EFFECT OF CITRIC ACID AND CLOVE ON CURED SMOKED MEAT (A TRADITIONAL MEAT PRODUCT)

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RESEARCH ARTICLE

EFFECT OF CITRIC ACID AND CLOVE ON CURED SMOKED MEAT (A TRADITIONAL MEAT PRODUCT)

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ABSTRACT

Smoking of meat enhances the taste and appearance of meat. It also increases its shelf life by slowing down the deterioration of fish fats and reduction in growth of bacteria. Lean meat from the forequarter of beef carcass was obtained from the Maiduguri abattoir. The meat was cut into four portions of weight ranging from 525 - 545 g. It was then diced into bits each measuring 8cm (length), 3.5 cm (thickness) and 64.5g (weight). Meat samples were then washed, cured with various concentration of sodium chloride, sodium nitrate, citric acid and clove for 30 min, drained and smoked in a smoking kiln at a temperature of 60^0C for 8 hr a day for 3 days. The products were stored at ambient temperature and evaluated microbiologically and organoleptically. The results showed an increase in pH, free fatty acid content and a decrease in water holding capacity and microbial count of the cured smoked meat. The panellists rated control samples significantly ($p < 0.05$) higher in terms of colour, texture, taste and overall acceptability than all the samples. The following organisms were isolated and identified during storage: *Bacillus subtilis*, *Streptococcus spp*, *Pseudomonas spp*, *Aspergillus niger*, *Candida* and *Penicillium* spp. The study forms a basis for new product development for the meat industry.

KEYWORDS— citric acid, clove, smoked meat

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INTRODUCTION

Meat is the flesh of animals used as food (Anonymous, 2014). Meat can be define as the whole or part of the carcass of any buffalo, camel, cattle, deer, goat, hare, sheep, poultry, or rabbit, slaughtered, but does not include eggs, or fetuses (Williams, 2007). Meat is one of the most popular and nutritious food items which come from flesh of animals that are suitable as food (Forest *et al*., 2001). Fresh meat and meat products are susceptible to chemical deterioration and microbiological spoilage and therefore represent a high risk for consumer health, in addition to producer economic losses (Irais *et al*., 2014). The composition of meat cannot be described simply in terms of the different components, it is necessary to specify the component. Variation in composition also occurs from species to species. Meat is well known as an excellent protein and energy source for our daily diets and after digestion, provides excellent nutrition (Jihad, *et al*., 2009, Chang and Huang, 1991).Meat is composed of water, fat, protein, mineral (ash) and a small proportion of carbohydrates. Meat and other animal products make valuable contributions to diets of developing countries due to its high nutritional qualities (Olusola *et al*., 2010).

In Nigeria, the most common name for dried meats are Tinko, Kilishi and Kundi majorly prepared in the Northern parts of the country. Others forms meat is consumed include Ndariko, Jiorge and Banda prepared from meats of donkey, asses, horses, camel, and buffalo (Okaka *et al*., 2006). There is a preferential consumption of different types of meat by communities which may be due to a combination of factors bordering on religious belief, culture, adaptability, food habits, sex, socio-economic factors and individual variations (Ajiboye, *et al*., 2011).The major contribution of fat to the diet is energy or calories. This is true because fat has 2.25 times as much as an equal quantity of carbohydrates or protein. Fat also supplies the essential fatty acids, which must be present in the diet to meet the needs of the body. Mineral content of meat is relatively low, due to the relatively low content of minerals in fatty tissue.

Meat smoking has been practiced since the beginning of recorded history. Curing and smoking of meat are closely interrelated and are often practiced together (Rodolfo, 2012). Large quantities of salt were used in the curing process and smoking times were quite long, sometimes involving days of exposure. Meat is cured with chemicals and spices for few minutes, and smoked in a kiln for 2-3 days at relatively high temperature. The primary objectives in meat smoking are preservation, protection from oxidation, development of flavour, creation of new products and development of colour.

