Influence of packaging Materials and Storage Length on the Physico-Chemical Quality of *Balangu*: A Nigerian Ready-To-Eat Meat Product

Ribah, M. I.[1], Jibir, M.[2] and I. S. Jega[3]

[1]*Department of Animal Science, Faculty of Agriculture, Kebbi State University of Science and Technology, Aliero, PMB 1144 Birnin kebbi, Nigeria*

[2]*Department of Animal Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, PMB 2346, Sokoto, Nigeria*

[3]*Department of Forestry and Fisheries, Faculty of Agriculture, Kebbi State University of Science and Technology, Aliero, PMB 1144 Birnin kebbi, Nigeria*

Abstract **- Physico-chemical qualities of *balangu,* a traditional ready-to-eat meat (rte-mp), were evaluated in a 3×4 factorial experiment involving three packaging materials (aluminium foil, paper and polythene) and four storage times (0 , 24, 48 and 72 hours). *Balangu* was prepared using traditional methods, packaged and stored according to the designated treatments. Data obtained from all treatments were analysed using in the general linear model analysis of variance, and means were separated by Tukey test at 5% level of significance. Both packaging materials and storage length had significantly affected ($P<0.05$) weight loss, pH, moisture, crude protein, ether extract and ash contents during storage. However, pH was not significantly affected by storage length. There was a significant interaction ($P<0.01$) between packaging materials and storage length on all parameters except weight loss, ether extract and ash. Paper packaging performed better than aluminium foil and polythene packaging while storage length however indicated an order of (0) > 24 > 48 >72 hours and ranked 1st, 2nd, 3rd and 4th, respectively. Paper packaging had shown better performance and could store *balangu* up to 48 hours with optimum sensory qualities.**

Keywords **– Physico-chemical, *balangu,* packaging materials, storage length.**

I. INTRODUCTION

In Nigeria, Ready-to-eat meat products (RTE-MP) including intermediate moisture meats like *balangu, tsire, guru* and dried meat products like *kilishi, dambun nama, banda*, were reported to be highly appreciated because of their characteristic taste and texture and [1]. Reference [2] (2010) considered the consumption of these products as safe due to the treatments that are usually involved during their production.

Balangu refers to meat that has been grilled over wood or coal fire. Specifically, no seasoning is applied to bring out the natural flavor of the particular type of meat which may be of goat, sheep or cattle. Salt and spices could be added to taste after preparation. Prepation of *balangu* as described by [3] involves using boneless flesh, offals and viscera of mutton or beef. It was reported by [4] that, in the past, *balangu,* were mainly popular only among the Hausas of Northern Nigeria and other African Countries where it is believed to have originated. Reference [5] reported that *balangu* production has blossomed as it is consumed throughout Nigeria and even extended to other countries. However, today, the product has gone beyond the borders of the Hausa communities and has become delicacies that cut across different ethnic groups, religion, sex, social and economic class. Also, the product has also made its way into the elite circles where it is often served in parties, conferences and clubs and also become widely known to be popular evening snack sold by roadside vendors and restaurants [6] who usually package the product in papers, aluminium foil, polythene bags and plastic containers for utilization by customers.

Food packaging is one of the technologies that control microbial growth and maintain product quality [7]. Considerable advances have been made in the type and design of packaging materials used for heat processed foods [8]. In addition to modified atmosphere packaging, modern technology has added numerous types of metal, glass, plastic and paper packaging. Generally, packaging improves food safety by protecting the food from contamination [9]. In Nigeria however, [10] reported that there are diverse and numerous types of locally produced RTE foods sold in public places for immediate consumption and the packaging of these foods is usually meant for containment with no attention paid to the safety of the consumers and the quality and shelf-life of the food. Furthermore, the hygienic state of the packaging materials and their appropriateness for the food products are not considered in their selection. Almost all the food products packaged by the local processors and vendors in Nigeria are unlabeled. No indication is given of the names of the products, their sources, composition nor any information on appropriate storage conditions and instructions for use.

Consequently, the role of packaging in the food industry, which includes protection, containments, transportation, preservation and advertisement are not achieved in almost all the packaging materials and methods used by street food vendors in Nigeria. This in turn results in a

huge loss of the food product not only during packaging processes but also during transportation and sales as a result of contamination by food spoilage microorganisms, dust and chemicals [10]. Hence, the current study was designed to compare packaging materials and storage length for physico-chemical characteristics of the RTE-MP.

