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**ORIGINAL ARTICLE**

# Production and Evaluation of Noodles from Rice, African yam-bean and Orange-Fleshed Sweet Potato Flour Blends

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**Abstract**

This study investigated the application of local rice, fermented African yam bean (AYB) and orange-fleshed sweet potato (OFSP) flours to develop noodle rich in proteins and pro-vitamin A. The local rice and African yam bean flours were blended in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 to produce noodle which was subjected to sensory evaluation to get the best blend (70:30). From the preliminary study, noodles were formulated from a combination of rice-African yam bean best flour blend and OFSP flour in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 respectively for samples RAYB/Pa(90% rice-African yam bean: 10% orange-fleshed sweet potato), RAYB/Pb, RAYB/Pc, RAYB/Pd and RAYB/Pe respectively, while sample RF (100% rice flour) was used as the control. The noodle products were subjected to physical, proximate, pro-vitamin A, cooking, microbiological and sensory analysis using standard methods. The results obtained showed that there was an increase in the provitamin A content of the noodle as the ratio of orange-fleshed sweet potato flour increased in the blend. The pro-vitamin A content ranged from 2.35 to 4.27 mg/100g. This makes the product a good source of vitamin A for people suffering from poor sight and vitamin A deficiency. The protein content of the noodles ranged from 8.71 – 18.43%. Sample RAYB/Pa (90:10) had the highest protein content and could help in alleviating protein malnutrition. These values were slightly higher than the control (100% rice flour). The total viable count ranged from 3.6 × 104 to 6.2 × 104cfu/g while mould was not detected in any of the samples. The microbial content of the samples were satisfactory and not high when assessed using the guideline for microbiological quality of noodle products. The sensory evaluation conducted showed that among the six noodles, 100 % rice flour and sample RAYB/Pa (90:10) were highly accepted. The study has shown that acceptable noodles could be produced from blends of rice, African yam bean and orange flesh sweet potato flour.

***Practical application***

The noodle produced and observed in this work is made from cheap and locally available raw materials; orange flesh sweet potato, African yam bean and local rice which are readily available. Local rice has antioxidant properties, African yam bean is rich in protein and B-vitamins, which can be used in alleviating protein energy malnutrition in children and help meet their daily energy requirement. The technology of processing can easily be adopted at industrial and household level

**Keywords:** *Noodles, Rice, yam-bean, Sweet potato, Flour, Proximate analysis, functional foods.*



## 1. Introduction

Noodles are long thin piece of food made from a mixture of flour, water and salt. Noodles are among the most available, affordable and convenient foods in the market. This is as a result of increase in population of working class mothers. It is consumed among people of all socioeconomic status including both urban and rural areas of the country. According to a 2008 survey, it was reported that the annual consumption of instant noodles in the world averaged about 94 billion cups (World Instant Noodle Association, 2008). Nutrient content of noodles varies widely depending on the type, quality and quantity of constituent materials as well as processing method (Hatcher, 2001). The main principal raw material for noodle production is durum wheat. However, wheat is imported since it is produced in small quantity in Nigeria. This has resulted to an immerse drain on the economy, suppressing and displacing of indigenous cereals, with a resultant detrimental effect on the agricultural and technological development (Kumara, 2015). In addition, noodles prepared from wheat flour cannot be consumed by the entire population, because some individuals are intolerant to gluten present in this flour. Gluten intolerance is an autoimmune disease that can potentially affect any organ, not just the gastrointestinal tract (Mearim *et al.*, 2005). Noodles prepared from wheat are deficient in essential amino acids and other essential nutrients such as vitamins A and β-carotene. Vitamin A deficiency (VAD) contributes to significant rates of blindness, disease and premature death in sub-Sahara Africa (Low *et al.*, 2009). However, this problem could be solved by incorporation of food materials which are high in protein, vitamin, minerals and fibre into noodles. There has been a growing demand for the utilization of functional plant proteins in specific food applications and in formulation as food ingredients (Wa sche, 2001). Cereals and legumes are known to complement themselves nutritionally (Duranti, 2006). They are excellent sources of energy because of their high carbohydrate and protein content.

The only satisfactory solution treatment for gluten intolerance is complete avoidance of wheat, rye, barley, oatmeal and their derivatives in the diet (Raymond *et al.*, 2006). The substitution of these cereals can be done with soy, rice, corn, potatoes, cassava and yams, and among these, rice is the least allergic.

Rice is the seed of monocot plant of the genus Oryza and of the grass family poaceae (Oko & Ugwu, 2011). They are about twenty wild species and two cultivated ones, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). *Oryza sativa* is the most commonly grown species throughout the world today. Rice is rich in many nutrient components including carbohydrate, proteins, certain fatty acids, vitamins and trace minerals. They are also sources of many bioactive non-nutrient compounds, known as antioxidant, including phenolic compounds (Frei & Becker, 2004). The consumption of cereal based food product is very common and popular especially in developing African countries where they constitute a major source of their staple food (Gernah *et al.*, 2011). Cereals are generally low in protein quality and are limited in some essential amino acids in particular, lysine and tryptophan. The absence of lysine makes the body difficult to synthesize protein, hormones, enzymes and antibodies which are needed for growth and other functions (Flodin, 1997). Supplementation of cereals with locally available legume such as African yam bean that are high in protein and lysine improves protein content of cereal-legume blends and their protein quality through complementation of their individual amino acids.

African yam (*Sphenostylis stenocarpa*) bean is an under-utilized indigenous African legume and one of the most important crops in the continent. There are seven species of the genus sphenostylis (Potter & Doyle, 1994). African yam bean has attracted research attention in recent times (Azeke *et al.,* 2005). Protein content is up to 19% in the tubers and 29% in the seed grain. The seeds form a valuable and prominent source of plant proteins in the diet of Nigerians. The seeds may be boiled and eaten with local seasoning, starchy roots and tubers. The seeds can also be roasted and eaten with coconut or palm kernels (Enwere, 1998).

Sweet potato (*Ipomoea batatas* (L) Lam.), on the other hand, is one of the major staple crops and most important food security promoting root crops in the world, especially in sub-Saharan Africa (Low *et al.,* 2009). Sweet potato is an excellent source of energy (438 kg/ 100 g edible portion) and can produce more edible energy per hectare per day than cereals, such as wheat and rice, and has other advantages, and wide ecological adaptability (Laurine *et al.,* 2012). Orange fleshed sweet potato is a naturally bio-fortified crop and it has a great potential to be used in food-based intervention programs to address vitamin A deficiency. The crop is a promising solution to vitamin A deficiency because it is rich in β-carotene. Sweet potatoes are generally suitable for people that are diabetic and obese due to its low starch content (Ellong *et al.,* 2014). Sweet potato leaves are recognized to be rich in essential amino acids such as lysine and tryptophan which are always limited in cereals. Hence, sweet potato can easily complement cereal based diets (Mwanri *et al.,* 2011). Recently, several research programmes are focusing on orange-fleshed sweet potato which has great potential to prevent and combat vitamin A deficiency for the sub-region (Inagabire & Hilda, 2011). The cost of importation of wheat for noodle production has resulted to an immerse drain on the economy. This has led to the use of composite flour in noodles production. The development of gluten-free noodles should reduce the severity of celiac disease caused by consumption of gluten obtained from wheat. Rice is believed to provide more health benefits than other carbohydrate based foods, since it contains several nutrients and anti-oxidative compounds (Frei & Becker, 2004). African yam beans are high in protein and have high amino acid content, making them ideal as a nutritional supplement to cereals. Orange-fleshed sweet potato has great potential to prevent and combat vitamin A deficiency (Inagabire & Hilda, 2011). The use of local rice, African yam beans and orange-fleshed sweet potato flour in noodles would reduce wheat importation, enhance the use of indigenous crops in value added products, encourage the agricultural sector, increase noodle varieties, reduce dependence on wheat flour for manufacturing of noodles and lower the cost of production.

Therefore, the broad objective of this study was to produce and evaluate the properties (proximate composition, and functional) of noodles from blends of local rice, African yam beans and orange-fleshed sweet potato flour as well as to evaluate the cooking characteristics, microbiological quality and sensory attribute of the formulated noodles.

## 2. Materials and Methods

### *2.1. Sources of materials*

Parboiled seeds of Rice (*Oryza sativa*) were obtained from Adani Rice Mill in Uzouwani Local Government Area, Enugu State. The seeds of African yam bean were obtained from Oba market in Nsukka Local Government Area, Enugu State, while mature orange-fleshed sweet potato (*Ipomeo batatas* L.) (umusco/3) was obtained from National Root Crop Research Institute, Umudike, Abia state, Nigeria.The cluster sampling method was applied at three levels, with random districts selection as the first level and random selection of neighborhoods as second level. The children and their mothers were randomly chosen from the last level.

