

PHYSICOCHEMICAL AND SENSORY CHARACTERISTICS OF FERMENTED SEEDS OF *Prosopis africana*

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Abstract

The Idoma people of Benue State, Nigeria use fermented seeds of *Prosopis africana* (locally known as okpehe) as food condiment. It was produced in the laboratory by simulating the traditional method and using starter cultures of *Bacillus subtilis* and *Bacillus licheniformis*. It was preserved for 14 weeks using different treatments: sun drying, oven drying, refrigerating, freezing, smoking, salting (5%, 10%, 15% and 20%), oven drying plus salting (5%). The aim of this study was to evaluate the physicochemical and sensory characteristics of the Okpehe samples during preservation. The pH increased significantly (6.53 - 7.46) while the crude protein (43.97% - 42.81%), total ash (4.13% - 3.88%), crude fiber (4.02% - 3.40%) and moisture content (12.76% - 6.06%) decreased significantly ($p < 0.05$) as the storage period increased. At the end of the storage period, the salted and oven dried Okpehe had the highest protein content of 43.64% whilst the refrigerated Okpehe had the least (42.81%). The sensory analysis revealed that the refrigerated samples were most preferred by the panelists in terms of colour with a score of 8.01. Smoking was rated highest in terms of aroma with a score of 7.68 while the sample with 5% salt and oven dried was most preferred in terms of general acceptability with a score of 7.61. It can be inferred from this study that Okpehe could be best preserved by combining salting (5%) with oven drying at 60°C.

Key Words: Okpehe, *Prosopis africana*, Proximate Constituents

Introduction

Legumes belong to the family Leguminosae and are one of the largest plant families in the world with about 18,000 species (Balogun, 2013). *Prosopis* consists of about 45 species of leguminous spiny trees and shrubs growing widely in subtropical and tropical regions of America, Africa and southwest Asia (Geising, 2011). *Prosopis africana* is the only *Prosopis* native to intertropical Africa, occurring from Senegal to Ethiopia throughout the Sudanian and Guinean ecozones, reaching the border of the Sahelian ecozone in the north (Le Houerou, 2011). It is one of the lesser-known legumes

used as food condiment in Nigeria by the Idoma and Igala people of the Middle Belt region.

Fermentation result in the breakdown of complex organic substances into smaller ones through catalysis thereby increasing the nutritional value of the food. It remains an effective, inexpensive method for extending the shelf life of foods (Tamang, 2009). In African countries, it is a method of making food storable and by this way attempting to have sufficient food in the lean seasons. Protein rich seeds are often fermented to make food condiments which enhance the flavor of foods. The high cost of animal

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protein has directed interest towards several leguminous seeds as potential sources of vegetable protein for human food and livestock feed (Ezenwah and Ikenebomeh, 2008). Most times, seeds that are used for fermentation are inedible in their raw unfermented or cooked state.

Indigenous fermented condiments have recently assumed a greater importance in Nigeria since the majority of the populace can no longer afford the high cost of edible plant and animal proteins (Ogbadu *et al.*, 1990). Traditional condiments have not attained worldwide commercial status due to the short shelf life, objectionable packaging materials, stickiness and the characteristic putrid odour (Arogba *et al.*, 1995). Fermented condiments often have a stigma attached to them as they are considered as food for the poor. Production of these condiments is by spontaneous fermentation carried out in people's homes using rudimentary utensils under varying hygienic conditions (Oguntoyinbo *et al.*, 2010).

In most African countries including Nigeria, the problem of food security is not just that of inadequate food but it is also a problem of loss of food due to spoilage. Lack of adequate food preservation methods is a major problem contributing to food insecurity in Africa. The high costs and infrastructural requirement of many advanced food preservation methods such as refrigeration, freezing, canning and irradiation have greatly reduced their applications in the developing world (Ibe and Orabuiké, 2009).

Food preservation is the process of treating and handling food to stop or slow down spoilage and thus allow for longer storage. According to Sivasankar (2009), the basic principles of food preservation primarily involve the process of inhibiting such processes as the growth and activity of microorganisms, activity of endogenous enzymes, chemical reaction which may

deteriorate the quality of food and invasion and spoilage by insects and rodents. Foods can be preserved using different methods like drying, refrigerating, freezing, addition of salt or sugar, smoking, canning, high heat processing (pasteurization), ionizing radiation, chemical preservatives, pickling *e.t.c.* Therefore the purpose of this work is to (i) determine the best preservative method for *Okpehe* using different preservation regimens and (ii) carry out physicochemical and sensory analysis on the samples.

