

# QUALITATIVE EVALUATION OF LAMB MEAT SAUSAGE PREPARED WITH DIFFERENT ANTIOXIDANTS

## Abstract

The present study is aimed to investigate fatty acids and microbial load in lamb meat sausage with different natural antioxidants. Lipid oxidation and the growth of undesirable microorganisms in food products result in the spoilage of flavor, rancidity, and deterioration of products unacceptable for human consumption. The experiment is carried out at the Animal Products and Processing Unit, Ladoko Akintola University of Technology, Ogbomoso, Oyo state, Nigeria. The present results show that the total bacterial count decreased significantly ( $p < 0.01$ ) with natural antioxidants included as the average bacterial load of the fresh and frozen samples of camel sausages were ( $3 \times 10^6$  and  $2 \times 10^6$  CFU/gm) respectively. For bacterial load, it is observed that the control (sample without natural antioxidants) had the highest load while moringa sausage with the least value greatly reduced the number of loads.

**Keywords:** Lamb meat, animal products, antioxidant, Lipid oxidation

## Introduction

Sausage is one of the oldest known forms of processed meat products and is very popular in many areas around the world. Sausages were invented to make the most of the leftovers of meat and entrails. Sausages can be defined as meat products that are manufactured by selecting, chopping, and mincing lean and fat, with or without offal, adding condiments, spices, additives, and starter culture (Leroy, 2006). The ingredients are stuffed into casings, ripened, cured, and in some cases smoked.

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). The most efficient and practical way to prevent oxidative and color deterioration of meat products is to incorporate antioxidants into formulations that could be natural or artificial (Kong *et al.*, 2010). Antioxidants are compounds or substances that can retard lipid oxidation and prolong the product's shelf life of meat (Nunez *et al.*, 2008). However, the application of synthetic antioxidants has been recently restricted because of the suspicion that they are carcinogenic. Natural antioxidants are various substances with different chemical characteristics, which are widely present in plants. Antioxidants retard or inhibit the oxidation of other substances by inhibiting the initiation or propagation of oxidizing chain reactions (Velioglu *et al.*, 1998). Some authors have reported that natural antioxidants do not affect the sensory characteristics of meat. Chaves *et al.*, (2008) did not detect any effect of essential oil compounds added to the diet of growing lambs. 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, 1994). Meat color has been reported as the most important factor when consumers assess meat quality since they relate color to freshness. However, color does not correspond to differences in

eating satisfaction (Carpenter *et al.*, 2001). Changes in meat color are due to **the** oxidation of red oxymyoglobin to metmyoglobin (MMG), which give **the** meat an unattractive brown color (Nerín *et al.*, 2006). 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). This study aimed at investigating **on** fatty acids and **the** microbial load of lamb meat sausage with different natural antioxidants.

## MATERIALS AND METHODS

The experiment was carried out at **the** Animal Products and Processing Unit, Ladoke Akintola University of Technology, Ogbomosho, Oyo state, Nigeria. The lamb meat was bought **from** Teaching and Research slaughter **Lab**, LAUTECH, and other ingredients such as spices, vegetable **oil**, and different natural antioxidants such as Garlic, Turmeric, Honey, **Ginger**, and Moringa were obtained from a local market in Ogbomosho, Oyo state.

**Table 1: Ingredients Composition of Lamb Sausage**

Ingredients	Control	Turmeric	Garlic	Honey	Moringa	Ginger
Lamb meat (mutton)	65	65	65	65	65	65
Binder (wheat flour)	20	20	20	20	20	20
Spices	3	1	1	1	1	1
Vegetable oil	6	6	6	6	6	6
Natural antioxidants	6	6	6	6	6	6
	-	2	2	2	2	2
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### Organoleptic evaluation

It was conducted using **10-member** trained panelists according to the procedures of AMSA (1995). Meat preparation was done using a wet cooking method. The prepared lamb sausages were served to **10-member** taste panels drawn from students in the Faculty of Agricultural **Science**, Ladoke Akintola University of Technology, Ogbomosho. The **semi-trained** panelists evaluated the samples for colour, flavour, juiciness, **tenderness**, and general acceptability. The assessment was based on a **9-point** hedonic scale. The score was arranged **in descending** order, **and** the maximum score **of 9** was given to **the** extremely like condition while the lowest score **of 1** was for the poorest condition.

