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Enhancement of the Nutritive and Sensory Characteristics of Bambara Nut Steamed Paste (*Okpa)* By Process Modification

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ABSTRACT: *This work assessed the enhancement of the nutritive and sensory characteristics of Bambara nut (Vigna subterranea) steamed paste (okpa) by process modification. Mature seeds of bambara nut were cleaned and divided into six portions. One portion was milled and sieved; the second portion was further divided into two sub-portions, milled and sieved; the third portion was fermented by steeping in fresh water (25±2^{0}C) for 48h, oven-dried (60^{0}C), milled and sieved. The fourth was allowed to sprout after 48h, oven-dried (60^{0}C), milled and sieved while the fifth and sixth portions were boiled for 8h and oven-dried; and roasted till brown, milled and sieved respectively. Each flour was reconstituted with potable water, with ingredients added and processed into steamed paste by cooking for 1h., except for the 2 sub-portions in the second portion to which 48h and 72h fermented ugba was incorporated and similarly steamed into okpa. The samples were subjected to proximate and sensory evaluations. A generally significant (P<0.05) increase was obtained in crude protein, ash, crude fibre, fat and carbohydrate contents, respectively; from the control steamed paste (CSP), 4.04g100g^{-1} to 6.66g100g^{-1} in the fermented steamed paste (FSP); 2.96g100g^{-1}to 4.288g/100^{-1} in Bambara nut + 72h fermented steamed paste (UFSP$_2$); 0.95g100^{-1} to 9.55g100g^{-1} in the boiled steamed paste (BSP); 14.80g100^{-1} to 20.60g100g^{-1} in BSP; and 13.95g^{-1} to 20.49g100g^{-1} in roasted steamed paste (RSP).The germinated steamed paste (GSP) had the highest moisture content (68.85%) while BSP had the least (51.90%) UFSP$_2$ was the most highly acceptable sample. Process modification of Bambara groundnut produced okpa samples with enhanced nutritive value. While FSP had the highest protein content, UFSP$_2$ had the highest mineral content, the least fat and the most highly acceptable.*

KEYWORD: bambaranut, enhancement, nutritive, sensory, characteristics

INTRODUCTION

Bambara groundnut (*Vigna subterrenea),* known in Ibo as *Okpa*, is an important but underutilized legume that is potentially very rich in protein and minerals (Minka and Bruneteau, 2000). It is grown extensively in Northern Nigeria because it is well favoured by the environmental conditions of the dry lands (Enwere and Hung, 1996; Mahazib, 2013) Mine *et al* (2011) had reported that Bambara nut contains carbohydrate (54.5-69.3%), protein (17-

24.6%), fat 5.3-7.8%), and calories (367.414 Kcal per 100g). It is also a good source of calcium, iron and potassium, usually high in methionine, an essential sulfur-containing amino acid. Seven different varieties of bambara groundnut had been reported. These are identified by colour variations ranging from black, red, cream/black eye, cream/brown eye, cream/no eye, spotted and brown (Karikari, 2001).

Bambara groundnut seed is consumed in various forms for food; the fresh seed could be consumed raw, boiled, grilled or dry seeds made into powdery form to make cakes (Adebowale and Lawal, 2012). In many countries of West Africa, fresh pods are boiled with salt and pepper, and eaten as a snack; while in East Africa, the seeds are roasted, pulverized and used in preparing soup (Goli, 2007).

In Nigeria, bambara groundnut is processed into steamed paste, (*Okpa),* snack (roasted) and substituted with wheat flour for baking. However, its beany flavour and lower bio-accessibility of the protein and minerals due to anti-nutrient factors such as tannins, trypson inhibitors, lectins and phytates are drawbacks in its utilization. (Adebowale *et al.*, 2013; Jayeola, 2012; Murevanhema and Jideani, 2013; Yagoub and Abdalla,2007).