Materials and Methods

Preparation of *Okpehe* Samples

Prosopis africana fruits were obtained from the University of Ilorin, Ilorin, Nigeria. *Okpehe* was prepared in the laboratory using the hot plate method described by Balogun and Oyeyiola, (2012) with some modifications. The seeds of *Prosopis africana* were removed by beating the fruits with a club on a concrete surface to break the tough fruit coat. Two thousand grams of seeds were boiled at 100°C for 6 hours in a stainless steel pot on a hot plate, during which the seed coats became soft and the seeds swollen. The seeds were allowed to cool. The seed coats were removed by pressing between fingertips. The seed coats were later decanted along with the washing water, leaving the clean cotyledons. The clean cotyledons were rinsed with sterile water before putting them in another clean pot with small amount of water and cooked on the hot plate set at 60°C for 30minutes. The cotyledons were later drained through a sterile sieve and inoculated with starter cultures of *Bacillus subtilis* and *Bacillus licheniformis* (1:1). The resulting mash after inoculation was first wrapped with pawpaw leaves and then in three layers of sterile aluminium foil. The pawpaw leaves used had been cleaned and surface sterilized with 70% alcohol and rinsed with sterile water

prior to their usage. The wrapped cotyledons were left at $30 \pm 2^\circ\text{C}$ for 72 hours in an incubating unit to ferment.

Preservation of Okpehe

One thousand grams of freshly prepared *Okpehe* was produced as described above. The *Okpehe* produced was divided into ten equal portions and then preserved using the following preservation treatments: freezing, refrigerating, sun drying, oven drying, salting (5%) plus oven drying, smoking and salting using the following concentrations; 5%, 10% 15% and 20%. The pH, proximate composition and sensory analysis of the preserved samples were determined according to standard methods at two weeks interval for fourteen weeks.

Statistical Analysis

The data obtained were analysed using one-way analysis of variance and means separated by Duncan multiple range tests according to Steel and Torrie, (1981).

Results and Discussion

Table (1) shows the result of the pH changes observed in *Okpehe* preserved for 14 weeks. The pH increased slightly (6.53 – 7.46) during the storage period although the pH of the treated samples was lower than fresh *Okpehe*. The crude protein (43.97% - 42.81%) (Table 2), total ash (4.13% - 3.88%) (Table 3), crude fibre (4.02% - 3.40%) (Table 4) and moisture content (12.76% - 6.06%) (Table 5) decreased significantly as the storage period increased. The significant decrease in total ash, crude fibre and crude protein observed during storage is consistent with the findings of Ademola *et al.* (2011) when they worked on preservation of processed locust bean (*iru*). They observed a decrease in the nutrient composition of *iru* during storage. The decrease in protein may be explained by the presence of proteolytic

enzyme present in the fermented *Okpehe*. At the end of the storage period, the salted and oven dried *Okpehe* had the highest crude protein content of 43.64% whilst the refrigerated *Okpehe* had the least (42.81%). The trend of the crude protein content for all the treatments after 14 weeks is shown thus salt + oven drying > oven drying > sun drying > salting > smoking > freezing > refrigerating.

The results of the sensory analysis of *Okpehe* are shown in Tables 6, 7 and 8. At the end of the storage period, the refrigerated sample was preferred by the panelists in terms of colour with a score of 8.01 ± 0.01 while the least preferred was the smoked sample with a score of 6.89 ± 0.02 (Table 6). This is in agreement with the work of Sivasankar, (2009) that refrigeration has no adverse effects on the colour, texture and nutritive value of foods. The smoked sample was rated highest in terms of aroma (7.68 ± 0.04) (Table 7). This is because the process of smoking helped in imparting some flavour on the *Okpehe*. For the general acceptability, panelists most preferred the salted and oven dried sample (7.61 ± 0.01) while the least preferred were the salted (15% and 20%) samples with a score of 5.50 ± 0.01 (Table 8). This may be because the combination of oven drying and salting (5%) helped to reduce the water activity of *Okpehe* and thus discouraged microbial growth. It may also be because the panelists were used to drying the condiment after processing before consumption. This result is consistent with the findings of Ibe and Orabuike, (2009).

Conclusion

It can be concluded from this work that *Okpehe* can be best preserved by combining salting (5%) with oven drying at 60°C .