### Chemical properties

Lamb sausage samples were analyzed for proximate composition and fatty acid profile by the procedures of AOAC (2002).

## Microbial assay

This was carried out following the procedures of APHA, (1992), Apata (2013), and AOAC, (2000). Colony forming units were counted and were expressed in log<sub>10</sub>cfu/g of samples for **the** Total Aerobic Counts (**TAC**), Total Coliform Counts (**TCC**), and Total Fungal Counts (TFC) while Gram-staining, motility test, and biochemical test techniques were conducted for clear identification as described by (Cheesebrough, 2000).

## Statistical analysis

All data collected from this study were subjected to a **one-way Analysis of Variance** (ANOVA) using the SAS (2000) analytical software.

## RESULTS AND DISCUSSION

**Table 2** Cooking yield of lamb meat sausage with different natural antioxidants

Samples	Cooking yield (%)
Control	96.36 <sup>a</sup>
Turmeric	95.83 <sup>a</sup>
Garlic	95.90 <sup>a</sup>
Honey	97.35 <sup>a</sup>
Moringa	93.73 <sup>b</sup>
Ginger	93.25 <sup>b</sup>
SEM	2.05

**Table 3** Organoleptic properties of lamb sausage prepared with different antioxidants

Parameters	Control	Turmeric	Garlic	Honey	Moringa	Ginger	SEM
Colour	4.50 <sup>ab</sup>	5.60 <sup>a</sup>	5.00 <sup>ab</sup>	3.60 <sup>b</sup>	4.50 <sup>ab</sup>	4.80 <sup>ab</sup>	0.24
Flavour	4.40 <sup>b</sup>	4.90 <sup>ab</sup>	6.30 <sup>a</sup>	4.20 <sup>b</sup>	4.00 <sup>b</sup>	4.30 <sup>b</sup>	0.26
Tenderness	4.60	5.00	5.90	5.10	5.60	5.80	0.21
Juiciness	3.30	3.80	4.40	3.40	4.00	4.20	0.25
Texture	4.50	5.20	4.30	4.40	4.80	4.50	0.25
Overall Acceptability	6.20 <sup>b</sup>	6.00 <sup>a</sup>	4.20 <sup>c</sup>	6.90 <sup>a</sup>	5.60 <sup>a</sup>	6.00 <sup>b</sup>	0.21

**Table 4** Proximate composition and lipid peroxidation of lamb sausage prepared with different natural antioxidants

Parameters	Control	Turmeric	Garlic	Honey	Moringa	Ginger	SEM
------------	---------	----------	--------	-------	---------	--------	-----

Crude protein	36.10 <sup>a</sup>	34.72 <sup>b</sup>	35.28 <sup>b</sup>	35.01 <sup>b</sup>	34.41 <sup>c</sup>	33.90 <sup>d</sup>
Ether extract	9.00	10.00	9.00	8.00	8.00	9.00
Ash	1.40	1.50	1.40	1.70	1.70	1.50
Dry matter	62.30 <sup>c</sup>	77.86 <sup>a</sup>	73.03 <sup>b</sup>	73.08 <sup>b</sup>	77.90 <sup>a</sup>	61.95 <sup>c</sup>
Moisture content	37.70 <sup>b</sup>	25.14 <sup>c</sup>	26.97 <sup>c</sup>	26.92 <sup>c</sup>	26.10 <sup>c</sup>	40.05 <sup>a</sup>
<b>Lipid peroxidation</b>	9.61 x 10 <sup>-03</sup>	1.28 x 10 <sup>-03</sup>	1.00 x 10 <sup>-04</sup>	2.00 x 10 <sup>-04</sup>	2.00 x 10 <sup>-04</sup>	3.00 x 10 <sup>-4</sup>

