

## Effects of various plant parts on storage stability and colour parameters of beef extracts

Betül Aykurt Oğuz, Cemalettin Sarıçoban\*, Hülya Şen Arslan

Department of Food Engineering, Agriculture Faculty, Selçuk University, 42050, Konya, Turkey

### Abstract

In this study, the effects of rosemary, laurel, eucalyptus and olive leaves on the storage stability of beef extract were investigated. Prepared the beef extracts were divided into six equal groups: (1) Control (no added plant leaf/BHA), (2) BHA (200 mg/kg), (3) rosemary leaf (1% RL), laurel leaf (1% LL), eucalyptus leaf (1% EL) and olive leaf (1% OL). Prepared samples were kept under refrigerator conditions for 15 days. Moisture, protein and fat were assayed in the beef extract samples on the 0th day. The pH, moisture, thiobarbituric acid and the colour ( $L^*$ ,  $a^*$  and  $b^*$ ) analyses were carried out periodically in the samples of beef extract on 1st, 3rd, 7th and 15th days. The pH values were found significant statistically the changes by storage time and the added material in beef extract samples and the highest pH values were found at the control group samples for all day of the storage. It was determined that the mean TBARS values of the samples varied between 0.1-0.7 mg malonaldehyde/kg. The lowest TBARS values were determined in the extract samples added with rosemary leaf (1%). The  $L^*$ ,  $a^*$  and  $b^*$  values were found to vary ranged from 65.6 to 76.5, -2.3 to 1.3 and 6.4 to 14.5, respectively. As a result; the usage of rosemary can be suggested as a natural antioxidant in the preparation of beef extract samples.

**Keywords:** rosemary, laurel leaf, eucalyptus leaf, olive leaf, beef extract

### 1.Introduction 11fă

Meat is one of the most sensitive foods against microbiological spoilage due to its physical and chemical properties [1]. Meat have an important place in daily nutrition because of rich proteins, essential minerals and trace elements. It is also important because it also meets the need for vitamin B [2]. Shelf life is one of the most important factors affecting quality and acceptability in meat and meat products. Meat has a limited shelf life due to its unique physical and chemical structure. Oxidation is one of the most important reasons for the limited shelf life of the meat [3].

Lipid oxidation which causes quality loss of meat and meat products, changes in the odor, color, texture and nutritional value of the product, while toxic components appear [4; 5; 6]. In addition to the undesired taste and odor of meat products, the product quality decreases with the reaction of oxidized lipid products with carbohydrates, proteins and vitamins in meat [7].

In addition, carcinogenic and mutagenic substances resulting from oxidation and malonaldehyde have a negative effect on the safety of foods [8]. In many studies on lipid oxidation; The use of antioxidants to control lipid oxidation in meat and meat products has been proposed [9; 10; 11; 12; 13].

It has been reported that lipid oxidation in foods can be delayed or slowed by antioxidant agents [3]. Vegetable and animal origin antioxidants are used in food industry. Antioxidants; During the production, preservation and transportation of foods containing oils and oils, they delay the effect of oxygen in the food. Thus, they affect the shelf life of food. Antioxidants neither give any taste and smell to the food and they nor increase the quality of food [14].

In recent years, some aromatic plants and spices have been used in food industry and scientific researches due to their antioxidant and antimicrobial properties. Phytochemicals such as vitamins, carotenoids, flavonoids, coumarins,

terpenoids, curcumin, which are contained in aromatic plants and spices have antioxidant and antimicrobial effects. In addition, non-volatile compounds such as carnosol, rosmarinic acid, quercetin, caffeic acid and the like can also be used as free radical scavengers [15; 16; 17]. In recent years, it has been determined that natural antioxidants containing high polyphenols such as rosemary, sage and green tea are more effective than synthetic antioxidants [3].

There are numerous studies in the literature that many substances of natural origin show significant antioxidant activity and some are more effective than synthetic antioxidants. Natural antioxidant sources include plants (spices, some oilseeds, cereals, vegetables and fruits, some teas), animal products (amino acids, peptides and carotenoids), enzymes (catalase glutathionperoxidase and superoxide dismutase) and some microorganisms [18].

The medicinal and aromatic plants rich in phenolic components such as rosemary, thyme, sage and clove have been accelerated in recent years. Intensive studies on rosemary were made from these plants. Rosemary has become a commercial product for sale as antioxidant in USA and Europe [19].

Carrot, cumin, thyme, sage, fenugreek (ginger), ginger, black and green tea, rosemary extract, cinnamon, black pepper, antioxidant activity, such as many spices are used to provide storage stability in meat and meat products [20; 21; 22].

In this study, it is aimed to compare the effects of rosemary, laurel, eucalyptus and olive tree leaves, which are used as natural antioxidants on the storage stability of beef extract produced from beef gerdew, with BHA, a synthetic antioxidant. Recently hundreds of herbal sources have been tested for their usefulness as antioxidants in foods.

## 2. Materials and methods

### 2.1. Materials and chemicals

The cattle neck used in the study was obtained from cattle grown in Konya, Turkey, at 48 h postmortem. Rosemary (*Rosmarinus officinalis* L.), laurel (*Laurus nobilis* L.), eucalyptus (*Eucalyptus globulus* L.) and olive tree leaves (*Olea europaea* L.) used in the research were obtained from the herbalist in Konya.