Table 1: Changes in pH of *Okpehe* During Storage Period

Preservation method	Preservation period (weeks)							
	0	2	4	6	8	10	12	14
Sun drying (32±2 ⁰ C)	7.01 ^a ± 0.00	7.01 ^a ± 0.01	7.02 ^a ± 0.01	7.06 ^{ab} ± 0.01	7.10 ^b ± 0.00	7.10 ^b ± 0.02	7.13 ^b ± 0.02	7.19 ^c ± 0.01
Freezer (-18±2 ⁰ C)	7.05 ^a ± 0.01	7.10 ^b ± 0.03	7.19 ^c ± 0.02	7.20 ^c ± 0.01	7.23 ^{cd} ± 0.01	7.24 ^d ± 0.01	7.32 ^e ± 0.02	7.42 ^f ± 0.03
Refrigeration (4±1 ⁰ C)	7.03 ^a ± 0.01	7.12 ^b ± 0.02	7.18 ^c ± 0.01	7.28 ^d ± 0.01	7.37 ^e ± 0.03	7.41 ^{ef} ± 0.02	7.42 ^f ± 0.01	7.46 ^g ± 0.00
Oven drying (60 ⁰ C)	6.84 ^a ± 0.01	7.02 ^b ± 0.01	7.03 ^b ± 0.02	7.13 ^c ± 0.01	7.14 ^c ± 0.02	7.23 ^d ± 0.03	7.27 ^e ± 0.01	7.33 ^f ± 0.01
Smoking (55±2 ⁰ C)	6.53 ^a ± 0.00	6.58 ^b ± 0.01	6.98 ^c ± 0.03	7.00 ^c ± 0.00	7.05 ^d ± 0.01	7.07 ^d ± 0.01	7.15 ^e ± 0.02	7.23 ^f ± 0.02
Salt (5%)+Oven Drying (60 ⁰ C)	6.71 ^a ± 0.02	6.89 ^b ± 0.02	6.99 ^c ± 0.01	7.01 ^c ± 0.00	7.03 ^{cd} ± 0.00	7.04 ^{cd} ± 0.02	7.07 ^d ± 0.01	7.15 ^e ± 0.02
Salting (5%)	6.85 ^a ± 0.01	6.94 ^b ± 0.02	7.15 ^c ± 0.00	7.29 ^d ± 0.01	7.34 ^d ± 0.02	7.40 ^e ± 0.02	7.44 ^e ± 0.03	7.54 ^f ± 0.03
Salting (10%)	6.74 ^a ± 0.01	6.83 ^b ± 0.01	6.86 ^b ± 0.03	7.06 ^c ± 0.01	7.22 ^d ± 0.02	7.23 ^d ± 0.01	7.31 ^e ± 0.00	7.45 ^f ± 0.02
Salting (15%)	6.62 ^a ± 0.00	6.85 ^b ± 0.01	6.85 ^b ± 0.01	6.89 ^{bc} ± 0.00	7.00 ^c ± 0.00	7.16 ^d ± 0.02	7.23 ^e ± 0.03	7.37 ^f ± 0.02
Salting (20%)	6.41 ^a ± 0.01	6.48 ^b ± 0.02	6.76 ^c ± 0.01	6.90 ^d ± 0.00	6.98 ^e ± 0.01	7.06 ^f ± 0.02	7.09 ^{fg} ± 0.00	7.13 ^g ± 0.01

Values are means of triplicate determinations ± SD; means within rows with different superscripts differ significantly (p < 0.05).