*2.2. Production of Raw Materials*

*2.2.1 Production of rice flour*

Rice flour was processed by modifying the method of Iwe *et al.* (2016) as shown in Figure 1. Parboiled rice grains were cleaned, sorted and washed, then steeped in water for 12 h, drained and dried in a hot air Gallenkamp oven (Model IH-150, Gallenkamp, England). Milling of the dried rice grains was done using attrition mill (Bentall Plate Mill, Model 200L 090, E. H. Bentall, England), and the milled grain was sieved using a 300 µm mesh size sieve to obtain fine flour and stored in a refrigerator (5 ± 2°C, 50% RH) until used for the production of noodles.

*2.2.2. Production of fermented African yam bean*

Fermented African yam bean flour was produced by modifying the method described by Onoja *et al.* (2014) as shown in Figure 2. African yam beans were cleaned by sorting to remove extraneous materials, washed under running water and shade-dried. The seeds were put in a container and subjected to natural lactic acid fermentation in deionised water in the ratio of 1:3 (w/v) at 28 ± 2°C for 24 h. The fermented samples were decorticated / de-hulled and dried at 55 ± 2°C in a hot air laboratory oven (LABE 1201, Divine International, Delhi), and milled in a hammer mill (I. G. Jurgens, Bremmer, Germany) into fine flour (500 µm mesh screen) and stored in a refrigerator (5 ± 2°C, 50% RH) until used for the production of noodles.

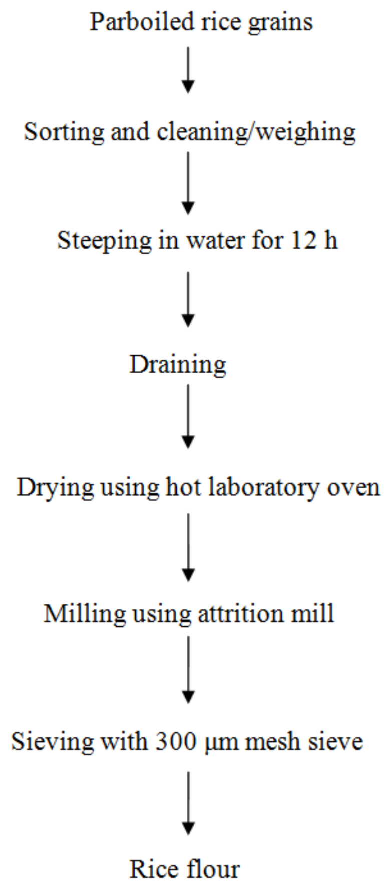


**Figure 1:** Production of rice flour



*2.2.3 Production of orange-fleshed sweet potato (Ipomoea batatas L.) flour*

Orange-fleshed sweet potato flour was processed by modifying the method described by Hagenimana & Owori (2016) as shown in Figure 3. The orange-fleshed sweet potato tuber (*Ipomeoa batatas*) was cleaned and trimmed to remove soil and other extraneous materials from the surface of the tuber. The cleaned tuber was thoroughly washed and brushed to remove adhering soil and other debris materials. After washing, the orange-fleshed sweet potato tuber was then sliced into smaller sizes and dried at 55 ± 2°C in a hot air laboratory oven (LABE 1201, Divine International, Delhi). The dried orange-fleshed sweet potato chips was then milled using a hammer mill (I. G. Jurgens, Bremmer, Germany) and the milled product sieved using a 300 µm mesh size sieve to obtain fine flour. The flour was packaged, sealed and stored in a refrigerator (5 ± 2°C, 50% RH) until used for until used for noodle production.

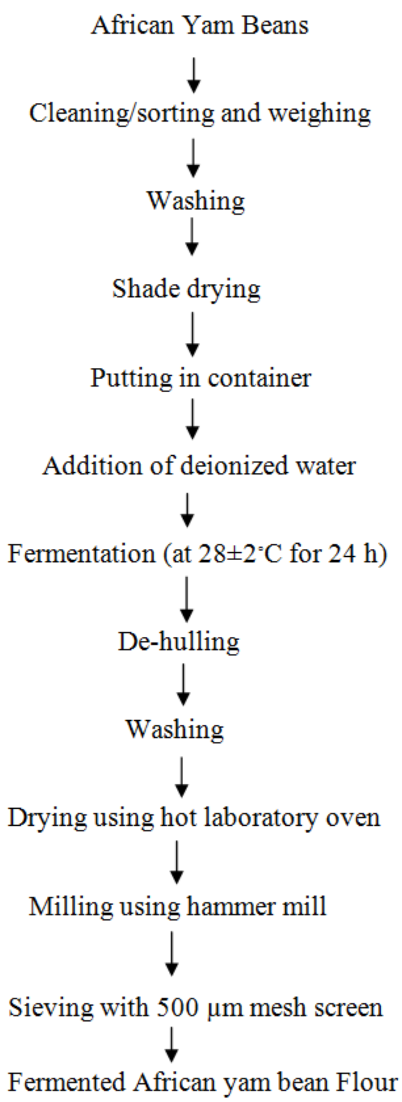


**Figure 2:** Production of African yam bean fermented flour

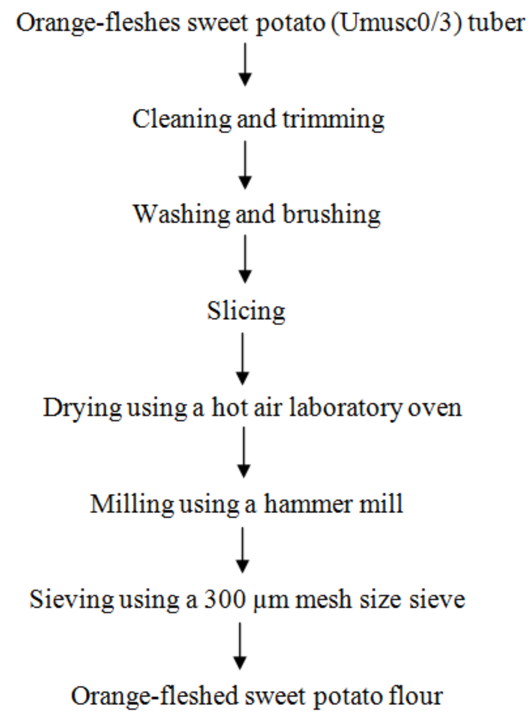


**Figure 3:** Production of orange-fleshed sweet potato flour



*2.2.4 Formulation of the flour blends for noodles production*

The flours obtained from local rice and malted African yam bean was blended in different percentage as shown in Table 1 to produce noodles. The noodles produced from the blended flour were subjected to sensory analysis in order to obtain the best blend. Based on the sensory evaluation of the noodles, the blend of RF + AYBF (70:30) was chosen as the best blend. The best blend was then blended with different percentages of orange-fleshed sweet potato flours as shown in Table 2 to produce the final product.

*2.3. Production of noodles*

Noodles were produced according to the method of Hou (2011). Two hundred grams (200 g) of the blended flour was be mixed with 60 g of water and 2 g of salt and kneaded until the flour forms dough sheets of about 3 mm thickness. The dough was rested for 30 minutes before extrusion using a pasta cutter. The extruded noodles were steamed for 90 seconds. The noodles were then placed in a wire basket fitted with a lid and the basket dipped in hot palm olein at 150°C for 1 minute and cooled at room temperature before packaging. The flow diagram for the preparation of noodles is given in Figure 4.

Raw materials

↓

Weighing

↓

Mixing/ conditioning

↓

Extrusion

↓

Frying

↓

Cooling/packaging and storage

**Figure 4:** Production of noodles

### *2.4. Analysis of Raw Materials and Noodles from Blends of Local Rice, Fermented African Yam Bean and Orange-Fleshed Sweet Potato*

The flour blends were analyzed for their proximate composition and functional properties, while the noodles were analyzed for their physical properties, proximate composition, micronutrient composition, microbiological properties, sensory and cooking properties.

**Table 1:** Blending ratios of local rice and fermented African yam bean

| Sample code | Local rice flour (%) | Fermented African yam bean |
|---|---|---|
| RF + AYBF (100:0) | 100 | 0 |
| RF + AYBF (0:100) | 0 | 100 |
| RF + AYBF (90:10) | 90 | 10 |
| RF + AYBF (80: 20) | 80 | 20 |
| RF + AYBF (70:30) | 70 | 30 |
| RF + AYBF (60:40) | 60 | 40 |
| RF + AYBF (50: 50) | 50 | 50 |

Key: RF + AYBF (100:0) = 100% Local rice flour and 0 % African yam bean flour; RF + AYBF (0:100) = 0% Local rice flour and 100 % African yam bean flour; RF + AYBF (90:10) = 90% Local rice flour and 10 % African yam bean flour; RF + AYBF (80:20) = 80% Local rice flour and 20 % African yam bean flour; RF + AYBF (70:30) = 70% Local rice flour and 30 % African yam bean flour; RF + AYBF (60:40) = 60% Local rice flour and 40 % African yam bean flour; RF + AYBF (50:50) = 50% Local rice flour and 50 % African yam bean flour.



