$0.32\pm0.03^{a,Y}$	$0.54\pm0.07^{a,X}$
10A	$0.22\pm0.01^{b,Z}$	$0.20\pm0.02^{b,Z}$	$0.19\pm0.01^{c,Z}$	$0.29\pm0.04^{a,Y}$	$0.36\pm0.07^{b,X}$

All values are means ± SD of three replicates.
For each analysis, means within the same column with different superscripts (a,b,c) are significantly different
For each analysis, means within the same row with different superscripts (X,Y,Z) are significantly different

Table 5. Color of chicken kavurma samples

Sample	day	30. day	60. day	90. day	120. day
L*					
4C	$75.13\pm1.57^{a,X}$	$72.31\pm1.26^{a,Y}$	$69.63\pm1.14^{a,Z}$	$68.33\pm1.74^{a,Z}$	$68.83\pm0.97^{a,Z}$
4A	$75.35\pm1.74^{a,X}$	$74.05\pm2.15^{a,X}$	$69.89\pm1.98^{a,Y}$	$68.05\pm1.31^{a,YZ}$	$66.02\pm2.37^{a,Z}$
10C	$75.13\pm1.57^{a,X}$	$72.93\pm0.52^{a,X}$	$69.43\pm2.09^{a,Y}$	$69.78\pm1.57^{a,Y}$	$66.98\pm1.51^{a,Z}$
10A	$75.35\pm1.74^{a,X}$	$71.75\pm1.84^{a,Y}$	$69.68\pm0.59^{a,YZ}$	$70.16\pm1.52^{a,Y}$	$67.47\pm1.76^{a,Z}$
a*					
4C	$3.69\pm1.06^{a,X}$	$2.65\pm0.65^{a,XY}$	$2.60\pm0.65^{a,XY}$	$2.13\pm0.23^{a,YZ}$	$1.29\pm0.72^{a,Z}$
4A	$3.19\pm1.14^{a,X}$	$2.62\pm0.55^{a,XY}$	$2.38\pm0.39^{a,XY}$	$2.13\pm0.35^{a,XY}$	$1.73\pm1.06^{a,Y}$
10C	$3.69\pm1.06^{a,X}$	$2.11\pm0.31^{a,YZ}$	$2.34\pm0.53^{a,Y}$	$1.29\pm0.07^{b,Z}$	$1.29\pm0.24^{a,Z}$
10A	$3.19\pm1.14^{a,X}$	$1.95\pm0.70^{a,Y}$	$2.14\pm0.73^{a,XY}$	$1.06\pm0.21^{b,Y}$	$1.33\pm0.64^{a,Y}$
b*					
4C	$12.44\pm0.43^{a,W}$	$14.82\pm0.80^{a,Z}$	$15.37\pm0.92^{a,YZ}$	$16.11\pm0.44^{a,Y}$	$17.35\pm0.64^{ab,X}$
4A	$11.78\pm0.57^{a,Z}$	$14.32\pm0.60^{a,Y}$	$15.71\pm0.38^{a,X}$	$15.89\pm0.49^{a,X}$	$15.65\pm0.56^{b,X}$
10C	$12.44\pm0.43^{a,Z}$	$14.54\pm0.35^{a,Y}$	$15.25\pm1.13^{a,Y}$	$17.10\pm1.34^{a,X}$	$18.53\pm1.40^{a,X}$
10A	$11.78\pm0.57^{a,Z}$	$14.38\pm1.41^{a,Y}$	$15.30\pm1.64^{a,XY}$	$16.48\pm1.11^{a,XY}$	$17.48\pm2.44^{ab,X}$

All values are means ± SD of three replicates.
For each analysis, means within the same column with different superscripts (a,b,c) are significantly different
For each analysis, means within the same row with different superscripts (X,Y,Z) are significantly different

affected all the color parameters of samples ($p<0.01$). However, storage temperature affected only a* values while antioxidant usage affected only b* values of samples ($p<0.01$). Interaction of all parameters on color values of samples were found insignificant ($p>0.05$).

