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Effect of Addition of Yellow-Fleshed Sweet Potato Flour (*Ipomoea batatas*) and Fermentation on Chemical, Functional, Microbial and Sensory Attributes of an Instant Fura Powder

Olaniyi Olawale Ojuko[1*] and Abiodun Adekunle Olapade[1]

[1]Department of Food Technology, Faculty of Technology, University of Ibadan, Oyo State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author OOO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author AAO managed the analyses of the study. Author OOO managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: The objective of this work was to produce instant fura powder from the addition of yellow-fleshed sweet potato flour with millet flour and fermentation.
Methodology: Pearl millet flour and yellow fleshed sweet potato flour was used to produce fura in the ratio 90:10, 80:20, 70:30, 60:40 and 50:50 with traditional fura (TF) 100% pearl millet as the control sample. However, preliminary sensory evaluation was conducted on the various blends and 70:30 ratios were most preferred which was used to prepare the final blend ratio of fermented and Non-fermented blended fura (FBF and NFBF) *respectively*. The samples were subjected to standard analytical methods for their chemical, functional, microbial and sensory attributes of the product.
Results: The protein contents ranged from 12.95 to 18.60%. The FBF and NFBF were not

**Corresponding author: E-mail: waleojuko26@gmail.com;*

significantly different (P≤0.05) but shows variation to the TF. The TF had the highest content of 77.12% and 364.78kj/kg, followed by 69.12% and 355.45 kj/kg while the FBF had 68.03% and 345.56kj/kg of carbohydrate and energy value respectively. There were no significant different (P≤0.05) in the ash, crude fibre, and fat content of the samples analyzed. The moisture content of the samples ranged from 5.00 to 9.20%. The selected functional properties of the samples during three months storage showed that there was significantly different (P≤0.05) between the loose and packed bulk density throughout the storage periods but there was no different in the TF and FBF samples in their packed bulk density. However, FBF had the lowest bulk density throughout the storage period. The reconstitution index (RI) and water absorption capacity (WAC) showed there were no significant different (P≤0.05) between the TF and NFBF throughout the storage periods. The NFBF had the highest value of bulk density (packed) and reconstitution index of 0.81 and 42.67g/cm^3 respectively while the TF had the highest value of WAC of 36.87g/cm^3 during the third month storage. The calcium content ranged from 276.00 to 329.67mg/100. The iron content ranged from 60.00 TF to 80.13mg/100g for FBF. However, FBF had the highest value of 3.92 and (1.31 mg/100 g) of pH and titratable acidity (TTA) respectively. The ^{0}Brix level ranged from 3.0 to 5.02. There were no significant (P≤0.05) in the beta-carotene content, the value ranged from 0.26 to0.44mg/100g. The phytate content ranged from 0.34 to 0.73mg/100g. The microbial results revealed that total viable count (TVC) of all the samples were within the acceptable limit during the three months storage. While the total mould and yeast count (TMYC) results revealed that the TF and NFBF sample had too numerous to count (TNTC) of TMY on the last week of the storage duration while the FBF sample is still within the microbial limit of detection (LOD). Total coliform count (TCC) showed that no coliform count was detected. There were no significant different (P≤0.05) in the texture of FBI and NFBF and the taste of TF and FBF. There was no significant different (P≤0.05) in the colour and overall acceptability of the all the samples.

Conclusion: It was evident from the study that fermentation had improved the proximate, functional compositions significant (P≤0.05), also reduced the phytate content and extend the shelf life of the products. More so, addition of yellow-fleshed sweet potato had greatly increased the mineral, vitamins, sugar contents and overall acceptability of the products. Apparently, this work has shown that more value would be added to sweet potato utilization.

Keywords: Fermentation; yellow-fleshed sweet potato; fura; microbial; functional; sensory attributes.

1. INTRODUCTION

Cereals are widely cultivated and consumed crops on a global basis especially in the Northern parts of Nigeria and are the major sources of energy in the diet of the people [1]. Several traditional foods are produced from such cereals, one of such traditional foods is fura. Fura is a thick or semisolid dumpling cereal meal that is traditional staple food in Nigeria particularly among the northerners. It is produced mainly from pearl millet *(Pennisetum glaucum*) flour, blended with spices compressed into flour balls, and boils for 30 minutes [2]. While still hot, the cooked balls are pounded to smooth, slightly elastic cohesive dough. The dough is further reconstituted in water with fermented milk, nunu or yoghurt and consumed as beverage, weaning food, refreshing drink, snacks and food for adults and children. However, fura in its traditional dough form has a limited shelf life 1-2 days, after which it shows cracks on the surface with visible mold growth [3]. Although efforts have been made to transform this product into powder which will enhance the shelf life and functional properties. Yusufu et al. [1] reported that fura is predominantly starchy, high in fat and a good source of B vitamins. The authors further reported that fura is deficient in protein, though complemented with the addition of nunu, low in potassium, fiber, Vitamin C and vitamin A, major micronutrients problem among children. Fermentation is known to be an effective method of improving starch digestibility and bioavailability of minerals [4]. During fermentation, some micro-organisms utilized some level of fat to thrive [5]. In addition, fermented foods having acidic PH, are microbiologically safe and can be stored for longer periods.