**Table 2:** Blending ratios of local rice/fermented African yam bean flour and orange-fleshed sweet potato flour

| Sample code | Local rice/fermented African yam bean flour blend (70:30 best blend) (%) | Orange-fleshed sweet potato flour (%) |
|---|---|---|
| RF (control) | 100 | 0 |
| RAYB/Pa (90:10) | 90 | 10 |
| RAYB/Pb (80:20) | 80 | 20 |
| RAYB/Pc (70 : 30) | 70 | 30 |
| RAYB/Pd (60: 40) | 60 | 40 |
| RAYB/Pe (50:50) | 50 | 50 |

Key: RF= Rice flour; RAYB =Rice + African yam bean blend; Pa –Pe = Orange-fleshed sweet potato in different ratios. RAYB/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RAYB/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RAYB/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RAYB/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; while RAYB/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour.

*2.4.1 Physical evaluation*

*2.4.1.1 Noodle width and height*

The width and height of the noodles were analyzed using a micrometer screw gauge.

*2.4.1.2 Noodle length*

The lengths of the noodles were measured using a measuring rule.

*2.4.2 Proximate composition*

The moisture content, crude protein, ash, crude fibre, fat content and carbohydrate content were determined according to the procedures described by AOAC (2010).

*2.4.3. Determination of β-carotene content*

The β-carotene content of the samples was determined using the method (Onyeka & Nwabekwu, 2007). The samples were weighed, W1 and homogenized in methanol in the ratio of 1:10 (%) using a laboratory blender. The homogenate was filtered using a filter paper of measured weight, $W_2$ to obtain the initial crude extract, washed with 20 ml of distilled water in separating funnel. The other layer was recovered and evaporated to dryness at a low temperature (35-50°C) in vacuum desiccator. The dry extract was saponified with 20 ml of ethanoic potassium hydroxide and was left overnight in a dark cupboard. After a day, the β-carotene was taken up in 20 ml of ether and then washed with two portions of 20 ml distilled water. The β- carotene content extract (ether layer) was dried in a desiccator and treated with petroleum (petroleum spurt) and allowed to stand overnight in a freezer. The next day, the precipitated steroid was removed by centrifugation and β-carotene extract was evaporated to dryness in a desiccator and weighed, $W_3$. The weight of the β- carotene was determined and expressed as a percentage of the sample weight.

$$\beta\text{-Carotene content (\%)} = \frac{W_3 - W_2}{W_1} \times \frac{100}{1}$$

Where $W_1$ = Weight of sample; $W_2$ = Weight of empty filter paper and $W_3$ = Weight of filter paper + Weight of precipitate.

*2.4.4 Determination of functional properties*

*2.4.4.1Determination of water absorption capacities*

Water absorption capacity was determined by modifying the method (Philips *et al.*, 1998). One gram (dry weight basis) of the sample was dispersed in 10 ml distilled water, vortexed intermittently for 10 minutes and centrifuged at 4500 rpm for 20 minutes. The aqueous supernatant obtained after centrifuging was decanted and the test tubes inserted and allowed to drain for 5 minutes on a towel. By weighing the residue, water absorption capacity was calculated as a percentage of a gram of water absorbed per gram of sample.

*2.4.4.2 Determination of oil absorption capacities*

The oil absorption capacity was determined by modifying the method (Beuchat, 1977).

Powdered samples were weighed 0.5 g each and mixed with 5 ml of oil (pure olive oil) for 30 seconds. The samples were allowed to stand at room temperature (30±2 °C) for 30 minutes after which the samples were centrifuged at 500 rpm for 30 minutes. The supernatant, mainly oil was decanted and the test tubes inverted and allowed to drain for 15 minutes on a towel. By weighing the residue, oil absorption capacity was calculated as oil absorbed per weight of samples.

*2.4.4.3 Determination of bulk density*

The bulk density was determined according to the method (Onwuka, 2005). A graduated measuring cylinder of 10 ml capacity was weighed and gently filled with the sample, followed by gently tapping the bottom until there was no further diminution of the sample level after filling to the 10 $cm^3$ mark. The bulk density was calculated as:

Bulk density (g / $cm^3$) = Weight of sample (g)/ the weight of sample after tapping ($cm^3$)

*2.4.4.4 Determination of swelling capacity*

The swelling capacity was determined by modifying the method (Onwuka, 2005). The flour sample (0.1 g) was weighed into a test tube and 10 ml of distilled water added. The mixture was heated in a water bath at a temperature of 50°C for 30 minutes with continuous shaking. In the end, the test tube was centrifuged at 1500 rpm for 20 minutes in order to facilitate the removal of the supernatant which was carefully decanted and the weight of the starch paste taken. This was carried out over a temperature range of 50-100°C. The swelling power was calculated as follows:

Swelling power = Weight of starch paste/ the weight of dry starch sample

*2.4.5. Cooking characteristics of noodles*

*2.4.5.1 Optimum cooking time*

The optimum cooking time of the noodles was evaluated according to the modified method of Schoenlechner *et al.* (2010). One hundred grams of noodles was put into a beaker containing 1 l of boiling water (without salt addition). Every minute, some pieces were taken out and pressed between two glass plates (2.5 cm × 2.5 cm). The optimal cooking time (OCT) corresponded to the disappearance of the white centre core

*2.4.5.2 Cooking yield and cooking loss*

Cooking yield and cooking loss was determined according to the method of American Association of Cereal Chemists (2000).

*2.4.6. Total Viable and Mould Count (TVC)*

The total viable count was determined according to the method Prescott et al. (2005). The samples were inoculated using nutrient agar after the serial dilution of the sample had been obtained. Pour plate method was used. The colony count was done after 24 hours of incubation at 37 °C using a colony counter (Gallenkamp colony counters, CNW 330-010X) and the number of colonies calculated using the following formula:

TVC (CFU / g) = (Number of colonies × Original concentration) / (Dilution factor × Volume of inoculums)
CFU = Colony Forming Unit

For the mould count, after the serial dilution of the samples, they were inoculated using Sabauroud dextrose agar (SDA). Pour plate method was used. The colony count was done after 72 hours on incubation at 37 °C, using a colony counter (Gallenkamp colony counter, CNW 330-010X) and the number of colonies calculated using the following method:

Mould count (CFU / g) = (Number of colonies ×Original concentration)/ (Dilution factor × Volume of inoculums)
CFU = colony forming unit.

*2.4.7 Sensory evaluation*

The noodles were cooked and assessed by a 20-man semi- trained panel consisting of students of Department of Food Science and Technology, University of Nigeria, Nsukka, for colour, flavour, taste, texture, after taste and general acceptability on a 9-point Hedonic scale (Ihekoronye & Ngoddy, 1985). Where 9 signify like extremely and 1 signifies dislike extremely.

Based on the sensory score, the best noodle from the composite flour was compared with 100% rice noodle. The samples were presented in coded plastic plates. The order of presentation of samples to the judges was randomized. Clean water was presented for the panelists to rinse their mouth in between evaluation.

*2.5 Data Analysis and Experimental Design*

The experimental design that was used is Completely Randomized Design and the mean values were subjected to analysis of variance (ANOVA) using Duncan's Multiple Range Test (DMRT) and SPSS (Statistical Product for Service Solution) version 20 computer was used. Significance was accepted at $p < 0.05$ (Steel & Torrie, 1980).

## 3. Results and Discussion

### *3.1 Proximate Composition (%) of the Local Rice, African Yam Bean and Orange-fleshed Sweet Potato Flours*

The proximate composition (%) of the sample flours (local rice, African yam bean and orange-fleshed sweet potato) are shown in Table 3. From Table 3, the moisture content varied from 7.51(fermented African yam bean flour), 9.62% (orange-fleshed sweet potato flour) and 8.86% (local rice). The samples were significantly ($p<0.05$) different from each other. The moisture content of the flour samples were found to comply with the regulations of the National Agency for Food and Drug Administration and Control that specifies 10% as the maximum moisture content for flour samples. The high moisture content of food is an index of spoilage since moisture enhances chemical and biochemical reactions that could lead to spoilage.

The fat content of the flour samples were as follows, local rice (0.70%), fermented African yam bean (1.12%) and orange-fleshed sweet potato (0.50%). The low fat content of orange-fleshed sweet potato flour indicates that it would not be easily susceptible to rancidity. Fat have been known to impart on the sensory attributes of food products, however, high fat content of food may reduce its keeping quality (Mbaeyi-Nwaoha & Ugwu, 2018).

From the results, it was observed that orange-fleshed sweet potato flour had the highest crude fibre (3.07%) and it was higher than that of African yam beans flour (2.10%) and local rice flour (1.08%). Fiber content of the flour samples was found to be relatively low. The samples were significantly ($p<0.05$) different from each other. The crude fiber content was similar to that reported by Mbaeyi-Nwaoha & Ugwu (2018). The fibre content would be effective in the delay of gastric emptying and a reduction in serum cholesterol (Kure *et al.*, 1998).