**Table 5 Fatty acid profile of lamb meat sausage prepared with different antioxidants**

Parameters (MEqL)	Control	<b>Turmeric</b>	Garlic	Honey	Moringa	Ginger	SEM
C12:0 SFA	4.22	6.11	4.30	2.00	4.34	6.05	
C18:0 SFA	5.69	8.53	5.49	2.84	5.64	8.63	
C16:0 SFA	5.42	7.79	5.16	2.56	5.12	7.69	
C24:0 SFA	7.37	11.25	7.37	3.68	7.57	11.05	
C17:0 SFA	5.45	8.12	5.44	2.70	5.41	8.21	
C 20:4n-6							
PUFA	6.48	9.23	6.68	3.04	6.58	9.13	
C18:3n-3							
PUFA	5.63	8.45	5.60	2.80	5.66	8.47	
C18:1n-9							
MUFA	5.67	8.47	5.65	2.82	5.55	8.47	
Total SFA	15.33	41.80	27.76	13.78	28.08	41.63	
Total PUFA	12.11	17.68	12.28	5.84	12.24	17.60	
Total MUFA	5.63	8.47	5.65	2.82	5.55	8.47	
Total FA	<b>33.07</b>	<b>67.95</b>	<b>45.69</b>	<b>22.44</b>	<b>45.87</b>	<b>67.70</b>	

**SFA- Saturated Fatty Acid**

**PUFA- Poly Unsaturated Fatty Acid**

**MUFA- Mono Unsaturated Fatty Acid**

**TFA- Total Fatty Acid**

**Table 6 Bacteria count of lamb meat sausage with different natural antioxidants**

Samples	Total Bacteria Counts (TBC) cfu/g x 10 <sup>6</sup>	Total Coliform Counts (TCC) cfu/g x 10 <sup>4</sup>	Total Fungi Counts (TFC) cfu/g x 10 <sup>3</sup>
<b>Control</b>	5.54 <sup>a</sup>	6.54a	6.12 <sup>a</sup>

<b>Turmeric</b>	1.24 <sup>c</sup>	4.32 <sup>b</sup>	5.32 <sup>b</sup>
<b>Garlic</b>	1.88 <sup>c</sup>	3.22 <sup>c</sup>	5.22 <sup>b</sup>
<b>Honey</b>	2.92 <sup>b</sup>	3.65 <sup>c</sup>	5.64 <sup>b</sup>
<b>Moringa</b>	1.19 <sup>c</sup>	2.76 <sup>d</sup>	2.34 <sup>c</sup>
<b>Ginger</b>	1.76 <sup>c</sup>	3.54 <sup>c</sup>	4.78 <sup>b</sup>
<b>SEM</b>	0.32	0.43	1.12

**Table 7 isolated**

<b>Samples</b>	<b>Characterized bacterial</b>
Control	<i>Pseudomonas aeruginosa</i>
Turmeric	<i>Pseudomonas aeruginosa</i>
Garlic	<i>Pseudomonas aeruginosa</i>
Honey	<i>Staphylococcus aureus</i>
Moringa	<i>Pseudomonas aeruginosa</i>
Ginger	<i>Proteus mirabilis</i>

## **RESULTS AND DISCUSSION**

### **Results**

Table 2 present the cooking yield of lamb meat sausage prepared with different natural antioxidants. The results revealed the sausage prepared with honey had the highest ( $p < 0.05$ ) coking yield (97.35%) while the least ( $p < 0.05$ ) value was found in those prepared with ginger (93.25%)

**The organoleptic** properties of lamb sausage prepared with different natural antioxidants are presented in Table 3. The results showed that tenderness, **juiciness**, and texture were not significantly affected ( $p < 0.05$ ) with the different antioxidants samples, while colour, **flavour**, and overall acceptability were significantly affected ( $p < 0.05$ ). The panelist rated turmeric, **garlic**, and honey **the highest** ( $p < 0.05$ ) for colour, **flavour**, and overall acceptability.

The proximate composition of lamb sausage prepared with different natural antioxidants is presented in Table 4. No significant ( $p > 0.05$ ) effects were reported in ether extract and ash while variations ( $p < 0.05$ ) were observed in Crude protein, dry **matter**, and moisture contents of the lamb sausage.

Table 5 shows the Fatty acid profiles of lamb meat sausage prepared with different natural antioxidants. The result showed that there were significant difference values in all the fatty **acids** analyzed except in **a few** parameters of the samples that have the same values. The highest value ( $p < 0.05$ ) was observed in turmeric (11.25) found in **lignoceric** acid and the lowest ( $p < 0.01$ ) was observed in **honey** with (2.00) in lauric acid. Control that has no inclusion of natural **antioxidants** has close values similar to garlic in all the parameters analyzed. Turmeric and ginger have the same values of (8.47) in oleic acid, also the same values were observed in control and garlic (7.37) in **lignoceric** acid. Ginger has the highest ( $p < 0.05$ ) values in all the parameters except in palmitic acid and **lignoceric** acid ~~that~~ turmeric values were higher.