Sweet potato (*Ipomoea batata)* belongs to the *Convolulaceae* family and is a root crop cultivated in many countries. It is grown extensively in the tropical and subtropical zones [6]. According to the [7], sweet potato has become an important global crop and is grown in diverse ecologies as one of the most important food crops in the world. CIP [8] reported that sweet potato played a pivotal role in improving household and national food security, health and livelihoods of poor families in sub Saharan African. Sweet potato is a very good source of Beta-carotene a precursor of vitamin A, Vitamin B, Potassium, Vitamin D and Magnesium [9]. Sweet potatoes generally possess sweet- taste but their natural sugars are slowly released into the bloodstream, indicating low glycemic index. Fura consumption has been a very prominent beverage in West Africa particularly among the people of Northern part of Nigeria. However, a considerate effort has to be taken to ensure it is nutritionally fit and general acceptability of this cereal-based food beverage. This present work was carried out to improve the nutritional status of fura beverages using fermentation process and an addition of yellow fleshed sweet potato flour.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Pearl millet, yellow-fleshed sweet potato and spices including Cloves, Red pepper and Ginger were purchased from Bodija Market in Ibadan, Oyo state Nigeria. They were taken to the Food Processing Laboratory unit, the Food Tech Department University of Ibadan for processing.

2.2 Sample Preparation

2.2.1 Preparation of millet flour

About 3.0 kg of clean seeds of pearl millet were washed with tap water, the grains were allowed to drained and dehulled in local wooden pestle and mortal. The dehulled grains were winnowed, washed and dried in an oven Gallemkamp (model OV-160) at 65ºC for 7 hours. The dried grains were milled and sieved through 200µm to obtain fine particles millet flour.

2.2.2 Preparation of yellow-fleshed sweet potato flour

Yellow-fleshed Sweet potato flour was produced using the method described by [10]. Yellow-fleshed Sweet potato roots were washed to remove sand, dirt and adhering materials. The roots were peeled using a sharp stainless knife and sliced using a kitchen slicer to obtain a slice thickness of about 6mm. The sliced were washed in tap water, drained and blanched at a temperature of 70ºC for 5 minutes to inactivate the enzymes that cause browning before drying in the cabinet dryer. The dried slices were milled in Bental attrition machine with sieve (mesh size 200 µm). The resulting flour was packed in a polyethylene bag and store at ambient temperature for further use.

2.2.3 Preparation of Traditional fura

Traditional powder fura was prepared according to the method described by [11]. About 3.0 kg of millet seeds were washed with tap water. The grains were drained, dry and dehulled using a local wooden pestle and mortal. The dehulled grains were winnowed, washed and dried in hot air oven Gallenkamp (Model Ov-160) at 70ºC for 5 hours. The dried grains were milled together with 2% each of the spices (ginger, cloves and red pepper). About 2.5 litres of distilled water was added to 3.0kg of millet flour and stirred. The paste was molded into balls and boiled in a metal pot for 20-30 minutes. The balls were removed, pounded and broken into small pieces, dried and milled into powder using Bental attrition mill with sieve (mesh size 200 μ m). The traditional fura produced was used as the control sample.

2.2.4 Preparation of the blends and production of fermented and non-fermented yellow-fleshed sweet potato-millet fura

The millet flour was blended with potato flour in ratios of 90:10, 80:20, 70:30, 60:40 and 50:50. The blends were spiced with 2% of each spice (ginger, clove and red pepper), conditioned with about 850ml distilled water to form a paste. The pastes were divided into two portions. The first portion was cover with aluminum foil and allowed to ferment at room temperature for 48 hours with occasional stirring. The pastes were molded into balls, boiled for 30 minutes, pounded with a local wooden pestle in a mortal and broken into pieces. The pieces were dried in a hot air oven Gallen kamp (model OV-160) at 80ºC for 5 hours, cooled and milled with Bental attrition mill using a mesh size of 200 μm to give fermented blended yellow-fleshed sweet potato – millet fura.

The pastes from the second portion were not fermented but followed the above procedure to give non- fermented of sweet potato – millet fura. Preliminary sensory evaluation was conducted on the fermented samples alone and the sample with blend ratio 70:30 (yellow-fleshed sweet potato flour 30% and millet flour 70%) was most preferred and was used throughout the experiment. The preparation of the various blends is shown in the Fig. 1.

2.3 Analysis of Samples

2.3.1 Proximate composition of yellow fleshed sweet potato-millet fura

Crude fibre, moisture content, ash content, crude protein was determined by Kjeldhal digestion and distillation method of [12], energy determination was determined using Atwater's conversion factor as reported by [13] while carbohydrate was by difference.

2.3.2 Functional properties of the yellow fleshed sweet potato – millet fura

Bulk density (loose and packed), reconstitution index and water absorption capacity was determined using standard methods of [14-16] respectively.

2.3.3 Determination of selected mineral composition, vitamin and ant nutritional contents of yellow fleshed sweet potato-millet fura

The phosphorus content, calcium content, iron content, pH, ^{0}Brix/total sugar contents were determined by the method of [17]. Titratable acidity, phytate content and beta-carotene were determined by the methods of [18-20] respectively.

2.4 Storage Stability Test

Microbial analysis of the sample was determined by the method described by [21]. About 20 g of the samples was sealed in polyethylene food bag and stored at ambient temperature (30 ± 2ºC). Samples were taken every week in the first month for microbial analysis and later, forth nightly for the period of 12 weeks.

2.4.1 Total viable count of bacteria (TVC)

One gram of the sample was homogenizing with distilled water. This was used for serial dilution by taking 1ml of test sample the first tube containing 9ml of diluents up to 10^{-5}. One ml aliquot from each dilution was transferred aseptically into sterile Petri dishes and to each plate, about 15ml of melted Nutrient agar (N.A). The inoculants were evenly mixed with the media by rotating the plates and allowed to solidify. The inverted plates were incubated for 37ºC for 48 hours. The result obtained was reported as colony forming unit (cfu/g) per gram.