Citric acid has been reported to enhance flavour, storage stability and reduce microbial counts of meat products (Leo, 2012). Clove is used as spice in the preparation of a number of food items such as *Kilishi*, Esice and others (Igene, 1987). Spices are known not only to improve flavour but also have antimicrobial properties. It is possible that a combination of clove and citric acid treatment for curing before smoking would have beneficial effect on the final products. This is necessary because effective processing and preservation of animal protein in general has a direct bearing on the people's nutritional and economic well-being.

The objectives of this research work are (i) evaluation of the effect of citric acid and clove on proximate composition of cured "Smoked Meat", (ii) determination of the microbial count of the citric acid and clove treated on smoked products, (iii) evaluation of the microbial flora associated with the products and effect of packaging on the quality of stored "smoked meat" and (iv) determination of acceptability of the final product.

MATERIALS AND METHODS

Source of Materials

Lean beef meat from the forequarters (Bosindicus) was purchased, before 7.30 am from Maiduguri abattoir and transported to Food Science and Technology Laboratory, University of Maiduguri in such a way as to minimize contamination. Sodium chloride (common salt) and clove were obtained from Monday Market Ltd, Maiduguri, citric acid and sodium nitrate from Food Science and Technology laboratory, University of Maiduguri, Borno State, Nigeria.Figures

Production of cured smoked meat

The raw meat was trimmed of visible fat and connective tissue. Meat weighing 3.5kg was diced into smaller portions with mean length 8cm, thick 3.5cm and mean weight of 64.5g. The samples were divided into four batches and each batch contained 8 pieces in number and was cured in various concentrations of the ingredient for 30 min. The ratio of meat to sodium was 1:1 (w/v). First group was cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples (S1). Second group was cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid as samples 2 (S2). Third group was cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove as sample 3 (S3). Fourth group was cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove, as sample 4 (S4) (Table 1).

The samples were drained for 3 min and weighed to determine the moisture absorption and yield after curing. The cured meat was smoked for 3 days (8 hr daily) at a temperature of 55-60^{0}C. After processing, it was cooled, packaged in black polyethylene bag and wrapped in white paper and stored at room temperature (28±32^{0}C) with relative humidity range of 42-85% for 4 weeks (Figure 1). Quality changes were observed at intervals of one week.

Proximate Composition

The moisture, protein, fat and ash contents were determined before and after processing according to AOAC (2000).

Sensory Evaluation

Ten panellists including the staff and students of University of Maiduguri who are familiar with the product rated the samples in terms of colour, texture, taste and overall acceptability using a nine point Hedonic scale with 9 representing 'like extremely' and 1 representing 'dislike extremely'.

Storage Stability
Free fatty acid (FFA), pH, and water holding capacity were determined using AOAC (2000) method. Microbiological analysis for bacteria and fungi were carried out during storage as described by Carter and Charles (1995) method. Identification of bacteria, mould and yeast were carried out using Carter and Charles (1995) method.

Statistical Analysis
Data were subjected to analysis of variance (Snedecar, 1956). Multiple comparison tests (analysis of variance) were used to separate the differences among the means.

RESULTS AND DISCUSSION

Percentage Yield
The percentage yield of "smoked meat" ranged from 25.14 – 28.28.83% (Table 2). Samples treated with citric acid had the lowest yield. This may be due to dehydration at the early stage of processing and loss of water holding capacity as a result of protein denaturation caused by the citric acid treatment. Sample 3 (clove S3) and sample 1 (control S1) had the highest yield and there was no significant difference ($p < 0.05$) between the 2 samples. The higher yield may be due to the influence of salt and nitrate.

Effect of Citric Acid and Clove on the Proximate Composition of Cured "Smoked Meat"
The proximate analysis of "smoked meat" indicated significant difference ($p > 0.05$) between the control sample and the other samples. The increase in fat, protein and ash contents in the final products showed an inverse relationship between moisture and other nutrients. The decrease in moisture contents in the final product led to increase in fat, protein and ash contents, since heat was applied during processing. The increase in ash content in the final product may have been contributed by added clove and citric acid. Such increase suggests a concentration of nutrients in the final product.

