



RESEARCH ARTICLE

EVALUATION OF THE PRESERVATIVE EFFECTS OF TWO SPICE POWDERS AND DRYING TEMPERATURE ON SOME QUALITY ATTRIBUTES OF BEEF

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ABSTRACT

Due to high perishability of fresh meat, drying is often employed to reduce the biochemical and microbial degradations that occur after animal slaughter. Spice powder or its derivatives are also added to food particles to enhance flavour and reduce microbial spoilage. This study was conducted at the Department of Food Science and Technology, Federal University of Agriculture Abeokuta (FUNAAB), Ogun State, Nigeria, to investigate the effect of spice type (ST), spice powder suspension concentration (SPC) and drying temperature (DT) on the chemical and microbial property of dried beef. About 100 g of fresh beef cut (1×5×10 cm) was soaked in alligator pepper (AP) and ginger (GE) powder suspension at 50 and 70% (w/w) for 30 min while that soaked in distilled water served as control. Total viable microbial count (TVC), *Staphylococci spp* (SS), *Escherichia coli* (EC), *Streptococcus aureus* (SA) and *Salmonella spp* (SaS) counts were determined in the fresh meat soaked for 0-24 h. The soaked beef cuts were then dried at 65, 75 and 85°C in a locally-fabricated convective dryer for 18 h. Proximate composition (protein, moisture, ash, crude fibre, fat and carbohydrate) of the processed dried meat were determined using standard methods. Data obtained were subjected to analysis of variance and LSD was used to separate significant means. The TVC, SS, EC and SA counts in the soaked meat samples were 4.0-4.6, 0.0-4.3, 0.0-4.39, and 0.0-4.3 cfu/g, respectively. There was significant reduction in the microbial load of the spiced dried meat samples with values ranging from 2.0-2.30 cfu/g for TVC and 0.01-2.0 cfu/g for *Staphylococcus*. The microbial count of spiced meat reduced significantly ($p < 0.05$) with soaking period whereas it increased in the control sample. However, *Salmonella spp* was not detected in both the fresh and dried meat samples. The crude protein, fat and crude fibre contents of the dried spiced meat was 78.65-88.89%, 2.85-11.51% and 0.36-0.94%, respectively. The untreated meat had lower protein and crude fibre than any of the spiced meat. The main effect of ST, SPC and DT were significant ($p < 0.05$) on the proximate composition. The PV, FFA and pH values of the dried meat were 1.71-4.12 meq/kg, 1.26-3.27%, and 6.06-6.47, respectively. Dried meat at 75 and 85°C had no viable microbial count. It can be concluded that using 70% GE and drying at 75°C showed greater potential for meat preservation.

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INTRODUCTION

Meat is a rich source of nutrients essential for human health, but is very costly in developing countries when compared with cereals and tubers crops (Awonorin et al., 1991). In appropriate amounts, foods of animal origin are valuable sources of complete high-quality, easily digestible, protein and many essential micronutrients such as iron, zinc, calcium, vitamin A and vitamin B12 (WHO, 2007). However, despite the increasing levels of livestock production in most developing countries (Chambers and Grandin, 2001), the proportion of meat in the diet of the average consumer remains

rather low. This is mainly because the human population grows rapidly in the face of short supply of meat. Meat is scarce in many places and its cost is comparatively high. Furthermore, shortage of livestock products in certain areas in developing countries is as a consequence of the traditional marketing systems in which fresh and unprocessed meat are sold few hours after slaughter. This is particularly so, in all the developing regions where no cold chain for refrigeration exists (FAO, 1991). Cow, a very important livestock in West-African agricultural system provides a good source of quality beef for the ever-increasing population. The quantity of Cow meat consumed was predicted by McMillin and Brock (2005) that are likely to be influenced by availability, processing techniques and value addition. The meat value may be increased through production practices or meat processing (McMillin and Brock, 2005).