Fermented African oil bean (*ugba)* had variously been reported to be eaten and savoured by consumers particularly in the Southeastern part of Nigeria (Enujugha, 2003; Enujugha and Agbede, 2000; Enujugha and Akanbi, 2005; Ukozor, 2011). *Ugba* has also been reported to be useful in flavouring soup and other dishes when used as condiment (Iwuoha and Eke, 2000). This researcher has personally observed that local *okpa* producers tend to improve the natural (beany) flavour of the food product by using such spice as scent leaf (*Occimum gratisimum).*

However, some work had been done to lessen the beany (natural) flavour of bambara groundnut steamed paste (*Okpa)* using malting (Kudre and Banjakal, 2014; Uvere *et al.*, 1999) and heat treatment (Jayeola,2012). In spite of these works, there is still need to modify the beany (natural) flavor of *Okpa* using various unit operations, and also assess the effect of these food processing methods on the nutritive and sensory value of the steamed paste. It is, therefore, to this effect that this work was designed to assess the extent process modification could enhance the nutritive and sensory characteristics of bambara groundnut steamed paste (*Okpa).*

MATERIALS AND METHODS

The materials used included bambara groundnut and African oil bean seed, and were procured from Eke-ukwu Owerri, Imo State. The variety of bambara groundnut used in the study was cream/black eye.The bambara nuts (3kg w/w) were cleaned by manually removing stones, dirt and other extraneous materials. It was divided into 6 portions – 500g each

Control bambara groundnut flour (CBGF)

The 1st portion was hammer-milled and sieved using 0.4mm pore size sieve. It was then stored in an air-tight plastic container. The 2nd portion was similarly milled, sieved, and stored.

Fermented bambara groundnut flour (FBGF)
The 3rd portion was washed with water (25 ± 2^0C), steeped in water (seed: water 1:10) for 48h to ferment and later dehulled. The seeds were subsequently dried in an oven (Gallen Kamp) at 60^0C for 12h, milled using a hammer mill, sieved (0.4mm pore size) and stored in an air-tight container.

Germinated bambara groundnut flour (GBGF)
The 4th portion was washed with water and soaked in water for 12h at an ambient (tropical) temperature of 28 ± 2^0C. Thereafter, the seeds were spread on wet jute bags and then covered with moistened muslin cloth, and allowed for 48h to sprout (germinate). The germinated seeds were evenly spread on oven trays and dried in an oven (Gallen Kamp) at 60^0C for 12h. The vegetative parts of the dried, germinated seeds were carefully removed by rubbing between palms, and then winnowed manually. The seeds were subsequently hammer-milled, passed through 0.4mm mesh size sieve, and then stored in an air-tight container.

Boiled bambara groundnut flour (BGGF)
The 5th portion was boiled in distilled water at 100^0C in a seed to water ratio of 1:10 (w/v) for 3h, 48min, taking a cue from the procedure used by local producers. The water was drained off after boiling, and the boiled seeds were oven dried at 60^0C for 12h; milled (hammer milled); sieved with 0.4mm mesh size sieve. It was stored in an air-tight container.

Roasted bambara groundnut flour (RBGF)
The 6th portion was roasted at 140^0C for 40min in an electric oven (Memment GmBH, Model (KG8540), cooled (air), milled, sieved by passing through 0.4mm mesh size and stored in an air-tight container.

Fermentation of African oil bean seed
African oil been seeds were washed in clean water, boiled overnight, peeled (dehulled) and sliced using a stainless steel kitchen knife. The seeds were traditionally fermented for 48h and 72h respectively, oven dried at 60^0C for 12h, and milled to obtain 2 samples of *Ugba* flours. $FAOB_1$ and $FAOB_2$, respectively, Fig.1 (Enujiugha, 2003).

Production of bambara nut steamed paste (*Okpa)*
The various samples of bambara nut steamed paste *(okpa)* were produced by modifying the original recipe as reported by Adumanya *et al*.,(2012) Five hundred grams (500g) each of the modified bambara nut flours namely, FBGF (fermented bambara nut Flour), GBGF (germinated bambara nut Flour, BBGF (boiled bambara nut flour) and RBGF (roasted bambara nut Flour), were compounded with the following ingredients- red pepper (dry,1tsp), salt (1/2 tsp), stock cubes (2 cubes), palm oil (8 tsb) and water (500ml). in each case, 500g of flour was poured into a stainless steel kitchen bowl, stock cubes were crushed and added in addition to salt. Palm oil was incorporated into the mix, while water was added; the whole mix was well stirred, poured into transparent, very low density polyethylene films and then tied. They were transferred into a pot containing some potable water. It was placed on the stove to boil for 1h, after which it was brought down to cool before serving.

