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QUALITY CHARACTERISTIC OF *KUNU* PRODUCED FROM ORANGE FLESHED SWEETPOTATO FOR EMPOWERMENT OF RURAL WOMEN IN NIGERIA

[1*]Ofoeze, M. A., [1]Ukpabi. U. J., [1]Adiele, J. G. and [2]Sanjeet, K.
[1]National Root Crops Research Institute, Umudike P.M.B 7006 Umuahia, Abia State, Nigeria.
[2]Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odisha, India.
Corresponding Authors' email: mimiofoeze@gmail.com

Abstract
Kunu is a non-alcoholic beverage consumed in Nigeria, and originated from the northern part of the country. It is being hawked by mostly women to earn a living, and originally produced using grains like millet and sorghum. Following the popularization of orange fleshed sweet potato (OFSP), *Kunu* was produced using variety 440293 of OFSP obtained from National Root Crops Research Institute Umudike. The production of *Kunu* from orange fleshed sweet potato was done at different fermentation periods of 0 hrs (Sample A), 6 hrs (Sample B), and 12 hrs (Sample C). The biochemical, microbial, sensory characterizations and cost analysis were carried out. The results showed that β-carotene content of *Kunu* was still retained compared to the fresh tuber sample. The sensory evaluation showed that sample B and C were most preferred to sample A in general acceptability, however, sample A ranked highest in appearance. The microbial analysis revealed that the microbial load of *Kunu* was low with 1.01CFU/mL x 10^6, 1.03 CFU/mL x10^6 and 1.04 CFU/mL x10^6 for A, B and C respectively. The cost analyses showed that *Kunu* from OFSP would be helpful in improving the income of rural women in Northern Nigeria.

Keywords: Orange fleshed sweet Potato, *Kunu*, Rural women and Vitamin A

Introduction

Kunu is a popular local indigenous drink consumed throughout Nigeria, mostly in the North for its nutritious and satisfying properties. It is a non-alcoholic beverage (Adeyemi and Umar, 1994; Elmahmood *et al*., 2007) and produced from mostly cereal**.** It is often consumed by children, people who have religion restrictions to alcohol consumption, recovering alcoholics and anyone wishing to enjoy flavoured drinks without alcohol (Ikpo *et al.,* 2013). It is also used as a weaning food for infants (Singh *et al*., 1987; Adeyemi and Umar, 1994; Adelekan *et al.,* 2013). There are various types of Kunu available in Nigeria, such as; *Kunu zaki, Kunu gyada, Kunu akamu, Kunu tsamiya, Kunu baule, Kunu jiko, Amshau* and *Kunu gayamb*a. *Kunu zaki* is the most popular commonly consumed (Gaffa *et al.,* 2002). It has a sweet-sour taste; the taste depends on the level of fermentation and saccharification. It is produced by the process of soaking cereals, wet milling, filtration, sedimentation, fermentation and gelatinization (Gaffa *et al., ibid*). Millet (*Pennisetum typhoideum*), Sorghum (*Sorghum vulgar*e), Maize (*Zea mays*), Rice (*Oryza sativa*) and Acha (*Digitalis exilis*) are used in its production. The grains are used singly or combined; sorghum/millet is the most common combination in a ratio of 1:2 (w/w). Recent studies indicate that other ingredients have been introduced such as sweet potatoes, malted rice, malted sorghum and *Cadaba farinosa* crude extract (Gaffa *et al.,* 2002). Some Kunu sellers add sweet potato *to Kunu* as a saccharification agent and for improved viscosity.

Orange fleshed Sweetpotato (OFSP) (*Ipomoea batats* Lam.) is an edible root crop which belongs to family *Convulvulacea* (Low *et al.,* 2009), and cultivated mostly in rural areas of Northern Nigeria (Egbe *et al.,* 2012). It can grow in a wide range of agro-ecologies and soil types, and provides essential nutrients as the roots are rich source of vitamins and other minerals besides its micronutrient providing qualities (CIP, 2013; Egeonu, 2004; Mitra, 2012), It also plays a vital role as energy source during lean periods, where people live below poverty line and in remote areas (Abidin, 2004; Mmasa *et al.,* 2013). The production, marketing and utilization of OFSP have expanded in the last decade to almost all ecological zones of Nigeria, presently between 381,000 and 510,000ha of land area are under sweet potato (including OFSP cultivation in Nigeria) as indicated by (FAO 2008). The roots are consumed as cooked vegetables, chips and other domestic dishes. However, following the popularization of OFSP as a means of fighting vitamin A deficiency (VAD) among children, the consumption of OFSP is spreading to other parts of Nigeria (Anderson *et al.,* 2007). OFSP possess multiple food nutrients, similar to cereals (high starch), fruits (high content of vitamins, pectin etc) and vegetable (vitamins, minerals and other essential nutrients). Thus,

it becomes a value-added product nutritionally accepted in the food-based approach of fighting VAD and other micronutrient deficiencies and enhances the economic conditions of the local communities. It has been used to produce some value-added products such as jam, soft drink, pickles and other foods.