Effect of Citric Acid and Clove on pH During Storage
There was a slight increase in pH during storage for the entire samples as shown in Table 4. But samples treated with citric acid had lower pH values (5.10 - 5-90). This might be due to the effect of citric acid. Other samples have pH values of 6.08 to 6.79. It was observed that samples stored in white papers had higher pH than samples stored in black polythene bag (leather bag). This may be as a result of absorption from the atmosphere or chemical reaction occasioned by the packaging materials. Sample packed in white paper was slightly significant ($p > 0.05$) from samples packed in black polythene bag at four (4) weeks of storage.

Effect of Citric Acid and Clove on Free Fatty Acid (FFA) During Storage
Initial values of free fatty acid after processing ranged from 1.24-1.51% as shown in Table 5. During storage samples stored in white paper had higher free fatty acid values when compared to

those stored in black polyethylene bag. This suggested that samples stored in black polyethylene had better keeping quality. Fatty acid oxidations occur slowly and spontaneously in the presence of light and contribute to the process called rancidification (Webb and Godwin, 1970). In addition, rancidification can be decreased, but not completely eliminated, by storing fats and oils in a cool, dark place with little exposure to oxygen or free radicals, since heat and light accelerate the rate of reaction of fats with oxygen. The black leather bag may have cut off light from penetrating the packaging material. This may have slowed down oxidation. After three weeks of storage samples in groups 2 and 3 had lower free fatty acid values than the control sample. The combined effect of citric acid and clove curing mixture did not appear to have a synesgislic effect on free fatty acid values. Nitrates generally are known for fixing colors (Lehman, 1899). Products packed in white papers were slightly significant ($p < 0.05$) from products packed in black polyethylene bag during four weeks of storage.

Effect of Citric Acid and Clove on Water Holding Capacity (WHC) During Storage

The water holding capacity of processed "smoked meat", stored for first and second months are shown in Tables 6 and 7. The water holding capacity of the second month showed a decrease, compared to first month of storage at ambient temperature. After one month of storage at ambient temperature the samples in black polythene bag generally had higher water holding capacity than those stored in white paper (WP). The reason for this is not obvious. It is possible that the black polythene (BP) completely cut off the supply of light, slowing chemical oxidation which reduced protein denaturation and hence water holding capacity. It was statistically observed that product packed in black polyethylene bag was significantly different ($p < 0.05$) from products packed in white paper in one month of storage. First month of storage differed significantly from second month of storage.

Effect of Citric Acid and Clove on Bacteria during Storage

The mean log bacteria counts are shown in Table 8. The fresh meat sample had mean log bacterial count of 6.15 cfu/g. After processing there was a decrease in bacterial count from 3.66 to 3.77 cfu/g for all sample irrespective of treatment. Bacteria count increased during storage. On week 0 (zero) it ranged from 3.66-3.98 cfu/g for a combination of citric acid and clove treated samples and from 4.05 – 4.25 cfu/g after eight weeks of storage at ambient temperature. The samples stored in black polyethylene bag and white paper during 4 weeks of storage showed no significant difference ($p > 0.05$)

Bacterial Isolates during Storage

The following suspected organisms were isolated and identified; *Bacillus species*, *Bacillus subtilis*, *Streptococcus* and *seudomonas*. There was a slight increase in bacterial count in all samples irrespective of treatment and packaging materials following storage for 4 weeks. The black polyethylene bag and white paper packaged sample and control samples had mean log 3.86 and 4.00 cfu/g on week 4. Citric acid treated sample increased from 3.87 and 3.92 to 4.00 and 4.04 respectively from week 1 to 4.

However after four weeks of storage the bacterial count ranged from mean log 3.98-4.1 white paper these samples can therefore be said to be wholesome after 4 weeks of storage and had no adverse effect on the health of the consumers. Mannitol salt agar was used for the isolation of *Staphylococcus aures*. However, none of the samples showed any detectable evidence of *Staphylococcus aureus*, suggesting that these processing was adequate. *Staphylococcus aureus* is pathogenic and is known to be responsible for most of the food poisoning syndrome (Jay, 2000). *Bacillus subtilis* is not pathogenic to man (Wilson and Miles, 1954) *Bacillus subtilis* bacteria are non-pathogenic. So also are most species of *Pseudemona* most of which are spoilage organisms (Jay, 1987). However, *Streptococcus faecalis* is pathogenic to man and is reported to form half that bacterial population of "plaque" a soft whitish material that accumulates on the surface of teeth of man that are not cleaned regularly (Matheson and Reed, 1959). It is also known to produce enterotxins which are responsible for the food poisoning syndromes (Jay, 1987). However, there were unidentified *Bacillus* species.