2.4.2 Total mould and yeast count (TMYC)

Acidified Potato Dextrose Agar (APDA) was used for enumeration of yeast and mould. Well, homogenized samples were serially diluted with 1ml sterile diluents up to 10^{-5} dilutions. Aliquot (1ml) from the suitable dilutions were transferred aseptically into solidified APDA plates. Samples were spread all over the surface of the plates using sterile bent glass rode. The plates were then incubated for 72 hours at 28ºC and the result obtained was reported as colony forming unit (cfu/g) per gram.

2.4.3 Total coliform count (TCC)

Mac Conkey Agar was used to enumerate the total coliform counts of the sample. Well homogenized samples were serially diluted with 1ml sterile diluents up to 10^{-5} dilution. Aliquot (1ml) from the suitable dilutions were aseptically transferred into sterile Petri dish and melted Mac Conkey Agar were poured on the Petri dish and allowed the inoculants to mixed by rotating the plates and allowed to solidify. The plates were inverted and incubated for 2 days at 37ºC. The colony obtained was counted using colony counting machine and the results were reported as colony forming unit (cfu/g) per gram.

2.5 Sensory Evaluation of the Yellow Fleshed Sweet Potato-millet Fura

Sensory evaluation of the samples was determined by a preference method. Ten (10) member panels were trained on sensory attributes for the evaluation. The scores were based on the intensity of organoleptic quality attributes of taste, colour, texture and overall acceptability using a 9-point hedonic scale, 9 for liked extremely and 1 for disliked extremely. Samples were reconstituted in ratio 1:3 (Sample: Water) and coded for the participating judges' ratings in a sensory evaluation booth under amber light.

2.6 Statistical Analysis

All the data obtained from the analytical determinations were subjected to analysis of variance and reported using descriptive statistics as mean ± standard deviation of the three determinations. Sample means were separated using Duncan's Multiple Range Test ($p < 0.005$). Analyses were done using statistical software package (SPSS, version 20.0).

3. RESULTS AND DISCUSSION

3.1 Effect of Fermentation and Yellow-Fleshed Sweet Potato Flour Addition on Proximate Composition of Fura

The result of the effect of fermentation and yellow-fleshed sweet potato flour addition of fura on proximate composition was shown in Table 1. According to the result, the significant difference ($p < 0.05$) was observed in the protein content of the samples. The control (TF) had the lowest protein content 12.95%. There was no significant difference ($p < 0.05$) between the FBF and NFBF. Although the FBF had the highest protein content of 18.60%, the slight increase could be due to the action of microbial enzymes during fermentation process [22]. This process enhances the protein content of fermenting products. The ash and crude fibre content ranged from 2.00 to 2.33% and 1.81 to 2.00% respectively. The ash and crude fibre content of the samples showed that there was no significant difference ($p <0.05$) among all the samples. However, the FBF had the highest ash content of 2.50% which was not statistically different. The increase could be as an effect of fermentation. This corroborates the findings of [23]. A similar trend was also observed on the crude fibre; the FBF had the highest fibre content of 2.38% among the samples but was not statistically different to TF and NFBF. The slight increase in fibre content of FBF was as due to fermentation. This observation agrees with the work of [24]. The fat content showed that there was no significant difference ($p < 0.05$) between the samples. The FBF had the highest value of 1.17%, followed by NFBF with a value of 1.15% and TF that had 1.12%. The increase in the fat content of FBF may be due to an increased activity of the lipolytic enzymes in the fermentation medium [22,25]. Moisture content ranged from 5.00 to 9.20%, the moisture contents obtained in this work showed that there were significant differences ($p < 0.05$) among all the samples. Low moisture content obtained in this work gives an indication that the samples will have good storage stability if properly packed. However, since water does not add any nutritional value to food but rather affect the keeping quality, it is mandatory to reduce it as much as possible. The low moisture level obtained here is in agreement with those obtained for other dried products [26]. This will reduce microbial growth and extend the shelf life of the product. Carbohydrate and energy value obtained in this work shows that the TF had the highest value of 77.12% and 364.78 kj/kg followed by NFBF with a value 69.12% and 355.43 kj/kg while FBF had the lowest value of 68.03% and 345.56kj/kg of carbohydrate and energy value respectively. The increase in TF could be due to high carbohydrate content in the pearl millet. However, the reduction in the carbohydrate and energy value of FBF sample could be attributed utilization of fermentable sugars by lactic acid bacteria for growth and other metabolic activities [27].

3.2 Effect of Fermentation and Yellow-fleshed Sweet Potato Flour Addition on Functional Properties of Fura Beverage during Three (3) Months Storage

The effect of fermentation and yellow-fleshed sweet potato flour addition on functional properties of fura during processing and three month storage is presented in Table 2. The loose and packed bulk density results obtained in each month throughout the three (3) months storage duration revealed that there were significantly different ($p < 0.05$) in the loose bulk density in all the samples, while there was no significant difference in packed bulk density of TF and NFBF samples. However, the FBF had the lowest bulk density (loose and packed). The low in the bulkiness could be as a result of fermentation and this would be an advantage in the preparation of infant foods. This corroborates with the work of [28]. Reconstitution index results showed there were no significant differences ($p < 0.05$) between the TF and NFBF samples throughout the storage period. Reconstitution index showed how easily a product can be dispersed in the water before consumption, this is depending on temperature and particles size as reported by Ingbian, (2004). However, the FBF had the lowest reconstitution index, this simply mean that fermentation may have induced a change in the texture of the hydrophilic components of the powder which may have influenced the ease of dispersibility of the sample. This corroborates with [29]. Ease of dispersibility is an important property in food formulation. The authors also reported that fermentation reduced the reconstitution time. The results on water absorption capacity WAC showed that there was no significant difference ($p < 0.05$) between the TF and NFBF throughout the three (3) months storage period. The FBF had the lowest WAC; this simply showed that fermentation decreases the water absorption capacity of cereal based product and this is in line with [28]. Low water absorption capacity indicates compactness of structure [30,31].

