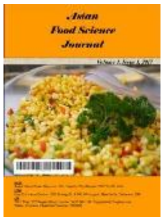

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Production and Evaluation of Pasta (Noodles) from Rice, Cowpea and Orange-Fleshed Sweet Potato Flour Blends

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Authors' contributions

This work was carried out in collaboration between both authors. Author IEM-N designed the study, wrote the protocol, supervised the research work and wrote the first draft of the manuscript. Author CIU managed some of the literature searches and the analyses of the study as well as wrote the last draft and tidied the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim was to produce and evaluate the properties (proximate and functional) of pasta from blends of local rice (*Oryza sativa*), white cowpea beans (*Vigna unguiculata*) and orange-fleshed sweet potato [*Ipomoea batatas* (L) Lam.] (umusco/3 variety) flours as well as to evaluate the cooking characteristics, microbiological quality and sensory attribute of the formulated pasta.
Study Design: The experimental design that was used is Completely Randomized Design.
Place and Duration of Study: The study took place at the Department of Food Science and Technology, University of Nigeria, Nsukka between December 2016 and September 2017.
Methodology: The study investigated the applicability of local rice, cowpea beans and orange-fleshed sweet potato flour to develop pasta rich in proteins and pro-vitamin A. The local rice and cowpea flours were blended in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 to produce pasta which was subjected to sensory evaluation to isolate the best blend (80:20). Following this preliminary study, pastas were formulated from a combination of rice-cowpea flour blend and OFSP flour in the ratio of 90:10, 80:20, 70:30, 60:40 and 50:50 for samples RC/Pa, RC/Pb, RC/Pc,

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RC/Pd and RC/Pe respectively, while unblended rice (100%) was used as the control. The pasta products were subjected to physical, proximate, pro-vitamin A, cooking, microbiological and sensory analysis using standard methods.
Results: The width, height and length of the samples ranged from 0.57 to 0.82 cm, 0.88 to 1.78 cm and 2.24 to 3.48 cm respectively. The protein content, fat, ash, crude fibre and moisture, carbohydrate and caloric contents ranged from 10.91 to 18.80%, 1.95 to 2.24%, 1.74 to 3.43%, 1.52 to 3.29%, 11.09 to 14.63%, 60.95 to 80.47% and 323.85 to 339.91 kcal/g respectively. The protein, fat, ash, fibre and moisture contents of the blends were significantly ($p<0.05$) higher than the control but their carbohydrate and caloric content were lower than the control. The pro-vitamin A content of the samples varied from 0.93 to 4.07 mg/100 g. There was an increase in the pro-vitamin A content as the ratio of orange-fleshed sweet potato increased in the blend. The cooking analysis showed that sample RC/Pa (90:10) had the highest cooking time and cooking loss while sample RC/Pe (50:50) had the highest cooking yield. The total viable count ranged from 2.0×10^4 to 6.2×10^4cfu/g while mould was not detected except on sample RC/Pd (60:40) which had 4.0×10^1 cfu/g. The microbial content of the samples was not high when assessed using the guideline for microbiological quality of pasta products. The sensory scores showed that all the samples had high ratings.

Keywords: Rice; Pasta (Noodles); Mung beans or cowpea beans; Orange-fleshed sweet potato.

1. INTRODUCTION

Pasta is one of the most ancient nourishments which are considered to be versatile both in nutritive and the gastronomic point of view. Pasta is a staple food of traditional Italian cuisine, with the first reference dating to 1154 in Sicily [1]. It is also commonly used to refer to the variety of pasta dishes. Typically, pasta is a noodle made from unleavened dough of durum wheat flour mixed with water and eggs and formed into sheets or various shapes, then cooked by boiling or baking [2]. It can also be made with flour from other cereals or grains. During the last 20 years, the annual consumption of pasta product has increased because of consumer perception of pasta [3]. According to a 2008 survey, it was reported that the annual consumption of instant noodles in the world averaged about 94 billion cups [4]. Instant noodles are normally consumed by people of all socio - economic status. Several kinds of pasta are present in Brazilian cuisine and served as a main dish or additional in the main meals. They have high acceptability due to its great convenience, fast preparation as well as the satiety they provide.

Pasta may be divided into two broad categories, dried and fresh pasta. Dry pasta is a traditional cereal-based food that has become increasingly accepted worldwide for the reason of its convenience, palatability and nutritional superiority. It also provides significant quantities of complex carbohydrates, protein, B-vitamins and iron. However, wheat which is the principal raw material for noodle production is being imported. Also, the traditional pasta prepared with 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 merely the gastrointestinal tract [5]. In addition, pasta products are low in sodium, amino acids and total fat. Noodles produced from wheat flour contain 11 - 15% protein (dry basis) but deficient in lysine and threonine (the first and second limiting amino acid), common to most cereal products [6]. The absence of lysine makes the body difficult to synthesize protein, hormones, enzymes and antibodies which are needed for growth and other functions [7].

