

EFFECTS OF POLYPHOSPHATE AND VINEGAR TREATMENT ON QUALITY OF *DAMBUN NAMA* (A TRADITIONAL NIGERIAN MEAT PRODUCT)

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Abstract

Lean meat from the hind quarters of bovine (*Bos indicus*) and spices were obtained from Maiduguri Monday Market Ltd. The meat was processed into *dambun nama* after the meat pieces had been treated with polyphosphate (0.3%) alone, and combination of 0.2% vinegar and 0.3% polyphosphate. Samples were evaluated for quality changes along with the non-treated controls during storage at ambient temperature (28^o - 37^oC). The use of polyphosphate increased (P<0.05) the yield of the product and the taste panelist rated the treated products higher (P<0.05) than the non-treated control in terms of taste and overall acceptability. The bacterial counts were generally low and the addition of polyphosphate and vinegar also decreased the total aerobic plate count during 20 weeks of storage. *Staphylococcus*, *Streptococcus* and *Bacillus* species were the main organisms isolated from the product during storage at ambient temperature.

1. Introduction

Meat is an excellent source of high quality proteins, essential amino acids, vitamins (such as B-complex) and minerals (such as iron and zinc). When cooked, lean meat is palatable, easily digestible and supplies the nutrients which contribute to the dietary balance of meals (Forrest *et al.*, 1975).

Dambun nama which is one of the varieties of meat products found in northern Nigeria is a boiled, spiced, pounded and fried meat product. This meat product is usually prepared from ram, goat or beef. It is common after major festivals and on special occasions when excess meat that could not be utilized or consumed are processed into *dambun nama* for preservation and storage in the absence of refrigerated storage facilities. Nowadays, *dambun nama* is increasingly becoming a popular meat item in cocktails, naming ceremonies, wedding parties and as convenience food item.

Although the demand for *dambun nama* is on the increase, not much research work appears to have been carried out on this meat item in Nigeria. During processing, this meat product is fried in oil, and if not properly handled, oxidative rancidity and quality deterioration could result. This could lead to consumer's rejection and loss in revenue for the processors. Various extracts, additives and antioxidants have been used in recent years to enhance the quality of meat products (Negbenebor *et al.*, 2000). Polyphosphate has been reported to enhance juiciness, colour and reduce cooking purge and microbial counts of meat products (Swift and Ellis, 1956; Klose *et al.*, 1962; Negbenebor *et al.*, 1990; Chen *et al.*, 1973). Vinegar improves flavour and preserves the meat by reducing the *pH* (Okafor, 1989). A combination of vinegar and tripolyphosphate might enhance the quality of this meat product. The objective of this study therefore, was to investigate the effects of polyphosphate and a combination of vinegar and polyphosphate on the quality of *dambun nama*.

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2. Materials and method

Lean meat from Maiduguri Monday Market Ltd was transported to the Food Science and Technology Laboratory of the University of Maiduguri in ice to minimize deterioration and then processed immediately. Other ingredients such as ginger, hot pepper, black pepper, clove, onion, bouillon cubes, groundnut oil and salt (Table 1) were also obtained from the same market.

Table 1: Ingredient formulation for dambun nama

Ingredients	Weight (kg)	Percentage (%)
Lean meat	6.000	71.5
Red Pepper	0.252	3.0
Ginger	0.084	1.0
Black Pepper	0.058	0.7
Clove	0.109	1.3
Onion	0.126	1.5
Salt	0.019	1.3
Buillion cube	0.100	1.2
Groundnut oil	1.458	17.3
Chitta Maiyaya	0.016	0.2