Women play major role in child care and other domestic responsibilities in Nigeria and other sub-Saharan African regions. According to CIP (2003), OFSP postharvest promotion will provide nutritional supplement and play diverse and vital roles in sustainable development of African women and give a rural platform for income generation, leading to effective empowerment of rural women in Nigeria. There is need to diversify the use of OFSP and highlighting the role against VAD among the children through the popular, accessible, and available drink, *Kunu*. There is also need for attention towards the possibilities of improving the economic conditions of rural women of Nigeria with OFSP *Kunu*. Therefore, an attempt has been made to evaluate the biochemical and sensory characterization of *Kunu* from OFSP at different fermentation levels along the microbial studies to validate the safety of the drinks.

Materials and Methods

Source of experimental sample

The OFSP tubers used in this study were obtained from the Sweet potato Programme of National Root Crop Research Institute (NRCRI), Umudike. The variety used was 440293**.**

Fig. 1: Orange Fleshed Sweet potato (OFSP)

Production of OFSP Kunu

The *Kunu* was prepared following the process developed by Adebayo *et al.* (2010) with slight modifications**.** About 3kg of OFSP was washed and peeled, then cut into small cubes (about 5mm^3). The lots were divided into three parts; the first part (A) was crushed with a locally fabricated grinder together with about 30gm of ginger and 15gm of cloves, then sieved with a white muslin cloth. While sieving, the quantity of clean water used was regulated to avoid the process of decanting, so the Vitamin A will not leach out. The filtrate was heated for 10 minutes with continuous stirring to avoid gel formation at the bottom of the pot. After this, adequate water was added to meet the consumer demand i.e., not too watery and not too thick. It was bottled in clean plastic transparent bottles and cooled at room temperature and refrigerated. The other lots were fermented for 12hrs (B) and 24hrs (C), respectively, before crushing (with ginger and cloves), sieved, boiled and bottled.

Fig 2: By-products of OFSP - KUNU

Proximate determination

The proximate composition (moisture, protein, lipid, fiber, ash, carbohydrate) of the fresh OFSP was determined according to the standard procedures (AOAC, 2000). Crude protein was expressed as % nitrogen x 6.25, while carbohydrate content was determined by difference.

Physicochemical characteristics of OFSP Kunu

Pro Vitamin A (Carotenoid) Determination

About 5gm of sample was weighed and grinded with mortar. A 50ml of cold acetone was used to extract the carotenoid, and filtered by suction through a sintered glass funnel. The mortar, pestle funnel, and residue were washed with acetone through the funnel to the suction flask.

Partition to Petroleum Ether

About 20ml of petroleum ether was poured into 500ml of separating funnel with each of the filtrate. Slowly, distilled water was introduced using wash bottles to the walls to the separating funnel. The lower aqueous phase

was discarded. The washing was done 3-4 times to remove residual acetone. After this, the petroleum ether phase was collected in a 25ml volumetric flask which was made to pass through a funnel containing anhydrous sodium sulfate to remove residual water (glass wool was plug to hold the sodium), and made up to mark using petroleum ether and absorbance read of 430nm.

Calculation

$$\text{Total carotenoid content } \left(\frac{\text{mg}}{100\text{g}}\right) = \frac{\text{A x volume (ml) x } 10^4 \text{ x Df}}{\text{A\% 1cm x weight of sample}} \text{ x } 100$$

Where, A = Absorbance, Volume = Total volume of extract, $A\%_{1cm}$ = Absorbance in efficient of β-carotene in petroleum ether (2592), Df = dilution factor, Multiple by 100 to give the carotenoid content in mg/100g.

Determination of pH

About 10ml of the *Kunu* beverage was shaken with 100ml of water and allowed to stand for a period of 30min. The mixture was filtered and the pH of the filtrate determined with a pH meter.