The protein content of the fermented African yam bean flour (25.54%) was higher than that of local rice flour (7.80%) and orange-fleshed sweet potato flour (2.12%) which makes it a good protein supplement. The ash content ranged from local rice flour (2.69%), African yam bean flour (2.40%) and orange-fleshed sweet potato flour (1.79%). Local rice flour had the highest ash content (2.69%) This ash value would probably increase the mineral and vitamin content of the blend since ash is an index of mineral content. The carbohydrate content of the flour was 79.91, 61.33 and 82.90% for local rice, African yam bean and orange-fleshed sweet potato flours respectively. Orange-fleshed sweet potato flour had the highest carbohydrate content while African yam beans had the lowest.

**Table 3:** Proximate composition (%) of Adani rice flour, fermented African yam bean flour and orange- flesh sweet potato flour

| Samples code | Moisture | Ash | Fat | Fiber | Protein | Carbohydrate |
|---|---|---|---|---|---|---|
| RF | $8.86^{b} \pm 0.02$ | $2.69^{a} \pm 0.02$ | 0.70b±0.15 | $1.08^{c} \pm 0.02$ | $7.08^{b} \pm 0.05$ | $79.59^{b} \pm 0.19$ |
| FAYBF | $7.51^{c} \pm 0.02$ | $2.40^{b} \pm 0.02$ | $1.12^{a} \pm 0.02$ | $2.10^{b} \pm 0.01$ | $25.54^{a} \pm 0.02$ | $61.33^{c} \pm 1.48$ |
| OFSPF | $9.62^{a} \pm 0.02$ | $1.79^{c} \pm 0.03$ | $0.50^{c} \pm 0.02$ | $3.07^{a} \pm 0.06$ | $2.12^{c} \pm 0.02$ | $82.90^{a} \pm 0.08$ |

Values are means ± SD of triplicate readings. Means within the column and rows with different superscript were significantly different ($p<0.05$)

* Keys: RF= adani rice flour, OFSPF= orange flesh sweet potato flour, FAYBF= fermented African yam bean flour

The solar drying technique employed during the processing of the flour helped in the retention of the nutrients present. The proximate composition of the flours compared favourably well with that reported by other researchers (Mepba *et al.*, 2007).

### *3.2 Functional Properties of Local Rice Flour, African Yam Bean Flour and Orange-fleshed Sweet Potato Flour*

Table 4 shows the functional properties of local rice flour, African yam bean flour and orange-fleshed sweet potato flour. Functional properties are carried out in order to monitor the behavior of nutrients in food during preparation, processing and storage. This is because they affect food quality and acceptability (Enwere, 1998).

From Table 4, orange-fleshed sweet potato flour had the highest water absorption capacity (266.42%) and was followed by local rice flour (161.40%), while African yam bean flour had the least water absorption capacity (138.67%). Water absorption capacity is the ability of a product (flour) to absorb incorporated water. Iwe & Onadipe (2001) reported that the ability of flour to absorb water improves dough making potentials. Water absorption capacity of flours depends on several factors such as size of granules, amylase/amylopectin ratio, intra and intermolecular forces (Akubor & Badifu, 2001). The relatively high water absorption capacity of orange-fleshed sweet potato flour could be attributed to its high amylose to amylopectin ratio (21:79) which gives it a higher affinity for water. The relatively low water absorption capacity of rice and African yam bean flour could be attributed to the presence of low amount of hydrophilic constituents in these flours (Matil, 2007).

**Table 4:** Functional properties of Adani rice flour, African yam bean and orange flesh sweet potato flours

| Samples | WAC (%) | BD(g/cm$^3$) | SC | OAC (%) |
|---|---|---|---|---|
| RF | 266.42$^a$±0.03 | 0.74$^b$±0.00 | 8.44$^a$±0.00 | 68.78$^c$±0.04 |
| FAYBF | 142.42$^b$±0.00 | 0.51$^c$±0.03 | 4.31$^c$±0.03 | 125.01$^b$±0.01 |
| OFSPF | 138.67$^c$±0.03 | 0.88$^a$±0.01 | 4.56$^b$±0.06 | 140.20$^a$±0.02 |

Values are means ± SD of triplicate readings. Means within the column and rows with different superscript were significantly different ($p<0.05$). *Key: RF: Rice flour, OFSPF=Orange flesh sweet potato, FAYBF=Fermented African yam bean flour, WAC: Water absorption capacity, BD: Bulk density, SC: Swelling capacity, OAC: Oil absorption capacity

The orange-fleshed sweet potato had the highest oil absorption capacity (140.20%) while the least was recorded with local rice flour (68.78%). The higher oil absorption capacity of orange-fleshed sweet potato indicated the presence of polar amino acids in the flour (Kinsella, 1976). Oil absorption capacity is the ability of the flour protein to physically bind fat by capillary action. This property is of great importance since fat acts as a flavour retainer and increases the mouth feel of foods especially bread and other baked foods (Akubor & Badifu, 2001).

Bulk density is the weight per unit volume of a material. Bulk density is important for determining packaging food requirements, material handling and application in the food industry (Taira, 2010). The bulk densities of local rice, African yam bean and orange-fleshed sweet potato flours were 0.74, 0.51 and 0.88 g/cm$^3$ respectively. It was observed that the bulk density of local rice flour was the highest while African yam bean flour had the least. This could be attributed to the fineness of the flour particle (500 µm). The low values of bulk densities make the flours suitable for high nutrient density food formulations.

The swelling capacity of local rice flour, African yam beans flour and orange-fleshed sweet potato flour was 8.44, 4.31 and 4.56 ml, respectively. This shows that rice flour had the highest swelling capacity (8.44 ml) which is significantly ($p<0.05$) different from African yam bean and orange-fleshed sweet potato flours. Swelling capacity is an indication of the water absorption index of the granules during heating (Kanura *et al.*, 1996).

*3.3 Sensory Scores of the Noodles Formulated from Local Rice and Fermented African Yam Beans Flour Blends*

The results of the sensory scores of the noodles formulated from the blends of local rice flour and fermented African yam beans flour for preliminary studies are shown in Table 5. The sensory scores for colour ranged from 4.55 to 7.95 with sample RF (rice flour) + AYBF (African yam bean flour) (50:50) having the lowest score while sample RF (100%) had the highest score. Samples RF+ AYBF (80:20), RF+AYBF (70:30), RF+AYBF (60:40) and RF+AYBF (50:50) were significantly ($p<0.05$) different from sample RF (100%).

**Table 5:** Preliminary sensory scores of noodles from blends of from rice, fermented African yam bean and orange flesh sweet potato flours

| Sample code | Colour | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| RF (100%) | 7.95$^{a}$±0.89 | 6.50$^{a}$±1.43 | 6.15$^{ab}$±1.66 | 6.90$^{a}$±1.65 | 7.15$^{a}$±1.53 |
| AYBF (100%) | 4.80$^{c}$±2.04 | 4.50$^{b}$±1.79 | 4.10$^{d}$±1.59 | 4.00$^{c}$±2.00 | 4.80$^{c}$±1.61 |
| RF+AYBF(80:20) | 5.85$^{b}$±1.31 | 5.20$^{b}$±1.36 | 5.50$^{bc}$±1.43 | 5.50$^{b}$±1.19 | 5.90$^{b}$±0.97 |
| RF+AYBF(70:30) | 6.75$^{b}$±1.80 | 7.05$^{a}$±1.23 | 7.10$^{a}$±1.37 | 7.00$^{a}$±1.86 | 7.15$^{a}$±1.53 |
| RF+AYBF(60:40) | 6.30$^{b}$±1.38 | 5.15$^{b}$±1.57 | 5.15$^{bc}$±1.63 | 5.15$^{b}$±1.39 | 6.00$^{b}$±1.26 |
| RF+AYBF(50:50) | 4.55$^{b}$±1.64 | 5.10$^{b}$±1.48 | 5.10$^{c}$±1.48 | 5.60$^{b}$±1.57 | 5.50$^{bc}$±1.61 |

Values are means ± SD of panelist scores. Means within a rows with the same superscript were not significantly different (p>0.05). *Keys: RF(100%): 100 % Rice flour; AYBF (100%): 100 % African yam bean flour, RF+AYBF(80:20): 80 % rice flour + 20 % African yam bean flour; RF +AYBF(70:30): 70 % rice flour + 30 % African yam bean flour; RF+AYBF(60:40): 60 % rice flour + 40 % African yam bean flour; RF+AYBF(50:50): 50 % rice flour + 50 % African yam bean flour.