2.1 Methods

Six kilogrammes of meat from the hind quarters of bovine (*Bos indicus*) was trimmed free of fat, cut into portions approximately 4 cm x 2.5 cm, washed with distilled water, drained and poured into an aluminum tower brand (ATB) stainless steel pot. The ingredients, obtained from a local processor in their normal composition ratio, were weighed out (excluding meat) and cleaned to remove extraneous matter, mixed in the proportions as shown in Table 1 and ground with a hammer mill (Gibbons Electric Mill) with 1.2 cm sieve size for 5 min. The ground spice mixture and water were mixed and added to the meat in the pot. The ratio of spice to water was 3:7 (W/V). The meat was mixed in the slurry of ingredients for 3 min., allowed to drain for 2 min., water cooked at 100°C for 1 hour 40 min. and pounded (using a mortar and pestle) into shreds for 5 - 10 min. The meat was divided into four samples and fried in the shallow ATB pan using groundnut oil at (173 – 176 °C) for 30 min. The ratio of meat to oil was 4:1 (W/V). Sample one (SM1) was prepared locally in town without polyphosphate and vinegar and this served as commercial control sample. Sample two (SM2) was a simulation of the commercial sample but was prepared in the laboratory and served as laboratory control sample. Sample three (SM3) was treated with 0.3% (W/V) sodium tripolyphosphate before frying, while sample four (SM4) was treated with a combination of 0.3 % polyphosphate and 0.2 % vinegar solution for 30 min. The ratio of polyphosphate solution to vinegar solution was 1:1.

The fried samples were cooled to ambient temperature, packaged and knotted in polyethylene bags separately and stored at ambient temperature (28 – 37 °C). The samples were observed for chemical and microbiological changes every month for a period of five months and evaluated organoleptically for sensory changes every other month for a period of six months.

Chemical analysis

Five grams of each sample in duplicate were weighed out into moisture determination cans

and dried in an oven ($105 \pm 2 \text{ }^{\circ}\text{C}$) for 2 h and the moisture content was determined as described by Pearson (1981). The protein contents of the samples were determined by the micro-Kjeldahl method (AOAC, 1984), while the fat content was determined by Soxhlet fat extraction method (AOAC, 1984). Ash content was evaluated by incineration of the sample in a Gallenkamp muffle furnace at $555 - 600 \text{ }^{\circ}\text{C}$ for 3 h (AOAC, 1984). For thiobarbituric acid (*TBA*) determination, 10 g were slurried with 50 ml of distilled water and the *TBA* values were determined by the method described by Tarladgis *et al.* (1964).

The *pH* of the sample was determined directly with a *pH* meter [Kent Eil 7045/46], after mixing 5 g of the meat in 20 ml distilled water. The water activity was calculated from the relative humidity (*RH*) measured with a Rotronic hygroscope *DT* (Negbenebor *et al.*, 1999).

Microbiological analysis

Ten grams of each sample was suspended in 90 ml sterile nutrient broth and serially diluted using the pour plate method. The serial dilution was plated out using blood agar and nutrient agar in duplicate plates separately and incubated for 48 h at $30 \text{ }^{\circ}\text{C}$ (Harrigan and McCance, 1976) for bacterial count. Bacterial colonies were isolated, purified using nutrient agar and inoculated into biochemical media, before identification using methods described by Collins and Lyne (1970) and Harrigan and McCance (1976). Selective counts were determined for staphylococcus and coliforms using Mannitol salt and McConkey agar respectively (Collins and Lyne, 1970)

Yield (%)

Total yield in percentage was determined as the weight of the fried product divided by the weight of the raw muscle and ingredients multiplied by 100.

Sensory evaluation

Sensory evaluation was conducted by a team of 15 panelists drawn from staff and students of the University of Maiduguri. The samples were rated for colour, texture, taste and overall acceptability based on a nine point hedonic scale with 9 representing 'like extremely' and 1 representing 'dislike extremely' (Amerine *et al.*, 1965), on the first day and after every 8 weeks for a period of 24 weeks.

Statistical analysis

Data were subjected to analysis of variance (Steel and Torrie, 1980), Duncan's multiple range and multiple F-test (Duncan, 1955) to separate the differences among the means.

3. Results and discussion

3.1 Proximate composition and yield

The proximate analysis of the fresh raw meat and processed samples shows a significant difference ($P < 0.05$) following frying (Table 2). There was a significant increase ($P < 0.05$) in the amount of protein, ash and fat contents with a significant decrease ($P < 0.05$) in the amount of moisture in the final samples when compared to the fresh sample. The decrease in moisture content was due to 'cook out' purge as a result of frying (Yang and Chen, 1979). This leads to a concentration of the nutrients. There was a significant difference ($P < 0.05$) in moisture content of *SM3* when compared to the controls (*SM1* and *SM2*). This might be responsible for the significant increase recorded in the fried yield of *SM3* (60%) compared to 40% of *SM1* and *SM2*. Polyphosphate has been reported to improve the water retention properties in meat and meat product (Sofos, 1986; Negbenebor *et al.*, 1990; Mandigo, 1982;

Eilert and Mandigo, 1996) and this agrees with these findings. However, there was no significant difference ($P < 0.05$) in yield between *SM4* and *SM1* & *SM2*.