SD – Standard Deviation

Table 2: Crude Protein Content (%) of *Okpehe* During Storage Period

Preservation method	0 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks
Sun drying (32±2 ⁰ C)	43.92 ^e ± 0.05	43.90 ^e ± 0.04	43.90 ^e ± 0.07	43.85 ^{de} ± 0.03	43.81 ^d ± 0.04	43.75 ^c ± 0.05	43.68 ^b ± 0.04	43.58 ^a ± 0.05
Freezer (-18±2 ⁰ C)	43.16 ^d ± 0.06	43.16 ^d ± 0.06	43.15 ^{cd} ± 0.03	43.13 ^c ± 0.05	43.10 ^c ± 0.04	43.04 ^b ± 0.04	43.00 ^{ab} ± 0.05	42.96 ^a ± 0.04
Refrigeration (4±1 ⁰ C)	43.16 ^e ± 0.05	43.16 ^e ± 0.04	43.14 ^{de} ± 0.07	43.11 ^d ± 0.05	43.05 ^c ± 0.06	43.01 ^c ± 0.04	42.91 ^b ± 0.03	42.81 ^a ± 0.04
Oven drying (60 ⁰ C)	43.97 ^f ± 0.04	43.96 ^e ± 0.04	43.94 ^e ± 0.06	43.89 ^{de} ± 0.05	43.84 ^d ± 0.05	43.79 ^c ± 0.05	43.72 ^b ± 0.04	43.62 ^a ± 0.06
Smoking (55±2 ⁰ C)	43.41 ^d ± 0.05	43.39 ^d ± 0.05	43.38 ^d ± 0.04	43.36 ^{cd} ± 0.06	43.31 ^c ± 0.04	43.23 ^b ± 0.05	43.23 ^b ± 0.03	43.14 ^a ± 0.07
Salt (5%)+Oven Drying (60 ⁰ C)	43.95 ^c ± 0.04	43.93 ^c ± 0.05	43.93 ^c ± 0.05	43.90 ^c ± 0.06	43.86 ^{bc} ± 0.08	43.86 ^{bc} ± 0.04	43.82 ^b ± 0.04	43.64 ^a ± 0.03
Salting (5%)	43.52 ^e ± 0.07	43.51 ^e ± 0.06	43.51 ^e ± 0.06	43.48 ^{de} ± 0.05	43.44 ^d ± 0.04	43.38 ^c ± 0.05	43.30 ^b ± 0.03	43.23 ^a ± 0.04
Salting (10%)	43.53 ^e ± 0.07	43.51 ^e ± 0.08	43.51 ^e ± 0.04	43.49 ^{de} ± 0.03	43.45 ^d ± 0.04	43.39 ^c ± 0.04	43.30 ^b ± 0.05	43.23 ^a ± 0.05
Salting (15%)	43.53 ^f ± 0.06	43.52 ^f ± 0.06	43.52 ^f ± 0.05	43.48 ^e ± 0.05	43.42 ^d ± 0.04	43.37 ^c ± 0.05	43.28 ^b ± 0.04	43.20 ^a ± 0.03
Salting (20%)	43.50 ^e ± 0.04	43.50 ^e ± 0.05	43.50 ^e ± 0.07	43.48 ^{de} ± 0.06	43.43 ^d ± 0.05	43.34 ^c ± 0.05	43.27 ^b ± 0.03	43.20 ^a ± 0.04

Values are means of triplicate determinations ± SD on dry weight basis; means within rows with different superscripts differ significantly (p < 0.05).

Table 3: Crude Fibre Content (%) of *Okpehe* During Storage Period

Preservation method	0 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks
Sun drying (32±2 ⁰ C)	4.02 ^b ± 0.03	4.02 ^b ± 0.01	4.02 ^b ± 0.02	4.02 ^b ± 0.01	4.00 ^b ± 0.01	3.98 ^a ± 0.02	3.96 ^a ± 0.01	3.95 ^a ± 0.01
Freezer (-18±2 ⁰ C)	3.82 ^b ± 0.02	3.82 ^b ± 0.03	3.82 ^b ± 0.01	3.81 ^b ± 0.01	3.80 ^a ± 0.02	3.78 ^a ± 0.02	3.78 ^a ± 0.01	3.77 ^a ± 0.02
Refrigeration (4±1 ⁰ C)	3.82 ^b ± 0.02	3.82 ^b ± 0.02	3.81 ^b ± 0.03	3.81 ^b ± 0.01	3.81 ^b ± 0.03	3.80 ^{ab} ± 0.01	3.79 ^a ± 0.01	3.76 ^a ± 0.02
Oven drying (60 ⁰ C)	4.00 ^c ± 0.01	4.00 ^c ± 0.01	3.99 ^c ± 0.01	3.97 ^c ± 0.02	3.92 ^b ± 0.03	3.90 ^{ab} ± 0.03	3.87 ^a ± 0.01	3.85 ^a ± 0.01
Smoking (55±2 ⁰ C)	3.75 ^c ± 0.01	3.74 ^c ± 0.01	3.74 ^c ± 0.01	3.72 ^{bc} ± 0.03	3.71 ^{bc} ± 0.01	3.68 ^b ± 0.03	3.68 ^b ± 0.02	3.62 ^a ± 0.02
Salt (5%)+Oven Drying (60 ⁰ C)	3.85 ^b ± 0.02	3.85 ^b ± 0.02	3.84 ^b ± 0.03	3.84 ^b ± 0.01	3.81 ^{ab} ± 0.02	3.77 ^a ± 0.01	3.76 ^a ± 0.02	3.75 ^a ± 0.02
Salting (5%)	3.54 ^b ± 0.01	3.53 ^b ± 0.01	3.52 ^b ± 0.02	3.51 ^b ± 0.02	3.51 ^b ± 0.02	3.50 ^a ± 0.02	3.48 ^a ± 0.00	3.46 ^a ± 0.01
Salting (10%)	3.49 ^b ± 0.01	3.49 ^b ± 0.02	3.49 ^b ± 0.03	3.47 ^b ± 0.01	3.47 ^b ± 0.02	3.45 ^a ± 0.01	3.43 ^a ± 0.01	3.41 ^a ± 0.03
Salting (15%)	3.49 ^b ± 0.01	3.48 ^b ± 0.03	3.48 ^b ± 0.03	3.47 ^b ± 0.02	3.46 ^b ± 0.02	3.45 ^a ± 0.01	3.42 ^a ± 0.01	3.41 ^a ± 0.02
Salting (20%)	3.45 ^a ± 0.01	3.45 ^a ± 0.01	3.44 ^a ± 0.04	3.44 ^a ± 0.02	3.43 ^a ± 0.01	3.43 ^a ± 0.02	3.42 ^a ± 0.01	3.40 ^a ± 0.03