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The preservation of the meat has always been a method to prevent against famine, but has also acquired a political and economic dimension as human population grows. In developed countries, this conservation depends largely upon the food industry rather than individuals. Conversely, in developing countries, consumption patterns in developing countries demands that means for meat preservation be explored for health reasons. Owing to the spoilage potential of meat, varieties of preservation techniques are employed in improving its keeping quality and shelf life (Olusegun and Iniobong, 2011). In good hygienic conditions, after slaughter and evisceration, the optimal way to preserve meat is under refrigeration at temperatures around 4°C (Castellano *et al.*, 2008). However, in Nigeria and most African countries, because of lack of refrigeration facilities in the slaughter house, ambient temperatures above 2°C, inadequate electricity supply and lack of suitable means of transportation between the production and marketing areas, meat can be exposed to conditions of high risk with respect to increased contamination resulting from growth of pathogens and spoilage microorganism (Gill and Newton 1978). Fresh meat constitutes the greatest bulk of meat consumed in West Africa. However, fresh meat deteriorates quickly due to high moisture and nutrient content, which is a suitable environment for microbial growth. This often reduces market values and leads to heavy financial loss in the meat industry. The demand for protein of animal origin in a developing country like Sierra Leone has far outstripped the supplies.

In addition, quality and quantity of livestock products consumed is often very low and falls far below FAO standards. This has resulted in increasing incidence of malnutrition thereby placing vulnerable communities at high risk. Therefore, the need to explore the preservative efficacies of Alligator pepper (*Aframomum melegueta*) and Ginger (*zingiber officinale*) as antimicrobial agents for traditional preservatives and drying equipment on extension of shelf-life of meat while being mindful of the quality of meat cannot be overemphasized.

MATERIALS AND METHODS

The study was conducted at the Department of Food Science and Technology, Federal University of Agriculture Abeokuta (FUNAAB), Ogun State, Nigeria from November 2014 till April, 2015.

Source and preparation of the meat used

Meat used for this experiment comprised of cut from the thigh region of a male healthy cow slaughtered in a certified abattoir at Kuto market, Abeokuta, Ogun State. The animal was subjected to slaughtering through the use of a sharp knife driven across the neck region of the animal and it was laid flat on clean polythene while blood was allowed to drain completely from the carcass for fifteen (15) minutes. Afterwards, the carcass was de-skinned, eviscerated and deboned while flesh was cut into one-kilogram in separate well-labelled bags. One hundred (100) gram of fresh beef cut from the thigh region was cut into 1x5x10 cm size in length, width and thickness on a sterile glass surface using a sharp knife. Adequate care was ensured to prevent contamination at every point of post-slaughtering handling.

The source and preparation of alligator pepper and ginger powder

Dried alligator pepper and fresh rhizomes of ginger were sourced from local farmers in Kuto market, Abeokuta. The processing of powder from fresh sample was achieved using the method of Adegoke and Skura (1994) as described by Adedeji and Ade-Omowaye (2013). Ginger (*Zingiber officinale*) rhizomes were peeled while alligator pepper (*Aframomum melegueta*) seeds were removed from the pods, sorted and cleaned from all extraneous materials and adhering particles. The samples were oven-dried in a hot air oven and crushed using an electric grinder 5 speed blender, (Model: BBEK1051 RSH 0005494-124, Rank sharp industries Ltd, 1801). Ground samples were soaked in equal volume of distilled water for twenty-four hours for maximum extract recovery as described by Doherty *et al.* (2010).

Preparation of Alligator pepper and Ginger suspension

One hundred percent (100%) of the resulting powder crude extract of alligator pepper and ginger was prepared using the prescribed method of Kim and Lee (1995) by weighing the alligator pepper and ginger powder using a sensitive electronic scale (AND EK-4100i, A&D CO.LTD JAPAN). Equal volume (cm³)/weight (g) of distilled water and ground sample of the plant materials at one hundred millilitre (100 mL) was poured into one hundred gram (100 g), then, the samples were then dissolved into an Erlenmeyer flask separately and labelled accordingly. These were left to rest for twenty four (24) hours for proper dissolution. Thereafter, dilution was done with varied proportion of distilled water making it each up to 100mL volume.