BHA (Sigma-Aldrich Co., St. Louis, MO., USA) was used as analytical purity synthetic antioxidant.

### 2.2. Preparation of samples

0.5 liter of water was added to each 1000 g of fresh meat used for the preparation of beef extract. The bone was boiled for 30 minutes under light and pressure. The foams formed on the surface as a result of boiling were removed by means of a filter. The bones were removed from the material obtained and a homogenous distribution of the meat particles in the broth was achieved by means of a blender. Homogenized beef extract was divided into 6 groups; Control (no antioxidant added) and BHA (200 mg / kg), rosemary leaf (1%), laurel leaf (1%), eucalyptus leaf (1%) and olive leaf (1%) were added. The extracts were placed in glass container and stored at 4±1 °C for 15 days.

### 2.3. Chemical composition

Moisture (hot air oven), protein (Kjeldahl, Nx6.25) and fat (ether-extraction) contents were determined using standard methods of the AOAC [23]. Moisture (%) was determined by drying a 5 g sample at 105 °C to constant weight. Protein (%) was analyzed according to the Kjeldahl method. Factor 6.25 was used for conversion of nitrogen to crude protein. Fat content (%) was determined by using a Soxhlet fat extraction apparatus.

### 2.4. pH values

pH values were determined with a pH meter (pH 3110/SET WTW, Germany) after blending 10 g of sample with 100 ml of distilled water for 60 s in a homogenizer (Homogenizer HG-15D, Wisd, Germany) [24].

### 2.5. Thiobarbituric acid reactive substance (TBARS) value

Lipid oxidation was assessed in beef patties during refrigerated (4 °C) storage under retail conditions the oxidative rancidity of raw patties was determined by measuring thiobarbituric acid according to Tarladgis et al. [25]. 10 g sample was blended with 50 mL of distilled water for 2 min and then transferred to a distillation tube. The cup used for blending was washed with an additional 47.5 mL of distilled water, which was added to the same distillation flask with 2.5 mL of 4 N HCl and a few drops of soybean oil o/w

antifoam agent. The mixture was distilled and 50 mL of the distillate was collected. Five millilitres of 2-thiobarbituric acid was added to a vial containing 5 mL of the distillate and mixed well. The vials were capped and heated in a boiling water bath for 30 min to develop the chromogen and then cooled to room temperature. The absorbance was measured using a UV/VIS spectrophotometer (Optizen 2120 UV plus, Mecasys Co. Ltd., Seoul, South Korea) at 538 nm against a blank prepared with 5 mL of distilled water and 5 mL of TBA reagent. The results were expressed as mg malondialdehyde/kg extract.

### 2.6. Colour measurement

The exterior surface colour of all extracts was measured using a chromameter (Konika Minolta CR-400, Minolta Camera Co. Ltd., Osaka, Japan) according to CIELab system ( $L^*$ : lightness,  $a^*$ : redness, and  $b^*$ : yellowness). The chromameter was calibrated using a white tile ( $L^* = 98.45$ ,  $a^* = -0.10$ ,  $b^* = -0.13$ ; Minolta calibration plate), using an 8 mm aperture, illuminate D65 (6500 K colour temperature) at a standard observation of  $2^\circ$ . Measurements were made by reading from three different points per sample on each measurement day. The average score of triplicate experiments was recorded. CIE  $L^*$  (lightness),  $a^*$  (redness), and  $b^*$  (yellowness) were determined by the method described by Hunt et al., [26].

### 2.7. Statistical analysis

Mean values for various parameters of extracts were calculated and compared by analysis of variance using MINITAB for Windows Release 16® [27]. Also, data collected for all other parameters were analyzed using one-way ANOVA with storage time and the treatments as main effects. When a significant ( $P < 0.05$ ) main effect was found, the mean values were further analyzed using Duncan's Multiple Range Test [26; 28]. The results of the storage time and the treatments are shown in the tables as the mean values and standard errors. Each parameter was tested in triplicate samples with two replications.

## 3. Results and discussion

### 3.1. Chemical composition

The moisture (%) protein (%) and fat (%) content of raw meat is 71.15%, 19.48% and

7.11%, respectively. The moisture composition of the raw beef neck is shown in Table 1. There were no significant differences ( $p > 0.05$ ) among the treatments for moisture. Also, the difference between the moisture values of the beef extract samples in the experiment during the storage period was not statistically significant ( $p > 0.05$ ).

### 3.2. pH results

The pH values of the beef extract are presented in Table 1. pH values ranged from 6.03 to 7.53 during storage days. The pH of beef extract containing various levels of olive leaf (OL) decreased slightly ( $P > 0.01$ ). Average pH values of control and BHA were 7.01, 7.05 respectively; the pH values of beef extract containing leaf 1% RL, 1% LL, 1% EL and 1% OL were 6.82, 6.81, 6.63 and 6.65 respectively. Among all treatment groups for storage days, the lowest pH value (6.31) was determined in extract with 1% OL storage for 15th days, the highest pH value (7.25) was found in control group at 1st day. Cheah and Hasim [29] found that the addition of 1-10% galangal (*Alpina galangal*) extract to beef ground beef had no significant effect on pH. Similarly, Nassu et al. [30] determined that the addition of rosemary to fermented goat sausages at 0.025% and 0.050% was not effective on pH.

