

## Reduction of Oxidative Rancidity and Microbial Activities of the Karadi Lamb Patties in Freezing Storage Using Natural Antioxidant Extracts of Rosemary and Ginger

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### Abstract

This experiment was designed to study the effect of adding rosemary or ginger together with the sodium lactate to lamb patties stored at -18°C for 150 days as antioxidant, antimicrobial and sensory attributes. Minced meat was blended with 1.5% salt (70% NaCl and 30% KCl), then was subdivided into five treatments. Treatment 1 was considered as a control; treatments 2 and 3 were blended with 0.050% rosemary extract (RE), and 0.50% ginger (GE), respectively. Whereas treatments 4 and 5 were blended with 3% sodium lactates in addition to rosemary (RE+SL) or ginger (GE+SL). The meat was thoroughly mixed and formed into patties (100g), and placed on plastic foam meat trays, and kept frozen at -18°C for 150 days. It appears from TBA values that treated lamb patties with GE, GE+SL, RE and RE+SL significantly retarded ( $p<0.01$ ) oxidative process by 65.6, 69, 58.8% and 58.5%, respectively compared to control patties. With increasing storage period, a significant ( $p<0.01$ ) rise in free fatty acids and total volatile nitrogen and a significant decrease in myoglobin and sensory attributes was observed for all treated and control patties. However, treatment with RE and GE and in particular with their combination with SL improved all sensory attributes in comparison to untreated patties. Addition of RE, GE or its combination with SL showed inhibitory effect against the test organisms as compared to control samples.

**Keywords:** *Rosemary extract, ginger extract, thiobarbituric acid, microbes, lamb patties*

### 1. Introduction

Lipid oxidation and growth of undesirable microorganisms in food products result in the development of spoilage, off flavor, rancidity and deterioration, rendering such products unacceptable for human consumption (Bozin *et al.*, 2007; Ibrahim *et al.*, 2010), and yielding many compounds that contribute to the pathogenesis of cancer, atherosclerosis, heart and allergic diseases (Mielnik *et al.*, 2008). In an effort to retard this process, several synthetic food additives have been widely used in the meat industry to extend food shelf-life, inhibit lipid oxidation and delay or

inhibit the growth of pathogenic microorganisms. However, the application of synthetic antioxidants has been recently restricted because there is suspicion that they are carcinogenic. For this reason a growing interest has been paid to the research of natural antioxidants, among which spices occupy an important position (Pokorny, *et al.*, 2001).

Spices and herbs have been added to food since ancient times, not only as flavoring agents, but also as folk medicine and food preservatives (Nakatani,

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1994). Furthermore, certain spices and herbs prolong the storage life of foods by preventing rancidity through their antioxidants activity or through bacteriostatic or bactericidal activity, also to food-borne pathogenic bacteria (Shelef *et al.*, 1980). Among herbs, rosemary (*Rosmarinus officinalis* L.) is the only one that is explored commercially as a natural antioxidant (Jadhav *et al.*, 1996). Rosemary extracts containing phenolic derivatives were reported to have strong antioxidant effects on cooked meat (Younathan, 1985, Rhee, 1988), and antimicrobial activity (Wang *et al.*, 2008). The rhizome of the ginger species, (*zingiber officinale*) is widely used as a spice and food seasoning due to its sweet aroma and pungent taste. It has been known to have antioxidant activity (Mansour and Khalil, 2000; Zia-ur-Rehman *et al.*, 2003) and is effective as antimicrobial (Shamsuddeen *et al.*, 2009; Ibrahim *et al.*, 2011).

Freezing is one of the most common methods used to prolong the shelf life of food products. The freezing process slows down the rate of many physico-chemical and microbiological changes. Stabilization of frozen food depends on its chemical composition and processing method used before freezing (Karpinska *et al.*, 2000). Therefore, the objective of the present study was to determine the effect of adding natural antioxidant extracts (rosemary & ginger) on the oxidative rancidity, microbial counts and sensory attributes in Karadi lamb patties.

## 2. Materials and Methods

### Materials

Rosemary (*R. officinalis*) and ginger rhizomes (*Zingiber officinal*) were obtained from local market in Duhok. Full details of the extraction methodology and determinations of active compounds are given in our previous paper (Baker *et al.*, 2012a). Briefly, batches of one hundred grams from each of dried ground rosemary and ginger were extracted with 1 liter of 95% ethanol. The tincture was kept in darkness for 24h and then filtered; the ethanol was evaporated in a vacuum oven at 40 °C. The extracts were stored in containers in the refrigerator until use. By using HPLC, it was found that the active compounds in rosemary extracts are Carnosol, Carnosic acid,

Rosmanol, Cirsimaritin, and Genkwanin, and the active compounds found in ginger Gingerol, Zingiberene,  $\alpha$ -farnesne,  $\beta$ -sesquiphellanderene,  $\beta$ -bisabolene and  $\alpha$ - Curcumene (Baker *et al.* 2012a).

### Preparations of Lamb Patties

The longissimus dorsi muscle was obtained from Karadi lambs carcasses. After 24h of chilled storage (4 °C), the excess of fat and connective tissue were trimmed from the meat, then chopped and minced through 0.8 cm plate in meat grinder. A combination of salt (70% NaCl and 30% KCl) based on our previous work (Baker *et al.*, 2012b) was added at a rate of 1.5% to the minced meat. The minced meat was subdivided into five equal parts (1kg each). Control treatment(C) was formulated without adding plant extracts. The other treatments were prepared by adding the optimum concentrations determined by the tested extracts from our previous experiment (Baker *et al.*, 2012a). Treatment 2 was blended with 0.05% rosemary extract (RE), treatment 3 was blended with 0.50% of ginger extract (GE), treatment 4 was blended with 0.050% rosemary extract + 3% sodium lactate (RE+SL) and treatment 5 was blended with 0.50% ginger extract + 3% sodium lactate (GE+SL) then mixed well and formed into patties (50 g) using a meat former (10-cm wide and 1-cm thick each). Patties were placed on plastic foam meat trays, wrapped with polyethylene film and kept in a refrigerator at -18 °C for 5 months, and evaluated for chemical, microbial and sensory attributes at 1, 60, 90, 120 and 150 days of storage.