Experimental design

The treatments consisted of two spices; alligator pepper and ginger. The spice were diluted with distilled water at concentration levels of 70: 30 and 50: 50 v/v respectively, while the untreated samples immersed in distilled water served as control. The soaked beef cuts were then dried at varied temperature 65, 75 and 85 °C in a locally-fabricated convective dryer for 18 hours till the samples were completely dried.

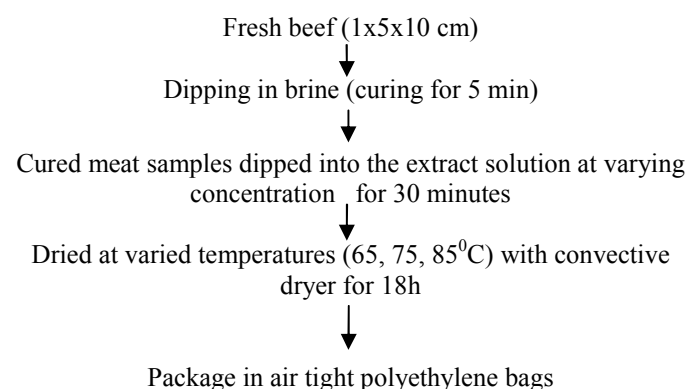


Figure 1. Flow chart for meat treatment and drying (Dale, 2011)

Determination of pH

Ten gram (10g) of fresh and dried meat sample was dissolved with thirty millimetres (30ml) of distilled water. The electrode was allowed to stabilize for few minutes. pH readings were taken through the use of JENWAY (3015, JENWAY LTD

FELSTED DUNMOW, England CM6 3LB ESSEX) pH meter. Buffer solution of 7.0 and 4.0 readings were used to standardize the meter prior to measurement. Readings were taken in triplicate while the average was taken for the pH value in accordance with AOAC (2000).

Table 1. Layout of the experiment

Spice	Concentration	Temperature
Control	100	65°C
Ginger (G ₁)	70:30	65°C
Ginger (G ₂)	50:50	65°C
(G ₁)	70:30	75°C
(G ₂)	50:50	75°C
(G ₁)	70:30	85°C
(G ₂)	50:50	85°C
ALLIGATOR PEPPER (A ₁)	70:30	65°C
ALLIGATOR PEPPER (A ₂)	50:50	65°C
(A ₁)	70:30	75°C
(A ₂)	50:50	75°C
(A ₁)	70:30	85°C
(A ₂)	50:50	85°C

Proximate composition analysis

The proximate compositions of the spiced dried meat were evaluated using the method of AOAC (2010). Dried spiced meat samples were ground in to a fine powder and mixed thoroughly before analysis was done. The analyses were carried out in triplicate.

Determination of moisture content

Approximately 5 g of the of the prepared samples was weighed into a pre-weighed clean Petri dishes and dried inside a Gallemkamp hot air oven (model 6094702 -880, GALLEMKAMP, UK) at a temperature of 105°C. The dishes with the dried samples were removed after 3 hrs. from the drying oven and put into a desiccator to cool and weighed. The samples were further oven dried for 45minutes and weighed. When a constant weight was obtained, the percentage moisture content was calculated as shown below:

$$\text{Percentage moisture content (\%)} = \frac{W_2 - W_1}{W} \times 100$$

Where:

W₁ = weight of pan + fresh samples

W₂ = weight of pan + dry samples

W = weight samples

Determination of crude protein

About 2 g of the prepared samples were weighed into the micro-Kjeldahl digestion flask was digested on an electro thermal heater until a clear solution was obtained. The flask was allowed to cool after which the digest was transferred into a 250 mL volumetric flask and made up to mark with distilled water. The distillation unit was then cleaned, and the apparatus set up. Five millilitres of 2% boric acid solution with few drops of methyl red indicator was introduced into a distillate collector. The conical flask was placed under the condenser. The 5g of the samples digest was pipetted into the apparatus, and washed down with distilled water. Five millilitres of 60% sodium hydroxide solution was added to the digest. The samples were heated until 100mL of distillate was collected in the receiving flask. The content of the receiving flask was

titrated with 0.049M H₂SO₄ to a pink coloured end point. A blank was subjected to the same procedure. Blank was run as such while protein was calculated as follows:

$$\% \text{ of crude protein} = \frac{(T - B) \times N \times 14.008 \times 100 \times F}{W_1}$$

where W₁ = weight of sample (mg)

T = Titration volume of sample (mL)

B = Titration volume of blank (mL)

N = Normality of acid to 4 decimal places

F = Conversion factor for nitrogen to protein = 6.25

Crude fiber

Crude fiber was determined by the method described by AOAC (2000) using fibertec hot/hydrolysis unit. The reagents: Acetone (technical grade), 1.25% H₂SO₄ solution and 1.25% NaOH solution were also used. Crucibles were dried at 130 ± 2°C for 30 minutes and were placed on a balance. One gram (1g) of well-prepared sample was weighed into the crucible containing the celite. The undigested residue was collected after digestion and ignited. The loss in weight after ignition was registered as crude fiber.

$$\% \text{ crude fiber} = \frac{W_1 - W_2}{W_0} \times 100$$

where; W₀ = sample weight

W₁ = weight of the dried sample

W₂ = weight of ash

Determination of total ash content

The ash content was determined using the method of AOAC (2000). A clean empty crucible was placed in a muffle furnace at 600 °C for 1 h, cooled in desiccator and then the weight of the empty crucible was noted. One gram of the sample was weighed into crucible. The sample was ignited over a burner with the help of a blowpipe, until it was charred. Then the crucible was placed in muffle furnace at 550°C for 6 hours. The appearances of a gray white ash indicated the complete oxidation of all organic matter in the sample. After ashing, the furnace was switched off. The crucible was cooled and weighed

$$\text{Ash content (\%)} = \frac{(Y_2 - Y_1)}{W} \times 100$$

where:

Y₂ = Weight of crucible + ash

Y₁ = Weight of empty crucible

W = Weight of sample

Determination of total carbohydrate content

Total carbohydrate content of the samples was determined by simple difference using the method described by Rampersad *et al.* (2003). The sum of the percentages of moisture, crude protein, crude fat, ash and crude fiber was subtracted from C = 100 - (% moisture + % ash + % protein + % fat + %crude fiber)

Statistical Analysis

Data from chemical, physicochemical and microbial were subjected to statistical analysis using SPSS version 21. Analysis of variance (ANOVA) was used to compare significant means. The Least Significance Difference (LSD) was used to determine the level of significance.

RESULTS

pH values of the spiced solution

The pH values of the spiced solution are shown in Figure 2. The alligator pepper had pH values ranging between 5.41 and 5.46, ginger between 4.11 and 5.36, compare to that of water 7.0 respectively.