Table 2: Effect of Tripolyphosphate and Vinegar on Proximate composition of processed *Dambun Nama*^{1,2}

Constituent	Processed Dambun Nama				
	Fresh meat	Control A <i>SM1</i>	Control B <i>SM2</i>	<i>SM3</i>	<i>SM4</i>
Moisture	75.0 ± 1.0a	14.4 ± 0.2c	15.3 ± 0.4c	17.1 ± 0.5b	14.7 ± 0.4c
Protein	19.8 ± 0.1b	47.2 ± 0.3a	46.2 ± 0.1a	45.7 ± 0.5a	47.5 ± 0.4a
Fat	3.2 ± 0.1b	32.6 ± 0.9a	31.1 ± 0.5a	31.3 ± 0.4a	31.3 ± 1.0a
Ash	1.4 ± 0.4b	5.7 ± 0.4a	5.8 ± 0.6b	6.5 ± 0.1a	6.1 ± 0.1a

1. Each reading is a mean of four determinations and standard deviation.

2. Means in a row with unlike letters differ significantly ($P < 0.05$)

Control (A) - *dambun nama* prepared locally in town (*SM1*)

Control (B) - *dambun nama* prepared in the laboratory (*SM2*)

SM3 - *dambun nama* treated with 0.3% tripolyphosphate.

SM4 - *dambun nama* treated with 0.3% polyphosphate and 0.2% vinegar.

3.2 Storage stability

The addition of tripolyphosphate and vinegar significantly decreased ($P < 0.05$) the *TBA* values of treated *dambu nama* samples at week 0 during storage (Table 3). However, there was no significant difference ($P < 0.05$) in *TBA* values for all samples after 8 weeks storage at ambient temperature regardless of treatment. Following storage there was a significant increase in malonaldehyde production. This increase may be due to 'oil pick up' during frying and oxidation which may have resulted in increased malonaldehyde production during storage (Rhee *et al.*, 1996). The proportion and degree of unsaturation of the fatty acid present in a lipid system should indicate the approximate susceptibility of that system to oxidative rancidity (Allen and Foegeding, 1981).

Table 3: *TBA* values of the various samples of *dambun nama* stored at ambient temperature^{1,2}

Storage time (weeks)	<i>SM1</i>	<i>SM2</i>	<i>SM3</i>	<i>SM4</i>
0	0.09 ± 0.01a	0.07 ± 0.03a	0.08 ± 0.02a	0.05 ± 0.01b
4	0.30 ± 0.02b	0.29 ± 0.04b	0.52 ± 0.04a	0.46 ± 0.13a
8	0.57 ± 0.01a	0.56 ± 0.02a	0.70 ± 0.17a	0.75 ± 0.08a
12	0.90 ± 0.06a	0.97 ± 0.05a	1.15 ± 0.04a	1.05 ± 0.30a
16	1.10 ± 0.01a	1.36 ± 0.03a	1.47 ± 0.29a	1.39 ± 0.07a
20	1.48 ± 0.40a	1.50 ± 0.10a	1.60 ± 0.10a	1.70 ± 0.20a
24	1.50 ± 0.30a	1.54 ± 0.20a	1.60 ± 0.20a	1.72 ± 0.30a