### Analytical Methods

Lipid oxidation as thiobarbituric acid (TBA) was determined by spectrophotometer (6400 – JENWAY, UK) according to the method described by Witte *et al.*, (1970). The results were expressed as mg malonaldehyde (MDA) /kg meat sample.

Free fatty acids (FFA) and total volatile nitrogen (TNV mg N/100 g meat) were determined following the methods described by Egan *et al.* (1981). The FFA was calculated (as oleic acid) as follows:

$$\text{FFA}\% = \frac{0.282 \times \text{ml NaOH (0.1N)} \times 100}{\text{Weight of sample (g)}}$$

And total volatide nitrogen (TNV) was calculated as the following equation:

TNV (mg N/100 g meat) = Titration (ml of 0.1 N H<sub>2</sub>SO<sub>4</sub>) x 14

### Microbial Count

Microbial count was determined as recommended by the American Public Health Association for food stuff examination (APHA, 1992). Total plate count (TPC) was determined on nutrient agar medium (LAB), and the plates of different dilutions were incubated at 37°C for 48 h. The average number of colonies per countable plate as well as the total number of colonies per gram (CFU/g) was determined. MacConky agar medium (LAB) was used for determination of coliform bacteria, and the inoculated plates were incubated at 37°C for 48 h. Psychrophilic bacteria were determined by using LAB for plating, and the inoculated plates were inoculated at 7°C for 10 days. Proteolytic and lipolytic bacteria counts were determined as recommended by Harrigan and MacCance, (1976).

### Sensory Evaluation

The investigated samples were evaluated using a panel test according to Cross et al. (1978).

### Statistical Analysis

General Linear Model was used to estimate Best Linear unbiased effects (SAS, 2002) of treatment, storage period and their interaction, on all studied traits. Duncan multiple range tests (Duncan, 1955) was used to detect significant differences among means of treatment combination (treatments X period).

## 3. Results and Discussion

### Thiobarbituric Acid (TBA) Values

In the present study, TBA of patties in the control started to increase significantly ( $p < 0.01$ ) from 1.75 (day 1) to reach 3.84 mg MDA/kg meat at the end of storage period. While, the maximum values for lamb patties treated with GE or GE+SL extracts were 1.32 and 1.19 mg MDA/kg meat at the end of frozen period. Thus the treatment apparently significantly retarded ( $p < 0.01$ ) oxidative rancidity compared to control by 65.6 and 69% for GE and GE+SL, respectively (Table1). Also, Formanek *et al.*, (2009) Ibrahim *et al.*, (2011), and Abu-almaaly (2011) reported that ginger extract as antioxidant was effective against TBA formation when incur-

porated into meat during frozen storage. Moreover, polyphenolic extracts are excellent electron and proton donors, and their intermediate radicals are quite stable due to electronic delocalization phenomena as well as owing to the lack of position attackable by O<sub>2</sub> (Djenane *et al.*, 2005). Also, treated lamb patties with RE and RE+SL resulted in retarding oxidative process by 58.8% at the end of storage period in comparison with untreated (control) patties (Table1). This result was consistent with studies in hog sausage (Newkirk *et al.*, 1993), and precooked roast beef (Murphy *et al.*, 1998). Trindade *et al.*, (2007) concluded that rosemary extracts contain phenolic primary antioxidants which react with lipid or hydroxyl radicals and convert them into stable products. Also, Fang and Wada (1993) demonstrated that the rosemary extracts may chelate metal ions, such as Fe resulting in a reduce rate of formation of activated oxygen. In the current study, since the natural extracts used in preparing lamb patties contained phenolic compounds, these substances could cause an inhibition of the chain reactions during lipid oxidation (El-Diwani *et al.*, 2009). Moreover, since TBA values is considered as indicators of rancidity in fat products, Verme and Sahoo (2000) indicate that MDA concentrations between 1.0 and 2.0 mg/kg as threshold values for rancidity. Accordingly, the patties treated with rosemary or ginger samples in the present study would not deceive consumers up to 150 days of storage.

### Free Fatty Acid (FFA)

The initial values of FFA ranged between 1.03 and 1.07 for all treated and control samples. A significant ( $p < 0.01$ ) rise with increasing storage period was noticed to reach its maximum values of 2.27, 2.17, 2.24, 2.24 and 2.27 for control, RE, RE+SL GE and GE+SL, respectively at the end of storage period. The increase in FFA (lipolysis) is a result of the enzymatic hydrolyses of esterified lipids (Hwang and Regenstein, 1993). This increase in FFA with increasing storage period is in agreement with those reported by other investigators (Ucak *et al.*, 2011; Abu-almaaly, 2011). However, results revealed that adding RE or GE with or without SL had no significant effect on FFA throughout the storage period. On the other hand, Ucak *et al.* (2011) noticed considerable differences ( $p < 0.01$ ) in FFA between the control

and rosemary treated groups in mackerel fish burgers. Also, Abu-almaaly (2011) indicated that addition of ginger powder to beef burger resulted in a decrease of FFA value at the end of 120 days storage period compared to control untreated samples. This discrepancy in the results may be due to differences in type of meat, level and method of addition the antioxidant.