### 3.3. Thiobarbituric acid reactive substance (TBARS) value results

Rosemary leaf exhibited a significant ( $p < 0.01$ ) inhibitory effect on the TBARS values (Table 1). Figure 1 shows that during storage TBARS values ranged from 0.09 to 0.49 MDA mg/kg for 15 days at  $4^\circ\text{C}$ . In general, TBARS values increased with increasing storage time. However, the addition of EL effectively slowed oxidation. While TBARS values belong to control, BHA and EL were 0.64, 0.39, 0.73 mg of MDA/kg sample at 1st day respectively, were 0.49, 0.16, 0.19 mg of MDA/kg sample at 15th day, respectively. Average TBARS values were higher in the control than in those containing RL, LL, EL, OL and BHT and the TBARS values of RL were the lowest over the storage period. In a study, 200 ppm BHA / BHT and 1500-2500 ppm rosemary extract were added to some of the prepared pork sausages and stored for 42 days. It was reported that TBA values of porcine sausages with rosemary extract added during storage were lower than BHA / BHT

combination pork sausages and that rosemary was more effective than BHA / BHT combination in preventing lipid oxidation [31]. Cooked turkey meats with 0, 100, 250 and 500 ppm rosemary extract were stored for 13 days. When samples were compared, it was reported that thiobarbituric acid (TBA) values of samples

containing 250 ppm and 500 ppm rosemary extract were lower than other groups [32]. Hayes et al. [33] reported that 100 ppm and 200 ppm olive leaf extract can be used instead of synthetic antioxidants in order to extend the shelf life of packaged dumplings.

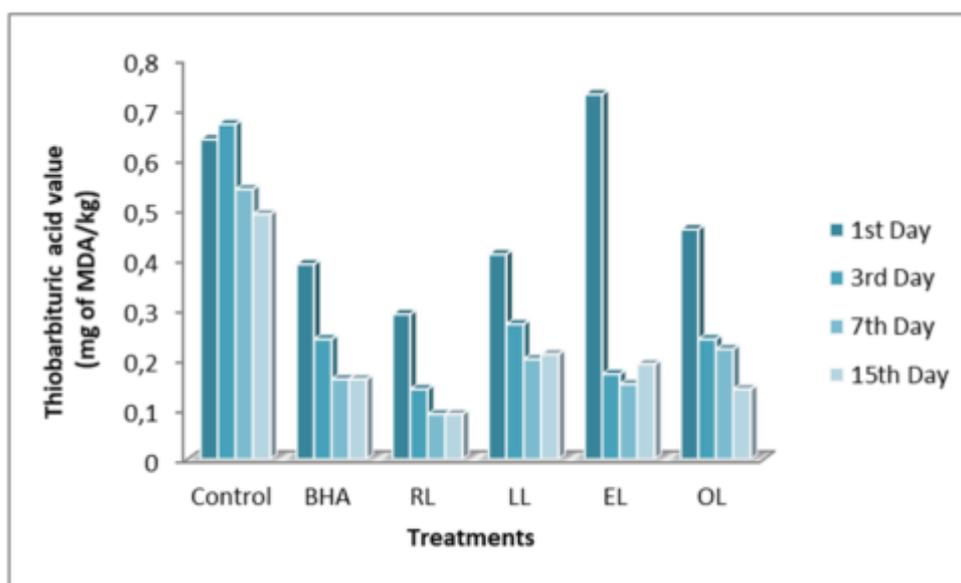
**Table 1.** The moisture, pH and TBARS (mg of MDA/kg meat) values of beef extract treated with leaves at different amount during storage at 4 °C for 15 days.