Table 6 shows the microbial load of lamb sausage prepared with different natural **antioxidants**. The results showed significant ( $p < 0.05$ ) differences in the microbial load of the lamb sausage samples as the highest values ( $p < 0.05$ ) were reported in the control for TAC, TCC and TFC compared to those prepared with the antioxidants. **However**, the least values ( $p < 0.05$ ) were **observed** in sausage prepared with moringa.

## Discussion

In general, lamb meat sausages treated with different antioxidants were rated better in colour, **flavor**, and overall acceptability than the control. These are the criteria the consumers see in a **product** before buying and consuming the products. The results were in agreement with Mohamed and Monsour (2012) who reported that the flavor score of patties prepared without **the** addition of antioxidants **was** significantly ( $p < 0.05$ ) lower than those of other samples treated with antioxidants and **panelists** detected a rancid flavor in the patties formulated without the addition of antioxidants.

The lowest values obtained from the sample with honey were in agreement with those reported by Muguerza (2001), Campos (2007), Rubio (2007), and Del (2009). It was observed **from** the values obtained in honey that its chemical composition has **a low** significant effect on all the parameters of fatty acid analyzed while the sample with ginger suggests its chemical component greatly contributes to the fatty acid analyzed. The sausage products studied have n-6/n-3 ratios higher than those suggested by International Health Organizations, which is in agreement with Jimenez (2007), who reported that meat products show **that** n-3 PUFAs **are** present in very low levels. The polyunsaturated fatty acid (PUFA)/saturated fatty acid (SFA) ratio is one of the major parameters currently used to assess the nutritional quality of the lipid of foods. Fatty acids from each sample (control, turmeric, garlic, honey, **moringa**, and ginger) were affected by **the** inclusion of a specific natural antioxidant. An increase was observed for turmeric and ginger, while honey values decreased. **An increase** in polyunsaturated fatty acids (PUFAs) after cooking **has** been observed in other studies. Maranesi *et al.*, (2005) observed an increase in polyunsaturated fatty acid (PUFA) **in the ribs of loins** after boiling and microwaving followed by final grilling. Some authors (Gerber *et al.*, 2008; Igene *et al.*, 1981 and Rodriguez *et al.*, 1997) have found an increase in polyunsaturated fatty acid (PUFA) levels of meat and meat products after cooking due to the lipid losses, containing mainly triacylglycerols of adipose tissues with relatively more saturated fatty acid (SFA) than polyunsaturated fatty acid (PUFA), as suggested by Ramamurti (1986).

However, PUFA levels were much lower than those found in the sausage of the present study. Sarries *et al.*, (2009) found no changes in the relative distribution of fatty acids upon cooking beef from **with** diets designed to enhance the concentration of conjugated linoleic acid (CLA) in tissue. This suggests that the oil added during manufacturing might help stabilize the presence of fatty acids during cooking.

The addition of antioxidants **is**, therefore necessary to increase **the** storage stability, sensory **quality**, and nutritional value of animal products as reported by Kazimierczak, (2008); Ladikos and Lougovois, (1990). Due to the positive health effects of **long-chain** n-3 polyunsaturated fatty acids (PUFA), there is an increased interest to produce meat products rich in n-3 polyunsaturated fatty acids (Wood, 2003). Increasing the amount of easily oxidized

polyunsaturated fatty acid (PUFA) in animal **products, however**, will also require a higher content of antioxidants in the end-product to protect the nutritional valuable fatty acids (FA).

The present results showed that the total bacterial count decreased significantly ( $P < 0.01$ ) with natural **antioxidants** included as the average bacterial load of the fresh and frozen samples of camel sausages were ( $3 \times 10^6$  and  $2 \times 10^6$  CFU/gm) respectively. The sample with moringa has the lowest counts. This result was in agreement with that reported by **Abbas**, (2009). In general, results in this study showed that the total viable count for the sausage ranged between ( $5.54 \times 10^{18}$  and  $1.88 \times 10^{18}$ ), these results **are in** line with the findings of SSMO, (2008). The present results showed that total bacterial count decreased significantly ( $P < 0.01$ ) with natural **antioxidants** included, this result is matching with that reported by **Abbas** (2009). The contamination that increases the microbes comes from different sources, mainly hides, hoofs, air, water, **equipment**, intestinal **contents**, and slaughtering **floors** as reported by Ikeme, (1990). Very few bacterial genera can thrive under freezing conditions Judge *et al.*, (1989). Results of the total viable bacterial counts obtained in the present study were in agreement with standards suggested by **the** Oregon Department of Agriculture, (1973).