Values are means of triplicate determinations ± SD on dry weight basis; means within rows with different superscripts differ significantly (p < 0.05).

Table 4: Total Ash Content (%) of *Okpehe* During Storage Period

Preservation method	0 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks
Sun drying (32±2 ⁰ C)	4.02 ^b ± 0.01	4.01 ^b ± 0.01	4.00 ^b ± 0.02	3.99 ^{ab} ± 0.01	3.99 ^{ab} ± 0.02	3.96 ^a ± 0.02	3.95 ^a ± 0.01	3.94 ^a ± 0.01
Freezer (-18±2 ⁰ C)	3.95 ^a ± 0.02	3.95 ^a ± 0.01	3.95 ^a ± 0.01	3.95 ^a ± 0.02	3.95 ^a ± 0.01	3.95 ^a ± 0.01	3.93 ^a ± 0.02	3.93 ^a ± 0.03
Refrigeration (4±1 ⁰ C)	3.95 ^b ± 0.03	3.94 ^b ± 0.02	3.94 ^b ± 0.02	3.93 ^{ab} ± 0.01	3.92 ^a ± 0.01	3.91 ^a ± 0.02	3.89 ^a ± 0.01	3.88 ^a ± 0.01
Oven drying (60 ⁰ C)	4.02 ^b ± 0.02	4.02 ^b ± 0.02	4.02 ^b ± 0.01	4.00 ^b ± 0.02	4.00 ^b ± 0.01	3.98 ^{ab} ± 0.01	3.97 ^{ab} ± 0.02	3.93 ^a ± 0.02
Smoking (55±2 ⁰ C)	4.09 ^c ± 0.01	4.08 ^c ± 0.03	4.07 ^c ± 0.02	4.03 ^b ± 0.01	4.03 ^b ± 0.02	4.00 ^b ± 0.01	4.00 ^b ± 0.01	3.91 ^a ± 0.01
Salt (5%)+Oven Drying (60 ⁰ C)	4.13 ^c ± 0.01	4.12 ^c ± 0.01	4.10 ^c ± 0.01	4.06 ^{bc} ± 0.02	4.05 ^b ± 0.01	4.01 ^b ± 0.03	3.99 ^{ab} ± 0.02	3.95 ^a ± 0.01
Salting (5%)	4.05 ^b ± 0.01	4.05 ^b ± 0.01	4.05 ^b ± 0.01	4.03 ^{ab} ± 0.03	4.03 ^{ab} ± 0.01	4.02 ^{ab} ± 0.01	4.01 ^a ± 0.02	3.98 ^a ± 0.01
Salting (10%)	4.07 ^b ± 0.01	4.07 ^b ± 0.01	4.07 ^b ± 0.02	4.03 ^a ± 0.01	4.03 ^a ± 0.01	4.01 ^a ± 0.01	4.00 ^a ± 0.01	4.00 ^a ± 0.02
Salting (15%)	4.07 ^b ± 0.01	4.07 ^b ± 0.01	4.07 ^b ± 0.02	4.04 ^a ± 0.02	4.04 ^a ± 0.01	4.01 ^a ± 0.01	4.01 ^a ± 0.02	4.00 ^a ± 0.01
Salting (20%)	4.08 ^b ± 0.02	4.07 ^b ± 0.01	4.06 ^b ± 0.01	4.03 ^{ab} ± 0.02	4.02 ^a ± 0.02	4.01 ^a ± 0.01	4.00 ^a ± 0.02	3.98 ^a ± 0.03

Values are means of triplicate determinations ± SD on dry weight basis; means within rows with different superscripts differ significantly (p < 0.05).