### Myoglobin (Mb)

In the current work, color values were seen significantly ( $p<0.01$ ) decreasing over storage period (Table 2). Similarly, Rai and Xia (2008), and Rojas and Brewer (2008) noticed a reduction in color throughout the frozen storage time, regardless of the treatment used. Moreover, addition of RE or GE extract to lamb patties stabilize color up to 90 and 60 days of storage, respectively. The loss of redness was due to the oxidation of myoglobin to metamyoglobin, and

rosemary retard this process to maintain meat redness longer. Also, a reduction in metamyoglobin formation was noticed and intense red color obtained in fresh beef steaks whose surface was sprayed with rosemary during refrigeration (Djenane *et al.*, 2005). Moreover, results showed an improvement in meat color when SL was added to rosemary or ginger treated samples. The addition of SL has been noticed to stabilize color and to increase the length of time that meat color is maintained during storage. This stabilization of meat color with the storage is most likely due to the higher pH that provides some protection against oxidation during meat storage (Miller, 2010). It is worth noticing that pH values in our present work increased significantly ( $p<0.01$ ) with the increasing storage period from their initial values (5.56) to reach the maximum (5.77) at the end of storage period in treated samples (Baker, 2012).

**Table 1**

Effect of adding rosemary or ginger extracts with or without sodium lactate to lamb patties on TBA (mg(MDA)/kg meat) values stored at  $-18^{\circ}\text{C}$  for 150 days (means $\pm$ s.e.).

| Days             | 1                             | 60                            | 90                            | 120                           | 150                           |
|------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| <b>Treatment</b> | <b>Rosemary extract</b>       |                               |                               |                               |                               |
| C                | 1.75 $\pm$ 0.07 <sup>d</sup>  | 2.33 $\pm$ 0.004 <sup>c</sup> | 3.00 $\pm$ 0.07 <sup>b</sup>  | 3.10 $\pm$ 0.02 <sup>b</sup>  | 3.84 $\pm$ 0.004 <sup>a</sup> |
| RE               | 0.64 $\pm$ 0.00 <sup>ij</sup> | 0.86 $\pm$ 0.03 <sup>h</sup>  | 1.06 $\pm$ 0.01 <sup>g</sup>  | 1.37 $\pm$ 0.05 <sup>f</sup>  | 1.58 $\pm$ 0.01 <sup>e</sup>  |
| RE+SL            | 0.57 $\pm$ 0.04 <sup>j</sup>  | 0.71 $\pm$ 0.006 <sup>i</sup> | 0.95 $\pm$ 0.005 <sup>h</sup> | 1.37 $\pm$ 0.05 <sup>f</sup>  | 1.59 $\pm$ 0.01 <sup>e</sup>  |
|                  | <b>Ginger extract</b>         |                               |                               |                               |                               |
| C                | 1.75 $\pm$ 0.07 <sup>e</sup>  | 2.33 $\pm$ 0.004 <sup>d</sup> | 3.00 $\pm$ 0.07 <sup>c</sup>  | 3.10 $\pm$ 0.02 <sup>b</sup>  | 3.84 $\pm$ 0.004 <sup>a</sup> |
| GE               | 0.53 $\pm$ 0.01 <sup>j</sup>  | 0.60 $\pm$ 0.01 <sup>ji</sup> | 0.65 $\pm$ 0.01 <sup>i</sup>  | 1.01 $\pm$ 0.001 <sup>h</sup> | 1.32 $\pm$ 0.01 <sup>f</sup>  |
| GE + SL          | 0.55 $\pm$ 0.02 <sup>j</sup>  | 0.60 $\pm$ 0.00 <sup>ji</sup> | 0.62 $\pm$ 0.01 <sup>ji</sup> | 1.00 $\pm$ 0.001 <sup>h</sup> | 1.19 $\pm$ 0.01 <sup>g</sup>  |

For each trait, means with different letters within each column and each row differed significantly ( $p<0.01$ ). C=control, RE=rosemary extract, SL=sodium lactate, GE=ginger extract.

**Table 2**

Effect of adding rosemary or ginger extracts with or without sodium lactate to lamb patties on Myoglobin (Mb) (mg /gm meats) values stored at -18°C for 150 days (means±s.e.).

| Days             | 1                       | 60                       | 90                     | 120                     | 150                     |
|------------------|-------------------------|--------------------------|------------------------|-------------------------|-------------------------|
| <b>Treatment</b> | <b>Rosemary extract</b> |                          |                        |                         |                         |
| C                | 3.93±0.001 <sup>e</sup> | 2.54± 0.02 <sup>e</sup>  | 2.30±0.11 <sup>f</sup> | 1.27±0.001 <sup>h</sup> | 1.03±0.01 <sup>i</sup>  |
| RE               | 4.52±0.001 <sup>b</sup> | 3.19± 0.01 <sup>d</sup>  | 2.56±0.06 <sup>e</sup> | 1.37±0.02 <sup>h</sup>  | 1.05±0.02 <sup>i</sup>  |
| RE+SL            | 4.68± 0.05 <sup>a</sup> | 3.20± 0.007 <sup>d</sup> | 2.67±0.06 <sup>e</sup> | 1.69±0.00 <sup>g</sup>  | 1.37±0.05 <sup>h</sup>  |
|                  | <b>Ginger extract</b>   |                          |                        |                         |                         |
| C                | 3.93±0.001 <sup>b</sup> | 2.54± 0.02 <sup>d</sup>  | 2.30±0.11 <sup>e</sup> | 1.27±0.001 <sup>g</sup> | 1.03±0.01 <sup>i</sup>  |
| GE               | 4.24± 0.07 <sup>a</sup> | 2.29± 0.02 <sup>e</sup>  | 1.79±0.06 <sup>f</sup> | 1.06±0.02 <sup>i</sup>  | 1.04±0.001 <sup>i</sup> |
| GE + SL          | 4.05±0.001 <sup>b</sup> | 3.21± 0.05 <sup>c</sup>  | 2.39±0.01 <sup>e</sup> | 1.36±0.01 <sup>g</sup>  | 1.16±0.001 <sup>i</sup> |

For each trait, means with different letters within each column and each row differed significantly (p<0.05). C=control, RE=rosemary extract, SL=sodium lactate, GE=ginger extract.