Storage Days	Treatments					
	Control	BHA	RL	LL	EL	OL
<b>Moisture (%)</b>						
1	84.81±2.03 <sup>a</sup>	86.91± 0.69 <sup>a</sup>	86.66± 1.50 <sup>a</sup>	85.90± 0.71 <sup>a</sup>	85.14± 0.16 <sup>a</sup>	85.36± 2.07 <sup>a</sup>
3	85.40± 2.14 <sup>a</sup>	87.07± 2.10 <sup>a</sup>	86.57± 0.33 <sup>a</sup>	87.47± 0.89 <sup>a</sup>	86.34± 0.44 <sup>a</sup>	87.18± 0.09 <sup>a</sup>
7	85.32± 1.94 <sup>a</sup>	87.16± 0.17 <sup>a</sup>	84.81± 0.81 <sup>a</sup>	87.31± 1.78 <sup>a</sup>	85.49± 1.19 <sup>a</sup>	87.03± 1.48 <sup>a</sup>
15	84.41± 5.66 <sup>a</sup>	83.88± 5.46 <sup>a</sup>	82.67± 4.60 <sup>a</sup>	82.33± 3.97 <sup>a</sup>	84.46± 5.34 <sup>a</sup>	84.57± 5.48 <sup>a</sup>
<b>pH</b>						
1	7,25±0,11 <sup>a</sup>	7.17± 0.01 <sup>a</sup>	7.07± 0.02 <sup>a</sup>	7.05± 0.01 <sup>a</sup>	6.78±0.03 <sup>a</sup>	6.87± 0.06 <sup>a</sup>
3	7,09±0,01 <sup>a</sup>	7.16± 0.01 <sup>a</sup>	6.83±0.00 <sup>a</sup>	6.85± 0.01 <sup>a</sup>	6.88±0.00 <sup>a</sup>	6.74± 0.01 <sup>a</sup>
7	7,02±0,11 <sup>a</sup>	6.99± 0.02 <sup>a</sup>	6.99± 0.12 <sup>a</sup>	6.87± 0.08 <sup>a</sup>	6.84±0.06 <sup>a</sup>	6.68± 0.00 <sup>a</sup>
15	6,65±0,14 <sup>a</sup>	6.87± 0.06 <sup>a</sup>	6.50± 0.01 <sup>a</sup>	6.49± 0.04 <sup>a</sup>	6.37±0.01 <sup>a</sup>	6.31± 0.04 <sup>a</sup>
<b>TBARS (mg MDA/kg)</b>						
1	0.64± 0.02 <sup>ab</sup>	0.39± 0.03 <sup>ef</sup>	0.29± 0.04 <sup>gh</sup>	0.41± 0.05 <sup>de</sup>	0.73± 0.05 <sup>a</sup>	0.46± 0.04 <sup>cde</sup>
3	0.67± 0.22 <sup>a</sup>	0.24± 0.03 <sup>gh</sup>	0.14± 0.01 <sup>ij</sup>	0.27± 0.01 <sup>gh</sup>	0.17± 0.00 <sup>kl</sup>	0.24± 0.01 <sup>gh</sup>
7	0.54± 0.05 <sup>bc</sup>	0.16± 0.03 <sup>kl</sup>	0.09± 0.01 <sup>j</sup>	0.20± 0.03 <sup>ghj</sup>	0.15± 0.01 <sup>ij</sup>	0.22± 0.04 <sup>gh</sup>
15	0.49± 0.02 <sup>cd</sup>	0.16± 0.01 <sup>kl</sup>	0.09± 0.00 <sup>j</sup>	0.21± 0.02 <sup>gh</sup>	0.19± 0.01 <sup>ghj</sup>	0.14± 0.01 <sup>ij</sup>

Values are means of triplicate samples (±SD).

<sup>a-n</sup> Means within rows with different superscript letters are significantly different ( $p < 0.01$ ).

Control: Beef extracts without leaf and BHA, BHA: Beef extracts with 200 mg/kg Bütillenmiş hidroksi anisol, RL: Beef extracts with 1% rosemary leaf, LL: Beef extracts with 1% laurel leaf, EL: Beef extracts with 1% eucalyptus leaf, OL: Beef extracts with 1% olive leaf.



**Figure 1.** The TBARS values of beef extract treated with leaves at different amount during storage at 4 °C for 15 days.

Control: Beef extracts without leaf and BHA, BHA: Beef extracts with 200 mg/kg Bütillenmiş hidroksi anisol; RL: Beef extracts with 1% rosemary leaf; LL: Beef extracts with 1% laurel leaf; EL: Beef extracts with 1% eucalyptus leaf; OL: Beef extracts with 1% olive leaf.

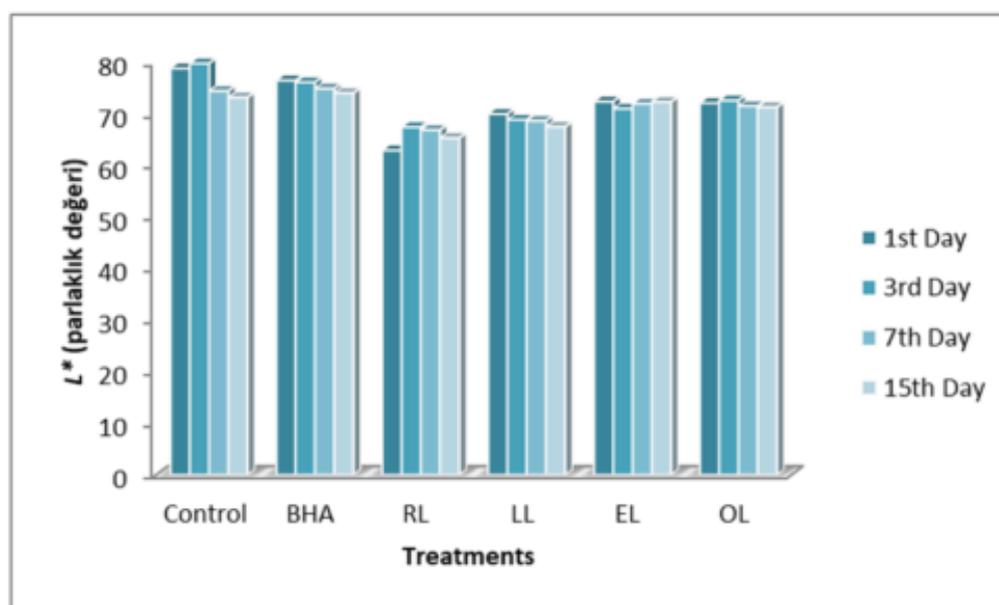


Figure 2. The  $L^*$  values of beef extract treated with leaves at different amount during storage at 4 °C for 15 days.