Table 5: Moisture Content (%) of *Okpehe* During Storage Period

Preservation method	0 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks
Sun drying (32±2°C)	8.61 ^c ± 0.14	8.60 ^c ± 0.10	8.58 ^c ± 0.10	8.55 ^b ± 0.08	8.53 ^b ± 0.06	8.52 ^b ± 0.08	8.49 ^{ab} ± 0.08	8.44 ^a ± 0.07
Freezer (-18±2°C)	12.76 ^c ± 0.09	12.75 ^c ± 0.09	12.73 ^{bc} ± 0.08	12.70 ^b ± 0.10	12.70 ^b ± 0.06	12.68 ^b ± 0.08	12.64 ^a ± 0.07	12.61 ^a ± 0.10
Refrigeration (4±1°C)	12.47 ^c ± 0.11	12.47 ^c ± 0.07	12.47 ^c ± 0.08	12.47 ^c ± 0.08	12.45 ^{bc} ± 0.06	12.43 ^b ± 0.06	12.40 ^b ± 0.11	12.34 ^a ± 0.09
Oven drying (60°C)	6.78 ^c ± 0.13	6.76 ^{bc} ± 0.06	6.76 ^{bc} ± 0.05	6.76 ^{bc} ± 0.09	6.75 ^b ± 0.08	6.73 ^b ± 0.07	6.72 ^{ab} ± 0.07	6.68 ^a ± 0.10
Smoking (55±2°C)	8.68 ^c ± 0.07	8.67 ^c ± 0.10	8.66 ^c ± 0.06	8.65 ^{bc} ± 0.07	8.65 ^{bc} ± 0.06	8.62 ^b ± 0.06	8.60 ^b ± 0.10	8.54 ^a ± 0.08
Salt (5%)+Oven Drying (60°C)	6.12 ^b ± 0.07	6.11 ^b ± 0.09	6.11 ^b ± 0.08	6.11 ^b ± 0.07	6.10 ^{ab} ± 0.10	6.09 ^a ± 0.07	6.08 ^a ± 0.08	6.06 ^a ± 0.08
Salting (5%)	10.70 ^d ± 0.09	10.69 ^d ± 0.11	10.66 ^{cd} ± 0.08	10.63 ^c ± 0.06	10.63 ^c ± 0.10	10.57 ^b ± 0.07	10.53 ^{ab} ± 0.07	10.48 ^a ± 0.06
Salting (10%)	10.17 ^c ± 0.08	10.17 ^c ± 0.08	10.17 ^c ± 0.06	10.16 ^c ± 0.07	10.15 ^{bc} ± 0.09	10.12 ^b ± 0.09	10.10 ^b ± 0.10	10.05 ^a ± 0.10
Salting (15%)	10.62 ^d ± 0.10	10.61 ^d ± 0.07	10.58 ^c ± 0.06	10.54 ^c ± 0.07	10.50 ^b ± 0.08	10.46 ^b ± 0.07	10.41 ^a ± 0.07	10.40 ^a ± 0.10
Salting (20%)	10.23 ^c ± 0.10	10.22 ^c ± 0.08	10.20 ^{bc} ± 0.07	10.20 ^{bc} ± 0.09	10.19 ^b ± 0.08	10.17 ^b ± 0.06	10.15 ^{ab} ± 0.08	10.09 ^a ± 0.06

Values are means of triplicate determinations ± SD on dry weight basis; means within rows with different superscripts differ significantly (p < 0.05).

