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Research Article

Effects of Sodium Citrate and Garlic on Organoleptic Properties, Proximate Composition, Free Fatty Acid and Thiobarbituric Acid Levels of Treated Smoke-Dried Meat Stored at Ambient Temperatures

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Abstract

The objective of this study is to determine the possible effects of varying levels of sodium citrate and garlic paste on composition and quality parameters of treated smoke dried meat stored at ambient temperature for twelve (12) weeks. Results obtained indicate that the treatments significantly ($p \leq 0.5$) retained the proximate composition (fat, protein and ash), and significantly reduced ($p \geq 0.5$) the spoilage indices measured by the thiobarbituric acid (TBA) and free fatty acid (FAA) levels in the meat products, with the best effects recorded in the samples treated with the combination of 0.4% and 2.0% sodium citrate and garlic paste, respectively. Also, results of the organoleptic analysis showed that samples treated with the combination of sodium citrate and garlic paste were scored better in terms of taste, colour, texture and overall acceptability when compared with the other

treatments and untreated control sample (A). It was concluded that combination of 0.4% and 2.0% sodium citrate and garlic paste, respectively, could be used to extend the shelf life of fresh meat, especially if smoke-dried.

Introduction

Meat is defined by the Codex Alimentarius as "all parts of an animal that are intended for, or have been judged as safe and suitable for, human consumption". Meat contains a number of important nutrients that are needed by human body for carrying out vital metabolic functions. These are proteins, fat, vitamins, minerals and other bioactive components, and small quantities of carbohydrates. From the nutritional point of view, meat's importance is derived from its high quality protein, containing all essential amino acids and it's highly bioactive minerals and vitamins [1-3]. All these nutrients are responsible for providing the body with energy and keeping it healthy.

The most common sources of meat are domesticated animal species such as cattle, pigs and poultry and to a lesser extent buffaloes, sheep and goats. In some regions of the world other animal species such as camels, yaks, horses, ostriches and game animals are also eaten as meat. To a limited extent, meat is also derived from exotic animals such as crocodiles, snakes and lizards [3]. The total meat production in developing countries increase from 30 million tones in 1970 to 69 million tones in 1990, and it was projected to reach 105 million tons in 2010 according to FAO projections [3]. Furthermore, world meat production is projected to double by 2050, most of which is expected in developing countries, including Nigeria. The growing meat market provides a significant opportunity for livestock farmers and meat processors in these countries. Nevertheless, increasing livestock production and the safe processing and marketing of hygienic meat and meat products is lacking and represent a big challenge. The steadily growing world population and increasing incomes creates higher demand for meat, but at the same time leaves limited space for expansion in livestock production [4]. Therefore, the maximum utilization of existing meat resources becomes even more important.

Meat is a highly perishable food which needs proper handling and preservation if it is to have a long shelf-life and retain a desirable quality and nutritional value. The spoilage of meat occurs, if untreated, in a matter of hours or days and results in meat becoming unappetizing, poisonous or infectious [5,6]. Spoilage of meat is caused by practically unavoidable infection and subsequent decomposition of meat by microorganisms (bacteria, moulds and yeasts), which are borne by the animal itself, by the people handling the meat, and by the handling implements [7-10]. In addition, the conditions under which animals are slaughtered in developing countries are often unhygienic - animals may be slaughtered and displayed for sale in the open air without any covering, making it possible for micro-organisms to be transmitted by flies, other animals, birds and even the meat handlers themselves [11,12]. Meat, like fish and milk, is low-acid, moist food which provides a good medium for the growth and multiplication of bacteria, yeasts and moulds (Thippareddi and Sanchez, 2006) [11]. This may lead to rapid deterioration of fresh meat in tropical environments and, fresh meat therefore has a very short-life in those climates. Therefore, in all meat processing, the aim is twofold: to preserve the meat for a longer storage life, to change the flavour and texture as well as to increase variety in the diet. The major methods of preserving meat include freezing, smoking, drying, chemical preservation and heat treatment such as canning (Thippareddi and Sanchez, 2006) [10,11,13,14].

Use of an appropriate preservation technique offers opportunity of overcoming the two main constraints to a better supply of livestock products, namely availability and affordable price.