At the beginning of storage, all color parameters were found similar ($p>0.05$). Initial L* values of samples were found 75.13 - 75.35 in C and A samples, respectively (Table 5). L* values of samples were found similar at each storage day; no significant changes were observed between samples ($p>0.05$). At the end of storage L* values of samples ranged between 66.02 - 68.83 and significant reductions were observed in all samples compared to the initial L* values and darker products were observed ($p<0.05$). This could be due to oxidative changes during storage. Color of the products generally depend on amount of oxygen available in package and storage temperature. Thus, during long term storage oxygen within the package could be spent in oxidative reactions of lipids and pigments that results darker products (Omana et al., 2012). Al-Hijazeen et al. (2016) stated that, storage time has high influence on color of chicken breast and significant reductions were observed in L* values of all samples whether antioxidant was used in samples or not. Similarly, Omana et al. (2012) stated that, lower L* values were found in turkey sausages after 5 weeks refrigerated storage.

a* values of samples were affected by the storage temperature and time ($p<0.01$). The initial a* values of samples were found 3.19 - 3.69, however at the end of storage a* values of samples were found between 1.29 - 1.73 (Table 5). Regardless of treatments and storage temperature, a* values decreased during storage ($p<0.05$). As previously stated, temperature is an important factor for oxidative changes in pigments. The average a* values of samples stored at 10°C was found lower than samples stored at 4°C. This behavior shows that the greater loss of a* values could be result of higher pigment oxidation in samples that stored at higher temperature.

Initial b* values of samples were found between 11.78 - 12.44 (Table 5). Use of antioxidant significantly affected the b* values of samples. At each storage temperature, samples with α-tocopherol showed lower changes in b* values compared to samples without α-tocopherol. In contrast to L* and a* values, b* values of samples were significantly increased during storage ($p<0.05$). This result was expected since previous studies showed the b* value increment during storage due to oxidative changes in samples (Xiao et al., 2011; Maqsood et al., 2016; Bolger et al., 2017).

Texture profile analysis

Textural parameters especially hardness and chewiness plays important role on consumer acceptability of product (Xu et al., 2018). Texture of meat products greatly influenced by parameters such as fat content and type, protein functionality, moisture/protein ratio, and process conditions (Al-Hijazeen et al., 2016; Freire et al., 2016; Yancey et al., 2016; Yıldız-Turp & Serdaroğlu, 2008).

Textural parameters in terms of hardness, springiness, cohesiveness, gumminess, and chewiness of samples are given in Table 6. Use of α-tocopherol did not differ textural parameters of samples significantly ($p>0.05$). This result was expected since both samples were produced with same formulation and after production, they had similar chemical composition (moisture, fat, protein). These results are agree with previous studies where different antioxidants were used in meat product formulations (Xu et al., 2018; Zhang et al., 2013).

CONCLUSION

The results of present study showed the effectiveness of using α-tocopherol and lower storage temperature on oxidative stability of chicken kavurma samples. Using α-tocopherol did not change the chemical composition of samples and all parameters were found within the standards ($p>0.05$). pH of samples were found between 6.51 - 6.52 and significantly decreased during storage ($p<0.05$). The use of α-tocopherol, storage temperature and storage time have significant influence on oxidative stability of chicken kavurma ($p<0.05$). The lowest TBARS result was

Table 6. Textural properties of chicken kavurma samples

Sample	Hardness (N)	Springiness (mm)	Cohesiveness	Gumminess (N)	Chewiness (Nxmm)
C	1904.67±328.22	3.07±1.07	0.52±0.04	976.77±138.85	30.35±14.33
A	1767.17±353.99	3.40±0.40	0.61±0.09	959.83±468.26	31.44±14.83

All values are means ± SD of three replicates.

observed in 4A at the end of storage. TBARS results of 4A sample on 0^{th} and 120^{th} days of storage were also found similar ($p>0.05$). Storage time significantly affected all the color parameters of samples. Using α-tocopherol in formulation can significantly decreased the TBARS values while no quality characteristic degradation was observed. For this reason, using α-tocopherol in retail products, where controlling retail temperature is hard, could be recommended to control lipid oxidation and maintain quality of products.

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