Determination of titratable acidity

Water extraction method (AOAC, 1990) was used in the determination. Approximately 18ml of *Kunu* was measured and shaken with 200ml of CO_2 free water in a conical flask and placed in a water bath at 40ºC for one hour with the flask loosely Stoppard. The mixture was filtered and 100ml of the clear filtrate was titrated with 0.05M of NaOH solution with phenolphalein indicator. The acidity of water extract increases during storage and is calculated as lactic acid or potassium dihydrogen phosphate (1ml of 0.05M of NaOH = 0.0068g of KH2PO4).

Determination of total solids

Five grams of *Kunu* was weighed into a pre-weighed moisture can and placed into the hot water bath for about 30minutes for the moisture to evaporate leaving the solid. It was then transferred into an oven maintained at 100°C for 2½ hrs, then transferred into a desiccator, cooled and weighed, and also transferred into the oven again for 1hr, cooled and weighed. The process continued until constant weight was obtained (AOAC, *ibid*). The total solid was calculated as the percentage of the difference in weight of the initial and final weight of the sample.

Determination of ash

The crucible dish was cleaned, dried ignited, cooled and weighed. A 24.4g of the *Kunu* was weighed accurately and directly in the dish. The substance was dried on a boiling water bath and then charred over a bursen flame or hot plate in fume cupboard until no more soot was given out. Then, it was then ashed with muffle furnace at 500ºC (AOAC, *ibid*). Percentage ash was calculated as difference of the initial and final weight of the sample.

Determination of moisture content

This method is based on loss on dry at an oven temperature at 105 ºC. Besides water, the loss will include other matter volatile at 105 ºC (AOAC, 2000). Five grams of *Kunu* was weighed into a pre-weighted dish and dried at an oven temperature of 105 ºC for 3 hrs. It was allowed to cool in an airtight dedicator and re-weighed, heated in the oven again for half an hour, cooled and weighed. The process was repeated until constant weight was obtained (AOAC, 2000). The percentage moisture was calculated from the difference in weight.

Sensory evaluation

Sensory evaluation was done on each of the OFSP *Kunu* samples; A, B and C (Figs.1 and 2), and evaluated by a panel of 20 Judges comprising of 50% trained and 50% untrained panelists. The quality characteristics; appearance, aroma, taste, mouth feel and overall acceptability of the samples were evaluated based on a nine-point hedonic scale (where, 1 = dislike extremely; 9=like extremely).

Cost Analysis

Ten female *Kunu* sellers in Umudike community were used to conduct the cost benefit analysis of the *Kunu*. About 5kg of OFSP and other ingredients including water was provided for them. They were thought the processing method and educated on GMP, and produced *Kunu* and marketed. The mean cost of production was calculated and subtracted from the estimated income and estimated profit estimated.

Microbial analysis

The procedure as reported in Onwuka (2005) and (Osungun and Aboaba, 2004) was carried out using standard microbiological techniques. The media used provides a favourable environment for the growth of bacteria. The samples were first serially diluted to 10-fold dilution and 0.1ml of appropriate dilution used to inoculate each of the plates were then incubated at 37 for 24 - 48hrs, and then counted after incubation period. The mean of duplicate results were recorded, the colony counted and the identification done thereafter.

Data analysis

Mean and SD (standard deviation) were calculated to evaluate triplicate values of biochemical parameters of samples using Excel, Microsoft Corporation-2010, US.

Results and Discussion

The proximate composition of the fresh experimental OFSP tuber showed that it is high in moisture content (73.946%); low in fat and protein, the β carotene content of the tuber was 9.021mg/100g (Table 6). After processing to *Kunu*, the β carotene ranged from 8.350 - 7.922mg/100g (Table 1); the minimal loss of β carotene during processing could be attributed to the processing method used in the preparation of the *Kunu*. Jaarsveld *et al.* (2006) reported that OFSP prepared by boiling recorded low loss of β-carotene when boiled than drying and frying, that makes the OFSP *Kunu* samples a good