Table 6: Sensory Evaluation of *Okpehe* During Storage

Preservation method	Period of Storage (weeks) / Colour							
	0	2	4	6	8	10	12	14
Sun drying (32±20C)	7.10b ± 0.01	7.18c ± 0.01	7.13b ± 0.02	7.06a ± 0.03	7.42e ± 0.03	7.25d ± 0.04	7.40e ± 0.02	7.51f ± 0.01
Freezer (-18±20C)	7.08a ± 0.02	7.47d ± 0.01	7.07a ± 0.01	7.41c ± 0.04	7.51d ± 0.04	7.37b ± 0.02	7.67f ± 0.02	7.60e ± 0.03
Refrigeration (4±10C)	7.13a ± 0.04	7.56d ± 0.04	7.08a ± 0.02	7.41b ± 0.02	7.53c ± 0.02	7.49c ± 0.02	7.68e ± 0.01	7.81f ± 0.01
Oven drying (600C)	7.11a ± 0.04	7.17b ± 0.04	7.17b ± 0.03	7.53c ± 0.03	7.50c ± 0.01	7.52c ± 0.02	7.64d ± 0.01	7.62d ± 0.01
Smoking (55±20C)	6.82a ± 0.03	6.83a ± 0.04	7.21c ± 0.02	7.34d ± 0.01	7.44e ± 0.03	7.42e ± 0.01	7.29b ± 0.03	6.89b ± 0.02
Salt (5%)+Oven Drying (60°C)	7.07a ± 0.02	7.22c ± 0.02	7.16b ± 0.02	7.37d ± 0.01	7.45e ± 0.02	7.22c ± 0.01	7.43e ± 0.01	7.47e ± 0.01
Salting (5%)	7.08ab ± 0.02	7.04a ± 0.01	7.13b ± 0.01	7.28d ± 0.02	7.20c ± 0.03	7.24c ± 0.03	7.24c ± 0.04	7.03a ± 0.04
Salting (10%)	7.07b ± 0.01	7.04a ± 0.01	7.13c ± 0.02	7.27e ± 0.13	7.21d ± 0.03	7.23d ± 0.02	7.24ab ± 0.01	7.01a ± 0.02
Salting (15%)	7.06b ± 0.03	7.04a ± 0.02	7.12c ± 0.03	7.26e ± 0.01	7.20d ± 0.01	7.23d ± 0.04	7.23d ± 0.01	7.00a ± 0.03
Salting (20%)	7.06b ± 0.01	7.04a ± 0.02	7.12c ± 0.02	7.25d ± 0.04	7.24d ± 0.02	7.23d ± 0.01	7.22d ± 0.03	7.01a ± 0.01

Values are means of triplicate determinations ± SD; means within rows with different superscripts differ significantly ($p < 0.05$).

Table 7: Sensory Evaluation of *Okpehe* During Storage

Preservation method	Period of Storage (weeks) / Aroma							
	0	2	4	6	8	10	12	14
Sun drying (32±2°C)	6.16 ^a ± 0.01	7.33 ^e ± 0.02	6.83 ^c ± 0.02	6.86 ^c ± 0.04	7.24 ^d ± 0.04	6.49 ^b ± 0.02	7.20 ^d ± 0.03	7.34 ^c ± 0.01
Freezer (-18±2°C)	6.08 ^a ± 0.02	7.17 ^f ± 0.04	7.26 ^g ± 0.04	6.92 ^d ± 0.01	6.61 ^c ± 0.02	6.40 ^b ± 0.02	7.00 ^e ± 0.03	7.21 ^f ± 0.02
Refrigeration (4±1°C)	6.08 ^a ± 0.01	7.16 ^d ± 0.01	7.24 ^e ± 0.03	6.93 ^c ± 0.03	6.62 ^b ± 0.01	6.05 ^a ± 0.01	6.89 ^c ± 0.03	7.16 ^d ± 0.01
Oven drying (60°C)	6.17 ^a ± 0.01	7.34 ^f ± 0.03	6.79 ^b ± 0.01	7.00 ^d ± 0.03	7.00 ^d ± 0.01	6.92 ^c ± 0.03	7.10 ^e ± 0.01	7.29 ^f ± 0.01
Smoking (55±2°C)	6.16 ^a ± 0.01	7.34 ^e ± 0.04	7.32 ^e ± 0.01	7.19 ^d ± 0.02	7.05 ^b ± 0.02	7.12 ^c ± 0.01	7.40 ^f ± 0.01	7.68 ^g ± 0.04
Salt (5%)+Oven Drying (60°C)	6.17 ^a ± 0.02	7.34 ^e ± 0.02	7.40 ^f ± 0.03	6.78 ^c ± 0.03	6.42 ^b ± 0.01	7.21 ^d ± 0.01	7.40 ^f ± 0.04	7.40 ^f ± 0.03
Salting (5%)	6.06 ^a ± 0.01	7.35 ^f ± 0.01	7.37 ^f ± 0.03	6.82 ^e ± 0.02	6.61 ^d ± 0.02	6.15 ^b ± 0.03	6.42 ^c ± 0.03	6.42 ^c ± 0.04
Salting (10%)	6.06 ^a ± 0.01	7.36 ^e ± 0.02	7.37 ^e ± 0.03	6.83 ^d ± 0.01	6.61 ^c ± 0.03	6.31 ^b ± 0.01	6.32 ^b ± 0.02	6.31 ^b ± 0.02
Salting (15%)	6.07 ^a ± 0.02	7.35 ^e ± 0.02	7.36 ^e ± 0.01	6.83 ^d ± 0.01	6.63 ^c ± 0.02	6.19 ^b ± 0.01	6.17 ^b ± 0.02	6.18 ^b ± 0.01
Salting (20%)	6.07 ^a ± 0.02	7.35 ^d ± 0.01	7.36 ^d ± 0.02	6.84 ^c ± 0.02	6.63 ^b ± 0.03	6.03 ^a ± 0.02	6.02 ^a ± 0.03	6.02 ^a ± 0.02