Smoking is a method of preparing particularly red meat (and fish) which originates in prehistory. In smoking, the effects of heat from the smoke, and chemicals in the smoke, combine to preserve the meat. Smoke also adds distinctive and attractive flavours and colours to the meat - especially when used in combination with other preservatives of plant or chemical origin such as garlic or sodium citrate [3,10,14].

Garlic is an herb which can be grown easily all year-round in mild climates. Garlic is botanically known as *Allium sativum*. It is widely used around the world for its pungent flavor as a seasoning or condiment and possibly due to its anti-microbial actions [14-16]. Although native of Mediterranean region, Asia, Americas, Africa and Europe, garlic is usually grown under irrigation by farmers as cash crop in savannah zone of Nigeria between the months of November and March when there is cool, dry weather conditions that favour growth and high crop yield [17,18].

On the other hand, sodium citrate (E331) refers to any of the sodium salts of citric acid (such as monosodium, disodium or trisodium citrates) that are commonly used as food preservatives. Sodium citrates are usually called sour salts to distinguish them from the common salt which is sodium chloride (NaCl). There are several reports indicating that sodium citrates may have desirable properties that may improve appearance, flavour retention, storage life and limiting microbial activity in treated meat (Fisher and Scott, 1997) [19]. The use of a combination of garlic and sodium citrate in meat smoking may be beneficial in improving the storage life of the smoked product. Although, their effects have been investigated separately, the literature on their combined effects is scanty. Therefore the objective of this study is to investigate the possible effects of sodium citrate and garlic on sensory and storage stability of smoked-dried lean meat.

Materials and Methods

Acquisition of Meat Sample and the Curing Ingredients

Four (4) kilograms of the front quarter of a beef carcass were purchased directly from Maiduguri abbatoir and transported aseptically to the Food Science and Technology Laboratory, University of Maiduguri; similarly, an adequate quantity of the garlic (*Allium sativum*) was purchased from the popular Maiduguri Monday Market, while the food grade sodium citrate (Monsonto, St Louis, mo, USA) was obtained from a chemical supply store in Maiduguri.

Preparation of the Meat Sample

The meat was properly trimmed off of adhering visible fatty tissues which could speed-up the rate of spoilage through oxidative rancidity, and also the connective tissues which could result to a tough final product; thoroughly washed with distilled water to remove dirt, extraneous matters and also to minimize the surface microbial contaminant (Figure 1). Finally, the meat was cut into cubes of eight (8) cm long and seven (7) cm wide. Five (5) treatments (A, B, C, D, and E) were carried out on six (6) cubes of the meat (the average weight of each cube was 120g). Treatment A was the control (Table 1), B was treated with 0.2% (w/w) sodium citrate, C with 2.0% (w/w) garlic, D with a combination of 0.2% sodium citrate and 2.0% garlic,

while sample E was treated with a combination of 0.4% and 2.0% sodium citrate and garlic, respectively. The samples were soaked in the various concentrations of sodium citrate and/or the garlic solution for two (2) hours. At the end of the soaking process, the samples were allowed to drain for five (5) minutes at the prevailing ambient temperatures (29 - 32°C) before weighing them again to determine the amount of moisture absorbed during the curing process (Figure 1).