3.3 Effect of Fermentation and Yellow-fleshed Sweet Potato Flour Addition on Selected Minerals, Vitamin and Anti-nutritional Content of Fura

The results of the effect of fermentation and yellow-fleshed sweet potato flour addition on selected minerals, vitamin anti-nutritional content of fura are shown in table 3. The calcium content of the sample ranged from 276.00 to 329.67 mg/100g but there was no statistical difference. The FBF had the highest calcium content 329.67 mg/100g, followed by TF with a value of 284.67 mg/100g and NFBF with a lowest value of 276.00 mg/100g. The slight increase could be attributed to fermentation effect. However, Iyang and Zakari [32] reported an increase in calcium content of fermented fura than traditional fura although the authors concluded that combination of germination and fermentation were best observed to improve the mineral contents of the instant fura. Iron content of the samples showed a similar trend with calcium contents; there was a significant difference ($p < 0.05$) in the iron content of the samples. The FBF had the highest value of 80.13 mg/100g, followed by NFBF with 65.42 mg/100g and TF with a lowest value of 60.00 mg/100g. This showed that fermentation had a positive impact in improving the iron content of fura product; this corroborates the findings of [32]. The phosphorus value of the samples ranged from 22.50 to 47.29 mg/100g. There was no significant difference ($p < 0.05$) in the phosphorus content of FBF and NFBF. The TF had the highest phosphorus content of 47.29 mg/100g, followed by NFBF with a value of 29.23 mg/100g, while FBF had the lowest value of 22.50 mg/100g. The reduction in the value of FBF could be attributed to the activities of fermenting organisms during fermentation; these organisms may have utilized the mineral during fermentation. Apena et al. [22] reported that fermentation decreased minerals content of cereals tested. The results of the pH revealed that there was a significant difference ($P < 0.05$) among the samples. The FBF had the lowest pH of 3.92 compared to TF and NFBF that had 5.49 and 5.04 respectively. The low pH in FBF sample could be as a result of metabolic activities of fermenting organisms which produced acids during fermentation and this pH level is in line with work earlier reported by [33]. The pH is a measure of the degree of acidity and alkalinity of a product. The low pH range obtained on the FBF is low enough to inhibit the growth of pathogenic micro-organisms such E.coli is pH 4.4, Salmonella and Shigella Spp is 4.5 [34]. Total titratable acidity showed that there was no significant difference ($p < 0.05$) between the TF and NFBF of the product. The TTA value ranged from 0.62 to 1.31 mg/100g. The results revealed that the FBF sample had the highest TTA value of 1.31 mg/100g and the increase may be due to the metabolic activities of the organisms involved during fermentation to produced acids. Moreover, Badejo [35] reported that the titratable acidity of fermented foods increases due to the production of various organic acids like lactic acids, propionic acid and pyruvic acid during fermentation. Acid production has been reported to be responsible for product stability and flavor development. The ^{0}Brix/Total sugar level obtained in this work showed that there were significant differences ($p < 0.05$) among all the samples. The degree brix measure the level of sweetness of the product and the ^{0}Brix level of the samples ranged from 3.0 to 5.04. The NFBF had the highest ^{0}Brix level and this could be attributed to the natural sugar in sweet potato added which could possibly serve as a replacement for refined or artificial sugar in fura consumption. The brix level obtained here is higher than 4.2 mg/100g reported by [1]. The beta carotene of the samples ranged from 0.26 to 0.44 mg/100g. The FBF had the highest beta carotene value of 0.44 mg/100g. The slight increase in the beta carotene content could be due to addition of yellow-fleshed sweet potato and fermentation. Oyarekua [36] observed a similar result in co-fermentation of maize/cowpea/ sweet potato. There were significant differences ($p< 0.05$) in the phytate level of all the samples analyzed. The phytate content ranged from 0.34 to 0.73 mg/100g, The TF had the highest phytate content, followed by NFBF while the FBF had the lowest phytate content. The reduction in the phytate level of FBF could be as a result of fermentation which may have degraded the chelating ability of the phytic acid due to activities of the phytase enzymes [26].