The following samples of *Okpa* were produced – fermented steamed paste (FSP), germinated steamed paste (GSP), boiled steamed paste (BSP) and roasted steamed paste (RSP). The control

bambara groundnut flour (CBGF) was similarly compounded with the ingredients (as above) and steamed to obtain control steamed paste (CSP). But 150g each of 48h and 72h fermented *Ugba* flour ($FAOB_1$, and $FAOB_2$, respectively) was mixed with 350g of CBGF (2nd portion). The same quantities of ingredients were added, water was incorporated and the whole mix was treated as above to obtain *Ugba* flavoured bambara nut steamed paste, $UFSP_1$ and $UFSP_2$, respectively.

Proximate composition of the *Okpa* samples

Proximate composition of the o*kpa* samples was done using the standard methods namely micro-kjeldahl method for crude protein, soxhlet extraction method for crude fat, the digestion method for crude fibre and ashing for determination of ash contents, all as prescribed by AOAC (2000). Carbohydrate was determined by difference. Moisture was determined by gravimetric method (AOAC, 2000).

Sensory evaluation

A-20-member panel of tasters were randomly selected amongst the staff and students of the Department of Home Economics, Alvan Ikoku Federal College of Education, Owerri, Imo State, and used for the sensory evaluation of the *Okpa* samples. It was done under the white light in the Food Laboratory, in the mid-morning hours (10.00am). The panelists were separately seated with a glass of clean, potable water provided to rinse their mouths in-between each tasting. All the samples were randomly presented to the tasters with the appropriate sample codes. The sensory attributes evaluated were appearance (colour), taste, aroma, mouth feel and then overall acceptability, using a 9-point hedonic scale of dislike extremely, (least score) to like extremely (highest score) for each attribute (Iwe, 2002).

Statistical analysis

Data generated were subjected to a one-way analysis of variance (ANOVA) using statistical package for social science (SPSS), while the means were separated using Fischer Least Significant Difference (LSD) test, at 95% confidence level ($P<0.05$), (O'Mahony, 1986.)

RESULTS AND DISCUSSION

The results of the proximate composition of the various modified samples of bambara groundnut steamed paste (*Okpa)* are presented in Table 1.

Proximate composition of the *okpa* samples

The protein content of the *Okpa* samples ranged from $3.33g100g^{-1}$ in the roasted steamed paste (RSP) to $6.66g100g^{-1}$ in the fermented steamed paste (FSP). The result indicated that protein increased significantly ($P<0.05$) from $4.0g100g^{-1}$ in the control steamed paste (CSP) to $4.71g100g^{-1}$ in boiled steamed paste (BSP), $5.20g100g^{-1}$ in *Ugba*-flavoured steamed paste, 72h ($UFSP_1$), $5.61g100g^{-1}$ in germinated steamed paste (GSP) and $6.66g100g^{-1}$ in the fermented steamed paste (FSP). The highest increment was observed in the FSP. However, protein decreased significantly ($P<0.05$) to $3.33g100g^{-1}$ in the roasted steamed paste (RSP).

These significant increases could be attributed to hydrolysis of the legume protein during boiling (heat treatment) as in BSP; fermentation of African oil bean leads to hydrolysis of complex legume proteins to amino acids and short-chain peptides leading to an increase in total

nitrogen (Enijiugha, 2003), as was observed in FSP. In the GSP, it was attributed to synthesis of enzymes (protein) during germination or compositional change following the degradation of other constituents. It has also been reported that total protein increased after germination process.

Significant increase was observed in ash content in $UFSP_2$ -*Ugba*-fermented steamed paste ($4.86g100g^{-1}$), from $2.96g100g^{-1}$ in CSP. However, there were significant decreases ($P>0.05$) in the other samples. This sole significant increase observed in $UFSP_2$ could be due to synthesis of divalent materials in the African oil bean seed (AOBS) during fermentation (Moat, 1979). Furthermore, Enujiugha (2003) reported a 35% increase in ash content after 3 days of AOBS fermentation. The losses observed in the other samples may be due to leaching of soluble minerals in the process water during fermentation of bambara nut; and to use-up of minerals during metabolism involved in germination. Fat content significantly increased from $14.80g100g^{-1}$ to $18.35g100g^{-1}$ (GSP), $18.90g100g^{-1}$ (FSP) and $20.00g100g^{-1}$ (BSP). Significant decreases were observed in the other samples. This significant increase could be as a result of extensive breakdown of large molecules of fat into fatty acids, usually inherent in germination and fermentation (Mbajunwa, 1995). The highest increase in the boiled sample could be attributed to mere hydrolysis of fat in heat treatment.