**Table 3**

Effect of adding rosemary or ginger extracts with or without sodium lactate to lamb patties on total volatile nitrogen (TVN) (mg N /100 gm meat) values stored at -18°C for 150 days (means±s.e.).

| Days             | 1                         | 60                       | 90                      | 120                      | 150                      |
|------------------|---------------------------|--------------------------|-------------------------|--------------------------|--------------------------|
| <b>Treatment</b> | <b>Rosemary extract</b>   |                          |                         |                          |                          |
| C                | 16.96±0.001 <sup>ef</sup> | 17.05±0.09 <sup>cf</sup> | 17.82±0.05 <sup>d</sup> | 19.35±0.06 <sup>bc</sup> | 20.72±0.07 <sup>a</sup>  |
| RE               | 16.44±0.17 <sup>gh</sup>  | 16.83±0.05 <sup>f</sup>  | 17.11±0.09 <sup>e</sup> | 19.27±0.01 <sup>bc</sup> | 19.48±0.04 <sup>b</sup>  |
| RE+SL            | 16.27±0.08 <sup>h</sup>   | 16.49±0.03 <sup>gh</sup> | 16.53±0.02 <sup>g</sup> | 19.24±0.001 <sup>c</sup> | 19.46±0.01 <sup>bc</sup> |
|                  | <b>Ginger extract</b>     |                          |                         |                          |                          |
| C                | 16.96±0.001 <sup>e</sup>  | 17.05±0.09 <sup>e</sup>  | 17.82±0.05 <sup>d</sup> | 19.35±0.06 <sup>c</sup>  | 20.72±0.07 <sup>a</sup>  |
| GE               | 16.37±0.06 <sup>hg</sup>  | 16.56±0.03 <sup>fg</sup> | 17.14±0.17 <sup>e</sup> | 19.24±0.001 <sup>c</sup> | 19.58±0.00 <sup>b</sup>  |
| GE + SL          | 16.35±0.02 <sup>h</sup>   | 16.56±0.05 <sup>fg</sup> | 16.69±0.01 <sup>f</sup> | 19.41±0.06 <sup>bc</sup> | 19.58±0.01 <sup>b</sup>  |

For each trait, means with different letters within each column and each row differed significantly (p<0.05). C=control, RE=rosemary extract, SL=sodium lactate, GE=ginger extract.

### Total Volatile Nitrogen (TVN)

Result indicates, as the storage period increased, the TVN values increased significantly (p<0.01) (Table 3), for all meat samples with different rates depending on the nature of treatment, and in particular in control reaching the highest value of 20.72 mg N/100g meat. This may be attributed to the breakdown of proteins as a result of activity of microbial and proteolysis enzymes (Yassin-Nessrien, 2003). This result is in accordance with

findings of other workers (El-Desoky *et al.*, 2006; Salem *et al.*, 2010). It seems that addition of rosemary or ginger with or without sodium lactate resulted in a significantly (p<0.01) lower values of TVN as compared to control. Similarly, Abu-almaaly (2011) reported that addition of ginger to beef burger improve TVN values. Also, it was found that rosemary added to minced meat had a longer shelf-life compared to control (El-Desouky *et al.*, 2006).

**Table 4**

Effect of rosemary extracts and sodium lactate on change on total plate count (TPC), coliform, psychrophilic (PSY), proteolytic, lipolytic count of lamb patties stored at -18°C for 150 days (means±s.e.).