II. MATERIALS AND METHODS

A. Experimental Design

This study investigated the physico-chemical qualities of *balangu* under different packaging materials. The laboratory experiment consisted of three food grade packaging materials: Aluminum foil (ALF), brown paper (BPP) and polyethylene (POL) with four storage times (0, 24, 48, and 72 hours). A total of twelve treatment combinations were obtained in a 3×4 factorial experiment involving three packaging materials and four storage periods in a completely randomized design.

B. Packaging Materials, Sample Preparation and Packaging

Packaging materials were purchased from Sokoto metropolitan supermarkets and processed according to required dimensions. A package consisted of a sheet of a material with the dimension of $25\times25cm^2$. *Balangu* was prepared from sliced beef (1-2cm thick) in a portable drum kiln specifically designed to process the product under optimal hygienic conditions. The sliced beef was placed on a brown craft paper sheet that has been spread over the wire mesh two feet above glowing fire from firewood. After two hours with regular turning interval of 30 minutes, *balangu* was produced. After gradual cooling for 30 minutes in the kiln, a clean knife was used to cut pieces of samples with dimension of $3\times3cm^2$.

A total of 120 *balangu* samples were prepared and ten samples were randomly allotted to each of the already prepared packaging material, carefully wrapped and represented a packaging treatment. All 12 wrapped packages were then arranged in a flat platform at room temperature for their respective storage length. After each storage length, three samples were randomly taken from each treatment combination and evaluated for proximate analysis and storage stability and seven samples were used for subjective sensory analysis as indicated in.

C. Determination of Physico-Chemical Composition of Balangu

Determination physico - chemical composition of *balangu* was carried out as described by [11] where weight loss, pH, Moisture content, crude protein, Crude fat, ash content were determined.

III. RESULTS AND DISCUSSION

A. Physical qualities

Packaging materials had significantly affected weight loss, pH and moisture content of the stored *balangu* (Table 1). Similarly, storage length had significant effects ($P<0.05$) on all parameters except pH. There was increased weight loss with increase in storage length. Balangu packaged in paper had significantly higher weight loss than those packaged in aluminium foil and polythene. The pH value was significantly higher in samples packaged in paper than those packaged in polythene which was higher than those packaged in aluminium foil. Aluminium foil packaged balangu had significantly higher moisture content than those packaged in polythene which was higher than the paper packaged samples. At storage, control samples had significantly lower weight loss which increased with increase in storage length up to 72 hours. Similarly, control samples had significantly lower moisture content which also increased with increase in storage length up to 72 hours of storage. There was a significant interaction ($P<0.01$) between packaging materials and storage length on moisture content with 72 and 48 hours having similar influence on weight loss, pH and moisture content for all packaging materials.

TABLE 1

EFFECT OF PACKAGING MATERIALS AND STORAGE LENGTH ON THE PHYSICAL QUALITIES OF *BALANGU*

Factor	Parameters		
	Weight loss (g)	**pH**	**Moisture Content (%)**
Packagingmaterials			
Aluminium foil	0.317^{c}	6.42^{c}	61.50^{a}
Paper	0.708^{a}	6.89^{a}	55.73^{c}
Polythene	0.350^{b}	6.59^{b}	60.25^{b}
SE	0.030	0.057	0.214
Storagelength (hours)			
0 (control)	0.211^{a}	6.717	50.17^{c}
24	0.389^{b}	6.601	60.11^{b}
48	0.600^{c}	6.682	63.44^{a}
72	0.633^{c}	6.541	62.91^{a}
SE	0.035	0.065	0.247
Interaction			
Packaging × Storage length	NS	NS	**

a,b,c = means with different superscript along the same column within a subset differ ($P<0.05$), ** = ($P<0.001$), NS= Not Significant

1) Weight loss

The higher loss in weight of balangu packaged in paper may be attributed to loss in moisture. Absorptive and permeability properties of the paper material [12] could also help in absorbing the moisture of the packaged samples leading to reduction in the weight of the contents. Reference [13] reported a weight loss in fresh beef streaks packaged with craft paper at room temperature and attributed it to the permeability of the material. Weight loss could also be as a result of environmental conditions of the surrounding.