3.4 Effect of Fermentation and Yellow-fleshed Sweet Potato Flour Addition on Microbial analysis during Three Month Storage on Fura

The results of the total viable bacteria count were shown in Table 4. There was no visible growth on bacteria during the first and second week of storage; this showed that there was a drastic reduction in microbial load after processing. This could be attributed to good manufacturing practices (GMP) which may have reduced the level of microorganism in the food product. On the third week of the storage, the microorganisms resurfaced on the TF, these organisms may have arisen from the stressed organisms which repaired themselves during storage or recontamination due to improper storage [37]. However, there were significantly different ($p < 0.05$) in the microbial load of all the samples throughout the storage periods, except on the week tenth where there was no variation between TF and FBF in their microbial load. The total viable bacteria count result trend in this study shows that there was gradual increase in the microbial load of all the samples as the storage period increasing; this could be that the packaging and the storage environment may have contaminated the samples. This corroborates with report of [38]. The FBF had the highest viable bacteria count of 2.30×10^4 cfu/g, followed by TF with a count of 2.01×10^4 cfu/g while NFBF had the lowest count of 1.17×10^4 cfu/g on the last week of the storage duration. The highest viable bacteria count on the FBF sample could be as a result of fermenting organism that responsible for fermentation. However, the total bacterial load recorded in this study are within the acceptable limit set by the international commission on microbiological specification for food [39] and Microbiological guidelines for ready-to-eat food. Centre for food safety, Hong Kong [40]. The results of yeast and mould count for the three months (3) storage periods were also presented in table 5. Mould and yeast count result also shows a similar trend with total viable bacterial plate counts on the microbial increase. There was less than 30 cfu/g of yeast and mould count during the first and second week. On the third week, there were no significant differences ($P < 0.05$) on the mould and yeast count of the samples while there was a variation from the fourth week down to the twelfth week of the storage. On the 10th week of the storage duration, the counts on all the samples were very still within the acceptable limit as specified by [39,40]. However, on the 12th week of the storage duration, the count on TF and NFBF were too numerous to count TNTC While the counts on FBF was still within the acceptable limit. The TNTC could be that storage period may have been better on tenth week months and some weeks or fermentation may have being the

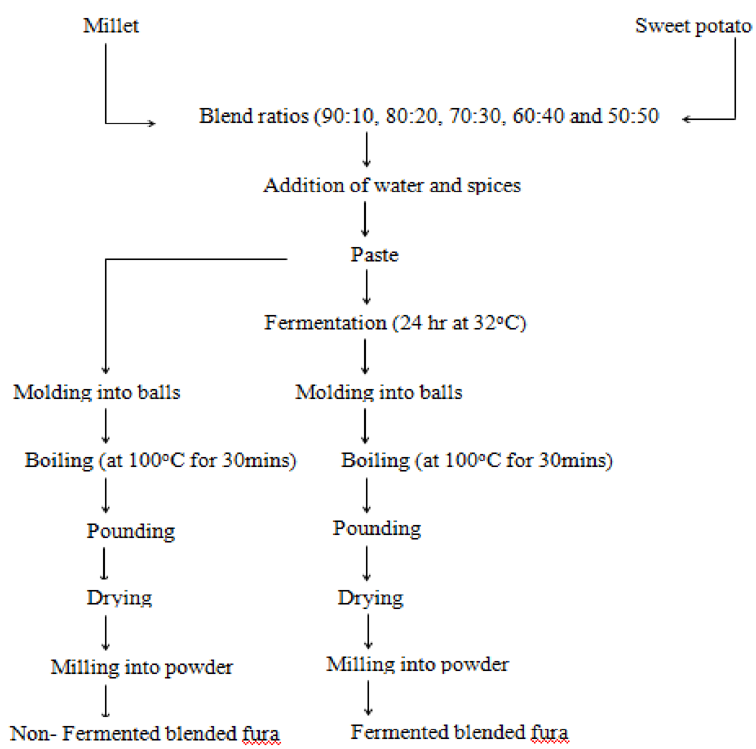

Fig. 1. Preparation of fermented and unfermented sweet potato-millet fura

Table 1. Proximate compositions of the yellow-fleshed sweet potato-fura powder on dry basis

Samples	protein (%)	Ash (%)	Fat (%)	Moisture (%)	Crude fibre (%)	CHO (%)	Energy (Kj/kg)
TF	12.95±1.96^{b}	2.00±0.5^{a}	1.1 2±0.01^{b}	5.00±0.52^{c}	1.81±0.37^{a}	77.12^{a}	364.78^{a}
FBF	18.60±1.52^{a}	2.50±0.00^{a}	1.17±0.02^{a}	6.27±0.60^{b}	2.38±0.36^{a}	68.03^{b}	345.56^{c}
NFBF	17.21±0.43^{a}	2.33±0.28^{a}	1.15±0.01^{ab}	9.20±0.43^{a}	2.00±0.01^{a}	69.12^{b}	355.43^{b}

± Standard deviation of the three replicates. Means values followed by different superscripts within the column are significantly difference at (P<0.05). Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura)

Table 2. Functional properties of the yellow-fleshed sweet potato-fura powder during storage

Storage time(Months)	Samples	Bulk density (loose) (g/cm^3)	Bulk density (packed) (g/cm^3)	Reconstitution Index (%)	Water absorption capacity (%)
1	TF	0.55 ± 0.00^{a}	0.80 ± 0.00^{a}	42.00 ± 1.00^{a}	36.89 ± 1.42^{a}
	FBF	0.47 ± 0.00^{c}	0.63 ± 0.01^{b}	33.67 ± 1.52^{b}	23.95 ± 0.42^{b}
	NFBF	0.51 ± 0.00^{b}	0.80 ± 0.02^{a}	42.33 ± 1.52^{a}	35.62 ± 1.51^{a}
2	TF	0.56 ± 0.00^{a}	0.80 ± 0.00^{a}	42.33 ± 0.57^{a}	36.89 ± 1.42^{a}
	FBF	0.46 ± 0.00^{c}	0.64 ± 0.01^{b}	33.67 ± 1.52^{b}	23.29 ± 0.25^{b}
	NFBF	0.51 ± 0.01^{b}	0.80 ± 0.00^{a}	42 .67 ± 1.15^{a}	35.62 ± 1.50^{a}
3	TF	0.57 ± 0.08^{a}	0.80 ± 0.00^{a}	42.33 ± 0.57^{a}	36.89 ± 1.42^{a}
	FBF	0.46 ± 0.00^{c}	0.64 ± 0.01^{b}	33.67 ± 1.52^{b}	23.34 ± 0.28^{b}
	NFBF	0.51 ± 0.01^{b}	0.81 ± 0.00^{a}	42.67 ± 0.15^{a}	35.22 ± 0.98^{a}