## CONCLUSION

It is observed from the result of this study that natural **antioxidants** in lamb meat sausage had varied **levels** of fatty acids. **Turmeric** sausages had **highly** increased **levels** of fatty acid due to **their** chemical composition and therefore have **a noticeable effect on the improvement of public health**.

For bacterial load, it is observed that **the** control (sample without natural **antioxidants**) had **the** highest load while moringa sausage with the least value greatly reduced the number of **loads**.

## RECOMMENDATION

This study, therefore, stresses the use of natural **antioxidants in-order** to reduce the number of microbes that may likely affect the quality and quantity of the meat product. **A natural** antioxidant **is a very good food** additive and therefore it should be incorporated **into** human foods.

## REFERENCES

- Abbas, M. O., (2009). Effect of adding different levels of citric acid on quality Attributes of fresh beef sausage. *Meat Science*. U.K.
- Adesiyun, A. A. (1993). Prevalence of *Listeria* spp., *Campylobacter* spp., *Salmonella* spp., and toxigenic *Escherichia coli* on meat and seafoods in Trinidad. *Food Microbiology*.10:345-403.
- Altekruse, S. F., Stern, N. J .Fields,P. I. and Swerdlow, D. L. (1999): *Campylobacter jejuni* – An emerging foodborne pathogen. *Journal Infectious Disease*. 5(1).
- Bozin, B, Mimica-Dukic, N, Samojlik, I, and Jovin, E.A. (2007), “Antimicrobial and antioxidant properties of rosemary and sage (*Rosmarinus officinalis* L. and *Salvia officinalis*).
- Carpenter, C.E, Cornforth, D.P. and Whittier, D. (2001). Consumer preferences for beef color and packaging did not affect eating satisfaction. *Meat Science*, 57: 359-363.

- Chaves, A.V, Stanford, K, Gibson, L.L, McAllister, T.A. and Benchaar, C. (2008). Effects of carvacrol and cinnamaldehyde on intake, rumen fermentation, growth performance, and carcass characteristics of growing lambs. *Animal Feed Science and Technology*, 145: 396-408.
- Cobos, A., Veiga, A., and Diaz, O. (2008). Chemical and lipid composition of deboned pieces of dry-cured pork forelegs as affected by desalting and boiling: The effects of vacuum packaging. *Food Chemistry*, 106, 951–956.
- Empey, W.A. and Scott, W.J. (1939). Investigation on chilled beef I. Microbial contamination acquired in the meat works. *Bull Science*. No. 126.
- Gerber, N., Scheeder, R. L., and Wenk, C. (2008). The influence of cooking and fat trimming on the actual nutrient intake from meat. *Meat Science*, doi:10.1016/j.meatsci.2008.07.012.
- Ibrahim, H.M., Abou-arab, A.A. and Abu Salam, F.M. (2010), “Addition of some natural extract and their effects on lamb patties quality”, *Journal of Food Technology*., 8:134- 142.
- Igene, J. O., Pearson, A.M., and Gray, J.I. (1981). Effects of length of frozen storage, cooking and holding temperatures upon component phospholipids and the fatty acid composition of meat triglycerides and phospholipids. *Food Chemistry*, 7(4), 289–303.
- Ikeme, A. I. (1990): Fermented sausage-dry and semi-dry. *Meat Science and Technology*. 1st edition. The African publishers Limited Nigeria. Pp 210.
- Judge, M.D.; Aberle, E.; Forrest, J.; Hedrick, H. and Merkel, R. (1990). *Principles of meat Science*. (2nd end.), Kendall/Hunt, Iowa, USA.
- Kong, B., Zhang, H., and Xiong, Y.L. (2010). Antioxidant activity of spice extracts in a liposome system and in cooked pork patties and the possible mode of action. *Meat Science*, 85: 772-8.
- Leroy, F., Verluyten, J., Vuyst, and L.D. (2006). Functional meat starter cultures for improved sausage fermentation. *International Journal of Food Microbiology*, 106: 270-85.
- Maranesi, M., Bochiccio, D., Montellato, L., Zaghini, A., Pagliuca, G., and Badiani, A. (2005). Effect of microwave cooking or broiling on selected nutrient contents, fatty acid patterns and true retention values in separable lean from lamb rib loins, with emphasis on conjugated linoleic acid. *Food Chemistry*, 90, 207–218.
- Mohamed, H.M. H and Monsor, H. A. (2012). Incorporating essential oils of marjoram and rosemary in the formulation of beef patties manufactured with mechanically deboned poultry meat to improve the lipid stability and sensory attributes. *LWT- Food Science and Technology*, 45, 79-87.
- McBride, N.T, Hogan, S.A, and Kerry, J.P. (2007) .Comparative addition of rosemary extract and additives on sensory and antioxidant properties of retail packaged beef. *International Journal of Food Science Technology*, 42: 1201-1207.