Values are means of triplicate determinations ± SD; means within rows with different superscripts differ significantly (p < 0.05).

Table 8: Sensory Evaluation of *Okpehe* During Storage

Preservation method	Period of Storage (weeks) /Acceptability							
	0	2	4	6	8	10	12	14
Sun drying (32±2 ⁰ C)	6.60 ^c ± 0.01	6.43 ^b ± 0.03	6.03 ^a ± 0.04	6.86 ^d ± 0.02	7.04 ^c ± 0.03	7.23 ^g ± 0.01	7.23 ^g ± 0.02	7.12 ^f ± 0.01
Freezer (-18±2 ⁰ C)	6.48 ^b ± 0.01	6.87 ^d ± 0.01	6.86 ^{cd} ± 0.03	7.02 ^e ± 0.02	6.81 ^c ± 0.02	6.20 ^a ± 0.01	7.00 ^e ± 0.01	7.24 ^f ± 0.01
Refrigeration (4±1 ⁰ C)	6.08 ^a ± 0.03	6.16 ^b ± 0.03	6.43 ^c ± 0.03	6.43 ^c ± 0.02	6.52 ^d ± 0.02	6.52 ^d ± 0.01	6.48 ^d ± 0.02	7.16 ^e ± 0.02
Oven drying (60 ⁰ C)	6.47 ^b ± 0.02	6.84 ^c ± 0.01	6.82 ^c ± 0.02	7.05 ^d ± 0.01	6.84 ^c ± 0.01	6.25 ^a ± 0.02	7.01 ^d ± 0.02	7.39 ^e ± 0.01
Smoking (55±2 ⁰ C)	5.86 ^c ± 0.01	6.25 ^d ± 0.01	5.82 ^b ± 0.02	5.47 ^a ± 0.01	6.01 ^d ± 0.02	5.81 ^b ± 0.02	6.02 ^d ± 0.03	6.01 ^d ± 0.03
Salt (5%)+Oven Drying (60 ⁰ C)	6.37 ^a ± 0.01	6.86 ^b ± 0.02	7.00 ^c ± 0.03	7.07 ^d ± 0.01	7.40 ^e ± 0.02	7.42 ^e ± 0.01	7.60 ^f ± 0.01	7.61 ^f ± 0.01
Salting (5%)	6.01 ^a ± 0.02	6.65 ^b ± 0.02	6.63 ^b ± 0.01	6.81 ^c ± 0.01	6.86 ^d ± 0.03	6.85 ^{cd} ± 0.02	6.84 ^c ± 0.02	6.82 ^c ± 0.01
Salting (10%)	6.06 ^d ± 0.03	6.64 ^e ± 0.04	6.63 ^e ± 0.01	5.72 ^a ± 0.01	5.85 ^b ± 0.02	5.83 ^b ± 0.03	5.82 ^b ± 0.01	6.01 ^c ± 0.02
Salting (15%)	5.86 ^d ± 0.02	6.04 ^e ± 0.02	5.62 ^c ± 0.02	5.67 ^c ± 0.02	5.64 ^c ± 0.03	5.54 ^a ± 0.02	5.57 ^b ± 0.01	5.50 ^a ± 0.02
Salting (20%)	5.86 ^d ± 0.01	6.03 ^e ± 0.01	5.62 ^c ± 0.01	5.65 ^c ± 0.02	5.63 ^c ± 0.03	5.53 ^a ± 0.01	5.56 ^b ± 0.02	5.50 ^a ± 0.01

Values are means of triplicate determinations ± SD; means within rows with different superscripts differ significantly (p < 0.05).

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