Values are means ± standard deviation of triplicate scores. Means followed by the same superscript on the vertical column are not significantly different (P<0.05). Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura)

method to reduce mould and yeast count of the product. The results of total coliform count on the final product were shown in the Table 6. Total coliform analysis was conducted on the first and the last week of the storage duration. Results revealed that there was no coliform detected in all the samples, the absence of coliform is an indicator that the product is safe for consumption and free of pathogens as the presence of pathogen in food have been reported to be a source of diarrhea and gastrointestinal disturbance to both adults and children [40].

3.5 Effect of Fermentation and Yellow-fleshed Sweet potato flour addition on Sensory attributes of Fura

The results of sensory evaluation shown in the table 7 revealed that there was significant different (P < 0.05) in all the samples in the colour. The FBF rated highest for colour with a value of 7.7, followed by NFBF with a value of 7.6, while TF rated lowest with a value of 6.5. Fermentation and addition of yellow-fleshed sweet potato could have influenced the highest score for the colour on the blended samples. There was no significant difference in the texture of the FBF and NFBF while there was significant different in TF sample and it was rated lowest. The result of the taste showed that sample TF and FBF indicated there was no significant (p < 0.05) difference while there was a significant difference in NFBF sample. However, the NFBF was rated lowest in taste, this could be that sweet potato-fura is a new product and consumers may not have familiar with the product. The overall acceptability showed that there was significant difference in all the samples, NFBF was rated highest with a value of 7.3, followed by FBF with a value of 7.1 while TF was rated lowest with a value of 6.7. The high rating of NFBF may be attributed to the natural sugar in the yellow-fleshed sweet potato and the yellow colour that replaced the dark colour of traditional fura and this agrees with the study of [1].

Table 3. Selected minerals, vitamins and anti-nutritional contents of Yellow-fleshed sweet potato-fura powder in (mg/100g)

Constituents	TF	FBF	NFBF
Calcium	284.67 ± 45.05^{a}	329.67 ± 87.55^{a}	276.00 ± 10.39^{a}
Iron	60.00 ± 1.96^{b}	80.13 ± 0.87^{a}	65.42 ± 4.58^{b}
Phosphorus	47.29 ± 0.85^{a}	22.50 ± 1.17^{b}	29.23 ± 6.94^{b}
pH	5.48 ± 0.00^{a}	3.92 ± 0.01^{c}	5.04 ± 0.00^{b}
TTA	0.62 ± 0.05^{b}	1.31 ± 0.17^{a}	0.63 ± 0.05^{b}
^{0}Brix	4.0 ± 0.00^{b}	3.0 ± 0.00^{c}	5.02 ± 0.05^{a}
Beta carotene	0.26 ± 0.02^{b}	0.44 ± 0.06^{a}	0.39 ± 0.09^{ab}
Phytate	0.73 ± 0.03^{a}	0.34 ± 0.02^{b}	0.49 ± 0.18^{b}

Values are means ± standard deviation of triplicate scores. Means followed by the same superscript on the vertical column are not significantly different (P<0.05).
Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura)

Table 4. Total aerobic plate count of Yellow-fleshed sweet potato-fura powder during three (3) months storage periods

Storage period (weeks)	Samples		
	TF (cfu/g)	FBF (cfu/g)	NFBF (cfu/g)
1	*	*	*
2	*	*	*
3	1.3 X 10^{3} ± 28.86^{a}	< 12 cfu/g	< 16 cfu/g
4	1.83X 10^{3} ± 23.09^{a}	1.08 X 10^{3} ± 25.16^{b}	5.26 X 10^{2} ± 150.11^{c}
6	1.29 X 10^{4} ± 115.47^{b}	1.44 X 10^{4} ± 404.14^{a}	1.84 X 10^{3} ± 17.32^{c}
8	1.51 X 10^{4} ± 115.47^{b}	2.15 X 10^{4} ± 500.00^{a}	8.33 X 10^{3} ± 208.16^{c}
10	2.02 X 10^{4} ± 602.77^{a}	2.09 X 10^{4} ± 115.47^{a}	1.05 X 10^{4} ± 305.50^{b}
12	2.01 X 10^{4} ± 945.16^{b}	2.30 X 10^{4} ± 1967.23^{a}	1.17 X 10^{4} ± 230.94^{c}

Values are means ± standard deviation of triplicate scores. Means followed by the same superscript on the vertical column are not significantly different (P<0.05).
*Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura), *= No visible growth, <= less than microbial limit of detection*

Table 5. Yeast and Mould count of Yellow-fleshed sweet potato-fura during three (3) months storage