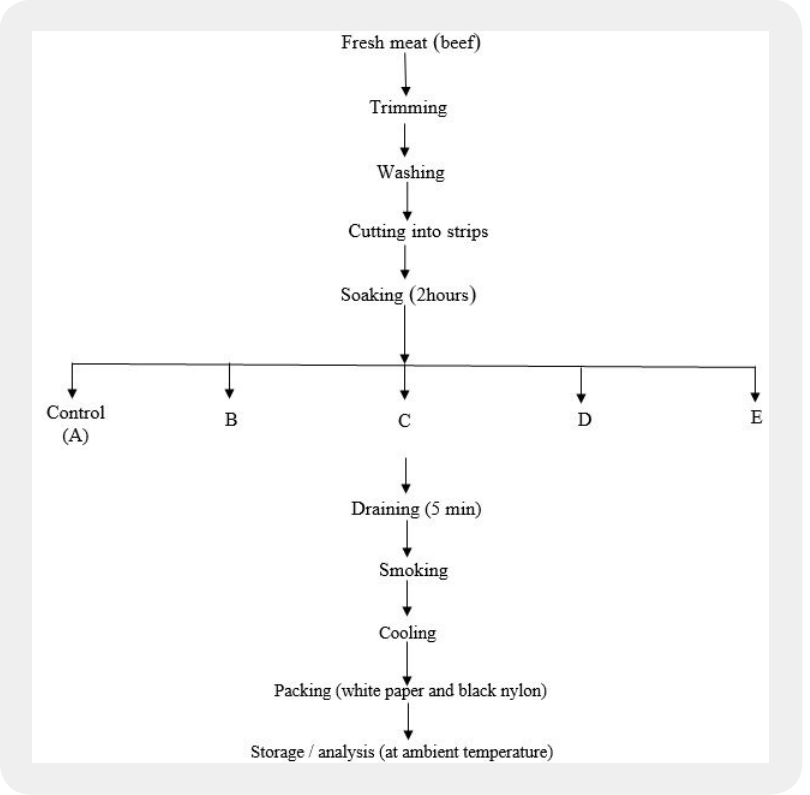

Figure 1: *Flow Chart for the Preparation and Smoking of the Meat Samples (B = 0.2% sodium citrate (sc); C = 2.0% garlic (g); D = 0.2% sc + 2.0% g; and E = 0.4% sc + 2.0% g (Modified from Negbenebor et al., 1999)[20]*

Table 1: *Concentration of the Sodium Citrate and Garlic used in the Treatment of the Meat Samples*

	Treatment Concentration (%)	
Sample Code[1]	**Sodium Citrate**	**Garlic Paste**
A	0.0	0.0
B	0.2	0.0
C	0.0	2.0
D	0.2	2.0
E	0.4	2.0

[1]A = Control; B = 0.2% sodium citrate (sc); C = 2.0% garlic (g); D = 0.2% sc + 2.0% g; and E = 0.4% sc + 2.0% g

Smoking of the Meat Samples

The treated meat samples were smoked in an Altona type oven, available in the smoke house of the Food Science and Technology Department, as described by Igwegbe *et al.* (2015) [21]. The smoker was fueled by sawdust or wood shavings [22] purchased from Baga timber market, Maiduguri, and smoking lasted for 8 to 12 hours at 55 to 60°C (the final product was not only smoked but also dried). The smoked samples were cooled under sterile conditions, wrapped separately with white paper which served as primary package before putting them in black polythene bags that served as secondary packages. Samples were stored for 12 weeks at ambient temperatures ranging from 29 - 35°C and a prevailing relative humidity (RH) of 70±5%. The proximate, free fatty acid, thiobarbituric acid and organoleptic analyses were conducted at three weeks intervals starting from zero to the end of the 12 weeks of storage period.

Physical Observation on the Meat Samples

The length and width of the fresh and processed meat were measured using a ruler while the thickness was measured using Vernier Caliper. The weight of each sample was determined using an automatic weighing balance (Metler Tolado AG 240).

Chemical Analysis of the Processed Meat

Free Fatty Acid (FFA) and Thiobarbituric Acid (TBA) Determination

Fat was extracted from five (5) grams of ground processed meat samples in a Soxhlet apparatus using hexane and heating until all the fat in the samples were extracted. The solvent was distilled off and the weight of the recovered fat was recorded. The acid value and the free fatty acid (FFA) were determined as outlined in AOAC, 2000 and Padre *et al.*, 2007) [23,24]. Approximately 1g of the fat sample was dissolved on 10ml of neutral ethanol and titrated with 0.1N KOH solution in the presence of 1% phenolphthalein indicator until a persistent pink colour was observed. The acid value and the FFA were calculated using the following equation:

Acid value = 56 x the molarity of KOH / weight of fat;

FFA as oleic acid % = 0.503 x titre value of acid (volume of 0.1N KOH consumed in the titration).

On the other hand, thiobarbituric acid (TBA) test is the most widely used tests for determining the extent of lipid oxidation. It measures the concentration of relatively polar secondary reaction products, i.e., aldehydes. In this study, thiobarbituric acid test for the level of rancidity in the processed meat was determined by the water extraction method as described by Igene and Tukur (1986) [25], with modification. Approximately 0.2883g of TBA reagent was dissolved in one litre of distilled water to obtain 0.02M. Ten grams of ground processed meat sample was mixed with 50ml of distilled water and blended for 2 minutes and the resultant slurry was quantitatively transferred into a clean beaker with additional 50ml of distilled water. The slurry was then filtered into a 100ml volumetric flask and the volume was made up to the mark with distilled water used in washing the filter paper. Five (5) ml of the filtrate was transferred into diluent bottles and five (5) ml of the TBA reagent was added, and the mixture was boiled for 40 minutes in a hot water bath at 100°C.