Effect of Citric Acid and Clove on Mould/Yeast during Storage

The effect of citric acid and clove on mould growth is shown in Table 9. Initially on week 0 (zero), no mould was isolated following processing irrespective of packaging material and treatment. This result suggested that the processing was effective in inhibiting mould growth. After 4 weeks of storage, there was mould growth in all the samples except those treated with a combination of clove and citric acid and cloves are very effective in controlling mould growth during storage at ambient temperature.

Isolated and identified Mould/Yeast during storage

The moulds and yeast identified were *Aspergillus* n*iger*, *Penicillium* and *Candida*. The presence of *Aspergillus* and *Candida* was observed in all the samples. These are the normal mould associated with smoked dried meat products. But *Asperigillus* species have been associated with *Mycotoxin* in stored products. So the presence of *Apergillus niger* is of some concern to the consumers.

Sensory Evaluation of the Cured "Smoked Meat"

Ten semi-trained panelist rated the colour, texture, taste and overall acceptability of the cured "smoked meat" as shown in Table 10. The control samples were rated higher ($p < 0.05$) than the other samples in all the parameters measured. There was significant difference ($p < 0.05$) between the control sample (S1) and sample group 4 (citric acid and clove). There was no significant different ($p < 0.050$ between sample group 2 (citric acid) and sample group 3 (clove). The result showed that the use of citric acid and clove was not very effective in enhancing the organoleptic properties at the levels used. It is possible the levels used were too high, thus producing sensations which were not quite acceptable to the panelists.

CONCLUSION

This study has demonstrated that citric acid had effect in reducing microbial load, because of the decrease in pH. There was an increase in fat and ash content of the final product when compared to the fresh sample. The storage of the product at room temperature for two months showed an increase in pH and free fatty acid values, mostly in samples stored in white paper, which created favourable condition for micro-organisms. Water holding capacity decreased from first month to the second month. It was observed that cured "smoked meat" product in black polyethylene bag had lower fatty acid content compared to sample packed in white paper. The effect of storage stability showed that cured "smoked meat" can be consumed without adverse effect on the health of the consumers.

Table 1: Formation Table of Smoking Meat with Different Treatment

	Treatment			
Ingredients	(S1)	(S2)	(S3)	(S4)
Meat (g)	525±8.25	545±11.75	535±0.75	529±4.25
Sodium Chloride (g)	53.5±0.82	54.5±1.17	53.4±0.07	52.9±0.42
Sodium Nitrate (g)	0.11±0.00	0.11±0.00	0.11±0.00	0.11±0.00
Citric Acid (g)	-	10.9±0.15	-	10.6±0.15

Table 2: Percentage Yield of Smoked Meat

Ingredients	Treatment			
	(S1)	**(S2)**	**(S3)**	**(S4)**
Initial weight of sample (g)	525±8.25	545± 1.75	534±0.75	529 ± 4.25
Weight after cured with treatment (g)	556 ± 1200	515±29.00	571 ± 27.00	534 ± 10.00
Weight after smoking (g)	147 ± 2.00	137 ± 8.00	154 ± 9.00	142 ± 3.00
Yield after cured with treatment (%)	108.17 ± 5.7	94.49± 7.98	106.3 ± 3.83	100.95± 1.54
Percentage of yield (%)	28.16 ± 0.91	25.14 ± 2.1	28.83 ± 1.59	26.84 ± 0.4
Clove (g)	-	-	10.68±0.05	10.58±0.05
Water (ml)	525±8.25	545±11.75	534±0.75	529±4.25