source of vitamin A for fighting VAD. The carbohydrate content (Tables 1 and 6) of the OFSP like most other root and tuber crop makes it possible for it to be used as energy food. The pH of the OFSP *Kunu* ranged from 6.07 – 5.05; acidity increased as the fermentation increased. The level of acidity of *Kunu* has been reported by Ikpoh *et al.* (2013), who attributed this to the presence of certain species (ginger and cloves) and lactic acid bacteria during the fermentation process. The percentage total solid decreased as fermentation increased; this could be attributed to the degradation of the carbohydrate to simple sugar by microorganisms present during fermentation. The sensory evaluation of the *Kunu* sample showed that the sample B and C were the most generally accepted (Fig. 3); this could be because *Kunu* is enjoyed as a fermented beverage which gives it the sweet sour taste that is desired. Sample A ranked highest in Colour (Fig. 3) and lowest in Taste, Mouth-feel and Aroma, however, this Sample could be improved by the addition of flavours like vanilla and fruity flavours to improve the taste for children. The cost benefit analysis shows that the rural women can make up to 40% profit from OFSP *Kunu* considering that all the raw materials are locally available, and will make it lot easier (Amusa and Odunbaku, 2009). The Bacterial identified in the experimental *Kunu* samples include; *Bacillus cereus, Lactobacillu splantarum, Streptococcus feacium, Micrococcus acidiophillus, Pseudomonas aureginosa* and *Streptococcus jactis.* Sample A recorded only two bacteria; this could be because *Kunu* did not undergo fermentation, this conforms with the report by Amusa and Odunbaku (2009); Osungun and Aboaba (2004). The associated mould and yeast include; *Aspergillus niger, Penicillium oxalicum, Candida mycoderma* and *Sacoromyces cerevisiae* with Sample A. There was no presence of *E. coli* in the experimental samples which makes the drink microbiologically safe for consumption. This may be because of the GMP done during preparation of samples. Sample A has the lowest load compared to the fermented samples. The microbial studies reveled that all the *Kunu* samples had low microbial load (Table 4). Essien *et al.* (2009) reported that the hawked *Kunu* in the market has more microbial load than the one made in the laboratory. The rural women that produce and marketed this product need to be educated on good manufacturing practices to assure the safety of the drink.

Table 1: Biochemical characteristics of *Kunu* samples*

Parameters	Sample-A	Sample-B	Sample-C
pH	6.07 ± 0.24	5.37 ± 0.46	5.05 ± 0.09
Moisture Content (%)	96.485 ± 0.95	96.749 ± 0.09	97.348 ± 0.54
Total Ash (%)	0.172 ± 0.01	0.177 ± 0.00	0.218 ± 0.04
Acidity (KH_2PO)	0.0072 ± 0.00	0.0083 ± 0.00	0.0128 ± 0.00
Total Solid (%)	3.542 ± 0.44	3.251 ± 0.63	2.652 ± 0.48
Protein (%)	0.003 ± 0.00	0.008 ± 0.00	0.014 ± 0.00
β-carotene (mg/100gm)	8.350 ± 1.09	8.200 ± 1.01	7.922 ± 0.33

Mean ± STD of Kunu Sample A: 0hr fermentation, Sample B: 6 hrs fermentation and Sample C: 12hrs Fermentation

Table 2: Incidence of Bacteria found associated with Experimental OFSP *Kunu* Samples

Sample	*Bacillus cereus*	*Lactobacillus plantarum*	*Streptococcus Feacium*	*Micrococcus acidiophillus*	*Escherishia coli*	*Pseudomonas aureginosa*	*Streptococcus jactis*
A	-	+	-	-	-	-	+
B	+	+	+	+	-	+	+
C	+	+	+	+	-	+	+

+ = Positive, - = Negative for incidence of Bacteria of Kunu Sample A: 0hr fermentation, Sample B:6 hrs fermentation and Sample C: 12hrs Fermentation

Table 3: Incidence of Mould and Yeast found associated with Experimental OFSP *Kunu* Samples

Sample	*Aspergillus niger*	*Penicillium oxalicum*	*Candida mycoderma*	*Sacoromyces cerevisiae*
A	-	-	_	+
B	+	+	+	+
C	+	+	+	+

+ = Positive, - = Negative for incidence of Mould and Yeast of Kunu Sample A: 0hr fermentation, Sample B:6 hrs fermentation and Sample C: 12hrs Fermentation

Table 4: Total microbial Load of experimental OFSP *Kunu* Samples

Sample	Total viable count (cfu $mL^{-1} \times 10^6$)	Total coliform count (cfu $mL^{-1} \times 10^6$)	Yeast count (cfu $mL^{-1} \times 10^6$)	Lactic acid bacterial count (cfu $mL^{-1} \times 10^6$)
A	1.0	Nil	25.01	10.97
B	2.4	Nil	25.52	50.76
C	3.6	Nil	27.08	53.01