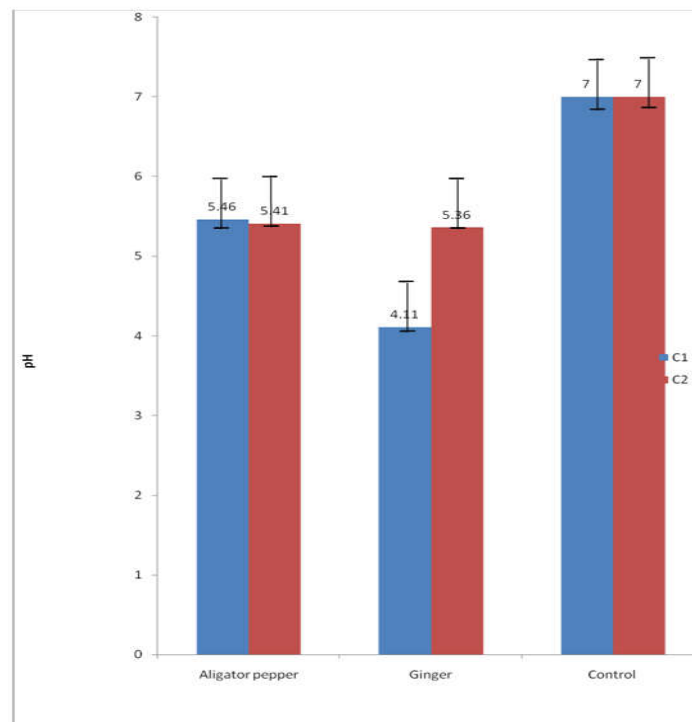


Figure 2. pH values of the spices solution at different concentration levels

Table 2. Effect of concentration of spices solution on microbial population of freshly treated beef

Microbial count (Log ₁₀ ³ cfu/g)						
Organisms	Time (hours)	G ₁	G ₂	A ₁	A ₂	Control
Total variable count	0	4.60	4.65	4.48	4.54	4.70
	6	4.30	4.48	4.34	4.54	4.78
	12	4.00	4.30	4.30	4.54	4.95
	18	4.00	4.15	4.29	4.45	5.11
Staphylococcus count	24	4.00	4.15	4.20	4.30	5.26
	0	4.15	4.30	4.15	4.15	4.30
	6	4.15	4.30	4.30	4.00	4.30
	12	4.00	4.15	ND	4.00	4.48
Escherichia coli Count	18	ND	4.00	ND	ND	4.70
	24	ND	4.00	ND	ND	4.85
	0	4.39	4.39	4.30	4.00	4.30
	6	4.30	4.30	ND	4.00	4.48
Streptococcus Count	12	ND	ND	ND	4.00	4.70
	18	ND	ND	ND	ND	4.78
	24	ND	ND	ND	ND	4.85
	0	4.00	4.30	4.0	4.00	4.30
Streptococcus Count	6	4.00	4.20	ND	4.00	4.41
	12	ND	ND	ND	4.00	4.53
	18	ND	ND	ND	ND	4.67
	24	ND	ND	ND	ND	4.85

Mean values with different superscripts within the same row are significantly different at 5% level.

KEYS: Control = 100% distilled water, G₁ = 70% ginger concentration, G₂ = 50% ginger concentration, A₁ = 70 % alligator pepper concentration, A₂ = 50% alligator pepper concentration, ND =Not detected

Effect of concentrations of spiced solution on the microbial population of freshly treated undried beef

Table 2 indicates result for the microbial quality of freshly treated beef. There was no growth of *Salmonella sp* in all the samples. However total viable, *Escherichia coli*, *Streptococcus*, and *Staphylococcus* count had significant differences ($p < 0.05$). The viable count ranged from 5.26 -4.00 x 10³cfu/g. Control had the highest viable count while ginger concentration at 70% accounted for the lowest microbial count. *Staphylococcal* count ranged from 4.85-400 x10³cfu/g. The high *Staphylococcus* count was observed in control with alligator pepper concentration at 70% had the least. The *Escherichia Coli* count values ranged from 4.85-4.00 x 10³cfu/g. Highest 4.85 x 10³cfu/g count was recorded in control, while the lowest 4.00 x 10³cfu/g was observed in

Table 3. Effect of spiced, concentration and drying temperatures on microbial population of dried beef samples