Reference [14] opined that purge could occur from the physical pressure of the external atmosphere on the surface of the product under package, and results in product weight loss. Reference [15] reported a significant weight loss when tomatoes were wrapped in paper than those wrapped in polythene bags. Furthermore, permeability of craft paper might also influence gain in weight. The apparent disagreement of this finding with that reported by [16] where plantain chips packaged in craft paper increased in weight after storage period of three months more than polythene bags and plastic containers could not be unconnected with the hygroscopic nature of the product packaged and the climatic factors (temperature and relative humidity) to which the packages were exposed. Hence, dry plantain chips might likely absorb moisture unlike *balangu* which has high moisture content. The implication of such moisture loss could result in reduced juiciness of the packaged product. Hence, craft paper packaging could not conveniently serve the purpose of water retention for meat products whose moisture is desired. Polythene and aluminium foil packaging had a relatively lower (0.350 and 0.317g, respectively) weight loss signifying their tendency to retain moisture in the stored product and protect weight losses due to their impermeability [12].

Balangu packaged in polythene also had greater weight loss than that packaged in aluminium foil (0.350 and 0.317, respectively). The only possible loss could be due to moisture loss [17]. It may also be as a result of external pressure which according to [14], purge could occur from the physical pressure of the external atmosphere on the surface of the product under package, and results in product weight loss. However, since aluminium foil is more rigid than polythene, the product packaged in it is likely to be subjected to more pressure and hence will purge less than polythene.

The higher weight loss observed at 48 and 72 hours of storage length (0.633 and 0.600) than 24 and 00 hours storage length (0.389 and 0.211) signifies increase in weight loss due to increase in storage length. This result agrees with the findings of [13] where increase in storage period engendered increase in weight loss of packaged meat streaks. This similar trend was reported by [18].

2) pH

The pH values obtained in the current study indicated that freshly produced *balangu* had a pH condition with values ranging between 6.42-6.89 across both packaging materials and storage length, indicating a slightly acidic condition. This high pH observed relative to ultimate pH of 6.0 suggested by [19] and 5.8-5.4 suggested by [20] indicated that the animal was stressed before or during the slaughtering process. Hence, the depleted glycogen was not sufficient to provide enough lactic acid and lower the pH. Reference [20] reported that immediately post-mortem, the pH of normal muscle at slaughter is about 7.0 but this will decrease in meat. In a normal animal, the ultimate pH falls to around pH 5.8-5.4, and that the degree of reduction of muscle pH after slaughter has a significant effect on the quality of the resulting meat.

Among packaging materials, balangu packed in paper had higher pH value (6.89) than those packaged in polythene and aluminium foil with 6.59 and 6.42, respectively. Parallel to the findings of the current studies, several previous researches for meat products did not find significant effects of packaging materials on pH of meat products but reported that pH increased with storage time [21][22]. Though, most of the studies were conducted in raw meat products on which continued metabolism and pH decline is expected under storage.

3) Moisture Content

The moisture content obtained in the current study with respect to packaging materials indicated that aluminium foil packaged samples had higher mean moisture content (61.5%) than samples packaged in polythene and paper which had 60.25 and 55.73%, respectively. The higher moisture content observed in balangu packaged in aluminium foil and poythene might be as a result of external physical pressure which according to [14], purge could occur from the physical pressure of the external atmosphere on the surface of the product under package, and results in product weight loss, which is only possible through moisture loss [17].

However, since aluminium foil is more rigid than polythene, the product packaged in it is likely to be subjected to more pressure and hence will purge less than polythene and hence, retain more moisture. The lower moisture content observed in paper packaged samples could be associated with possibility of moisture loss as a result of the permeability, absorptive and texture properties of the material [12]. Storage length had however shown that samples stored for 48 and 72 hours had retained more moisture (63.44 and 62.91%) than samples stored for 24 hours and the control samples (60.11 and 50.17%).

The phenomenon of greater moisture in the samples stored for 48 and 72 hours could be as a result of some chemical reactions taking place in the packaged condition such as lipid oxidation, microbial activity and denaturation of proteins [17] releasing water as a result of the inability to bind water. Similar to the moisture content values obtained in the current study for the product had been reported in previous works suhc as [23] found 48.3% in *balangu*, 62.27% was obtained by [24] in *balangu*, and [25] reported a range of 35.0-39.09%. in *balangu*.

B. Chemical Properties

Results for chemical qualities of *balangu* according to packaging materials and storage length are presented in Table III. Results indicated that chemical properties of balangu were significantly affected ($P<0.05$) by packaging materials and storage length. Paper packaged samples had significantly higher crude protein than aluminium foil packaged samples, which was higher than polythene packaged

samples. Ether extract was significantly higher in samples packaged in aluminium foil than those packaged in paper and polythene which did not significantly differ. Ash content was significantly higher in samples packaged in aluminium foil than those packaged in paper and polythene which did not significantly differ. Balangu samples stored for 48 hours had significantly higher crude protein than those stored for 72 and 24 hours which did not differ significantly and higher than the control samples. Ether extract was significantly higher in control and reduce gradually with increase in storage length. Ash content was significantly higher in control than 24 hours of storage which was higher than 72 and 48 hours of which the ash content did not differ significantly. There was a significant interaction ($P<0.01$) between packaging materials and storage length on crude protein content.