Storage period (weeks)	Samples		
	TF (cfu/g)	FBF (cfu/g)	NFBF (cfu/g)
1	*	*	*
2	*	*	*
3	4.56 X 10^{2} ± 128.97^{a}	3.23 X 10^{2} ± 15.27^{a}	3.53. X 10^{2} ± 85.44^{a}
4	4.96 X 10^{2} ± 85.44^{a}	3.73 X 10^{2} ± 50.33^{ab}	3.30 X 10^{2} ± 26.45^{b}
6	1.23 X 10^{3} ± 45.09^{a}	4.50 X 10^{2} ± 104.40^{c}	1.05 X 10^{3} ± 26.45^{b}
8	1.48 X 10^{3} ± 203.05^{a}	5.26 X 10^{2} ± 179.25^{c}	1.13 X 10^{3} ± 83.26^{b}
10	2.14 X 10^{3} ± 105.83^{b}	1.06 X 10^{3} ± 52.91^{c}	2.32 X 10^{3} ± 312.41^{a}
12	TNTC	1.09 X 10^{3} ± 66.58^{a}	TNTC

Values are means ± standard deviation of triplicate scores. Means followed by the same superscript on the vertical column are not significantly different (P<0.05).
*Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura), TNTC (Too numerous to count), *= No visible growth*

Table 6. Total coliforms count during the first and last weeks of the storage periods

Samples	Total coliform count (cfu/g)	
	First week of production	Last week of storage duration
TF	ND	ND
FBF	ND	ND
NFBF	ND	ND

Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura), ND (Not detected)

Table 7. Sensory attributes of yellow-fleshed sweet potato-fura powder

Samples	Colour	Texture	Taste	Overall acceptability
TF	6.5 ± 0.05^c	5.8 ± 0.05^b	6.4 ± 0.05^a	6.7 ± 0.05^c
FBF	7.7 ± 0.05^a	6.4 ± 0.05^a	6.4 ± 0.05^a	7.1 ± 0.05^b
NFBF	7.6 ± 0.05^b	6.6 ± 0.05^a	6.3 ± 0.05^b	7.3 ± 0.05^a

Values are means ± standard deviation of triplicate scores. Means followed by the same superscript on the vertical column are not significantly different (P<0.05). Key: TF (Traditional fura), FBF (Fermented blended fura), NFBF (Non-fermented blended fura)

4. CONCLUSION

It was evident from the study that fermentation improved the proximate and functional compositions of the product significantly ($P < 0.05$). On the other hand, addition of yellow-fleshed sweet potato to fura and fermentation had greatly increased the minerals and vitamins contents of the product. The results of microbial analysis also revealed that shelf stability of yellow-fleshed sweet potato-fura could be stored for three months if produced through fermentation and well packaged. Analysis of sensory evaluation also demonstrated that addition of yellow-fleshed sweet potato flour had improved the colour and Overall acceptability of the product. Apparently, this work has shown that more value would be added to sweet potato utilization.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yusufu PA, Mosiko TB, Ojuko OO. Effect of firm ripe plantain fruit flour addition on the chemical, sensory and microbial quality of fura powder. Nigerian Food Journal. 2014;32(1):38-44.
2. Jideani VA, Wedzidia BI. Reaction of sobic and thiols in millet and sorghum dough. Food Additives and Contaminants. 1994;11:539-548.
3. Jideani VA, Durojaye OO, Jideani IA. Moisture sorption isotherm of intermediate moisture millet dough. Journal of Food Science. 1995;13:94-102.
4. Kiplamai FK, PJ Tuittoek. Effects of fermentation on total carotenoids, fat, free fatty acids and Minerals in soybean and sweet potato blends; 2010. Available:http://irlibrary.ku.ac.ke/ir/ir/handle/123456789/5519. (Accessed on April 4, 2012.)
5. Talaro KP, Talaro A. Foundation in microbiology. 2002; 4th edn. McGraw Hill College In: Amajor et al. Studies on the characteristic properties of fermented, Sun-Dried Orange-fleshed Sweet Potato Flour. 2014;32(1):45-53.
6. Islam MJ, Haque MZ, Majunder UK. Growth and yield potential of nine genotype of sweet potato. Pakistan Journal of Biological Science. 2002;5(5):537-538.
7. Firon N, LaBonte D, Villordon A, McGregor C, Kfir Y, Pressman E. Botany and physiology: Storage root formation and development. In: Amajor, JU; Oti, E; Ekeledo, N, Omodamiro Amayo EE, Aniedu C. 2014. Studies on the characteristic properties of fermented, Sun-Dried orange fleshed sweet potato flour. Nigerian Food Journal. 2009;32(1): 45-53.
8. CIP. "www.Cipotato.org/publication/005039.pdf." Center International Potato. 2009.
9. FAO. Production year book. Food and Agricultural Organization. Rome. 1991:361.