Control: Beef extracts without leaf and BHA, BHA: Beef extracts with 200 mg/kg Bütillenmiş hidroksi anisol; RL: Beef extracts with 1% rosemary leaf; LL: Beef extracts with 1% laurel leaf; EL: Beef extracts with 1% eucalyptus leaf; OL: Beef extracts with 1% olive leaf

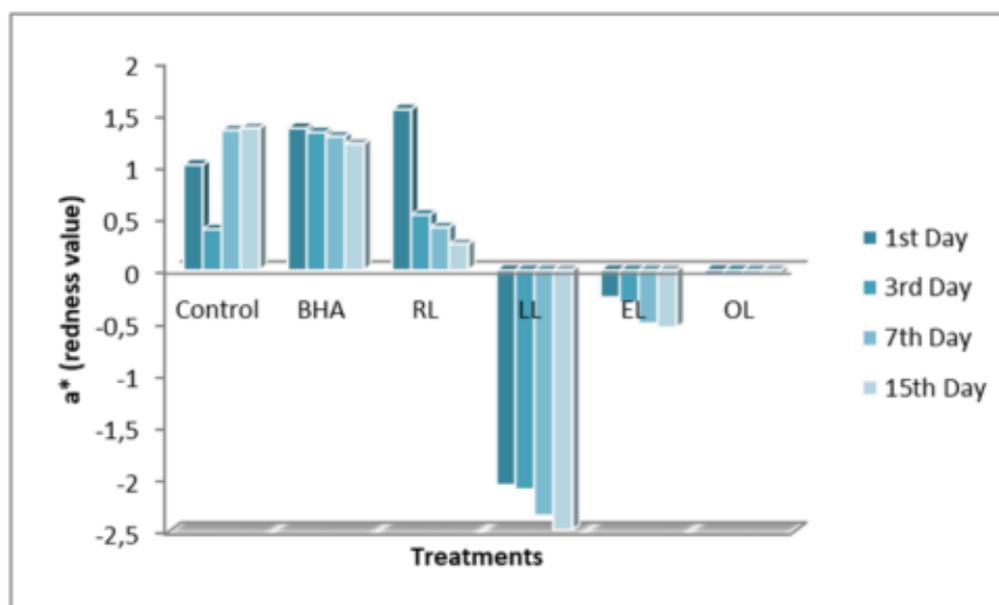
Table 2. The colour (CIE  $L^*$ ,  $a^*$ ,  $b^*$ ) parameters of beef extract treated with leaves at different amount during storage at 4 °C for 15 days.

Storage Days	Treatments					
	Control	BHA	RL	LL	EL	OL
$L^*$						
1	78.77±0.10 <sup>ab</sup>	76.44±0.90 <sup>bc</sup>	62.89±0.08 <sup>a</sup>	69.93±0.65 <sup>bc</sup>	72.33±0.34 <sup>defgh</sup>	72.05±0.13 <sup>efgh</sup>
3	79.73±0.38 <sup>a</sup>	76.07±0.06 <sup>c</sup>	67.38±1.08 <sup>klm</sup>	68.81±0.22 <sup>kl</sup>	70.96±1.15 <sup>lmj</sup>	72.56±1.10 <sup>defg</sup>
7	74.39±0.14 <sup>cde</sup>	74.87±0.60 <sup>cd</sup>	66.82±0.06 <sup>lm</sup>	68.61±0.81 <sup>kl</sup>	71.91±0.54 <sup>efgh</sup>	71.44±0.46 <sup>efgh</sup>
15	73.12±0.19 <sup>defg</sup>	73.97±1.29 <sup>cdef</sup>	65.27±1.02 <sup>lmn</sup>	67.45±0.61 <sup>klm</sup>	72.25±0.01 <sup>efgh</sup>	71.23±0.04 <sup>efh</sup>
$a^*$						
1	1.01±0.05 <sup>c</sup>	1.36±0.01 <sup>ab</sup>	1.54±0.09 <sup>a</sup>	-2.06±0.01 <sup>i</sup>	-0.26±0.03 <sup>g</sup>	-0.04±0.33 <sup>f</sup>
3	0.39±0.04 <sup>de</sup>	1.32±0.02 <sup>b</sup>	0.53±0.04 <sup>d</sup>	-2.10±0.02 <sup>i</sup>	-0.31±0.01 <sup>g</sup>	-0.05±0.02 <sup>f</sup>
7	1.34±0.00 <sup>b</sup>	1.28±0.03 <sup>b</sup>	0.41±0.09 <sup>de</sup>	-2.35±0.04 <sup>j</sup>	-0.51±0.01 <sup>h</sup>	-0.05±0.00 <sup>f</sup>
15	1.36±0.05 <sup>ab</sup>	1.21±0.01 <sup>b</sup>	0.25±0.07 <sup>e</sup>	-2.49±0.12 <sup>j</sup>	-0.55±0.05 <sup>h</sup>	-0.05±0.01 <sup>f</sup>
$b^*$						
1	6.64±0.24 <sup>gh</sup>	6.63±0.17 <sup>gh</sup>	12.72±0.12 <sup>cde</sup>	13.56±0.83 <sup>bcd</sup>	12.04±0.53 <sup>de</sup>	12.26±0.18 <sup>cde</sup>
3	7.27±0.68 <sup>gh</sup>	6.18±0.62 <sup>h</sup>	12.28±0.07 <sup>cde</sup>	13.59±0.27 <sup>cd</sup>	11.47±0.35 <sup>ef</sup>	12.74±0.07 <sup>cde</sup>
7	7.35±0.14 <sup>gh</sup>	6.66±0.37 <sup>gh</sup>	12.47±0.24 <sup>cde</sup>	15.33±0.05 <sup>ab</sup>	10.13±1.28 <sup>f</sup>	13.54±0.35 <sup>cd</sup>
15	8.20±0.05 <sup>g</sup>	6.22±0.06 <sup>h</sup>	12.00±0.02 <sup>de</sup>	15.60±0.60 <sup>a</sup>	11.16±0.21 <sup>ef</sup>	13.98±0.04 <sup>abc</sup>

Values are means of triplicate samples (±SD).