Spice	Concentration	Temperature (°C)	Microbial count (Log ₁₀ ³ cfu/g)			
			T. <i>bacteria</i> Count	<i>Streptococcus</i>	T. <i>Escherichia coli</i>	T. <i>Staphylococcus count</i>
Control		65	2.3	ND	ND	2.0
	70%	65	ND	ND	ND	ND
	50%	65	ND	ND	ND	ND
	70%	75	ND	ND	ND	ND
	50%	75	ND	ND	ND	0.1
	70%	85	ND	ND	ND	ND
Alligator pepper	50%	85	ND	ND	ND	ND
	70%	65	ND	ND	ND	ND
	50%	65	ND	ND	ND	ND
	70%	75	ND	ND	ND	ND
	50%	75	ND	ND	ND	ND
	70%	85	ND	ND	ND	ND
	50%	85	ND	ND	ND	ND

Mean values with different superscripts within the same column are significantly different at 5%

KEYS: Control = 100% distilled water, G₁ = 70% ginger concentration, G₂ = 50% ginger concentration, A₁ = 70 % alligator pepper concentration, A₂ = 50% alligator pepper concentration, ND =Not detected

Table 4. Effect of spice, concentrations and drying temperatures on the proximate composition of dried beef sample

Spice	Concentration	Drying Temperature (°C)	Proximate composition (%)					
			Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate
Ginger	Control	65	13.30±0.14 ^{bc}	76.78±0.70 ^d	4.63±0.04 ^e	0.23±0.01 ^h	5.44±0.01 ^{gh}	7.85±0.86 ^h
	70%	65	12.40±0.00 ^{de}	82.55±0.01 ^c	3.00±0.00 ^g	0.53±0.00 ^f	8.17±0.00 ^b	5.74±0.00 ^d
	50%	65	12.67±0.03 ^d	80.32±0.01 ^c	4.85±0.00 ^e	0.61±0.07 ^d	8.13±0.07 ^b	6.07±0.00 ^d
	70%	75	12.39±0.00 ^{de}	82.07±0.02 ^c	4.62±0.00 ^e	0.36±0.01 ^g	8.22±0.00 ^b	4.72±0.04 ^e
	50%	75	9.70±0.00 ^f	81.78±0.02 ^c	11.51±0.01 ^b	0.80±0.00 ^c	6.06±0.08 ^c	4.84±0.04 ^e
	70%	85	18.45±0.49 ^a	86.50±0.23 ^b	5.52±0.00 ^{cd}	0.45±0.01 ^f	5.67±0.43 ^{gh}	1.85±0.69 ^{hi}
Alligator pepper	50%	85	18.40±0.14 ^a	87.25±0.26 ^b	2.85±0.07 ^h	0.47±0.00 ^{ef}	5.85±0.18 ^{ef}	3.57±0.51 ^f
	70%	65	13.59±0.01 ^{bc}	85.06±0.01 ^b	5.26±0.00 ^{cd}	0.74±0.00 ^c	6.97±0.02 ^c	1.95±0.03 ^{hi}
	50%	65	12.10±0.00 ^d	78.65±0.00 ^{bc}	3.13±0.00 ^{fg}	0.94±0.00 ^a	7.15±0.00 ^c	10.11±0.00 ^a
	70%	75	9.89±0.00 ^{fg}	83.54±0.00 ^b	7.55±0.07 ^a	0.50±0.00 ^c	5.56±0.22 ^{gh}	2.96±0.05 ^{ef}
	50%	75	12.70±0.42 ^d	79.89±0.02 ^{cd}	3.54±0.00 ^{fg}	0.77±0.01 ^{cd}	8.88±0.00 ^a	6.91±0.00 ^c
	70%	85	12.10±0.00 ^d	85.75±0.02 ^a	5.48±0.55 ^b	0.82±0.04 ^b	5.70±0.07 ^{fg}	2.24±0.45 ^{gh}
	50%	85	12.63±0.18 ^d	88.89±0.00 ^a	3.51±0.07 ^{fg}	0.73±0.07 ^c	6.63±0.01 ^d	1.23±0.04 ⁱ

Mean values with different superscripts within the same column are significantly different at 5%.