On crude fibre, significant increase was observed in all the samples except for $UFSP_1$ (*Ugba* flavoured steamed paste,48h). These significant increases could be ascribed to changes in the composition of the other nutrients caused by the various processing methods. Increased fibre content in foods confers a better health on the human digestion stystem (Azizah and Lainon, 2009).

Results on carbohydrate indicated that it significantly increased ($p<0.05$) from $13.95g100g^{-1}$ in CSP to $16.78\ g100g^{-1}$ in $UFSP_1$, $17.83\ g100g^{-1}$ in $UFSP_2$ and $20.49\ g100g^{-1}$ in RSP. It, however, showed a significant decrease ($p>0.05$) in the other samples. These significant increases as observed in the *Ugba* flavoured samples could be due to the contribution made by the carbohydrate content of fermented AOBS, whereas in the RSP, roasting being a high heat processing method, could have destroyed some proteins, fibre, leading to an increase in carbohydrate (Fellows, 2000). On the other hand, the significant decreases could be attributed to the utilization of carbohydrate by the fermenting microorganisms as in FSP, while in germination, it could have been used up as s source of energy for embryonic growth (Ahmad and Patthak, 2000; Bua *et al*, 2007).

The moisture content (MC) of the samples significantly increased from $63.30\ g100g^{-1}$ is CSP to $64.10\ g100g^{-1}$ ($UFSP_1$) and $67.51\ g100g^{-1}$ (GSP). It significantly decreased in the other samples. The increase in the *Ugba*-flavoured sample (48h) could be attributed to the MC of the *Ugba* incorporated in the food process modification while germination could have led to more cell growth in the structure of the legume, retaining more moisture.

In Table 2, FSP (fermented sample) indicated 64.85% increment in protein; $UFSP_2$ showed 44.59% increment in ash while BSP showed an astronomical (905.26%) increment in crude fibre. The highest increment (39.19%) in fat was observed in BSP; RSP (roasted sample) showed the highest (46.88%) in carbohydrate.

The result of the sensory evaluation of the samples is shown in Table 3. It indicated that the most highly acceptable sample was $USFP_2$ (72h *Ugba*-fermented streamed paste), though not significantly different from 48h *Ugba* flavoured steamed paste ($UFSP_1$). The least acceptable was the control sample – CSP

CONCLUSION

This work revealed that process modification of bambara nut steamed paste *(Okpa)* by varying processing method and addition of natural flavourant *(Ugba)* improved considerably the nutrient and sensory value of the product *(Okpa)*. It led to significant increases in protein, except in the roasted sample (RSP); in crude fibre, carbohydrate, except in FSP (fermented sample), GSP – germinated sample and BSP (boiled sample). It, however, significantly decreased the fat contents in RSP, $UFSP_1$, *(Ugba*-flavoured sample, 48h) and $UFSP_2$ (*Ugba*-flavoured sample 72h). It significantly increased the ash (total mineral) content of $UFSP_2$. Flavouring *Okpa* with *Ugba* could considerably improve its natural flavour.