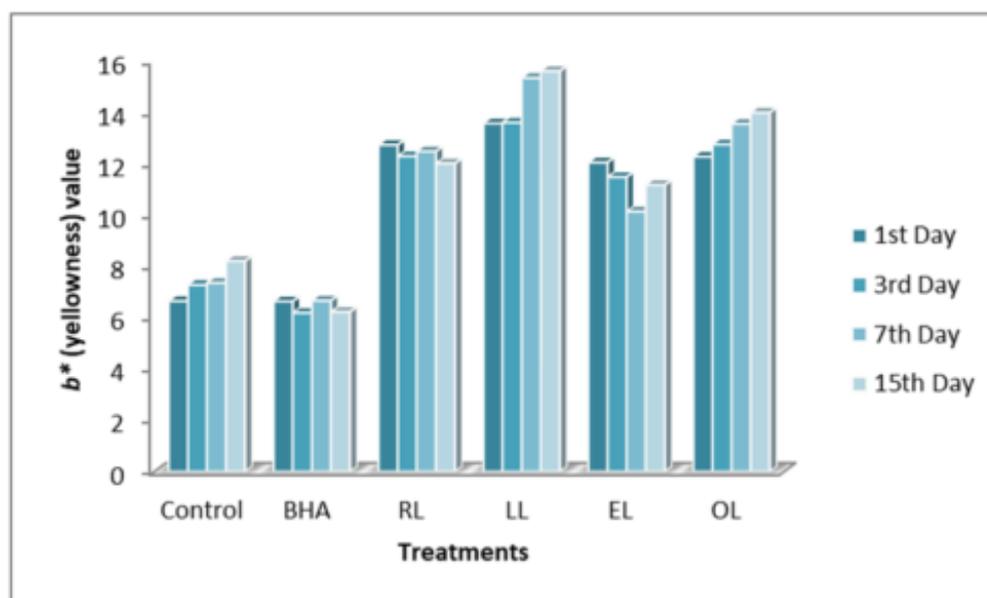
<sup>a-a</sup> Means within rows with different superscript letters are significantly different ( $p < 0.01$ ).

Control: Beef extracts without leaf and BHA, BHA: Beef extracts with 200 mg/kg Bütillenmiş hidroksi anisol, RL: Beef extracts with 1% rosemary leaf, LL: Beef extracts with 1% laurel leaf, EL: Beef extracts with 1% eucalyptus leaf, OL: Beef extracts with 1% olive leaf.



**Figure 3.** The  $a^*$  values of beef extract treated with leaves at different amount during storage at 4 °C for 15 days.

Control: Beef extracts without leaf and BHA, BHA: Beef extracts with 200 mg/kg Bütillenmiş hidroksi anisol; RL: Beef extracts with 1% rosemary leaf; LL: Beef extracts with 1% laurel leaf; EL: Beef extracts with 1% eucalyptus leaf; OL: Beef extracts with 1% olive leaf



**Figure 4.** The  $b^*$  values of beef extract treated with leaves at different amount during storage at 4 °C for 15 days.

Control: Beef extracts without leaf and BHA, BHA: Beef extracts with 200 mg/kg Bütillenmiş hidroksi anisol; RL: Beef extracts with 1% rosemary leaf; LL: Beef extracts with 1% laurel leaf; EL: Beef extracts with 1% eucalyptus leaf; OL: Beef extracts with 1% olive leaf.

### 3.4. Colour results

Table 2 shows that the effects of leaf on the colour of the extract when stored at 4 °C for 15 days. Colour values of extracts has been quite effect ( $p < 0.01$ ) with addition leaf. The highest  $L^*$  value (76.50) was observed in the control group, while the lowest  $L^*$  value (65.59) was observed in rosemary-treated beef extract. Figure 2 shows that during storage,  $L^*$  values decreased and the highest  $L^*$  values were observed on the 1st and 3rd day of storage, while the lowest  $L^*$  values were observed on the 15th day. Although fluctuations in  $a^*$  values were observed, the highest  $a^*$  value (1.29) was observed in BHA-treated extract, while the lowest  $a^*$  values (-2.25) were observed in laurel leaf treated sample groups. According to Figure 3, the highest  $a^*$  value was observed on the 1st day of storage while the lowest  $a^*$  value was seen on the 3rd, 7th and 15th days of storage. There were statistically significant differences between  $b^*$  values ( $p < 0.01$ ). The highest  $b^*$  values (14.51) were seen in the samples treated with laurel leaves, while the lowest  $b^*$  values (6.42) were observed in the BHA treated samples. There was a slight increase in  $b^*$  values during storage. There was no statistically significant difference between  $b^*$  values on day 1st and day 3rd during storage, while the highest  $b^*$  value (11.19) was observed on day 15 of storage (Figure 4). Hettiarachchy et al., [34]; Bekhit et al., [35]; Aksu and Kaya, [36]; Estevez et al., [37]; Fernandez-Lopez et al., [38]; Mitsumoto et al., [39]; Vasavada and Cornforth, [40] found that  $L^*$  values were changed during the preservation of antioxidant added meat products. The effect of rosemary on the  $a$  values of meat and meat products has been studied by various researchers. It was determined that the rosemary plant preserves its color properties (redness) [41; 37; 38].