Blank was prepared exactly in the same manner but without the treated meat sample. The absorbance of the extract was measured with a spectrophotometer (SpectrumLab 22 PC) at the wavelength of 532 nanometers after standardizing the instrument with the TBA reagent. The TBA value was obtained using the following equation:

TBA value = Optical density (OD) x 1.44.

Proximate Analysis

The processed meat samples were analyzed for moisture, protein, fat and ash contents. The moisture, protein, fat and ash contents were measured in accordance with the procedures outlined in AOAC, 2000, Nielson, 2010, and Alwan *et al*., 2014 [23,26,27]. Protein was determined through the quantification of the nitrogen content by the standard Micro-Kjeldahl method [27,28] and multiplying the total nitrogen obtained by a conversion factor of 6.25 to arrive at protein content. Fat content was determined by the Soxhlet extraction method using petroleum ether [23,27]. The ash content was determined following the procedures described by Igwegbe *et al*. (2013) [29].

Sensory Evaluation of the Meat Product

Sensory evaluation of the meat product was undertaken to determine the taste, colour, texture, aroma and overall acceptability of the treated meat products. A total of fifteen (15) taste panelists consisting of students and staff of the University of Maiduguri who are familiar with the desirable and undesirable characteristics of spiced smoked-dried meat, were deployed in the sensory evaluation. Each panelist was asked to evaluate the five coded samples (A, B, C, D, and E randomly presented) and to score each product for preference on a 9-points hedonic scale with 9 representing extremely liked and 1 representing extremely disliked. The panelists were further asked to indicate any observed difference in visual appearance (texture, aroma, and colour) and extent of variation among the products [30,31].

Statistical Analysis

The data generated from the experiments were subjected to analysis of variance (ANOVA) as described by Steel and Torrie (1980) [32], while tests for significant differences between means were determined using Duncan's Multiple Range Test [33] at 5% level of significance.

Results and Discussion

The proximate composition generally means the percentage composition of five major constituents of a food such as water, protein, fat, carbohydrate and ash. The energy-yielding nutrients such as protein, fat and carbohydrate are usually considered as macronutrients that are present in high levels; whereas the non energy-yielding nutrients like vitamins and minerals are referred to as micronutrients and are usually present in small quantities. Proximate composition of meat not only varies widely depending on several factors including maturity stage, season and feeding regimes, but also in different sexes. In the present study, The results of the proximate analyses indicate that the fresh meat used in this study was of an average quality, with mean percent contents of 74.60±1.33, 22.18±0.25, 1.80±0.17, and 1.20±0.18 moisture, protein, fat and

ash, respectively, which are in line with the results of similar studies reported by other researchers [3,5,24,34-38]. Moreover, the treatments and subsequent smoke-drying resulted in a significant decrease ($p \leq 0.05$) in percent moisture contents and highly significant increase ($p \geq 0.05$) in percent protein, fat and ash contents when compared with the fresh raw and processed meat samples (Table 2). As can be seen in Table 2, there was a dramatic and highly significant increase ($p \geq 0.05$) in percent of protein, fat and ash contents compared with fresh raw samples. The increase in these three major components was inversely related with the decrease in percent moisture contents. This last observation was in line with the findings of Igene (1986) [25]. It is well known that heat treatment of meat usually results in coagulation of proteins - particularly on the surface of the muscle, followed by protein denaturation which in turn leads to structural changes that affect their solubility in the meat system. Similarly, the fat content in meat is highly variable and is dependent on the amount of fat removed from the muscle during preparation of the meat cut. The higher retention of protein and fat recorded in the processed samples in this study suggests that the two preservatives, sodium citrate and garlic, might have exerted some degrees of protection against protein and fat denaturation and melting out / oxidation, respectively. The highest percent protein, fat and ash contents 59.97±1.02, 12.59±1.02, and 7.87±0.21, respectively, were recorded in processed meat samples treated with the combination of sodium citrate and garlic (Table 2).