The flavour score ranged from 4.50 to 7.05 with sample AYBF (100%) having the least score while sample RF+AYBF (70:30) had the highest score. The low score observed for sample AYBF (100%) was due to the intense beany flavor of the fermented African yam bean flour. There were no significant ($p < 0.05$) difference among samples AYBF (100%), RF+AYBF (80:20), RF+AYBF (60:40) and sample RF+AYBF (50:50) in flavour. The sensory score for taste ranged from 4.10 to 7.10 with sample AYBF (100%) having the least score while sample RF+ AYBF (70:30) had the highest score. The texture score ranged from 4.00 to 7.00 with sample AYBF (100%) having the least score while sample RF+ AYBF (70:30) had the highest value. Samples RF+ AYBF (80:20), RF+AYBF (60:40) and RF+AYBF (50:50) were significantly ($p<0.05$) different from sample RF (100%), RF+ AYBF (70:30) and AYBF (100%).The score for the overall acceptability ranged from 4.80 to 7.15 with sample AYBF (100%) having the least score while sample RF+AYBF (70:30) had the highest score. Based on the overall acceptability, the sample containing 70% rice and 30% African yam bean flour had the highest mean value It was chosen as the most preferred blend and used for the formulation of the main product by replacing 10 - 50% of the composite flour (consisting of 70% rice and 30% African yam bean flours) with orange-fleshed sweet potato flour. The noodles produced from 100 % African yam bean flour had the lowest score because it was too sticky.

### 3.4 *Physical Characteristics of Noodles Formulated from Local Rice, African Yam Beans and Orange-fleshed Sweet Potato Flour Blends*

The physical characteristics of noodles formulated from local rice flour, fermented African yam bean flour and orange-fleshed sweet potato flour blends at different ratios are shown in Table 6.

**Table 6:** Physical properties (cm) of noodles formulated from flour blends of rice, African yam bean and orange -fleshed sweet potato

| Sample code | Width | Height | Length |
|---|---|---|---|
| RF | $0.37^{a}\pm0.06$ | $0.27^{ab}\pm0.06$ | $2.33^{bc}\pm0.25$ |
| RAYB/Pa | $0.40^{a}\pm0.00$ | $0.27^{ab}\pm0.06$ | $4.30^{a}\pm0.10$ |
| RAYB/Pb | $0.33^{a}\pm0.12$ | $0.33^{a}\pm0.06$ | $2.30^{bc}\pm0.26$ |
| RAYB/Pc | $0.37^{a}\pm0.15$ | $0.33^{a}\pm0.06$ | $2.73^{b}\pm0.38$ |
| RAYB/Pd | $0.37^{a}\pm0.06$ | $0.27^{ab}\pm0.06$ | $2.20^{bc}\pm0.79$ |
| RAYB/Pe | $0.40^{a}\pm0.10$ | $0.20^{b}\pm0.10$ | $1.90^{c}\pm0.10$ |

Values are means ± SD of triplicate determination. Means within a rows with the same superscript were not significantly different (p>0.05).RF: 100% rice flour; RAYB/Pa:=90% of best blend + 10% orange flesh sweet potato flour; RAYB/Pb: 80% of best blend +20% orange flesh sweet potato flour; RAYB/Pc: 70% best blend + 30% orange flesh sweet potato flour, RAYB/Pd: 60% of best blend + 40% orange flesh sweet potato flour; RAYB/Pe: 50% of best blend + 50% orange flesh sweet potato flour

The width of the noodles produced from blends of local rice, African yam beans and orange-fleshed sweet potato flour ranged from 0.33 to 0.40 cm. There were no significant ($p < 0.05$) difference among the samples.

The height of the noodles varied from 0.20 to 0.33 cm with sample RAYB/Pe (50:50) having the lowest value while sample RAYB/Pc (70:30) and RAYB/Pd (60:40) having the highest value. The heights of samples RAYB/Pb (80:20) and RAYB/Pc (70:30) were not significantly ($p<0.05$) different, samples RAYB/Pa (90:10), RAYB/Pd (60:40) and RAYB/Pe (50:50) were also not significantly ($p<0.05$) different.

The length of the noodles varied from 1.90 to 4.30 cm with sample RAYB/Pa (90:10) having the highest value while sample RAYB/Pe (50:50) had the least value. Sample RAYB/Pb (80:20) and RAYB/Pd (60:40) were not significantly ($p<0.05$) different. Also, samples RAYB/Pb (80:20) and RAYB/Pe (50:50) were not significantly ($p<0.05$) different from the control (100% rice) while sample RAYB/Pa (90:10) differed significantly ($p<0.05$) from other samples including the control (100% rice). The widths of the samples were similar to that reported by Akubeze (2015) whereas the values for the length and height of the samples were found to be different.

### *3.5 Proximate Composition of Noodle Formulated from Local Rice, Fermented African Yam Beans and Orange-fleshed Sweet Potato Flour Blends*

The proximate composition of noodle produced from local rice, African yam bean and orange-fleshed sweet potato flour blends are shown in Table 7.

The protein content of noodle formulated from the blend of local rice, African yam bean and orange-fleshed sweet potato flour varied from 8.61 to 18.43% with sample RAYB/Pe (50:50) having the lowest value and sample RAYB/Pa (90:10) having the highest protein content. The results showed that the blending ratios influence the protein content of the noodle. It was observed that the protein contents of all the samples were significantly ($p<0.05$) different from the control (100% rice). The increase in protein content of the products was due to the high protein content of the African yam bean flour in the blends. The high protein content could be used to eradicate the protein-energy malnutrition especially in developing country like Nigeria.

**Table 7:** Proximate composition (%) of noodles produced from blends of rice, African yam bean and orange- fleshed sweet potato flours

| Sample code | Moisture | Protein | Fat | Ash | Fiber | Carbohydrate |
|---|---|---|---|---|---|---|
| RF | $3.44^{f}\pm0.05$ | $4.39^{f}\pm0.01$ | $0.20^{b}\pm0.01$ | $1.24^{f}\pm0.02$ | $1.89^{f}\pm0.02$ | $88.84^{a}\pm0.04$ |
| RAB/Pa | $5.23^{a}\pm0.03$ | $18.43^{a}\pm0.03$ | $0.31^{a}\pm0.01$ | $2.25^{e}\pm0.02$ | $2.72^{e}\pm0.02$ | $71.06^{d}\pm0.06$ |
| RAB/Pb | $3.90^{e}\pm0.02$ | $12.3^{b}\pm0.02$ | $0.21^{b}\pm0.01$ | $2.43^{d}\pm0.01$ | $3.01^{d}\pm0.01$ | $78.15^{b}\pm0.05$ |
| RAB/Pc | $4.2^{d}\pm0.03$ | $9.91^{c}\pm0.01$ | $0.19^{b}\pm0.01$ | $2.73^{c}\pm0.08$ | $3.22^{c}\pm0.01$ | $79.75^{c}\pm0.03$ |
| RAB/Pd | $4.30^{c}\pm0.01$ | $8.71^{d}\pm0.01$ | $0.14^{c}\pm0.01$ | $3.39^{a}\pm0.01$ | $3.54^{b}\pm0.01$ | $80.22^{b}\pm0.04$ |
| RAB/Pe | $4.42^{b}\pm0.02$ | $8.61^{e}\pm0.01$ | $0.10^{d}\pm0.01$ | $3.40^{a}\pm0.01$ | $3.61^{a}\pm0.01$ | $79.86^{c}\pm0.02$ |

Values are means ± SD of triplicate determination. Means within a rows with the same superscript abc were not significantly different (p>0.05). Key: RF: 100% rice flour; RAYB/Pa:=90% of best blend + 10% orange flesh sweet potato flour; RAYB/Pb: 80% of best blend +20% orange flesh sweet potato flour; RAYB/Pc: 70% best blend + 30% orange flesh sweet potato flour, RAYB/Pd: 60% of best blend + 40% orange flesh sweet potato flour; RAYB/Pe: 50% of best blend + 50% orange flesh sweet potato flour

The fat content of the noodle formulated from the blends of local rice, African yam beans and orange-fleshed sweet potato flour varied from 0.10 to 0.31% with sample RAYB/Pa (90:10) having the highest value and RAYB/Pe (50:50) having the least fat content. There were significant ($p<0.05$) differences among the samples. The fat content of all the samples were significantly ($p<0.05$) different from the control (100% rice) except for sample RAYB/Pc (70: 30) and sample RAYB/Pb (80:20). The fat contents of all the samples were found to be generally low. This result was not in agreement with the findings of Umego (2012) using wheat-sweet potato-soybean flour blends. The results of the fat content obtained by Umego (2012), showed the relative high-fat content of the products. The relatively low-fat content of the food blends could contribute to the extension of the shelf-life of noodles by retarding the onset of rancidity.

The low-fat content of all the blends could also make the product an excellent food for diabetic and obese patients (Jeckins, 2000).