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove

Table 3: Proximate Composition (%) Of Fresh and Processed "Smoked Meat"

Composition (Percentage)	**Fresh sample**	**Treatment processed sample**			
		(S1)	(S2)	(S3)	(S4)
Moisture content	71.86± 0.19	14.28±0.49	13.34± 0.00	14.37±0.24	14.09 ± 0.26
Protein content	17.50± 0.27	58.73±0.43	56.31± 0.16	57.91±0.55	55.11 ± 0.03
Fat content	3.61 ± 0.34	9.47 ± 0.21	9.98 ± 0.53	9.84 ± 0.45	8.84 ± 0.53
Ash content	0.99 ± 0.00	8.87 ± 0.38	9.11 ± 0.07	9.63 ± 0.28	10.44 ± 0.21

Key:
Each reading is a mean ± standard deviation of duplicates
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.

Table 4: The Effects of Citric and Clove on The pH of Cured "Smoked Meat" During Storage Ambient Temperature

		Treatment			
Weeks of storage	**Material use during storage**	**(S1)**	**(S2)**	**(S3)**	**(S4)**
0	BP	6.80±0.43^{a}	5.38±0.27^{b}	6.05±0.4^{a}	5.10± .55^{c}
	WP	6.06 ±0.38^{a}	5.15±0.53^{b}	6.39±0.71^{a}	5.11±0.57^{b}
1	BP	6.33 ± 0.45^{a}	5.60± 0.28^{b}	6.18 ± 0.3^{a}	5.40 ± 0.48^{c}
	WP	6.48 ± 0.49^{a}	5.44± 0.55^{b}	6.51 ± 0.52^{a}	5.52 ± 0.47^{b}
2	BP	6.49 ± 0.45^{a}	5.75± 0.29^{b}	6.40 ± 0.36^{a}	5.52 ± 0.52^{c}
	WP	6.56 ± 0.45^{a}	5.55± 0.56^{b}	6.64 ± 0.53^{a}	5.67 ± 0.44^{b}
3	BP	6.70 ± 0.51^{a}	5.90± 0.29^{b}	6.58 ± 0.39^{a}	5.57 ± 0.62^{c}
	WP	6.79± 0.46^{a}	5.98± 0.35^{b}	6.66 ± 0.33^{a}	5.90 ± 0.43^{b}

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
Each reading is a mean ± standard deviation of duplicates
BP = Black Polyethylene
WP = White paper

Table 5: Effects of Packaging on Free Fatty Acid of Cured "Smoked Meat" Ambient Temperature

		Treatment			
Weeks of storage	**Material use during storage**	**(S1)**	**(S2)**	**(S3)**	**(S4)**
0	BP	1.24b±0.08	1.21b±0.11	1.26±0.6^{b}	1.57 ± 0.25^{a}
	WP	1.25 ±0.09^{b}	1.23± 0.11^{c}	1.27±0.7^{c}	1.59± 0.27^{a}
1	BP	1.26± 0.18^{b}	1.56± 0.12^{b}	1.27±0.17^{b}	1.66 ± 0.22^{a}
	WP	1.57± 0.13^{b}	1.62± 0.08^{c}	1.51±0.17^{c}	2.11± 0.41^{a}
2	BP	1.46± 0.07^{b}	1.71± 0.18^{b}	1.31±0.22^{b}	1.63 ± 0.1^{a}
	WP	1.61± 0.19^{b}	1.71 ± 0.9^{c}	1.56±0.24^{c}	2.33± 0.53^{a}
3	BP	1.82± 0.11^{b}	1.01 ± 0.7^{b}	1.81 ± 0.1^{b}	2.21 ± 0.50^{a}
	WP	2.26± 0.03^{b}	1.11± 0.85^{c}	1.91±0.05^{c}	2.54± 0.58^{a}

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
Each reading is a mean ± standard deviation of duplicates
BP = Black Polyethylene
WP = White paper

Table 6: Effects of Chemical Dip of Water Holding Capacity of Cured Smoked Meat Following Packaging and Storage at Ambient Temperature