Processed wheat which is used for noodles production is also discovered to be deficient in certain essential nutrients such as vitamins A, C, E, K, and β-carotene [8] unless blended with other food materials such as orange -fleshed sweet potatoes. A growing demand for functional plant proteins has been identified, and their properties customized for specific applications and formulations as food ingredients [9]. Consequently, legumes and cereals are nutritionally complementary [10]. Cereals and legumes are an excellent sources of energy due to their relatively high content of carbohydrates and proteins [11].

The only satisfactory treatment for gluten intolerance is a complete avoidance of wheat, rye, barley, oatmeal and their derivatives in the diet [12]. The substitution of these cereals can be done with soy, rice, corn, potatoes, cassava and yams, and among these, rice is the least allergic

[13]. Rice (*Oryza sativa*) is a staple food that is widely consumed in the South-East and South-South geopolitical zones in Nigeria, and also Nigeria as a whole. It is believed to provide more health benefits than other carbohydrate-based foods since it contains several nutrients and anti-oxidative compounds [14]. Rice is rich in many nutrient components including carbohydrate, proteins, certain fatty acids and micronutrients (vitamins and trace minerals). They are also sources of many bioactive non-nutrient compounds, known as an antioxidant, including phenolic compounds [15]. Rice, due to its nutritional properties, hypoallegenicity, pleasant taste and not interference in the colour of the final product, has been used industrially in the production of rice flour which is subsequently used as an additive in puddings, ice cream and similar products [16]. Cereals are generally low in protein quality and are limiting in some essential amino-acids, notably lysine and tryptophan, supplementation of cereals with locally available legumes such as cowpea beans (*Vigna unguiculata*) that are high in protein and lysine improves the protein content of cereal-legume blends and their protein quality through complementation of their individual amino acids. Cowpea (*Vigna unguiculata*) is a legume that is grown throughout the world as annual crop. This inexpensive crop, packed with nutrition is a widely cultivated especially in the developing countries. The different varieties of cowpea are available in a range of sizes and colours. These protein rich peas have high amino acid content, making them ideal as a nutritional supplement to cereals.

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). Well adapted to the tropical and subtropical regions, sweet potato has nutritional advantage for the rural and urban dwellers [17]. 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 [18]. Sweet potato roots are rich in starch, sugar, vitamin C, β-carotene, iron, and several other minerals [18,19]. Despite its high carbohydrate content, sweet potato has a low glycemic index due to low digestibility of starch, making it suitable for diabetic or overweighed people [20,21]. The root is reported to usually have higher protein content than other roots and tuber, such as cassava and yams [19]. In addition, some varieties of sweet potato contain coloured pigments, such as β-carotene, anthocyanin, and phenolic compounds. These pigments form the basis for classifying the foods as nutraceuticals [19]. Sweet potato leaves are recognised 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 [22,19]. Moreover, sweet potatoes have high technological potential and it is reported that it can be used for various products, such as drinks (wine, liquor and vinegar), sugar production, biscuits, flour, pasta, alcohol among others [20]. Nowadays, several research programmes are focusing on orange-fleshed or vitamin A sweet potato with great potential to prevent and combat vitamin A deficiency for the sub-region [17].

Meanwhile, wheat, which is the principal raw material for noodle production is imported since it is produced in small quantity in Nigeria. This results to an immerse drain on the economy while also suppressing and displacing indigenous cereals, with a resultant detrimental effect on the agricultural and technological development and course of poverty in Nigeria [8]. Also, the traditional pasta prepared with wheat flour cannot be consumed by the entire population, because some individuals are intolerant to gluten present in this flour [5]. In addition, noodles prepared from wheat are deficient in essential amino acids and other essential nutrients. Vitamin A deficiency (VAD) contributes to significant rates of blindness, disease and premature death in sub-Sahara Africa (SSA) [23]. However, this problem could be solved by incorporation of food materials which are high in protein, vitamin, minerals and fibre into noodles.

The development of gluten-free pasta (noodles) should encourage the manufacture of products originated from mixed flours, attending a special portion of consumers and reducing the severity of celiac disease caused by consumption of gluten obtained in wheat. Rice is believed to provide more health benefits than other carbohydrate based foods, since it contains several nutrients and anti-oxidative compounds [15]. Cowpea beans are protein rich peas that have high amino acid content, making them ideal as a nutritional supplement to cereals. Sweet potatoes are rich in starch, sugar, vitamin C, β-carotene, iron, and several other minerals. Orange-fleshed or vitamin A sweet potato has great potential to prevent and combat vitamin A deficiency [17]. The use of local rice, orange-fleshed sweet potato and cowpea beans composite flour in noodles would reduce wheat importation and enhance the use of indigenous crops in value added products.