Table 2: *Effect of Sodium Citrate and Garlic on Proximate Composition (%) of Fresh and Treated Smoke-Dried Beef*[1]

Proximate Composition(%)[2]				
Samples[3]	**Moisture**	**Protein**	**Fat**	**Ash**
Fresh meat	74.60±1.33[a]	22.18±0.25[a]	1.80±0.17[a]	1.20±0.18[a]
A	24.58±1.00[b]	57.55±2.11[b]	10.54±1.05[b]	6.58±0.21[b]
B	20.84±1.20[c]	58.97±1.22[c]	12.51±0.98[c]	7.08±0.20[c]
C	21.85±1.30[c]	59.02±1.23[c]	11.00±1.08[c]	7.50±0.20[c]
D	19.38±1.33[c]	59.33±1.00[c]	12.59±1.02[c]	7.29±0.19[c]
E	19.93±1.30[c]	59.97±1.02[c]	11.70±1.00[c]	7.87±0.21[c]

[1]Values are means of three determinations;
[2]In every column, means bearing different superscripts are significantly different ($p \leq 0.05$)
[3]A = Control; B = 0.2% Sodium citrate; C = 2% garlic; D = 0.2% sodium citrate and 2% garlic; E = 0.4% sodium citrate and 2% garlic.

Similarly, the spoilage of meat occurs if the meat is not treated in a matter of hours or days, and that would result in the meat becoming unappetizing, poisonous or even infectious. Spoilage may be caused by practically unavoidable infection and subsequent decomposition of the meat by bacteria, mould and yeast, which are borne by the animal itself, by the meat handlers themselves, and by the implements that come in contact with the meat during meat handling. The result of the present study has shown that meat could be kept edible for a much longer time, though not indefinitely, if proper hygienic measures are observed during slaughtering and processing, and if appropriate safety, good manufacturing practices and proper storage procedures are applied. Table 3 indicates that without the application of preservatives and stabilizers, the fats

in meat, as represented by the levels of TBA, may also begin to decompose rapidly after processing, leading to an objectionable quality product. In this Table, combination of smoking and treatment with sodium citrate and garlic was observed to significantly reduce the oxidative decomposition of fat in the treated samples. On Table 3, it is observed that the TBA values continuously decreased from the third week up to the ninth week, indicating that the smoking process effectively and significantly ($P \leq 0.05$) reduced the extent of oxidative decomposition of fat in the smoked meat. Also, the levels of TBA were significantly decreased ($P \leq 0.05$) in the meat samples treated with the combination of (0.2%) sodium citrate and (0.2%) garlic when compared with the TBA levels in untreated control samples. Moreover, increasing the level of sodium citrate to 0.4% in combination with 0.2% garlic did not result to additional reduction in the levels of the TBA up to the ninth week (Table 3). Lipids are one of the major constituents of foods, and are important in our diet for a number of reasons. They are major sources of energy and provide essential lipid nutrients. Nevertheless, over-consumption of certain lipid components can be detrimental to our health, e.g. cholesterol and saturated fats as has been observed by researchers including Simopoulos *et al*. (1999); Alfaia *et al*. (2007); Barton *et al*. (2007) and Muchenje *et al*. (2009) [5,39-41]. In many foods the lipid component plays a major role in determining the overall physical characteristics, such as flavor, texture, mouthfeel and appearance as reported by Fisher *et al*. (2000); Wood *et al*. (2003); Calkins and Hodgen (2007) and Nohr Biesalski (2007) [42-45]. However, many fats are prone to lipid oxidation, which leads to the formation of off-flavors and potentially harmful products. Foods which contain high concentrations of unsaturated lipids are particularly susceptible to lipid oxidation. Lipid oxidation is an extremely complex process involving numerous reactions that give rise to a variety of chemical and physical changes in the lipid components. Without the application of preservatives and stabilizers, the fats in meat may also begin to rapidly decompose after cooking or processing, leading to an objectionable taste known as warmed over flavor.