The ash content of the noodle varied from 2.25 to 3.30% with sample RAYB/Pe (50:50) having the highest ash content while sample RAYB/Pa (90:10) had the lowest value. The ash content is an index of the mineral content of a food sample which is necessary for growth and development. This result showed that sample RAYB/Pe (50:50) contained highest mineral element than other samples including the control (100% rice) due to the increase in the ratio of the orange-fleshed sweet potato flour in the blend. It was observed that samples RAYB/Pd (60:40) and RAYB/Pe (50:50) were not significantly ($p<0.05$) different. The ash content of all the blends was found to be significantly ($p<0.05$) different from the control (100% rice).

The crude fibre content of the noodles varied from 2.72 to 3.61% with sample RAYB/Pa (90:10) having the lowest fibre content and sample RAYB/Pe (50:50) having the highest value. The fibre contents of the blends were observed to be higher than that of the control (100% rice). The fibre contents of all samples were significantly ($p<0.05$) different from each other. The increase in the fibre contents of the blends was due to the high contents of fibre in African yam beans and orange-fleshed sweet potato flours. Fibre is important for the removal of waste from the body, thereby preventing constipation and other health disorders (Jeckins, 2000).

The moisture content of the noodle ranged between 3.90 to 5.23% with sample RAYB/Pa (90:10) having the highest value and RAYB/Pb (80:20) having the lowest moisture content. The moisture content of all the blends was shown to be significantly ($p<0.05$) different from the control (100% rice). All the sample blends, had low moisture contents. Low moisture content enhances the storage stability of foods. This is because moisture enhances the biochemical reactions that would lead to food spoilage.

The carbohydrate content of the control (100% rice) was higher (88.84%) than that of the blends while sample RAYB/Pa (90:10) had the least carbohydrate content. The carbohydrate contents of all the samples were significantly ($p<0.05$) different from the control (100% rice).

The values obtained for the proximate compositions compared favourably well with the values reported by David (2015) using maize and cowpea flour blends and that of Akubeze (2015) using wheat/maize and mungbean flour blends.

### *3.6. Pro-Vitamin A Content of Noodles Formulated from Local Rice, Fermented African Yam Beans and Orange-fleshed Sweet Potato Flour Blends*

The Vitamin A contents of noodles produced from the blends of local rice, African yam bean and orange-fleshed sweet potato flours are shown in Table 8.

**Table 8:** Pro-Vitamin A composition (mg/100 g) of noodles produced from blends of rice, African yam bean and orange flesh sweet potato flours

| Sample code | Pro-vitamin A |
|---|---|
| RF | $0.23^f\pm0.01$ |
| RAYB/Pa | $2.35^e\pm0.01$ |
| RAYB/Pb | $2.87^d\pm0.02$ |
| RAYB/Pc | $3.11^c\pm0.01$ |
| RAYB/Pd | $3.58^b\pm0.01$ |
| RAYB/Pe | $4.27^a\pm0.01$ |

Values are means ± SD of triplicate determination. Means within a rows with the same superscript were not significantly different ($p>0.05$). Key: RF: 100% rice flour; RAYB/Pa:=90% of best blend + 10% orange flesh sweet potato flour; RAYB/Pb: 80% of best blend +20% orange flesh sweet potato flour; RAYB/Pc: 70% best blend + 30% orange flesh sweet potato flour, RAYB/Pd: 60% of best blend + 40% orange flesh sweet potato flour; RAYB/Pe: 50% of best blend + 50% orange flesh sweet potato flour

The pro-vitamin A content (mg/100 g) of noodles formulated from local rice, African yam bean and orange-fleshed sweet potato flour blends ranged from 2.35 to 4.27 mg/100 g with sample RAYB/Pa (90:10) having the least provitamin A content while sample RAYB/Pe (50:50) had the highest pro-vitamin A content. The control (100% rice) was found to contain little trace amount of pro-vitamin A. The pro-vitamin A content of the samples were significantly ($p<0.05$) different from each other. This was due to the variation in the quantity of orange-fleshed sweet potato in the samples. The amount of provitamin A in the noodle increased with an increase in the blending ratio of orange-fleshed sweet potato. This makes the product a good source of vitamin A for people suffering from poor sight. The products could, therefore, aid in reducing blindness, disease and death caused by Vitamin A Deficiency (VAD) (Inagabire & Hilda, 2011). The use of solar dryer in the drying of the orange-fleshed sweet potato flour prevented the loss of the pro-vitamin A component of the flour.

### *3.7 Cooking Characteristics of Noodles Formulated from Local Rice, African Yam Beans and Orange-fleshed Sweet Potato Flour Blends*

The results of the cooking characteristics of the noodle produced from blends of local rice, African yam bean and orange-fleshed sweet potato flours are shown in Table 9.

**Table 9:** Cooking properties of the different noodle blends produced from rice, African yam bean and orange- flesh sweet potato flours

| Samples | Cooking yield (%) | Cooking loss (%) | Cooking time (min) |
|---|---|---|---|
| ARF | $86.22^{f} \pm 0.02$ | $13.78^{a} \pm 0.02$ | $13.32^{a} \pm 0.02$ |
| RYS1 | $91.52^{e} \pm 0.01$ | $8.47^{b} \pm 0.01$ | $11.21^{b} \pm 0.01$ |
| RYS2 | $91.87^{d} \pm 0.01$ | $8.13^{c} \pm 0.01$ | $10.04^{c} \pm 0.02$ |
| RYS3 | $92.12^{c} \pm 0.02$ | $7.88^{d} \pm 0.02$ | $9.43^{c} \pm 0.03$ |
| RYS4 | $93.10^{b} \pm 0.01$ | $6.90^{e} \pm 0.01$ | $9.32^{e} \pm 0.01$ |
| RYS5 | $93.87^{a} \pm 0.01$ | $6.13^{f} \pm 0.01$ | $7.13^{f} \pm 0.01$ |

Values are means ± SD of triplicate determination. Means within a rows with the same superscript were not significantly different (p>0.05).RF: 100% rice flour; RAYB/Pa:=90% of best blend + 10% orange flesh sweet potato flour; RAYB/Pb: 80% of best blend +20% orange flesh sweet potato flour; RAYB/Pc: 70% best blend + 30% orange flesh sweet potato flour, RAYB/Pd: 60% of best blend + 40% orange flesh sweet potato flour; RAYB/Pe: 50% of best blend + 50% orange flesh sweet potato flour

The cooking time of the noodle formulated from blends of local rice, African yam beans and orange-fleshed sweet potato flours varied from 7.30 to 13.32 min with sample RAYB/Pe (50:50) having the lowest cooking time while the control (100% rice) had the highest cooking time. The control (100% rice) had significantly (p<0.05) higher cooking time than other samples. The longer cooking time of the control could probably be attributed to its relatively low moisture content.

The cooking yield varied from 91.52 to 93.87% with sample RAYB/Pa (90:10) having the least cooking yield while sample RAYB/Pe (50:50) had the highest cooking yield. The cooking yield of the blends was significantly (p<0.05) different from the control (100% rice) There was an increase in the cooking yield as the ratio of orange-fleshed sweet potato in the blend increases. This could probably be because the orange-fleshed sweet potato flour had the highest water absorption capacity than the local rice and African yam bean flours. Also, the low cooking loss would give rise to high cooking yield. The cooking loss varied from 6.13 to 8.47% with sample RAYB/Pe (50:50) having the least cooking loss while sample RAYB/Pa (90:10) had the highest cooking loss. The cooking loss of the blends was significantly (p<0.05) different from the control (100% rice). The blends had the lowest cooking loss than the control (100% rice). This could be attributed to the low solubility of the rice, African yam bean and orange-fleshed sweet potato flour blends. The overall network that holds the noodle structure might consist primarily of protein and starch matrices (Saifullah *et al.*, 2009).

### *3.8 Microbiological Content of Noodle Formulated from Local Rice, Fermented African Yam Beans and Orange-fleshed Sweet Potato Flour Blends*

The total viable count and mould count of noodle formulated from blends of local rice, African yam bean and orange-fleshed sweet potato flours are shown in Table 10.

**Table 10:** Microbiological properties of noodle formulated from rice African yam bean and orange-fleshed sweet potato flour blends

| Sample code | Total viable count(CFU/g) | Mould count(CFU/g) |
|---|---|---|
| Control (100% rice) | $2.0 \times 10^4$ | ND |
| RAYB/Pa (90:10) | $4.5 \times 10^4$ | ND |
| RAYB/Pb (80:20) | $4.3 \times 10^4$ | ND |
| RAYB/Pc (70:30) | $3.6 \times 10^4$ | ND |
| RAYB/Pd (60:40) | $4.3 \times 10^4$ | ND |
| RAYB/Pe (50:50) | $6.2 \times 10^4$ | ND |

RF: 100% rice flour; RAYB/Pa:=90% of best blend + 10% orange flesh sweet potato flour; RAYB/Pb: 80% of best blend +20% orange flesh sweet potato flour; RAYB/Pc: 70% best blend + 30% orange flesh sweet potato flour, RAYB/Pd: 60% of best blend + 40% orange flesh sweet potato flour; RAYB/Pe: 50% of best blend + 50% orange flesh sweet potato flour.