KEYS: Control = Distilled water, G₁ = 70% ginger concentration, G₂ = 50% ginger concentration, A₁ = 70 % alligator pepper concentration, A₂ = 50% alligator pepper concentration, ND =Not detected

alligator pepper concentration at 70%. Streptococcal count ranged from 4.85-4.00 x10³cfu/g. Streptococcal count was perceived highest, 4.85 x 10³cfu/g in control while the lowest 4.00 x 10³cfu/g was recorded in sample treated with 70% alligator pepper concentration.

Effect of spiced, concentration and drying temperatures on microbial population of dried beef samples

Table 3 displays the effect of spice solution concentration and drying temperature on microbial population of processed and dried beef samples. There were significant difference (p<0.05) in the microbial population. The control sample dried at 65°C had 2.3 x 10³cfu/g count for Streptococcus and 2.0 x10³cfu/g count for Escherichia respectively. Sample treated with 50% ginger concentration and dried at 75°C had 2.00x10³cfu/g of Streptococcus. There was no growth for Salmonella and Staphylococcus throughout the experiment.

Effect of types of spice, concentrations and drying temperatures on the proximate composition of dried beef sample

Table 4 shows the proximate composition of processed and dried beef samples in dry matter basis. Significant differences (p<0.05) were observed in the mean values of moisture, protein, fat, crude fibre, and carbohydrate contents,

respectively. The values for moisture content ranged from 9.70 – 18.45 %. Samples treated with 70% ginger concentration and dried at 85°C retained the highest level moisture content of 18.45% while sample treated with 50% ginger concentration and dried at 75°C had the lowest level of moisture content of 9.70%. Values for crude protein of the treated and dried beef ranged between 76.78 and 87.89%. Samples treated with 50% alligator pepper concentration and dried at 85°C had the highest value of crude protein of 88.42% while the lowest 76.78% was obtained in control sample dried at 65°C. In addition fat content ranged from 2.26-11.51% with samples treated with 50% ginger concentration and dried at 75°C having the highest value for fat, while samples treated with 50% ginger concentration dried at 75°C had the least value of 2.28% for fat content. Furthermore, the range of values for crude fibre was 0.23-0.94%. Samples treated with 50% alligator pepper concentration and dried at 65% had the highest level of crude fibre value of 0.94% while control sample with distilled water and dried at 65°C had the lowest mean value of crude fibre of 0.23%. The ash content for treated and dried beef ranged from 5.44-8.88%. Samples treated with 70% alligator pepper concentration and dried at 75°C had the highest level of 8.88%, while control sample dried at 65°C had the least level of ash content. Carbohydrate content ranged from 1.23-10.11%. Samples treated with 50% alligator pepper and dried at 65°C was observed to have the highest value, while samples treated with 70% alligator pepper concentration

and dried at 85°C had the least (1.23%) value for carbohydrate content.