1. Each value is a mean and ± S.D. of four determinations.

2. Means in a row with unlike letters differ significantly ($P < 0.05$)

3.3 Microbial count

The fresh meat sample had initial mean log bacterial count which ranged from 4.08 to 4.39 cfug⁻¹. This is less than the 5.04 - 6.7 cfug⁻¹ reported by Negbenebor *et al.* (1990). Following processing, the bacterial count decreased to 2.4 - 2.8 cfug⁻¹ (Table 4). This value was less than 4.2 - 5.6 cfug⁻¹ reported for *kilishi* (Negbenebor *et al.*, 1990) and 7.18 ± 0.26 cfug⁻¹ for *tsire* meat products (Igene and Abulu, 1984). The variation in counts may be as a result of the weather, handling methods, sanitary conditions and the methods of processing which

subjected the meat samples to different temperature regimes. Bacterial count of 8.0 cfug^{-1} and above is an indication of spoilage in meat products (Jay, 1987). The samples treated with a combination of polyphosphate and vinegar had the least bacterial count following processing and storage (Table 4). Okafor (1989) stated that vinegar had some preservative effects on meat, possibly by reducing the *pH* of the meat. Polyphosphate solutions are effective in the control of gram-positive micrococci and staphylococci in meat (Chen *et al.*, 1973). There was a decrease in bacterial count for all samples irrespective of treatment during storage (Table 4) at ambient temperature ($28 - 37^{\circ}\text{C}$) for 24 weeks.

Table 4: Total aerobic plate count of the various samples of *dambun nama* stored at ambient temperature^{1,2}

Storage time (weeks)	SM1	SM2	SM3	SM4
0	$2.8 \pm 0.5a$	$2.7 \pm 0.1a$	$2.6 \pm 0.1a$	$2.4 \pm 0.1a$
4	$2.6 \pm 0.3a$	$2.5 \pm 0.1a$	$2.5 \pm 0.1a$	$1.8 \pm 0.3b$
8	$2.5 \pm 0.6a$	$2.3 \pm 0.1a$	$2.1 \pm 0.1a$	$1.6 \pm 0.3b$
12	$1.9 \pm 0.5a$	$2.0 \pm 0.2a$	$1.8 \pm 0.3a$	$1.1 \pm 0.1b$
16	$1.5 \pm 0.2a$	$1.3 \pm 0.6a$	$1.5 \pm 0.1a$	$0.5 \pm 0.1b$
20	$1.1 \pm 0.1a$	$1.1 \pm 0.1a$	$1.0 \pm 0.2a$	$0.4 \pm 0.2b$
24	$1.1 \pm 0.2a$	$1.0 \pm 0.2a$	$1.2 \pm 0.3a$	$0.4 \pm 0.2b$

1. Each value is a mean and \pm S.D. of four determinations.

2. Means in a row with unlike letters differ significantly ($P < 0.05$)

This decrease in microbial count paralleled similar decrease in water activity values of the samples from 0.88 - 0.95 on week 0 to 0.71 - 0.74 on week 24. The decrease in water activity during storage was as a result of samples losing moisture to the surroundings due to the prevailing low humidity (RH of 31% at 32°C) of the environment obtained at the time in Maiduguri. Banwart (1979) indicated that a water activity level above 0.85 would readily support the growth of most microorganisms. He also considered a water activity of 0.70 or less as safe and suitable for the storage of dried foods.

3.4 Isolates

The organisms isolated after 4 weeks of storage are shown in Table 5. *Staphylococcus aureus*, *Streptococcus faecalis*, *Bacillus cereus* and *Bacillus subtilis* were the bacterial organisms isolated from the products. The numbers of bacteria found in this study were low (less than mean $\log 3.0 \text{ cfug}^{-1}$). Such figures are common in commercial beef products and are not enough to cause food poisoning. *Staphylococcus aureus* is a pathogenic organism which has been implicated in food poisoning when the number is up to $\log 5.0 \text{ cfug}^{-1}$ (Banwart, 1979). It also causes infection commonly in tissues and sites with lower resistance, such as damaged skin and mucous membrane. It is also common in the haematoma in the cancellous tissues of long bone, following injury which predisposes it to osteomyelitis (Maibach and Hildic-Smith, 1965; Mudd, 1970; Jay, 1987). *Streptococcus faecalis* is pathogenic and forms 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). *Bacillus cereus* produces enterotoxins which are responsible for two food-poisoning syndromes: diarrheal syndrome which is mild and consists of cramp-like abdominal pain, tenesmus and stool, and emetic syndrome which is more acute than the first (Jay, 1987; Cruickshank *et al.*, 1973). *Bacillus subtilis* is not pathogenic to man (Wilson and Miles, 1954).