First month

			Treatment			
Time (min)	**Temp. (ºC)**	**Material use during storage**	**(S1)**	**(S2)**	**(S3)**	**(S4)**
30	28	BP	178.35 ± 1.11^{a}	172.75± 4.49^{a}	168.41±8.83^{b}	189.46 ± 12.22^{a}
		WP	169.69 ± 6.6^{a}	153.07±10.02^{c}	167.53±4.44^{b}	162.05 ± 1.04^{a}
60	28	BP	188.67± 10.67^{a}	174.96 ± 3.09^{a}	175.88±2.17^{b}	172.67 ± 5.38^{a}
		WP	184.54 ± 16.27^{a}	155.40 ± 12.87^{c}	165.82±2.45^{b}	167.30 ± 0.97^{a}
90	28	BP	191.14 ± 7.01^{a}	192.74 ± 8.61^{a}	171.36±2.77^{b}	181.26± 2.87^{a}
		WP	184.97 ± 11.44^{a}	166.68 ± 6.85^{c}	165.98±7.55^{b}	176.47±2.94^{a}
120	28	BP	197.78 ± 8.32^{a}	196.47 ± 7.01^{a}	178.30±11.1^{b}	185.30 ± 4.16^{a}
		WP	188.89 ± 8.97^{a}	168.95 ± 10.97^{c}	183.29±3.37^{b}	178.56 ± 1.36^{a}

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
Each reading is a mean and standard deviation of two determinations
BP = Black Polyethylene
WP = White paper

Table 7: Effect of Chemical Dip on Water Holding Capacity Of Cured Smoked Meat Following Packaging and Storage at Ambient Temperature

Second month

			Treatment			
Time (min)	**Temp. (ºC)**	**Material used during storage**	**(S1)**	**(S2)**	**(S3)**	**(S4)**
30	28	BP	170.44±11.83^{a}	146.77± 1.84^{b}	165.42 ± 6.81^{a}	152.12± 6.49^{a}
		WP	147.56 ± 7.46^{a}	155.99± 0.97^{b}	154.28 ± 0.74^{a}	162.25± 7.23^{a}
60	28	BP	163.86 ± 2.8^{a}	148.41±13.27^{b}	169.14 ± 7.46^{a}	165.30± 3.62^{a}
		WP	163.18 ± 1.49^{a}	165.22± 0.55^{b}	163.45 ± 1.22^{a}	166.85± 2.18^{a}
90	28	BP	170.13 ± 1.19^{a}	163.68 ± 7.64^{b}	176.96 ± 5.64^{a}	174.51± 3.19^{a}
		WP	179.30± 10.13^{a}	168.52 ± 0.65^{b}	160.31 ± 8.86^{a}	168.55± 0.62^{a}
120	28	BP	179.26 ± 3.27^{a}	164.64±11.35^{b}	180.26 ± 4.27^{a}	179.81± 3.82^{a}
		WP	199.83± 19.76^{a}	164.01±16.09^{b}	186.88 ± 6.81^{a}	169.55± 10.52^{a}

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
Each reading is a mean ± standard deviation of duplicates
BP = Black Polyethylene, WP = White Paper

Table 8: Changes in Bacterial Count during Storage Mean Log Count (Cfu/G)

		Temperature			
Weeks of storage	**Material use during storage**	**(S1)**	**(S2)**	**(S3)**	**(S4)**
0	BP	3.77± 0.01	3.8 ± 0.04	3.82± 0.06[a]	3.66 ± 0.1
	WP	4.00± 0.08[a]	3.87± 0.05[a]	3.92± 0.00[a]	3.88 ± 0.04[a]
1	BP	3.86± 0.02[a]	3.85 ± 0.00[a]	3.87± 0.03[a]	3.8 ± 0.05[a]
	WP	4.03± 0.06[a]	3.96 ± 0.00[a]	3.96± 0.00[a]	3.92 ± 0.04[a]
2	BP	3.96± 0.01[a]	3.93 ± 0.01[a]	3.95± 0.01[a]	3.92 ± 0.02[a]
	WP	4.06± 0.07[a]	4.01 ± 0.02[a]	3.9 ± 0.09[a]	3.98 ± 0.01[a]
3	BP	3.98± 0.03[a]	3.94 ± 0.02[a]	3.98± 0.03[a]	3.92 ± 0.04[a]
	WP	4.07± 0.07[a]	3.97 ± 0.03[a]	4.00± 0.00[a]	3.96 ± 0.04[a]
4	BP	4.10± 0.05[a]	4.08 ± 0.03[a]	4.04± 0.01[a]	3.98 ± 0.07[a]
	WP	4.10± 0.07[a]	4.05 ± 0.01[a]	4.09± 0.05[a]	3.9 ± 0.14[a]
8	BP	4.25± 0.09[a]	4.17 ± 0.01[a]	4.14± 0.02[a]	4.08 ± 0.08[a]