Microorganisms play a significant role in the determination of the shelf life of products. Microorganisms are usually responsible for spoilage of many food items. From the Table, the total viable count of the noodles ranged from 3.6 × 104 to 6.2 × 104 CFU/g with sample RAYB/Pc (70:30) having the least value and sample RAYB/Pe (50:50) having the highest value. Mould count was not detected on the noodle samples. The total viable count and mould count of the samples were not high when assessed using the guidelines for microbiological quality of pasta products (ICMSF, 1986) which indicated 104 CFU/g for satisfactory, 104 to 105 CFU/g acceptable and 106 CFU/g and above as being of unsatisfactory quality.

### *3.9 Sensory Scores of Noodles Formulated from Local Rice, Malted African Yam Beans and Orange-fleshed Sweet Potato Flour Blends*

The sensory scores of the noodles formulated from local rice, African yam beans and orange-fleshed sweet potato flour blends are shown in Table 11. The sensory scores for colour ranged from 5.75 to 7.55 with sample RAYB/Pe (50:50) having the least score while the control (100%) rice had the highest score. There were no significant ($p<0.05$) difference among the samples. The colour of the noodles became darker (from light brown to dark brown) with increasing level of orange-fleshed sweet potato in the blend. This could probably be because potatoes are more apt to scotch or discolour during dehydration or darken during product storage when they have high reducing sugar content. Orange-fleshed sweet potato used to formulate the noodle products contained a high amount of reducing sugar. This discolouration could be due to the reactions involving amino acids and reducing sugars (Tewe *et al.*, 2003). A similar result was obtained by Mbaeyi-Nwaoha & Ugwu (2018) using rice- cowpea bean-orange-fleshed potato flour blends for pasta production. The sensory score for flavour ranged from 5.75 to 6.75 with sample RAYB/Pe (50:50) having the least score and sample RAYB/Pa (90:10) having the highest score. There were no significant ($p<0.05$) different in flavour among samples RAYB/Pa (90:10), RAYB/Pb (80:20), RAYB/Pc (70:30) and RAYB/Pd (60:40) and the control (100% rice). Also, there was no significant ($p<0.05$) difference in flavour among samples RAYB/Pc (70:30), RAYB/Pd (60:40) and RAYB/Pe (50:50), while the control (100% rice) was significantly ($p<0.05$) different in flavour from sample RAYB/Pe (50:50). The sensory scores for taste ranged from 6.05 to 6.90

**Table 11:** Sensory scores of the different noodle blends produced from rice, African yam bean and orange-flesh sweet potato flours

| Samples | Color | Flavour | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| ARF | $7.55^{b} \pm 1.50$ | $6.65^{a} \pm 0.93$ | $7.00^{a} \pm 1.04$ | $6.75^{a} \pm 1.33$ | $7.15^{a} \pm 1.18$ |
| RYS1 | $6.35^{ab} \pm 1.87$ | $6.75^{a} \pm 1.59$ | $6.90^{a} \pm 1.59$ | $6.40^{a} \pm 1.85$ | $7.10^{a} \pm 1.5$ |
| RYS2 | $6.40^{ab} \pm 2.09$ | $6.70^{a} \pm 1.17$ | $6.75^{a} \pm 1.21$ | $6.30^{a} \pm 1.60$ | $6.70^{ab} \pm 1.63$ |
| RYS3 | $6.05^{b} \pm 1.99$ | $6.25^{ab} \pm 1.29$ | $6.05^{a} \pm 1.23$ | $6.45^{a} \pm 1.61$ | $6.30^{ab} \pm 1.30$ |
| RYS4 | $6.00^{b} \pm 1.86$ | $6.55^{ab} \pm 1.32$ | $6.35^{a} \pm 1.38$ | $6.20^{a} \pm 1.58$ | $6.15^{ab} \pm 1.76$ |
| RYS5 | $5.75^{b} \pm 1.68$ | $5.75^{b} \pm 1.59$ | $6.25^{a} \pm 1.71$ | $5.90^{a} \pm 2.02$ | $5.90^{b} \pm 1.89$ |

Values are means ±SD of triplicate determination. Means within a rows with the same superscript were not significantly different (p>0.05).RF: 100% rice flour; RAYB/Pa:=90% of best blend + 10% orange flesh sweet potato flour; RAYB/Pb: 80% of best blend +20% orange flesh sweet potato flour; RAYB/Pc: 70% best blend + 30% orange flesh sweet potato flour, RAYB/Pd: 60% of best blend + 40% orange flesh sweet potato flour; RAYB/Pe: 50% of best blend + 50% orange flesh sweet potato flour

with sample RAYB/Pc (70:30) having the lowest score and sample RAYB/Pa (90: 10) having the highest score. There was no significant ($p<0.05$) difference in the taste of the blends and the control (100% rice). The samples were found to have a good taste which could be attributed to the sweetness of the orange-fleshed potato flour as a result of its high reducing sugar content. The sensory scores for texture ranged from 5.90 to 6.45 with sample RAYB/Pe (50:50) having the least score and sample RAYB/Pc (70:30) having the highest score. The low texture score of sample RAYB/Pe (50:50) could be attributed to the increase in the amount of orange-fleshed sweet potato flour in the blend. This was because; the orange-fleshed sweet potato had a coarse particle size (300 µm). There were no significant ($p<0.05$) difference among the samples and the control (100% rice). Based on the overall acceptability, the control (100% rice) had the highest score (7.15) followed by sample RAYB/Pa (90:10) which scored 7.10, while sample RAYB/Pe (50:50) had the least score (5.90). There were no significant ($p<0.05$) difference between the control (100% rice) and samples RAYB/Pa (90:10), RAYB/Pb (80:20), RAYB/Pc (70:30) and RAYB/Pd (60:40). Sample RAYB/Pe (50:50) was not significantly ($p<0.05$) different from samples RAYB/Pb (80:20), RAYB/Pc (70:30) and RAYB/Pd (60:40) but was significantly ($p<0.05$) different from the control (100% rice) and sample RAYB/Pa (90:10). All the samples had a good rating for all the sensory attributes since their scores were higher than the mean 4.5 for a 9-point Hedonic scale used for the sensory. The sensory scores compared favourably well with the data (Mbaeyi-Nwaoha & Ugwu, 2018) using rice-cowpea bean-orange-fleshed potato flour blends and cassava-African yam bean pasta (Dib *et al.*, 2018).

## 4. Conclusion and Recommendation

From the study, it has shown that acceptable noodle could be produced from blends of local rice, African yam bean and orange-fleshed sweet potato flour. The result showed that the addition of African yam beans and orange-fleshed sweet potato in the noodle formulation affected the chemical, cooking and sensory properties of the noodle. Addition of African yam beans improved the protein content of the rice noodle. The use of orange-fleshed sweet potato improved the pro-vitamin A content of the noodle, thereby making the product a good source of vitamin A which could aid in reducing blindness, disease and death caused by vitamin A deficiency. The use of rice-African yam bean-orange-fleshed sweet potato noodle would help to alleviate problems of protein-energy malnutrition and micro-nutrient deficiency in Nigeria and other developing countries. In addition, the sample obtained by blending 90% of rice/African yam bean flour blend and 10% orange-fleshed sweet potato and sample that had 100% rice was most preferred among all the samples formulated. The sample had the highest mean score on all the sensory attributes evaluated. Based on the result of the study, it is recommended that the use of underutilized agricultural produce such as local rice (Adani rice “Faro 54”) and African yam beans should be encouraged in food product formulations and development because it reduced nutritional imbalance and would help in boosting of rural dwellers income. Consumers should be enlightened on the nutritional and health benefits of orange-fleshed sweet potato as a strategy for food diversification. Further studies should also be carried out on the shelf stability and colour of the noodle formulated from the flour blends.

## Conflict of interest

The authors declare that there are not conflicts of interest.

## Ethics

This Study does not involve Human or Animal Testing.