Table 3: *Effect of Sodium Citrate and Garlic on 2-Thiobarbituric Acid Value (ppm) of Smoked-Dried Beef stored at Ambient Temperature for Twelve Weeks*[1]

	Storage Period (Weeks)[2]				
Sample[3]	**0**	**3**	**6**	**9**	**12**
A	2.16 ± 0.21^{a}	1.88 ± 0.18^{a}	1.58 ± 0.11^{a}	0.85 ± 0.06^{a}	1.42 ± 0.13^{a}
B	1.46 ± 0.11^{b}	1.31 ± 0.14^{b}	1.14 ± 0.09^{b}	0.48 ± 0.03^{b}	0.85 ± 0.06^{c}
C	2.00 ± 0.20^{a}	1.85 ± 0.16^{a}	1.53 ± 0.20^{a}	0.49 ± 0.03^{b}	1.36 ± 0.12^{b}
D	1.42 ± 0.13^{b}	1.29 ± 0.12^{bc}	1.14 ± 0.08^{b}	0.41 ± 0.01^{b}	1.09 ± 0.10^{bc}
E	1.06 ± 0.10^{b}	0.92 ± 0.06^{c}	0.76 ± 0.05^{c}	0.35 ± 0.01^{b}	0.70 ± 0.06^{cd}

[1]Values are means of three determinations;
[2]In every column, means bearing different superscripts are significantly different ($p \leq 0.05$)
[3]A = Control; B = 0.2% Sodium citrate; C = 2% garlic; D = 0.2% sodium citrate and 2% garlic; E = 0.4% sodium citrate and 2% garlic.

On the other hand, Table 4 shows that the initial value of free fatty acid (FFA as oleic acid %) immediately after processing (week 0) ranged between 0.70-1.76 and from 1.10-2.65 at the end of the storage period (12 weeks). Sample A which is the control had significantly higher ($p \leq 0.05$) free fatty acid content than the

treated samples (B, C, D, and E). The highest anti-oxidative effects was recorded from the samples treated with the combination of sodium citrated and garlic, that is samples D and E; with sample E exhibiting the highest effects in the reduction of free fatty acid (Table 4). The term rancidity is sometimes used to refer to any change in fats or oils that is accompanied by undesirable flavours and odors, regardless of the cause. As a result of these changes, consumer acceptance of the product is lowered. Rancidity may however, be caused by either hydrolytic or oxidative changes in the fat component. Hydrolytic rancidity involves chemical or enzymatic hydrolysis of fats into free fatty acids and glycerol; while oxidative rancidity involves the addition of atmospheric oxygen, which may be catalyzed by various metals, by moisture or even microorganisms; such oxidation can be prevented or delayed by natural or added antioxidants as observed in this study. Hydrolytic activity is important in dairy products as observed by Alwan and Igwegbe (2014) [26]. The present study has shown that increasing the levels of sodium citrate in combination with garlic significantly reduced fat oxidation, as determined by the percent free fatty acids, up to the twelfth week, when compared with other treatments (Table 4). The level of free fatty acid in processed meat is another indication of the extent of fat oxidation in the product, and affects sensory characteristics of the product. The ranges of the free fatty acids obtained in this study are within the values of 1.54 to 4.64 reported by other researchers including Aldai *et al.* (2006), Alfaia *et al.* (2007) and Muchenje *et al.* (2007) [34,39]. In the present study, the lower values of free fatty acids recorded in the treated smoked-dried meat stored for a period of 12 weeks could be attributed to the combined anti-oxidative effects of the smoke components, sodium citrate and the garlic. And the combination of 0.2% sodium citrate and 2% garlic (treatment E) was found to be most effective in reducing free fatty acid values.

Table 4: *Effect of Sodium Citrate and Garlic on the Free Fatty Acid (FFA) Value of Smoke- Dried Beef Stored at Ambient Temperatures for Twelve Weeks*[1]

	Storage Period (Weeks) / FFA Value[2]				
Sample[3]	**0**	**3**	**6**	**9**	**12**
A	1.76±0.03^{a}	2.06±0.20^{a}	2.36±0.13^{a}	2.63±0.33^{a}	2.65±0.23^{a}
B	1.26±0.10^{bc}	1.48±0.11^{bc}	1.73±0.20^{bc}	1.81±0.12^{bc}	1.86±0.21^{bc}
C	1.35±0.10^{b}	1.66±0.20^{ab}	2.16±0.22^{ab}	2.57±0.15^{a}	2.06±0.33^{a}
D	0.96±0.02^{cd}	1.11±0.22^{cd}	1.31±0.12^{cd}	1.41±0.23^{cd}	1.50±0.23^{cd}
E	0.70±0.02^{d}	0.81±0.01^{d}	0.90±0.11^{d}	1.01±0.02^{d}	1.10±0.22^{d}