| Days             | 1                                  | 60                         | 90                        | 120                       | 150                       |
|------------------|------------------------------------|----------------------------|---------------------------|---------------------------|---------------------------|
| <b>Treatment</b> | <b>TPC x10<sup>5</sup></b>         |                            |                           |                           |                           |
| C                | 39.00 ±0.57 <sup>c</sup>           | 45.00 ±0.57 <sup>d</sup>   | 55.00 ±0.57 <sup>c</sup>  | 67.00 ±2.30 <sup>b</sup>  | 78.00 ±1.73 <sup>a</sup>  |
| RE               | 11.50 ±0.28 <sup>i</sup>           | 12.80 ±0.11 <sup>hi</sup>  | 14.20 ±0.20 <sup>h</sup>  | 17.60 ±0.17 <sup>g</sup>  | 20.30 ±0.17 <sup>f</sup>  |
| RE +SL           | 6.40 ±0.05 <sup>k</sup>            | 7.83±0.37 <sup>k</sup>     | 8.90 ±0.05 <sup>j</sup>   | 11.50 ±0.20 <sup>i</sup>  | 12.40 ±0.11 <sup>hi</sup> |
|                  | <b>Coliform x10<sup>2</sup></b>    |                            |                           |                           |                           |
| C                | 88.00 ±1.15 <sup>c</sup>           | 96.66 ± 0.88 <sup>d</sup>  | 115.33 ±1.76 <sup>c</sup> | 125.0 ± 0.57 <sup>b</sup> | 141.66±1.45 <sup>a</sup>  |
| RE               | 16.56±0.23 <sup>gh</sup>           | 19.5 ± 0.25 <sup>g</sup>   | 26.53 ± 0.14 <sup>f</sup> | 28.73 ± 0.40 <sup>f</sup> | 30.50±0.28 <sup>f</sup>   |
| RE +SL           | 12.86±0.13 <sup>h</sup>            | 14.63 ± 0.20 <sup>gh</sup> | 16.66± 0.17 <sup>gh</sup> | 19.33 ± 0.44 <sup>g</sup> | 20.40 ±0.23 <sup>g</sup>  |
|                  | <b>PSY x10<sup>5</sup></b>         |                            |                           |                           |                           |
| C                | 14.76 ±0.14 <sup>c</sup>           | 25.00 ± 1.73 <sup>d</sup>  | 44.00 ± 2.30 <sup>c</sup> | 62.00 ± 0.57 <sup>b</sup> | 70.0± 0.57 <sup>a</sup>   |
| RE               | 6.20±0.11 <sup>igh</sup>           | 7.20 ± 0.00 <sup>gh</sup>  | 8.60 ± 0.11 <sup>g</sup>  | 11.10 ± 0.20 <sup>f</sup> | 14.10± 0.20 <sup>e</sup>  |
| RE +SL           | 4.10 ± 0.15 <sup>i</sup>           | 4.90 ± 0.05 <sup>ih</sup>  | 6.90 ± 0.11 <sup>gh</sup> | 7.80 ± 0.11 <sup>g</sup>  | 8.20 ± 0.05 <sup>g</sup>  |
|                  | <b>Proteolytic x10<sup>5</sup></b> |                            |                           |                           |                           |
| C                | 29.0 ± 0.57 <sup>c</sup>           | 32.00 ± 0.57 <sup>d</sup>  | 41.0 ± 0.57 <sup>c</sup>  | 44.33±0.88 <sup>b</sup>   | 62.0±1.15 <sup>a</sup>    |
| RE               | 9.20±0.11 <sup>j</sup>             | 11.10±0.11 <sup>i</sup>    | 12.70±0.05 <sup>h</sup>   | 14.20±0.15 <sup>g</sup>   | 16.30±0.15 <sup>f</sup>   |
| RE +SL           | 4.00±0.05 <sup>l</sup>             | 4.20±0.17 <sup>l</sup>     | 5.00±0.11 <sup>kl</sup>   | 6.20±0.11 <sup>k</sup>    | 8.20±0.11 <sup>j</sup>    |
|                  | <b>Lipolytic x10<sup>5</sup></b>   |                            |                           |                           |                           |
| C                | 27.70 ±0.17 <sup>c</sup>           | 34.00 ± 1.15 <sup>d</sup>  | 38.0 ± 1.15 <sup>c</sup>  | 41.0 ± 1.15 <sup>b</sup>  | 52.0 ± 1.15 <sup>a</sup>  |
| RE               | 10.33 ±0.33 <sup>h</sup>           | 11.80± 0.11 <sup>gh</sup>  | 12.20 ± 0.10 <sup>g</sup> | 12.80 ±0.20 <sup>fg</sup> | 14.30 ± 0.05 <sup>f</sup> |
| RE + SL          | 4.96 ± 0.08 <sup>j</sup>           | 5.30 ± 0.11 <sup>j</sup>   | 6.20 ± 0.11 <sup>j</sup>  | 6.50 ± 0.05 <sup>j</sup>  | 8.30 ± 0.15 <sup>i</sup>  |

For each trait, means with different letters within each column and each row differed significantly (p<0.01). C=control, RE=rosemary extract, SL=sodium lactate.

### Microbial Changes

In the current study, results revealed that in untreated sample there were a significant (p<0.01) steady rise with increasing storage period up to 150 days from their initial values in TPC (39 vs 78X10<sup>5</sup>), coliform (88 vs 141.66X10<sup>2</sup>), PSY (14.76 vs 70.00X10<sup>5</sup>), proteolytic (29.00 vs 62.00X10<sup>5</sup>) and lipolytic (27.70 vs 52.00X10<sup>5</sup>) (Tables 4 and 5). Also, the results indicate that addition of rosemary, ginger and their combination with sodium lactate resulted in a marked significant (p<0.01) reduction on all count of studied bacteria. The greatest decline was recorded in treated meat

samples with ginger and sodium lactate which amounted to 87.00% in TPC and coliform, 91% in PSY and 86.2% in proteolytic bacteria and 84.6% lipolytic bacteria compared to control untreated group. However, although sodium lactate mode of action to inhibit microbial growth remains unclear, two possible mechanisms have been proposed. First, sodium lactate is a weak lipophilic acid and it can pass through the cell membrane in its undissociated form and dissociate within the cell to acidify the cell interior. Second, sodium lactate may have the ability to lower the water activity of an environment, making it less suitable for bacteria

to grow (Shelef, 1994). Similarly, Kulshrestha and Rhee (1996), Rhee, *et al.*, (1997) Shelef, *et al* (1997), noted that sodium lactate had antimicrobial effect in different meat products. Also, the inhibitory effect of rosemary or ginger against

microbial have been documented by many authors including Jitoe, *et al* (1992), Zia-ur-Rehman *et al* (2003), Jatosińska and Wilczak (2009), AbdEl-Hamied *et al* (2009), Malu, *et al.*, (2009); Kenar *et al.*, (2010), Ibrahim *et al.*, (2011).