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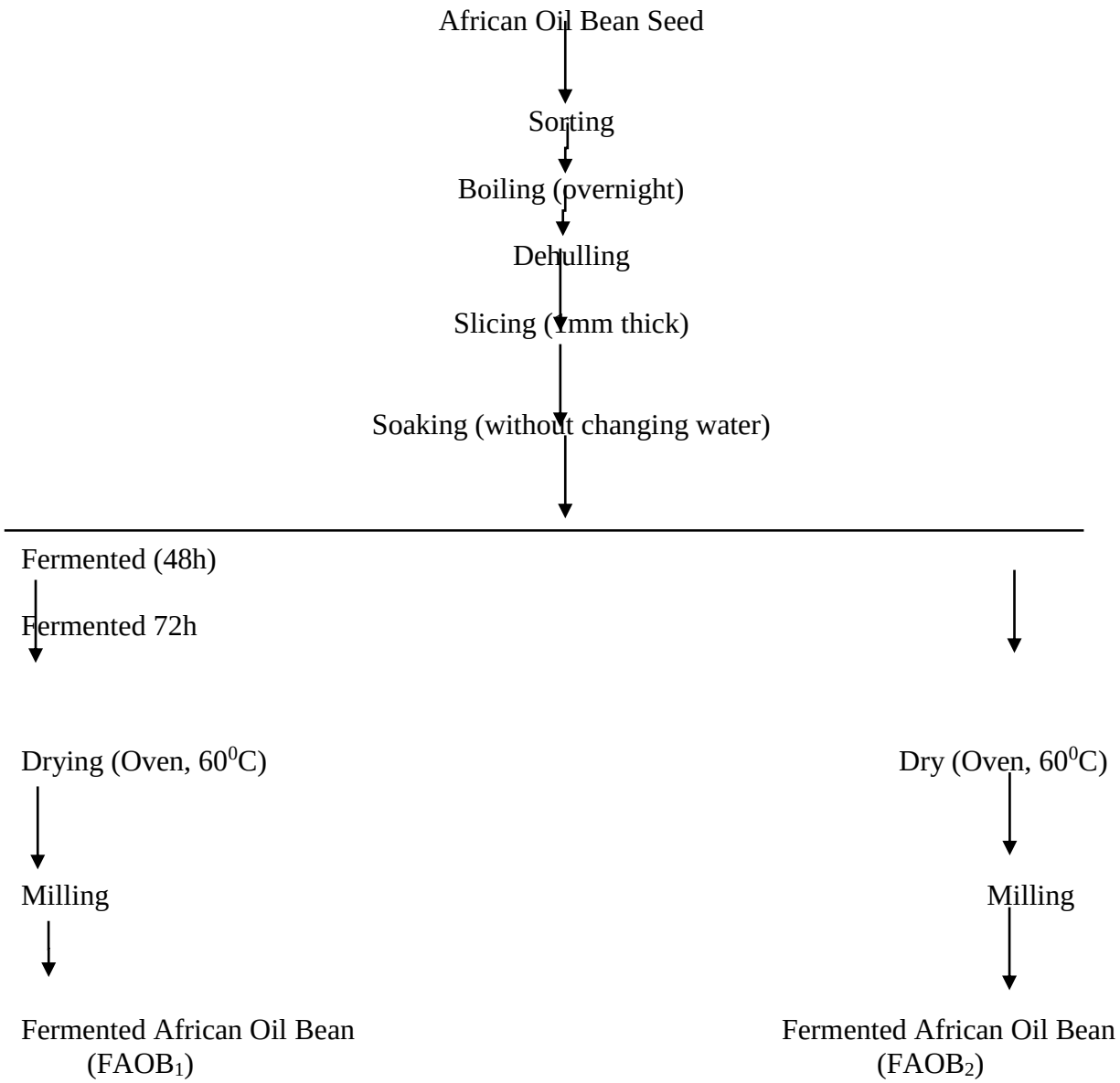

Fig 1: **Flow Diagram for fermentation of /African oil bean seeds**

Bambara Groundnut Seed				
Sorting/cleaning				
Soaking (fresh water 48h)	Sprouting (germinated)	Boiling (8h)	Roasting (till brown)	
Drying (oven 60^0C)	Drying (oven 60^0C)	Drying (oven 60^0C)		
Milling	Milling	Miling	Milling	Milling
Sieving (0.4mm)	Sieving (0.4mm)	Sieving (0.4mm)	Sieving (0.4mm)	Sieving (0.4mm)

Unmodified flour	Unmodified Roasted flour	Fermented flour	Germinted flour		Boiled
Flour	flour RBGF)	(FBGF)	GBGF)		(BBGF)
(CBGF)	(BGF)				
Mixing /Ingredients	Incorporate palm oil	Mixing ingredient	Mixing	Mixing	Mixing
Water					
Steaming (1h) (1h)	Steaming (1h)	Steaming (1h)	Steaming (1h)	Steaming (1h)	Steaming
Control Steam Boiled	Ugbo-flavoured Roasted	Ugbo-flavoured	Fermented	Germinated	
Paste (CSP) SteamedPaste	Steamed Paste	Steamed Paste	Steamed Paste	Steamed Paste	Steamed
	($UFSP_1$)	($UFSP_2$	(FSP)	(GSP)	(BSP (RSP)

Figure 2: **Flow diagram for production of various samples of bambara nut steamed paste (*Okpa)***

Table 1: Proximate composition of bambara groundnut steamed paste *(Okpa)* samples