DISCUSSION

The pH is an important determinant factor that influences the growth and activities of microbes. The higher the pH the more spoilage potential of beef shelf life (Gregory *et al.*, 1994). The result obtained is in agreement range of stable shelf life (Walker and Betts, 2000). Jamilah *et al.* (2008) further reported that ultimate pH of meat offers significant resistance to spoilage because most bacteria grow optimally at specific pH range. Pathogen can enter into meat samples during processing, through air, unclean hand, unsanitary equipment, unsafe water and sewage and through cross contamination between fresh and finished products (FDA, 2001). The range of specific microbiological limits recommended by International Commission on Microbiological Specifications for Foods (1986) for meat and meat products are as follows: for TVC, the maximum recommended bacterial count for quality products (m), was 5×10^5 (5.7 log 10cfu/g) and the marginally acceptable quality products (M) was 10^7 (7 log 10 cfu/g). For *E. coli*, the value was 11 (1.0 log 10 cfu/g) and the m value 500 (2.7 log 10 cfu/g), and for staphylococcus, m value is 10^3 (3 log 10 cfu/g) (ICMSF, 1986). The TVC values obtained from the experiment for both the fresh and dried beef samples were within the range of specific microbiological limits recommended by ICMSF (1986) for meat and meat products. The lower values of TVC in ginger and alligator pepper-spiced fresh beef could be due to antimicrobial properties of ginger and alligator pepper. However, the higher viable counts observed in the control samples may be due to pre-slaughter and post-slaughter handling of meat in which handling play an important part in deterioration of meat quality (Dave and Ghally, 2011). The *Staphylococcus* count values obtained from both the fresh and dried beef samples were below the specified recommended value for meat and meat products. The *Staphylococcus aureus* safety level is equal to or greater than 10^4 /g and in many cases, these levels represent the point at or above which the agency will take legal action to remove products from the market according to Food and Drug Administration (2001). In addition, spices and drying reduced *Staphylococci* counts. The result obtained is in conformity with several Scientists including Shamsuddeen *et al.*, (2009) and Ibrahim *et al.*, (2011) who stated that spices apart from their noticeable antioxidant activity they also serve as an effective antimicrobial substance. Furthermore, the isolation of *Staphylococcus* in dried beef samples can be attributed to post processing contamination. The *E. coli* count values obtained for both the fresh and dried beef samples were below the specified range of microbiological limits recommended by ICMSF (1986). However, the control and samples treated with 50% ginger concentration and dried at 65°C need to be cooked before consumption in order to get rid of the *E. coli* present in the dried beef to prevent possibility of food poison, as *E. coli* serve as an indicator organisms for faecal contamination of foods. The population of *Streptococcus* in the fresh beef samples was all below 5.0×10^5 cfu/g as the specified microbiological limits recommended by ICMSF (1986). There was no growth of *Streptococcus* in the dried samples.

There was no detection of *Salmonella* in both samples. The microbial result corroborated with ICMSF specified limits and hence samples were of acceptable microbial quality. The amount of water present in food plays significant role in the

keeping quality of the food items, the lower the moisture content the lower the water activity. Conversely, the higher the moisture level, the more susceptible to rapid microbial growth which in turn affects its shelf life. The range of values for moisture obtained is in agreement with Isah and Okubanjo (2012) who reported a value of 16.65% for dried meat. The high moisture level retained in samples treated with ginger extracts might be as a result of addition of ginger having hydrophilic properties. This result further agree with the report of Naveena *et al.* (2004) who mentioned that increase in the moisture with increasing concentration of ginger extract indicates improvement in hydrophilic properties by the enzyme treatment. The crude protein content recorded indicates that as ginger concentration increases, protein level of the ginger treated samples also increases. This could be attributed to the protein content of ginger (12.60%) which contributed significantly to the increase in protein content of the samples. However, samples treated with alligator pepper had a higher crude protein than samples treated with ginger extracts and this is in contrast with the work of Adedeji and Ade-Omowaye (2013) who reported a higher crude protein content for bean cake spiced with ginger than that of samples spiced with alligator pepper. The significantly higher crude fat observed in the samples treated with ginger and alligator pepper extract might be attributed to the relatively high lipid content in these extracts which increased the fat content of the samples. Fiber is reported to lower serum cholesterol, control blood sugar and increase bulk stool (Okon, 1983). Ash content is an indication of mineral content in food. The result shows that ash content increased with the addition of alligator pepper spice and increased in temperature. The high ash content observed in the various treated beef samples might be due to the contribution of the high mineral content especially in alligator pepper spice (Adelakun *et al.*, 2009). Nutritional properties in terms of protein, fat and ash were high in respect of spices and drying. This suggests that the treatments possibly have antioxidants which despite drying and treatment application still kept the nutrients content of the samples intact.

Conclusion

Based on the result obtained, the application of extract of ginger and alligator pepper reduced microbial population and affected proximate composition. Additionally, 70% ginger concentration was more effective than alligator pepper. Drying beef at a high temperature for long time reduced moisture content and microbial population of the treated dried beef. However, further comparative research in respect of natural and synthetic sources of preservatives as well as use of different drying methods for meat is necessary to explore more possibilities.

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