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

2. MATERIALS AND METHODS

2.1 Raw Materials

Parboiled seeds of Rice (*Oryza sativa*) were obtained from Adani Rice Mill in Uzouwani Local Government Area, Enugu State. The seeds of white cowpea V*igna uguiculata*) "akidi charamanya" was obtained from Ogige market in Nsukka Local Government Area, Enugu State and authenticated at the Department of Crop Science, University of Nigeria, Nsukka, while mature orange-fleshed sweet potato (*Ipomeo batatas* L.) (umusco/3) was obtained from National Root Crop Research Institute, Umudike, Abia state (Plates 1 – 3).

2.2 Production of Raw Materials

2.2.1 Production of rice flour

Rice flour was processed by modifying the method [24] as shown in Fig. 1. Parboiled rice grains were cleaned, sorted and washed, then steeped in water for 12 h, drained and dried in a hot air laboratory oven (LABE 1201, Divine International, Delhi). Milling of the dried rice grains was done using hammer mill (I. G. Jurgens, Bremmer, Germany) and the milled grains was sieved using a 300 μm mesh size sieve to obtain fine flour which is designated as DM/PRF (Dried or Milled Parboiled Rice Flour).

Plate 1. Picture of the white cowpea

Plate 2. Picture of Adani rice (Faro 54) "akidi charamanya"

Plate 3. Picture of the orange-fleshed sweet potato tubers (umusco/3 variety)

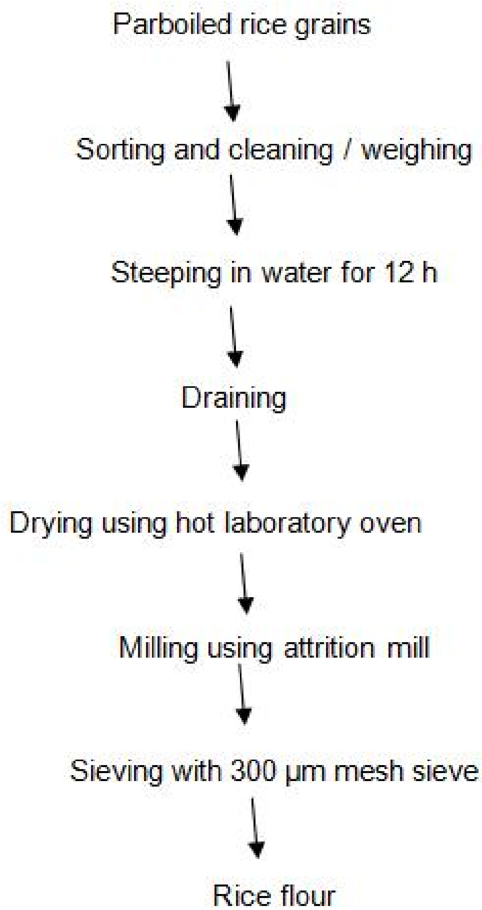

Fig. 1. Production of rice flour

2.2.2 Production of fermented white cowpea flour (*Vigna unguiculate*) (akidi charamanya)

Fermented white cowpea flour was produced by modifying the method described by [25] as shown in Fig. 2. White cowpea (akidi charamanya) grains 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.

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 [26] as shown in Fig. 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 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 until used for noodle production.

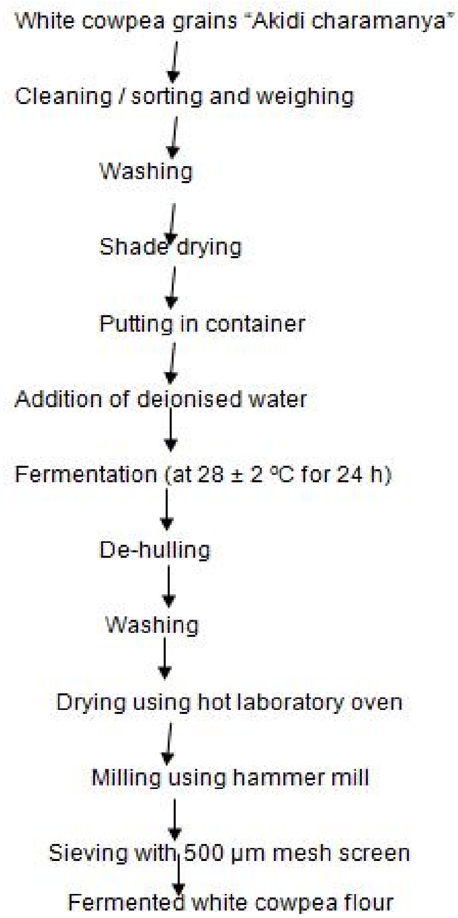

Fig. 2. Production of fermented white cowpea (akidi charamanya) flour

2.3 Formulation of the Flour Blends for Noodles Production

The flours obtained from local rice and fermented white cowpea 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 + CF (80:20) 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.