**Table 5**

Effect of ginger extracts and sodium lactate on change on total plate count (TPC), coliform, psychrophilic (PSY), proteolytic, lipolytic count of lamb patties stored at -18°C for 150 days (means±s.e.)

| Days             | 1                                  | 60                        | 90                       | 120                      | 150                       |
|------------------|------------------------------------|---------------------------|--------------------------|--------------------------|---------------------------|
| <b>Treatment</b> | <b>TPC x 10<sup>5</sup></b>        |                           |                          |                          |                           |
| C                | 39.00±0.57 <sup>c</sup>            | 45.00±0.57 <sup>d</sup>   | 55.00±0.57 <sup>c</sup>  | 67.00±2.30 <sup>b</sup>  | 78.00 ±1.73 <sup>a</sup>  |
| GE               | 10.33± 0.44 <sup>i</sup>           | 14.00±0.28 <sup>h</sup>   | 15.30±0.5 <sup>gh</sup>  | 17.60± 0.26 <sup>g</sup> | 20.400±0.17 <sup>f</sup>  |
| GE + SL          | 4.73± 0.14 <sup>k</sup>            | 5.70± 0.05 <sup>k</sup>   | 6.50± 0.2 <sup>kj</sup>  | 8.40± 0.15 <sup>ij</sup> | 10.10± 0.10 <sup>i</sup>  |
|                  | <b>Coliform x10<sup>2</sup></b>    |                           |                          |                          |                           |
| C                | 88.00 ± 1.15 <sup>e</sup>          | 96.66 ± 0.88 <sup>d</sup> | 115.33±1.7 <sup>c</sup>  | 125.0± 0.57 <sup>b</sup> | 141.66± 1.45 <sup>a</sup> |
| GE               | 16.66± 0.20 <sup>ji</sup>          | 19.50±0.32 <sup>h</sup>   | 26.86±0.14 <sup>g</sup>  | 28.03±0.43 <sup>fg</sup> | 30.13± 0.35 <sup>f</sup>  |
| GE + SL          | 11.83± 0.08 <sup>l</sup>           | 12.56±0.28 <sup>lk</sup>  | 14.43±0.20 <sup>jk</sup> | 16.60±0.20 <sup>ji</sup> | 18.53± 0.20 <sup>hi</sup> |
|                  | <b>PSY x10<sup>5</sup></b>         |                           |                          |                          |                           |
| C                | 14.76 ± 0.14 <sup>c</sup>          | 25.0±1.73 <sup>d</sup>    | 44.0± 2.3 <sup>c</sup>   | 62.00 ±0.57 <sup>b</sup> | 70.0± 0.57 <sup>a</sup>   |
| GE               | 6.10± 0.05 <sup>g</sup>            | 6.70± 0.17 <sup>g</sup>   | 7.80± 0.46 <sup>g</sup>  | 10.40± 0.23 <sup>f</sup> | 13.40± 0.23 <sup>e</sup>  |
| GE + SL          | 3.00± 0.17 <sup>i</sup>            | 3.60±0.23 <sup>ih</sup>   | 5.60±0.23 <sup>gh</sup>  | 6.20± 0.10 <sup>g</sup>  | 6.30± 0.05 <sup>g</sup>   |
|                  | <b>Proteolytic x10<sup>5</sup></b> |                           |                          |                          |                           |
| C                | 29.0 ± 0.57 <sup>e</sup>           | 32.0± 0.57 <sup>d</sup>   | 41.0±0.57 <sup>c</sup>   | 44.33±0.88 <sup>b</sup>  | 62.0±1.15 <sup>a</sup>    |
| GE               | 8.2 ± 0.11 <sup>j</sup>            | 11.1± 0.4 <sup>i</sup>    | 12.8± 0.11 <sup>h</sup>  | 14.4± 0.23 <sup>g</sup>  | 17.6± 0.34 <sup>f</sup>   |
| GE + SL          | 4.2± 0.11 <sup>l</sup>             | 4.60±0.11 <sup>l</sup>    | 6.2± 0.11 <sup>k</sup>   | 7.20±0.23 <sup>kj</sup>  | 8.50± 0.001 <sup>j</sup>  |
|                  | <b>Lipolytic x10<sup>5</sup></b>   |                           |                          |                          |                           |
| C                | 27.70± 0.17 <sup>e</sup>           | 34.0±1.15 <sup>d</sup>    | 38.0± 1.15 <sup>c</sup>  | 41.0± 1.15 <sup>b</sup>  | 52.0± 1.15 <sup>a</sup>   |
| GE               | 9.20± 0.98 <sup>gh</sup>           | 9.20± 0.23 <sup>gh</sup>  | 11.0±0.50 <sup>fg</sup>  | 12.1± 0.11 <sup>f</sup>  | 12.80± 0.15 <sup>f</sup>  |
| GE + SL          | 3.30± 0.17 <sup>j</sup>            | 4.50± 0.11 <sup>ij</sup>  | 5.20± 0.11 <sup>ij</sup> | 5.60± 0.001 <sup>i</sup> | 8.0± 0.11 <sup>h</sup>    |

For each trait, means with different letters within each column and each row differed significantly (p<0.05). C=control, SL=sodium lactate, GE=ginger extract.

**Table 6**

The effect of adding rosemary extracts and sodium lactate on the change in sensory attributes of lamb patties during storage at -18°C for 150 days (means±s.e.).