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
Each reading is a mean ± standard deviation of duplicates
BP = Black Polyethylene
WP = White Paper

Table 9: Changes Mould during Storage Mean Log Counts (Cfu/G)

		Temperature			
Weeks of storage	**Material use during storage**	**(S1)**	**(S2)**	**(S3)**	**(S4)**
0		ND	ND	ND	ND
1	BP	ND	ND	ND	ND
	WP	ND	ND	ND	ND
2	BP	ND	ND	ND	ND
	WP	3.00 ± 0.01	3.00± 0.10	3.30 ± 0.2	ND
3	BP	3.00 ± 0.00	3.00± 0.00	ND	ND
	WP	3.00 ± 0.10	3.00± 0.10	3.30 ± 0.2	ND
4	BP	3.00 ± 0.00	3.00± 0.00	3.00± 0.00	ND
	WP	3.30 ± 0.1	3.30 ± 0.2	3.30 ± 0.1	ND

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
ND = Non Detectable
BP = Black Polyethylene
WP = White Paper

Table 10: Physical And Biological Characteristics Of Bacteria Isolates During Storage

Isolate	**Morphology**	**Gram stain**	**Maltose**	**Sucrose**	**Lactose**	**Fructese**	**Glucose**	**Sarbitter**	**Suspected organism**
1 A	Long thin reds	-ve	+ve	+ve			+ve	+ve	*Bacillus* species
1 B	Short thick reds	+ve		+ve	+ve		+ve	-ve	*Bacillus subtilis*
1A	Regular or irregular clusters	+ve	+ve	+ve		-ve	+ve		*Coccus*
2B	Spherical and avoid cells	+ve	+ve		+ve		+ve	-ve	*Streptococcus*
3A	Reds	-ve	+ve		+ve	+ve	+ve	+ve	*Pseudomonas*

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
+ = Reaction, - = No Reaction, +ve = Positive, -ve = Negative

Table 11: Moulds/Yeast Isolated From Cured Smoked Meat during Storage

Treatment				
(S1)	**(S2)**	**(S3)**	**(S4)**	**Suspected organism**
+ve	+ve	+ve	-ve	*Aspergillus niger*
+ve	-ve	+ve	-ve	*Candida*
+ve	+ve	+ve	-ve	*Penicillium species*

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
+ve = Positive
-ve = Negative

Table 12: Moulds/Yeast Isolated From Cured Smoked Meat during Storage

	(S1)	**(S2)**	**(S3)**	**(S4)**
Colour	8.3a±1.48	6.9a±0.08	6.7b±0.12	5.5c±1.32
Texture	8.3a±1.33	6.9b±0.18	7.0b±0.033	5.8c±1.18
Taste	7.4a ± 0.9	6.0b ± 0.5	6.7b± 0.02	5.9c ± 0.6
Overall Acceptability	7.4a±0.73	6.8b±0.13	6.8b± 0.13	5.7c±0.98

Key:
Ratio of water to meat 1
S1:- Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and served as control samples.
S2:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% citric acid.
S3:-Meat cured with 10% sodium chloride, 200 ppm sodium nitrate and 2% clove.
S4:-Meat cured with 10% sodium chloride 200 ppm sodium nitrate, 2% citric acid and 2% clove.
Each value is a mean ± standard deviation of 10 observations

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