Total micobial load {Total viable count (cfu $mL^{-1} \times 10^6$, Total coliform count (cfu $mL^{-1} \times 10^6$), Yeast count (cfu $mL^{-1} \times 10^6$)and Lactic acid bacterial count (cfu $mL^{-1} \times 10^6$)} of Kunu Sample A: 0hr fermentation, Sample B:6 hrs fermentation and Sample C: 12hrs Fermentation

Table 5: Cost Analyses for OFSP

Parameter	Unit	Quantity	Unit price(N)	Value (N)
A. Yield of OFSP *Kunu*				
i. *Kunu* yield	(0.75L/bottle)	bottles	50.00	750.00
ii. Sievate from *Kunu* (kg)	Kg	0.052kg		30.00
Gross Income				**780.00**
B. Labour/ Operational Demand				
i. Cost of Blending	kg	1	20.00	20.00
ii. Cost of Transportation	Km	2	30.00	60.00
iii. Labour	Hrs	5	10.00	50.00
Total				**130.00**
C. material Input Cost				
i. OFSP tubers	Kg	1	100.00	100.00
ii. Empty bottles	0.75litre	21	5.00	105.00
iii. Water	litre	30	0.25	7.50
iv. Spices/ flavours	30g	1	20.00	20.00
Total				**232.50**
D. Other Costs				
i. Rented utensils	No	4	10	40.00
ii. Marketing expenses	(5% of sales)	-	-	54.00
Total				**94.00**
Gross Operating Margin =Gross income – Total Variable cost = (A)-[(B)+(C)+(D)]			**Yield of OFSP *Kunu***	**323.50**

Table 6: Proximate composition and β carotene (mean values, n=3) of Fresh OFSP Sample (440293)

Parameters	Values
Moisture content	73.946%
Fat	0.002%
Protein	0.235%
Crude fibre	2.93%
Total ash	0.218%
carbohydrate	22.669%
β Carotene	9.021mg/100g

Values are percentage of proximate composition and carotene content of fresh OFSP

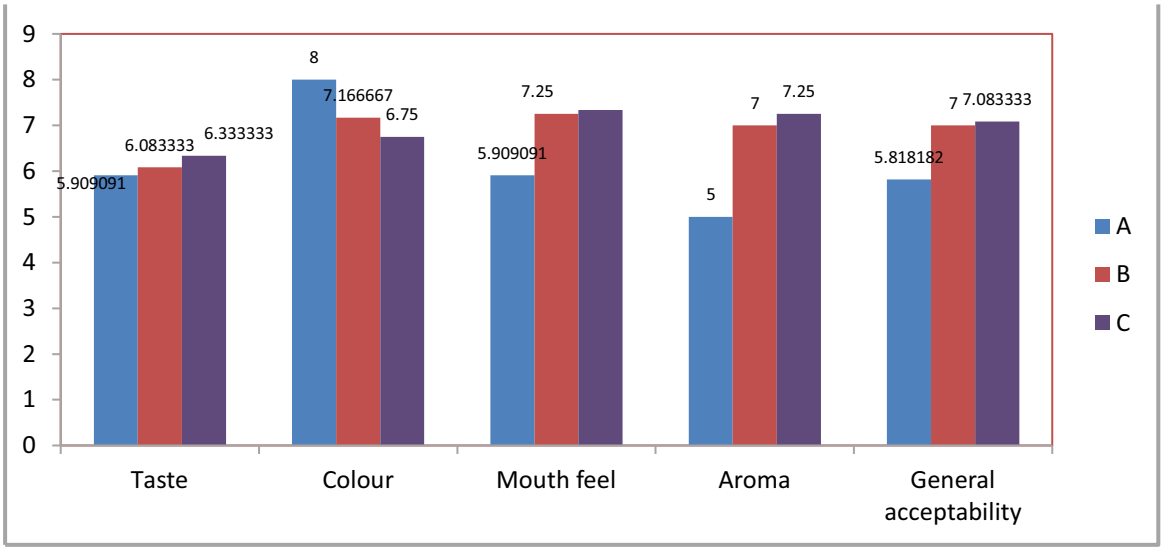

Fig 3: Sensory evaluation of Kunu samples: Kunu Sample A: 0hr fermentation, Sample B: 6 hrs fermentation and Sample C: 12hrs Fermentation

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