| Days             | 1                         | 60                        | 90                          | 120                       | 150                        |
|------------------|---------------------------|---------------------------|-----------------------------|---------------------------|----------------------------|
| <b>Treatment</b> | <b>Color</b>              |                           |                             |                           |                            |
| C                | 3.25±0.25 <sup>cde</sup>  | 2.75±0.25 <sup>ef</sup>   | 2.50±0.28 <sup>gf</sup>     | 2.50±0.28 <sup>gf</sup>   | 1.75±0.25 <sup>h</sup>     |
| RE               | 4.25±0.25 <sup>b</sup>    | 3.50±0.28 <sup>cd</sup>   | 3.25±0.25 <sup>cde</sup>    | 3.00±0.001 <sup>def</sup> | 2.00±0.001 <sup>gh</sup>   |
| RE + SL          | 5.00±0.00 <sup>a</sup>    | 3.75±0.25 <sup>bc</sup>   | 3.50±0.28 <sup>cd</sup>     | 3.25±0.25 <sup>cde</sup>  | 3.0±0.001 <sup>def</sup>   |
|                  | <b>Flavor</b>             |                           |                             |                           |                            |
| C                | 3.25±0.25 <sup>def</sup>  | 2.75±0.47 <sup>ef</sup>   | 2.50 ±0.28 <sup>gf</sup>    | 2.50±0.28 <sup>gf</sup>   | 1.75±0.25 <sup>g</sup>     |
| RE               | 4.50±0.28 <sup>ab</sup>   | 4.0±0.001 <sup>abcd</sup> | 3.75 ±0.25 <sup>bcd</sup>   | 3.50±0.28 <sup>cde</sup>  | 3.25 ±0.25 <sup>def</sup>  |
| RE + SL          | 4.75±0.25 <sup>a</sup>    | 4.25± 0.25 <sup>abc</sup> | 4.0 ± 0.001 <sup>abcd</sup> | 3.75±0.25 <sup>bcd</sup>  | 3.50±0.28 <sup>cde</sup>   |
|                  | <b>Tenderness</b>         |                           |                             |                           |                            |
| C                | 3.25±0.25 <sup>edgf</sup> | 3.0± 0.40 <sup>gef</sup>  | 2.75 ±0.25 <sup>ghf</sup>   | 2.50±0.28 <sup>gh</sup>   | 2.0± 0.40 <sup>h</sup>     |
| RE               | 4.50±0.28 <sup>ab</sup>   | 4.25±0.25 <sup>abc</sup>  | 4.0±0.001 <sup>bcd</sup>    | 3.75±0.25 <sup>bcd</sup>  | 3.50±0.28 <sup>cdef</sup>  |
| RE + SL          | 5.0±0.001 <sup>a</sup>    | 4.50±0.28 <sup>ab</sup>   | 4.25 ±0.25 <sup>abc</sup>   | 4.0±0.001 <sup>bcd</sup>  | 3.75±0.25 <sup>bcd</sup>   |
|                  | <b>Juiciness</b>          |                           |                             |                           |                            |
| C                | 3.25±0.25 <sup>cd</sup>   | 2.75± 0.25 <sup>de</sup>  | 2.75 ±0.25 <sup>de</sup>    | 2.25±0.25 <sup>e</sup>    | 2.0± 0.40 <sup>e</sup>     |
| RE               | 4.50±0.28 <sup>ab</sup>   | 4.25±0.25 <sup>ab</sup>   | 4.0±0.001 <sup>abc</sup>    | 3.75±0.25 <sup>bc</sup>   | 3.25 ± 0.25 <sup>cd</sup>  |
| RE + SL          | 4.75±0.25 <sup>a</sup>    | 4.50± 0.28 <sup>ab</sup>  | 4.25 ± 0.25 <sup>ab</sup>   | 4.0±0.001 <sup>abc</sup>  | 3.75±0.25 <sup>bc</sup>    |
|                  | <b>Acceptance</b>         |                           |                             |                           |                            |
| C                | 3.25±0.25 <sup>cdef</sup> | 2.75±0.47 <sup>defg</sup> | 2.50 ±0.28 <sup>efg</sup>   | 2.25±0.47 <sup>fg</sup>   | 2.0 ±0.4 <sup>g</sup>      |
| RE               | 4.62±0.23 <sup>ab</sup>   | 4.25±0.47 <sup>abc</sup>  | 4.25 ±0.47 <sup>abc</sup>   | 4.0±0.001 <sup>abc</sup>  | 3.50 ± 0.28 <sup>cde</sup> |
| RE + SL          | 4.87±0.12 <sup>a</sup>    | 4.75± 0.25 <sup>ab</sup>  | 4.75 ± 0.25 <sup>ab</sup>   | 4.25±0.25 <sup>abc</sup>  | 3.75 ±0.25 <sup>bcd</sup>  |

For each trait, means with different letters within each column and each row differed significantly ( $p<0.01$ ). C=control, SL=sodium lactate, RE=Rosemary extract.

### Sensory Evaluation

The data on sensory evaluation of the lamb patties stored for 150 days at -18°C are shown in Tables 6 and 7. The overall acceptability, color and flavor of products was highest ( $p<0.01$ ) in treated samples as compared with the control treatment at the end of storage period. Similarly, Labell (1987) and Naveena and Mendiratta (2004) reported a significant ( $p<0.01$ ) improvement in flavor,

tenderness and overall palatability of GE-treated samples over the control. Such increase in flavor of GE treated samples could be attributed to flavor-producing reaction that occurs during cooking (Pawar *et al.*, 2007). Moreover, Abdel Hamied *et al.* (2009) and Sallam *et al* (2004) indicated that organoleptic properties of mined beef treated with rosemary were acceptable by the panelists compared to untreated samples.

**Table 7**

The effect of adding ginger extracts and sodium lactate on the change in sensory attributes of lamb patties during storage at -18°C for 150 days (means±s.e.).