10. Adeleke RO, Odedeji JO. Functional properties of wheat and sweet potato blends. Pakistan Journal of Nutrition. 2010;6(9):535-538.
11. Jideani V, Nkama I, Agbo E, Jideani I. Survey of fura production in some Northern states of Nigeria. Plant food and Human Nutrition. 2001;56:23-36.
12. AOAC. Official Methods of Analysis of Association of Analytical Chemist (17th Ed.) Washington DC; 2010.
13. Agbon CA, Akinyemi CO, Adeleke A, Okeke EC. Chemical and sensory characteristics of fufu made from mixtures of cassava and African breadfruit flours. Journal of Natural sciences, Engineering and Technology. 2010;9(1):84 -89.
14. Maninder K, Kawaljit S, Narprinde SS. Comparative study of functional, the meal and pasting properties of flours from different field pea and pigeon pea cultivars. Food Chemistry. 2007;10:259-267.
15. Kulkarni KO, Kulkarni DN, Ingle UM. Sorghum malt based weaning food formulation preparation, functional properties and Nutritive value. Food and Nutrition Bulletin. 1991;13(14):322-327.
16. Olunlade BA, Akinfolarin KO, Adeola AA. A comparative evaluation of proximate, functional, and pasting properties of maize-cassava flour blends and wheat flour. Journal of Applied and Environmental Sciences. 2013;1-8.
17. AOAC. Association of Official Analytical Chemist. Official method of Analysis. 13th edn. Washington D.C; 2005.
18. Akpapunam MA, Sefa- Dedeh S. Traditional lactic acid fermentation, malt addition and quality development in maize-cowpea weaning blends. Food Nutrition Bulletin. 1995;16(1):75-80.
19. Onwuka GL. Food analysis and instrumentation, theory and practices. Lagos: Napthali Prints; 2005.
20. Rodriguez-Amaya DB, Mieko K. Harvest plus handbook for carotenoid analysis. International Food Policy Resaerch Institute (IFPRI). 2004;34-36.
21. Adegoke GO. Understanding food Microbiology. Ibadan: Alleluia Ventures Ltd; 2004.
Apena A, Opeolu SO, Bamidele FA, Shittu A. Nutrient changes during fermentation of some selected cereals. Sky Journal of Biochemistry Research. 2015;4(3):010-012.
22. Ojokoh AO, Fayemi OE, Ocloo FCK, Nwokolo FJ. Effect of fermentation on proximate composition, physicochemical and microbial characteristics of pearl millet (*Pennisetum glaucum* L. R. Br) and Acha (*Digitaria exilis* (Kippist) Stapf) flour bends. Journal of Agriculture Biotechnology and Sustainable Development. 2015;7(1):1-8. DOI 10.5897/jabsd2014.0236.
23. Onwurafor EU, Onweluzo JC, Ezeoke AM. Effect of fermentation methods on chemical and microbial properties of mung bean (*Vigna radiata*) Flour. Nigerian Food Journal. (2014);32(1):89-96.
24. Achinewhu SC. The effect of fermentation on carbohydrate and fatty acid composition of Africa oil bean seeds (Pentaclethra Macrophylla). Food Chem. 1986;105-116.
25. Nnam NM. Evaluation of effect of sprouting on the viscosity, proximate composition and mineral content of Hungary rice, acha (Digiteria exilis) flours. Nigeria Food Journal. 2000;18:57-62.
26. Ojokoh AO, Daramola MK, Oluoti OJ. Effect of fermentation on nutrient and anti-nutrient composition of breadfruit (*Treculia africana*) and cowpea (*Vigna unguiculata*) blend flours. African journal of Agric. Res. 2013;8:3566-3570.
27. Elkahalifa AO, Schiffler B, Bernhardt R. Effect of fermentation on functional properties of sorghum flour. Journal of Food Chemistry. 2004;92(1):1-5. DOI:10.1016/j.foodchem.2004.05.058.
28. Onweluzo JC, Nwabugwu CC. Fermentation of millet (Pennicetum americana) and pigeon pea (*Cajanus cajan*) seed for flour production: Effects on composition and selected functional properties. Pakistan Journal of Nutrition. 2009;8(6):737-744.
29. Adebowale YA, Adeyemi IA, Oshodi AA. Functional and physicochemical properties of flour of six mucuna species. African Journal of Biotechnology. 2005;4(12): 1461-1463.
30. Oladipupo FY, Nwokocha LM. Effect of *Sida acuta* and *Corchorus olitorius* mucilages on the physico-chemical properties of maize and sorghum starches. Asian Journal of Applied Science 2011;4: 514-525.
31. Iyang CU, Zakari UM. Effect of Germination and fermentation of pearl millet on proximate, chemical and sensory properties of Instant 'Fura'- A Nigerian

cereal food. Pakistan Journal of Nutrition, 2008;(1):9-12.
32. Owusu-Kwarteng J, Tano- Debrah K, Glover RLK, Akabanda F. Process characteristics and microbiology of Fura produced in Ghana. Nature and Science. 2010;8(8):41-51.
33. Mensah P, Tomkins AM, Drssar BS, Harrison TJ. Fermentation of cereals for reduction of bacterial contamination of weaning foods in Ghana. Lancet. 1990;336:140-143.
34. Badejo F.M. Introduction to food science and Technology. Ilorin: I/C Kitamas Academic and Industrial publishers. 1999; 105-108.
35. Oyarekua MA. Effect of co- fermentation on nutritive quality and pasting properties of maize/cowpea/sweet potato as complimentary food. African Journal of Food Agriculture, Nutrition and Development. 2013;13(1):7171-7191.
36. Bibek R. Fundamental food microbiology. Third edition. CRC press, London. 2004; 105-118.
37. Amajor JU, Oti E, Ekeledo N, Omodamiduro R, Amajor EE, Aniedu C. Studies on the characteristic properties of fermented, sun-dried Orange- fleshed sweet potato flour. Nigerian Food Journal. 2014;32(1):45 -53.
38. ICMSF. International commission on microbiology and specification for food, principles and specification application. University of Toronto Press, Toronto; 1986.
39. CFS. Center for food safety (Microbiology guidelines for Ready - to - eat food in general and specific food items). Hong Kong. 2014;7.
40. Owheureghe UB, Afi O, Ekundayo DF, Oboh PA, Orhvi P. Bacteriological examination of some ready to eat food marketed in Ekpoma, Edo State Nigeria. Nigeria Food Journal. 1993;11:45-52.

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