### 4. Conclusions

The results show that the addition of leaves have effectively retarded lipid oxidation during the storage period for 15 days. RL had an inhibitory more effect on lipid oxidation of beef extract when compared to the other leaves. The addition of leaves to beef extracts was statistically significant in terms of color values ( $L^*$ ,  $a^*$ ,  $b^*$ ) and pH ( $p < 0.01$ ).

**Acknowledgements.** The authors would like to thank the Selçuk University Coordinating Office for Scientific Research Projects (SU-BAP, Konya TURKEY) for financial support (**Project Number: 13201161**). This research was produced from the Master Thesis Betül AYKURT OĞUZ.

**Compliance with Ethics Requirements.** Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

### References

1. Soyutemiz, E. Et ve et ürünlerinde mikrobiyal bozulmalar. *Gıda* 2000, 3: 52-57.
2. Buckley, D.; Morrissey, P.; Gray, J., Influence of dietary vitamin E on the oxidative stability and quality of pig meat. *Journal of Animal Science* 1995, 73(10): 3122-3130.
3. Kaynakçı, E.; Kılıç, B., Et ürünlerinde yeni eğilimler: Daha sağlıklı ürün geliştirme çabaları. *Akademik Gıda* 2009 7(6): 52-59.
4. Gray, J.I.; Monahan, F.J. Measurement of lipid oxidation in meat and meat products. *Trends in Food Science & Technology* 1992, 3: 315-319.
5. Kanner, J. Oxidative processes in meat and meat products: quality implications. *Meat Science* 1994, 36(1): 169-189.
6. Miller, M.; Andersen, M.; Ramsey, C; Reagan, J., Physical and sensory characteristics of low fat ground beef patties. *Journal of Food Science* 1993, 58(3): 461-463.
7. Labuza, T.P.; Dugan Jr, L., Kinetics of lipid oxidation in foods. *Critical Reviews in Food Science & Nutrition* 1971, 2(3): 355-405.
8. Shahidi, F.; Rubin, L.; Wood, D., Control of lipid oxidation in cooked meats by combinations of antioxidants and chelators. *Food Chemistry* 1987, 23(2): 151-157.
9. Chen, C.; Pearson, A.; Gray, J.; Merkel, R., Effects of salt and some antioxidants upon the TBA numbers of meat. *Food Chemistry* 1984, 14(3): 167-172.
10. Gray, J.I.; Gomaa, E; Buckley, D., Oxidative quality and shelf life of meats. *Meat Science* 1996, 43: 111-123.
11. Lee, B.J.; Hendricks, D.G.; Cornforth, D.P., A comparison of carnosine and ascorbic acid on color and lipid stability in a ground beef pattie model system. *Meat Science*, 1999, 51(3): 245-253.
12. Sahoo, J.; Anjaneyulu, A., Quality improvement of ground buffalo meat by preblending with sodium ascorbate. *Meat Science* 1997, 46(3): 237-247.