Sample	Protein	Ash	Fat	Crude fibre	Carbohydrate	Moisture
CSP	4.04^{d}±0.01	2.96^{b}±0.14	14.80^{c}±0.08	0.95^{d}±0.49	13.95^{d}±0.06	63.30^{c}±0.21
FSP	6.66^{a}±0.02	2.57^{b}±0.07	18.90^{b}±014	3.70^{b}±0.42	9.65^{f}±0.28	58.52^{f}±0.21
GSP	5.61^{b}±0.38	1.10^{d}±0.18	18.35^{b}±0.21	1.64^{c}±0.63	5.79^{g}±0.29	67.51^{a}±0.21
BSP	4.71^{e}±0.35	1.00^{d}±0.01	20.60^{a}±0.01	9.55^{a}±0.49	13.05^{e}±0.10	51.09^{g}±0.28
RSP	3.33^{e}±0.01	1.86^{c}±0.01	10.00^{d}±0.01	1.50^{c}±0.42	20.49^{a}±0.01	62.82^{d}±0.02
$UFSP_1$	5.20^{b}±1.12	$1.86^{c0.21}$	$10.8o^{d}$±0.54	1.26^{d}±0.09	16.78^{c}±0.26	64.10^{b}±0.21
$UFSP_2$	5.29^{b}±1.06	4.28^{a}±0.02	9.39^{e}±0.84	1.76^{c}±0.23	17.83^{b}±0.34	61.38^{e}±0.07
LSD	0.61651	0.40113	0.40938	0.43243	0.22393	0.23918

Means on the same row with different superscripts are significantly different ($P<0.05$); CSP = Control steamed paste; FSP = fermented steamed paste; GSP = germinated steamed paste; BSP = boiled steamed pastes; RSP = roasted steamed paste; $UFSP_1$ = *Ugba*-flavoured steamed paste (48h);$UFSP_2$ = = *Ugba*-flavoured steamed paste (72h).

Table 2: Percentage Increase/Decrease in the Proximate Composition of *Okpa* Samples

Treatment	Ash	Fat	C.F	Protein	CHO
CSP	2.96(%)	14.80(%)	0.95(%)	4.04 (%)	13.95(%)
FSP	13.18	27.70	289.47	64.85	30.82
GSP	62.84 ↓	23.99	72.63	38.86	58.49
BSP	66.22	39.19	905.26	16.58	6.45
RSP	37.16 ↓	32.43	57.89	17.57 ↓	46.88
$UFSP_1$	37.16 ↓	27.08	32.63	28.71	20.29
$UFSP_2$	44.59	36.55	85.26	30.94	27.81

CSP = Control steamed paste; FSP = fermented steamed paste; GSP = germinated steamed paste; BSP = boiled steamed pastes; RSP = roasted steamed paste; $UFSP_1$ = *Ugba*-flavoured steamed paste (48h); $UFSP_2$ = = *Ugba*-flavoured steamed paste (72h).

Key ↑ = significant increase ↓ = significant decrease

Table 3: Sensory mean scores of the process modified *Okpa* samples

Sample	Appearance	Aroma	Taste	Texture	Overall acceptability
CSP	7.45^{a}±0.82	2.95^{c}±0.58	4.06^{c}±0.12	6.90^{a}±1.12	3.80^{c}±0.14
FSP	5.25^{b}±1077	6.20^{b}±0.89	6.10^{b}±0.85	7.00^{a}±0.85	6.15^{b}±1.59
GSP	6.00^{b}±1.62	6.36^{b}±0.85	6.40^{b}±0.82	7.50^{a}±0.76	6.65^{b}±0.93
BSP	5.95^{b}±1.60	6.30^{b}±0.65	6.40^{b}±0.04	7.05^{a}±10.5	6.45^{b}±1.50
RSP	5.95^{b}±1.1	6.15^{b}±0.98	6.25^{b}±0.96	7.10^{a}±1.07	6.65^{b}±0.87
$UFSP_1$	5.75^{b}±1.68	$8.4.^{a}$±0.75	8.30^{a}±0.75	7.45^{a}±1.80	8.45^{a}±0.60
$UFSP_2$	4.80^{b}±1.19	8.50^{a}±0.60	8.75^{a}±0.55	7.70^{a}±0.55	8.65^{a}±0.58
LSD	0.381	0.500	0.354	2.148	0.431

Means on the same row with different superscripts are significantly different ($P<0.05$); CSP = Control steamed paste; FSP = fermented steamed paste; GSP = germinated steamed paste; BSP = boiled steamed pastes; RSP = roasted steamed paste; $UFSP_1$ = *Ugba*-flavoured steamed paste (48h);$UFSP_2$ = = *Ugba*-flavoured steamed paste (72h).