Table 5: Biochemical characteristics of the isolated colonies

Sample	Morphology	Spore	Mortality	Gram stain	Glucose	Sucrose	Mannitol	Maltose	Indole	Catalase	Coagulase	Possible organism
1	Cocci cells which form clusters	-	-	+	+	-	+	+	-	+	+	<i>Stap. aureus</i>
2	Spherical cells arranged in chains	-	-	+	+	-	+	+	-	+	-	<i>Streptococcus faecalis</i>
3	Large celled rods in chains (aerobic)	+	-	+	+	-	+	+	-	+	-	<i>Bacillus cereus</i>
4	Small rods growing aerobically	+	-	+	+	-	+	+	-	+	-	<i>Bacillus subtilis</i>

+ positive or present
 - negative reaction or absent

3.5 Sensory evaluation

A semi-trained panelist consisting of 15 members rated the taste, overall acceptability, texture and colour of the samples immediately after production and after 24 weeks of storage at ambient temperature. Samples *SM3* and *SM4* were rated better ($P < 0.05$) than the control samples in taste and overall acceptability (Table 6). Polyphosphate and vinegar have been reported to improve flavour (Chen *et al.*, 1973; Okafor, 1989). However, there was no significant difference ($P > 0.05$) in texture and colour of treated samples when compared to the controls. Results suggest that polyphosphate and vinegar can be used without adverse effects on colour and texture. The presence of ingredients such as pepper, clove and onion in the formulation may have acted as antioxidant or masked the off-flavour and thus reduce flavour deterioration in the finished products (Marquez *et al.*, 1989).

Table 6: Effect of the polyphosphate and vinegar on sensory evaluation of four samples of *dambun nama*

Storage time (weeks)	<i>SM1</i>	<i>SM2</i>	<i>SM3</i>	<i>SM4</i>
Taste				
0	6.3±0.1a	6.5±0.3a	9.7±0.1b	8.2±0.1b
8	6.1±0.3a	6.1±0.1a	8.3±0.1b	8.5±0.1b
16	5.6±0.1a	5.7±0.2a	7.9±0.8b	7.8±0.2b
24	5.4±0.1a	5.5±0.3a	7.6±0.2b	7.5±0.3b
Colour				
0	8.3±0.3a	8.1±0.2a	8.2±0.2a	8.1±0.3a
8	8.1±0.1a	7.8±0.1a	7.9±0.2a	7.5±0.3a
16	7.6±0.1a	8.8±0.2a	7.4±0.3a	7.2±0.1a
24	7.3±0.3a	7.5±0.1a	7.2±0.3a	7.1±0.2a
Texture				
0	7.2±0.4a	7.4±0.3a	7.6±0.5a	7.0±0.2a
8	7.2±0.4a	7.5±0.2a	7.8±0.5a	7.4±0.2a
16	6.8±0.2a	6.9±0.5a	7.2±0.2a	7.1±0.1a
24	6.5±0.2a	6.6±0.2a	6.7±0.1a	6.6±0.1a
Overall acceptability				
0	7.1±0.1b	7.1±0.3b	8.7±0.5a	8.5±0.2a
8	7.4±0.1b	7.2±0.2b	8.1±0.6a	8.1±0.1a
16	6.5±0.1b	6.2±0.2b	7.6±0.3a	7.7±0.1a
24	6.1±0.2b	6.1±0.1b	7.4±0.4a	7.2±0.1a

Means within a row in a subset with unlike letters differ significantly ($P < 0.05$)

4. Conclusion

The use of a combination of polyphosphate and vinegar in the production of *dambun nama* significantly reduced the microbial count following processing and storage when compared to the controls. A treatment which reduces microbial count early in the production cycle may be beneficial in enhancing the quality of product. The use of a combination of polyphosphate and vinegar also improved the taste and overall acceptability of the product. This could help increase the rate of turn-over of the product for the processor. It is not yet possible to commercially market *dambun nama* that is completely free of microorganisms. The presence of some of these potentially pathogenic organisms such as *S. aureus*, *B. cereus*, are of interest

to food scientists, meat processors and consumers because of their public health significance. The number of bacteria found in this study was low and are similar to those normally found in commercial beef products. However, efforts should be made to improve the hygienic nature of the environment during processing.

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