13. Wu, S.; Brewer, M., Soy protein isolate antioxidant effect on lipid peroxidation of ground beef and microsomal lipids. *Journal of Food Science* **1994**, 59(4): 702-706.
14. Çakmakçı, S.; Gökalp, H.Y., Gıdalarda Kısa Oksidasyon; Antioksidantlar ve Gıda Sanayiinde Kullanımları. *Atatürk Üniversitesi Ziraaat Fakültesi Dergisi* **1992**, 23 (2): 174-192.
15. Calucci, L.; Pinzino, C.; Zandomenighi, M.; Capocchi, A.; Ghiringhelli, S.; Saviozzi, F.; . . . Galleschi, L., Effects of  $\gamma$ -irradiation on the free radical and antioxidant contents in nine aromatic herbs and spices. *Journal of Agricultural and Food Chemistry* **2003**, 51(4): 927-934.
16. Ng, T.; Liu, F.; Wang, Z., Antioxidative activity of natural products from plants. *Life sciences* **2000**, 66(8): 709-723.
17. Zheng, W.; Wang, S.Y., Antioxidant activity and phenolic compounds in selected herbs. *Journal of Agricultural and Food Chemistry* **2001**, 49(11): 5165-5170.
18. Hall, C., Sources of Natural Antioxidant: Oil Seed, Nuts, Legumes, Animal Product and Microbial Sources in J. Pokorny, N. Yanishlieva dan M. Gordon (ed.). Antioxidant. *Didalam Food Practical Application*. New York: CRC Press. **2001**.
19. Bozin, B.; Mimica-Dukic, N.; Samojlik, I.; Jovin, E., Antimicrobial and antioxidant properties of rosemary and sage (*Rosmarinus officinalis* L. and *Salvia officinalis* L., Lamiaceae) essential oils. *Journal of Agricultural Food Chemistry* **2007**, 55: 7879-7885.
20. Abd El-Alim, S.S.L.; Lugasi, A.; Hovari, J. Dworschak, E., Culinary herbs inhibit lipid oxidation in raw and cooked minced meat patties during storage. *Journal of the Science Food and Agriculture* **1999**, 79, 277-285.
21. Al-Jalay, B.; Blank, G.; McConnel, B.; Al-Khayat, M., Antioxidant activity of selected spices used in fermented meat sausage. *Journal of Food Protection* **1987**, 25-27.
22. Palitzsch, A.; Krizanec, D.; Dikanovic-Lucan, Z., The antioxidant properties of spices in dry-fermented sausages. *Fleischwirtschaft* **1993**, 73: 670-672.
23. AOAC., Official Methods of Analysis, Association of Official Analytical Chemists, Virginia, USA, **2000**.
24. Gökalp, H.Y.; Kaya, M.; Tülek, Y.; Zorba, Ö., Et ve Et Ürünlerinde Kalite Kontrolü ve Laboratuvar Uygulama Kılavuzu. Atatürk Üni. Yayın no: 751, Ziraat Fak. Yayın no: 318, Ders Kitapları Serisi No:69. Erzurum, **1995**.
25. Tarladgis, B.G.; Watts, B.M.; Younathan, M.T.; Dugan Jr, L. A distillation method for the quantitative determination of malondialdehyde in rancid foods. *Journal of the American Oil Chemists' Society* **1960**, 37(1): 44-48.
26. Hunt, M.; Acton, J.; Benedict, R.; Calkins, C.; Cornforth, D.; Jeremiah, L.; Shivas, S., *Guidelines for meat color evaluation*. Paper presented at the 44th Annual Reciprocal Meat Conference **1991**.
27. Minitab, Computer program, MINITAB release 16.0 for windows. Minitab Inc., USA **2010**.
28. Snedecor, G.W.; Cochran, W.G., *Statistical Methods*, (7th Edition) Iowa State Univ. Press, Ames, Iowa, **1980**.
29. Cheah, P.B.; Hasim, N.H.A., Natural antioxidant extract from galangal (*Alpinia galanga*) for minced beef. *Journal of the Science of Food and Agriculture* **2000**, 80: 1565-1571.
30. Nassu, R.T.; Goncalves, L.A.G.; Silva, M. A. A. P.; Beserra, F.J., Oxidative stability of fermented goat meat sausage with different levels of natural antioxidant. *Meat Science* **2003**, 63: 43-49.
31. Sebranek, J.; Sewalt, V.; Robbins, K.; Houser, T., Comparison of a natural rosemary extract and BHA/BHT for relative antioxidant effectiveness in pork sausage. *Meat Science* **2005**, 69(2): 289-296.
32. Yu, L.; Scanlin, L.; Wilson, J.; Schmidt, G., Rosemary extracts as inhibitors of lipid oxidation and color change in cooked turkey products during refrigerated storage. *Journal of Food Science* **2002**, 67(2): 582-585.
33. Hayes, J.; Stepanyan, V.; Allen, P.; O'Grady, M.; Kerry, J., Effect of lutein, sesamol, ellagic acid and olive leaf extract on the quality and shelf-life stability of packaged raw minced beef patties. *Meat Science* **2010**, 84(4): 613-620.
34. Hettiarachchy, N.S.; Glenn, K.C.; Gnanasambandam, R.; Johnson, M.G., Natural antioxidant extract from fenugreek (*Trigonella foenumgraecum*) for ground beef patties. *Journal of Food Science* 1996, 61: 516-519.
35. Bekhit, A.E.D.; Geesing, G.H.; Ilian, M.A.; Morton, J.D.; Bickerstaffe, R., The effects of natural antioxidants on oxidative processes and metmyoglobin reducing activity in beef patties. *Food Chemistry* **2003**, 81: 175- 187.
36. Aksu, M.D.; Kaya, M., The effect of  $\alpha$ -tocopherol and butyleted hydroxyanisole on the colour properties and lipid oxidation of kavurma, a cooked meat product. *Meat Science* **2005**, 71: 277-283
37. Estevez, M.; Ventanas, S.; Cava, R., Protein oxidation in frankfurters with increasing levels of added rosemary essential oil: effect of color and texture deterioration. *Journal of Food Science* **2005**, 70: 427-432.

38. Fernandez-Lopez, J.; Zhi, N.; Aleson-Carbonell, L.; Perez-Alvarez, J.A.; Kuri, V., Antioxidant and antibacterial activities of natural extracts: application in beef meatballs. *Meat Science* 2005, 69: 371-380.
39. Mitumoto, M.; O'Grady, M.N.; Kerry, J.P.; Buckley, D.J., Addition of tea catechins and vitamin C on sensory evaluation, colour and lipid stability during chilled storage in cooked or raw beef and chicken patties. *Meat Science* 2005, 69: 773-779.
40. Vasavada, M.N.; Cornforth, D. P., Evaluation of antioxidant effects of raisin paste in cooked ground beef, pork and chicken. *Journal of Food Science* 2006, 71: 242-246.
41. Sanchez-Escalante, A.; Djenane, D.; Torrescano, G.; Beltran, J.A.; Roncales, P., The effects of ascorbic acid, taurine, carnosine and rosemary powder on colour and lipid stability of beef patties packaged in modified atmosphere. *Meat Science* 2001, 58: 421-42.