- Mielnik, M.B, Signe, S, Bjorg, E. and Grete, S. (2008), “By-products from herbs essential oil production as ingredient in marinade for turkey thighs”, *Food science Technology*, 41: 93- 100.
- Nakatani, N. (1994), Antioxidative and antimicrobial constituents of herbs and spices, *in: Spices, Herbs and Edible Fungi* (ed. G. Charalambous). Elsevier Science, New York, pp. 251—271.
- Nerín, C, L, Tovar, D, Djenane, J, Camo, J, Salafranca, J.A, Beltrán, L.O and Roncalés. P. (2006). Stabilization of beef meat by new active packaging containing natural antioxidants. *Journal of Agriculture and Food Chemistry*, 52:5598-5605.
- Nunez-Gonzalez, M, Boleman, R.M, Miller, R.K, Keeton, J.T. and Rhee, K.S. (2008). Antioxidant properties of dried plum ingredients in raw and precooked pork sausage. *Journal of Food Science*; 73(5): H63-71.
- Oregon Department of Agriculture (1973). Oregon meat bacterial criteria. Cited by Michael, H.W. In: Attitudes and policies of state governments. *Journal of Food Technology*.
- Pokorny, J. (2001), Introduction in Antioxidants in Food Practical Applications. CRC Press, Boca Raton, Boston, New York, pp. 1-3
- Ramamurti, K. (1986). Effects of cooking, freezing, and frozen storage on the fatty acid pattern of ground beef. *Food Technology*, 19(6), 477–481.
- Rodriguez-Estrada, M.T., Penazzi, G., Caboni, M.F., Bertacco, G., and Lercker, G. (1997). Effect of different cooking methods on some lipid and protein components of hamburgers. *Meat Science*, 45, 365–375.
- Sarries, M.V., Murray, B.E., Moloney, A.P., Troy, D., and Beriain, M. J. (2009). The effect of cooking on the fatty acid composition of longissimus muscle from beef heifers fed rations designed to increase the concentration of conjugated linoleic acid in tissue. *Meat Science*, 81, 307–312.
- Shehu, L. M. and Adesiyun, A. A.(1990): Characteristics of strains of *Escherichia coli* isolated from locally fermented milk (Nono) in Zaria, *Nigerian Food Journal Protection* 53:574-577.
- Sherwin, E.R. (1990). Antioxidants. In *Food Additives*, 1st Ed. (A.L. Branen, P.M. Davidson and S. Salminen, eds.), Marcel Dekker, Inc., New York, NY. 139-191.
- Skirrow, M B., and Blaser M.J. (1995): *Campylobacter jejuni*. Infections of the gastrointestinal tract. Raven Press, Ltd, New York, p.825.
- SSMO, (2008). Sudanese Standards Meteorology Organization. Khartoum, Sudan.
- Velioglu, Y.S, Mazza, G, Gao, L, and Oomah, B.D. (1998). Antioxidant activity and total phenolics in selected fruits, vegetables, and grain products. *Journal of Agriculture and Food Chemistry*, 46: 4113 - 4117.
- Waszkowiak, K, and Dolata, W. (2007). The application of collagen preparations as carriers of rosemary extract in the production of processed meat. *Meat Science*, 75: 178-83.