| Days             | 1                         | 60                        | 90                        | 120                       | 150                       |
|------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| <b>Treatment</b> | <b>Color</b>              |                           |                           |                           |                           |
| C                | 3.25±0.25 <sup>cde</sup>  | 2.75±0.25 <sup>ef</sup>   | 2.50 ± 0.28 <sup>f</sup>  | 2.50±0.28 <sup>f</sup>    | 1.75 ±0.25 <sup>g</sup>   |
| GE               | 4.0 ±0.001 <sup>b</sup>   | 3.50 ±0.28 <sup>bcd</sup> | 3.25±0.25 <sup>cde</sup>  | 3.00 ±0.00 <sup>def</sup> | 2.50± 0.28 <sup>f</sup>   |
| GE + SL          | 4.75± 0.25 <sup>a</sup>   | 4.0 ±0.00 <sup>b</sup>    | 4.0 ± 0.00 <sup>b</sup>   | 3.75± 0.25 <sup>bc</sup>  | 3.25±0.25 <sup>cde</sup>  |
|                  | <b>Flavor</b>             |                           |                           |                           |                           |
| C                | 3.25 ±0.25 <sup>def</sup> | 2.75± 0.47 <sup>ef</sup>  | 2.50± 0.28 <sup>gf</sup>  | 2.50 ± 0.28 <sup>gf</sup> | 1.75±0.25 <sup>g</sup>    |
| GE               | 4.50± 0.28 <sup>ab</sup>  | 4.25± 0.25 <sup>abc</sup> | 4.00±0.00 <sup>bcd</sup>  | 3.75± 0.25 <sup>bcd</sup> | 3.50 ±0.28 <sup>cde</sup> |
| GE+ SL           | 5.00 ±0.00 <sup>a</sup>   | 4.50± 0.28 <sup>ab</sup>  | 4.25± 0.25 <sup>abc</sup> | 4.00±0.00 <sup>bcd</sup>  | 3.75±0.25 <sup>bcd</sup>  |
|                  | <b>Tenderness</b>         |                           |                           |                           |                           |
| C                | 3.25±0.25 <sup>cde</sup>  | 3.00± 0.40 <sup>de</sup>  | 2.75±0.25 <sup>ef</sup>   | 2.50± 0.25 <sup>ef</sup>  | 2.00±0.40 <sup>f</sup>    |
| GE               | 4.50±0.28 <sup>ab</sup>   | 4.25±0.25 <sup>ab</sup>   | 4.00± 0.00 <sup>bc</sup>  | 3.75± 0.25 <sup>bcd</sup> | 3.75±0.25 <sup>bcd</sup>  |
| GE + SL          | 5.00± 0.00 <sup>a</sup>   | 4.50±0.28 <sup>ab</sup>   | 4.25±0.25 <sup>ab</sup>   | 4.00± 0.00 <sup>bc</sup>  | 4.00±0.00 <sup>bc</sup>   |
|                  | <b>Juiciness</b>          |                           |                           |                           |                           |
| C                | 3.25± 0.25 <sup>de</sup>  | 2.75±0.25 <sup>ef</sup>   | 2.75 ± 0.25 <sup>ef</sup> | 2.25 ±0.25 <sup>f</sup>   | 2.00±0.40 <sup>f</sup>    |
| GE               | 4.50±0.28 <sup>ab</sup>   | 4.25±0.25 <sup>abc</sup>  | 3.75 ±0.25 <sup>bcd</sup> | 3.75 ±0.25 <sup>bcd</sup> | 3.50±0.28 <sup>cde</sup>  |
| GE + SL          | 4.75± 0.25 <sup>a</sup>   | 4.25±0.25 <sup>abc</sup>  | 4.25± 0.25 <sup>abc</sup> | 4.00±0.00 <sup>abcd</sup> | 4.00±0.00 <sup>abcd</sup> |
|                  | <b>Acceptance</b>         |                           |                           |                           |                           |
| C                | 3.25± 0.25 <sup>cde</sup> | 2.75±0.25 <sup>def</sup>  | 2.50 ± 0.28 <sup>ef</sup> | 2.25 ± 0.47 <sup>f</sup>  | 2.00± 0.40 <sup>f</sup>   |
| GE               | 4.25±0.25 <sup>ab</sup>   | 4.00 ±0.00 <sup>abc</sup> | 4.00 ±0.00 <sup>abc</sup> | 3.75 ±0.25 <sup>abc</sup> | 3.50± 0.28 <sup>bcd</sup> |
| GE + SL          | 4.50±0.28 <sup>a</sup>    | 4.25 ±0.25 <sup>ab</sup>  | 4.25 ±0.25 <sup>ab</sup>  | 4.25±0.25 <sup>ab</sup>   | 4.00±0.00 <sup>abc</sup>  |

For each trait, means with different letters within each column and each row differed significantly ( $p < 0.01$ ). C=control, SL=sodium lactate, GE=ginger extract.

Treatment with GE, and RE with or without SL also improved juiciness and tenderness scores of the patties (Tables 6 and 7). The improvement in juiciness in the treated samples may be due to an increase in water holding capacity (WHC) and the moisture retentions property of the added extract. Also, an improvement in juiciness of meat samples treated with GE or SE were reported by others Naveena and Mendiratta 2004 and AbdEl-Hamied

*et al* 2009). In the present study, results revealed that adding SL to both GE and RE improved all studied sensory attributes (Tables 6 and 7). Also, Rai and Xia (2008) showed that the samples treated with SL at 2% were superior in quality parameters. Moreover, Miller (1998) stated that juiciness in meat containing sodium lactate is not surprising, whole muscle meat containing SL has been shown to be more tender. A sodium lactate addition has been associated with increasing pH

that result in increased water holding capacity (WHC) and less cook losses, and the resultant meat would be more tenders. Also, sodium lactate has been shown to enhance the cooked pork flavor and to limit the subsequent decline in this aromatic during refrigerated storage, and to reduce the development of off- flavor associated with lipid oxidation (Miller, 1998).

#### 4. Conclusion

Results of the present study demonstrate that addition of natural antioxidants (rosemary and ginger) with sodium lactate to lamb meat shows a

preservation effect in precooked meat patties, stored under frozen condition, (-18 °C) for 150 days. Exerting a protective effect against lipid oxidation and inhibit microbial growth. Further result could investigate the combined application of rosemary and ginger in different meat products as well as the use of different quantities to those used in this study for optimization of the anti-oxidative effect. Also, further work on the mechanism of enzymes in plants, regulating the levels of bioactive components for food purposes is needed.

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