[1]Values are means of three determinations;

[2]In every column, means bearing different superscripts are significantly different ($p \leq 0.05$)

[3]A = Control; B = 0.2% Sodium citrate; C = 2% garlic; D = 0.2% sodium citrate and 2% garlic; E = 0.4% sodium citrate and 2% garlic.

Finally, the sensory, as well as the nutritional properties are the most important motivators for liking and purchase of processed meat. Components of the palatability of meat products include tenderness or ease of mastication, juiciness and flavour. Also, aroma, or the impression that one forms on the first bite of the processed meat is an important sensory characteristic. In the present study, Table 5 shows that sample C scored significantly higher ($p \leq 0.05$) than the control and other treated samples with regards to aroma, while

samples C, D and E scored significantly higher ($p \leq 0.05$) than the control in terms of texture, taste, colour and overall acceptability. The observed higher aroma in samples C, D and E could be, without doubt, due to the strong and pungent odor which is contained in garlic. Also, sample E was rated highest in terms of taste and overall acceptability (Table 5). The sensory scores recorded in this study are within the ranges reported in literature, including those of Monson *et al.* (2005) and Muchenje *et al.* (2008b) [31,46], in terms of taste, aroma and overall acceptability. Throughout recorded history, application of heat to meat increases the palatability in addition to extending the storage life of the treated meat. Other benefits associated with the heating process such as smoke-drying applied in this study, include better flavor, palatability and texture, extended durability, colour modification and desirable organoleptic characteristics. In addition, the flavour and aroma of processed meat are dependent on many other factors including the species and part of the carcass used, spices used, and amount and kind of fat in the muscle [24]. Other flavours are produced by Maillard-type reactions on the surface of the meat products as observed by Ranken (2000) [11].

Table 5: *Effects of Varying Levels of Sodium Citrate and Garlic on the Sensory Attribute Scores of the Smoked-dried Beef*[1]

Sensory Attributes[2]					
Sample[3]	**Taste**	**Colour**	**Texture**	**Aroma**	**Overall Acceptability**
A	7.75 ± 0.10^{c}	6.60 ± 0.12^{c}	6.66 ± 0.01^{c}	6.60 ± 0.20^{c}	7.27 ± 0.15^{c}
B	7.80 ± 0.01^{c}	6.90 ± 0.10^{bc}	7.00 ± 0.02^{c}	7.25 ± 0.22^{b}	7.50 ± 0.13^{bc}
C	7.84 ± 0.10^{bc}	7.00 ± 0.01^{b}	7.25 ± 0.02^{bc}	8.25 ± 0.12^{a}	7.75 ± 0.13^{b}
D	8.00 ± 0.02^{b}	7.25 ± 0.01^{ab}	7.75 ± 0.02^{b}	8.00 ± 0.13^{a}	8.30±0.20a
E	8.25 ± 0.10^{a}	7.50 ± 0.13^{a}	8.25 ± 0.11^{a}	8.05 ± 0.13^{a}	8.50 ± 0.23^{a}

[1]Values are means of scores from fifteen (15) panelists;
[2]In every column, means bearing different superscripts are significantly different ($p \leq 0.05$)
[3]A = Control; B = 0.2% Sodium citrate; C = 2% garlic; D = 0.2% sodium citrate and 2% garlic; E = 0.4% sodium citrate and 2% garlic.

Conclusion

All foods undergo varying degrees of deterioration during storage. Deterioration may include losses in organoleptic desirability, nutritional value, safety, and aesthetic appeal. Foods may change in color, texture, flavor, or any quality attributes depending on the method of processing, condition and length of storage. This study has clearly indicated that smoke-drying in combination of additives such as sodium citrate and garlic can significantly reduce spoilage in processed meat caused by fat oxidation and the resultant free fatty acids, thereby maintaining the quality characteristics of the processed meat and extending the shelf life of the fresh meat. The higher the levels of sodium citrate and garlic, the better the preservative effects observed.

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