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## References

A.O.A.C. (2010). Association of Analytical Chemists. Official methods of Analysis, 18th edition Gaithersburg, Maryland, USA

AACC. (2000). Approved methods of the American association of cereal chemists (10th edition), American Association of Cereal Chemists. St. Paul, Minnesota. pp.276-280

Akubeze, V. O. (2015). Production and evaluation of noodles from blends of wheat/maize and mungbean flour blends. A B.Sc. Project, Department of Food Science and Technology, University of Nigeria, Nsukka

Akubor, P. I. & Badifu, G. O. (2001). Chemical composition, functional properties and baking potential of African bread fruit kernel and wheat flour blends. *International Journal of Food Science and Technology*, 39, 223-229

Azeke, M. A., Frettzdorf, B., Buening-pfane, H., Holzapfel, W. & Betsche, T. (2005). Nutritional Value of African yam bean (*Sphenostylis stenocapa* L): Improvement by Lactic Acid Fermentation, *Journal of Food Science and Agriculture*, 85(2), 963 - 970

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. *Journal of Agricultural Food Chemistry*, 25, 258-261

David, O. (2015). Development of instant noodles from maize and cowpea. An M.Sc. dissertation, Kwame Nkrumah University of Science and Technology, Kumesi, Ghana

Dib, A., Wójtowicz, A., Benatallah L., Zidoune, M. N., Mitrusb, M. & Sujak, A. (2018). Optimization of rice-field bean gluten-free pasta improved by the addition of hydrothermally treated rice flour. *Italian Journal of Food Science*, 30, 226-248

Duranti, M. (2006). Grain legume proteins and nutraceutical properties. *Fitodorapia*, 77, 67-82

Ellong, E. N., Billard, C. & Adenet, S. (2014). Comparison of physiochemical, organoleptic and nutritional abilities of eight sweet potato (*Ipomoea batatas* L) varieties. *Food and Nutrition Science*, 5(2), 196

Enwere, N. J. (1998). Foods of plants Origin: Processing and Utilization with Recipes and Technology profiles. 1st Edition. Afro-orbis Publications Limited.Nigeria. pp: 56-60

Flodin, N. W. (1997). The metabolic roles, pharmacology and toxicology of lysine. *The Journal of the American College of Nutrition*, 16(1), 7-21

Frei, M. & Becker, K. (2004). Agro-biodiversity in subsistence-oriented farming systems in a Philippine upland region: Nutritional considerations. *Biodiversity and Conversion*, 13, 1591-1610

Gernah, D. I., Ariahu, C. C. & Ingbian, E. K. (2011). Effect of malting and lactic fermentation on some chemical and functional properties of maize. *American Journal of Food Technology*, 11, 432-435

Hagenimana, V. & Owori, C. (2016). Process of producing sweet potato flour; Available: http//www. R7036 - sweet potato flour.pdf (Accessed December 22nd, 2016)

Hatcher, D. N. (2001). Asian noodle processing. In: Cereals processing. (Owens, G. Ed.)

Hou, G. (2011). Oriental noodles. *Advances in Food and Nutrition Research*, 43, 141-193

Ihekoronye, A.l. & Ngoddy P.O., (1985). Integrated food science and technology for the tropics. Macmillan Publishers, London

Inagabire, M. R. & Hilda, V. (2011). Comparison of the nutrient composition of flour sweet potato varieties cultivated in Rwanda. *American Journal of Food and Nutrition*, 13, 35- 38

International commission on microbiological specifications for foods. ICMSF (1986). Microorganisms in Foods 2, Sampling for Microbiological Analysis: Principles and Specific Applications

Iwe, M. O. & Onadipe, O.O. (2001). Effect of extruded full fat soy flour into sweet potato flour on functional properties of the mixtures. *Journal of Sustain Agriculture Environment*, 3(1), 109-117

Iwe, M. O., Onyeukwu, U. &Agiriga, A. N. (2016). Proximate, functional and pasting properties of FARO44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food and Agriculture*, 2, 1-10

Jeckins, D.A. (2000). Dietary fibre, Lente carbohydrates and the insulin resistant diseases. *British Journal of Nutrition*, 83, 157-163

Kanura, D., Noel, D. & Dilip, K. (1996). Significance of the functional properties of plant products. Food and Nutrition Bulletin. United Nation University. 17(2)

Kinsella, E. (1976). Functional properties of proteins in foods: Critical review. *Food Science and Nutrition Journal*, 1(3), 219-280

Kumara (2015). Routledge studies in the modern world eceonomy: Poverty, inequality, and growth in Developing countries: Theoretical and empirical approaches edited by Atsushi Maki. Routledge publishers Canada. P.130

Kure, O. A., Bahago, E. J. & Daniel, E. A. (1998). Studies on the proximate composition and effect of flours particle size and susceptibility of biscuits produced from blends of soybeans and plantain flours. *Namado Technology Scope Journal*, 3(2), 17-22

Laurine, S. M., Van Jaarsveld, P. J., Faber, M., Philpott, M. F. & Labuschagne, M. T. (2012). Trans-βcarotene, selected mineral content and potential nutritional contrition of 12 sweet potato varieties. *Journal of Food Composition Analysis*, 27, 151-159

Low, J., Lynam, J., Lemaga, B., Crissman, C., Bakr, I. & Thece, G. (2009). Sweet potato in subSahara Africa. Netherlands; Springer, 359-390

Matil, K. F. (2007). Functional requirement of proteins for foods. *Journal of American Oil Chemistry Society*, 48, 477-480

Mbaeyi-Nwaoha, I. E. & Ugwu, C.I. (2018). Production and Evaluation of Pasta (Noodles) from Rice, Cowpea and Orange-fleshed Sweet Potato Flour Blends. *Asian Food Science Journal*, 4(1), 1-25

Mearim M. L., Invarsson, A. & Dickey, W. (2005). Celiac disease: Is it time for mass screening? *Best Practice and Research Clinical Gastroenterology*, 19(13), 41-452

Mepba, D. H., Eboh, L. & Nwaojigwa, S. U. (2007). Chemical composition, functional and baking properties of wheat - plantain composite flours. *African Journal of Food and Agriculture nutrition and Development*, 7(1), 40-45

Mwanri, A., Kogi-Makanu, W. & Laswai, H. (2011). Nutrients and anti-nutrients composition of raw, cooked and sun-dried sweet potato leaves. *African Journal of Food and Agricultural Nutrition Development*, 11(5), 5142-5156

National Root Crops Research Institute (2009). National Root Crops Research Institute Umudike Root Crops Division. http://74.6.239.67/search/cache?ei=8&p=www.nrcri.org% pages%2fsptato.htm&i...

Oko, A. O. & Ugwu, S. I. (2011). The proximate and mineral compositions of five major rice varieties in Abakaliki, South-Eastern Nigeria. *International Journal of Plant Physiology and Boichemistry*, 3(2), 25-27

Onoja, U. S., Akubor, P. I., Njoku, I., Atama, C. I., Onyishi, G. C., Ekeh, F. N., Eyo, J.E. & Ejere, V.C. (2014). Nutritional composition, functional properties and sensory evaluation of breads based on blends of 'orarudi' (Vigna specie) and wheat flour. *Journal of Food Science and Nutrition*, 9(24), 1119-1026

Onwuka, G. I. (2005). Food analysis and instrumentations theory and practice.1st edition. Lagos; Naphtali Prints. 29-73. 34.Schoen

Onyeka, E. U. & Nwabekwu, I. O. (2007). Phytochemical profile of some leafy vegetables dried using solar dryer. *Nigeria Food Journal*, 1, 72-82

Philips, R. D., Chinnan, M. S., Branch, A. L., Miller, J. & Mcwatters, K. H. (1998). Effects of pre-treatment on functional and nutritional properties of cowpea meal. *Journal of Food Science*, 53, 805-809

Potter, D. & Doyle, J. J. (1994). Origin of African yam bean (*Sphensostylis stenocapa*, leguminosae). Evidence from morphology, isoymers, chloroplast DNA and linguistics. *Economic Botany*, 46, 276-292

Prescott L. M., Harley, J. P. & Kelein, O. A.(2005). Microbial nutrition: Types of media. In: Microbiology, Sixth edition. New York; McGrawill. 93-105

Raymond, N., Heap, J. & Case, S. (2006). The glutenfree diet: An update for health professionals. Practice. *Gastroenterology*. 30(9), 67-9

Saifullah, R., Abbas, F. M., Yeoh, S. Y. & Azhar, M. E. (2009). Utilization of green banana flour as a functional ingredient in yellow noodle. *International Food Research Journal*, 16, 373-379

Schoenlechner, R., Drausinger, J., Ottenschlaeger, V., Jurackova, K. & Berghofer, E. (2010). Functional properties of gluten-free pasta produced from amaranth, quinoa and buckwheat. *Plant Foods of Human Nutrition*, 65(4), 339-349

Steel, R. G. and Torrie, J. H. (1980). Principles and procedures of statistics: A biometrical approach. 2nd Edition. New York: McGraw Hill

Taira, H. (2010). Buckwheat introduction. Encyclopaedia of Food Technology. pp:139

Tewe, O. O., Ojeniyi, F. E. & Abu, O A. (2003) Sweet potato production, utilization and marketing in Nigeria. Department of Social Sciences, International Potato Centre (CIP), Lima, Peru

Umego, E. (2012). Chemical composition, physical and sensory properties of fried noodles prepared from wheat, sweet potato and soybean flour blends. A B.Sc. Project, Department of Food Science and Technology, University of Nigeria, Nsukka

Wa sche, A. Muller, K. & Knauf, U. (2001). New processing of lupin protein isolates and functional properties. *Nahrung/Food*, 45, 393-395

World Instant Noodle Association. Instant Noodle Facts Worldwide; (2008) Available:http//www.Instant%20noodle%20-%20Wikipedia.mht (Accessed on January, 2020)

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