TABLE 2

EFFECT OF PACKAGING MATERIALS AND STORAGE LENGTH ON THE CHEMICAL QUALITIES OF *BALANGU*

Factor	Proximate component		
	Crude Protein (%)	**Ether Extract (%)**	**Ash (%)**
Packaging materials			
Aluminium foil	26.35 [b]	2.54 [a]	2.21 [a]
Paper	32.83 [a]	2.21 [b]	1.96 [b]
Polythene	23.32 [c]	2.00 [b]	1.75 [b]
SE	0.138	0.083	0.076
Storage length (hours)			
0 (control)	24.17 [c]	3.78 [a]	2.78 [a]
24	28.09 [b]	2.11 [b]	2.17 [b]
48	29.23 [a]	1.72 [c]	1.44 [c]
72	28.51 [b]	1.39 [d]	1.50 [c]
SE	0.159	0.096	0.088
Interactio			
Packagin × Storage length	NS	NS	NS

a,b,c,d = means with different superscript along the same column within a subset differ

1) Crude Protein

The crude protein content was higher (32.83%) in samples packaged in paper than aluminium foil and polythene (26.35 and 23.32%, respectively). The high crude protein content observed in the paper packaging could be due to the evaporative and moisture loss that was consequent to weight loss. This could have resulted in loss of moisture content and subsequent concentration of muscle protein more than its corresponding aluminium foil and polythene packaged samples. The findings agrees with the 31.8% crude protein reported by [25] (31.72%) and [26] (32.96%) for *balangu*.

Although some forms of packaging are very effective at slowing oxidative changes in meat system over time, research has shown that some packaging techniques still allow or enhance the occurrence of oxidative modifications [18] during storage. Hence, storage length had shown an irregular trend in the protein content. Samples stored for 48 hours had greater protein content (29.23%) than 72 and 24 hours having 28.51 and 28.09%, respectively with control samples having 24.17%. This irregular trend could best be explained in terms of processes of protein oxidation which is a covalent modification of protein induced either directly by reactive species or indirectly by reaction with secondary by-products of oxidative stress [27]. Scientific evidence has shown that the mechanism of free radical attack on protein molecules results in protein cross-linking, protein fragmentation, and/or modification of amino acid side chains [18], with each reaction yielding a specific oxidative derivative. Reference [27] observed that not only are these modifications critical for technological and sensory properties of muscle foods, they may have implications on human health when consumed.

2) Ether extract

The lipid content in terms of ether extract obtained with respect to packaging materials in the current study indicated that aluminium foil packaged samples had significantly greater lipid content (2.54%) at the end of storage period. Paper and polythene packaged samples had statistically the same lipid content (2.21 and 2.0%, respectively). However, a progressive decrease in lipid content with increase in storage length was observed. the control samples had higher lipid content (3.78%) than 2.11, 1.72 and 1.39% for samples stored at 24, 48 and 72 hours, respectively.

The decrease in lipid content could be due to lipid oxidation and production of free radicals which were reported by [28] as natural processes which affect fatty acids and lead to oxidative deterioration of meat and off-flavours development, and production volatile fatty acids which may escape leading to the reduction in the weight of lipids. It was also reported that under storage conditions, fats and the lipid content of foods may undergo oxidation and the rate of oxidation depends on the fat level, profile of fatty acids and the specific storage conditions [29].

3) Ash content

The greater ash content found in aluminium foil packaged samples (2.21%) than in paper and polythene packaged samples (1.96 and 1.75%, respectively) could be related to the moisture content of the samples. In the current study, aluminium foil packaged samples had higher moisture content than paper and polythene packaged samples (Table 3). Similar results were reported by previous works on the product and its related types. Reference [25] reported a range of 1.8-2.8% ash content in *balangu*, [30] found a mean ash content of 2.4 in *balangu*, (0.41), [26] reported 5.56% in *balangu*, [23] found 5.9% ash content in *balangu*.

IV. CONCLUSION

Packaging and storage length had significantly affected the physico-chemical characteristics of balangu, and paper packaging had shown better performance and could store *balangu* for up to 48 hours. Therefore, it was concluded that the favourable combination of packaging material and storage length that could optimize the physico-chemical qualities of *balangu*, was found to be packaging in paper and utilized within 48 hours of production.

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