2.3.1 Production of noodles

Noodles were produced according to the method [27]. 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 Fig. 4.

2.4 Analysis of Raw Materials and Noodles from Blends of Local Rice, Fermented White Cowpea "Akidi Charamanya" and Orange-Fleshed Sweet Potato

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

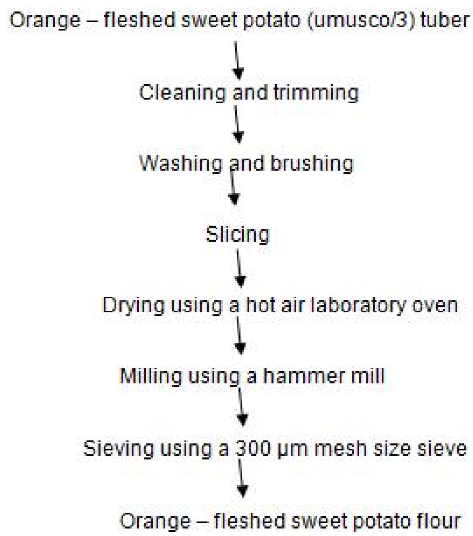

Fig. 3. Production of orange – fleshed sweet potato flour

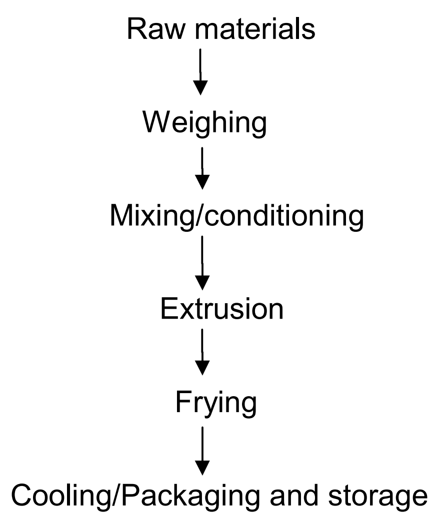

Fig. 4. Production of noodles

Table 1. Blending ratios of local rice and fermented white cowpea

Sample code	Local rice flour (%)	Fermented white cowpea flour (%)
RF + CF (100:0)	100	0
RF + CF (0:100)	0	100
RF + CF (90:10)	90	10
RF + CF (80:20)	80	20
RF + CF (70:30)	70	30
RF + CF (60:40)	60	40
RF + CF (50:50)	50	50

Key: RF + CF (100:0) = 100% Local rice flour and 0% cowpea flour; RF + CF (0:100) = 0% Local rice flour and 100% Fermented white cowpea flour; RF + CF (90:10) = 90% of local rice flour and 10% fermented white cowpea flour; RF + CF (80:20) = 80% Local rice flour and 20% fermented white cowpea flour; RF + CF (70:30) = 70% Local rice flour and 30% fermented white cowpea flour; RF + CF (60:40) = 60% Local rice flour and 40% fermented white cowpea flour; while RF + CF (50:50) = 50% Local rice flour and 50% Fermented white cowpea flour

Table 2. Blending ratios of local rice/fermented white cowpea flour and orange-fleshed sweet potato flour

Sample code	Local rice/fermented white cowpea flour blend (80:20 best blend) (%)	Orange-fleshed sweet potato flour (%)
RF (Control)	100	0
RC/Pa (90:10)	90	10
RC/Pb (80:20)	80	20
RC/Pc (70:30)	70	30
RC/Pd (60:40)	60	40
RC/Pe (50:50)	50	50

Key: RF = Rice flour; RC = Rice + Cowpea blend; Pa – Pe =Orange-fleshed sweet potato in different ratios. RC/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; while RC/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 analysed using a micrometre screw gauge.

2.4.1.2 Noodle length

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

2.4.2 Proximate composition

2.4.2.1 Determination of moisture content

Moisture content was determined according to the methods of Association of Official Analytical Chemists [28]. The Samples were dried at 105°C for 3 h using the preset oven mechanized convection air oven (Phoenix furnace, model 534, SN: 524-85, Chapel town, Sheffield).

2.4.2.2 Determination of crude protein

The protein content (% nitrogen x 6.25) of the sample was determined using the Kjeldahl method [28].

2.4.2.3 Determination of crude protein

The crucible containing the pre-weighed samples were placed in a heated furnace mechanized convection air oven (Phoenix furnace, model 534, SN: 524-85, Chapel town, Shefffield). at 600°C for 6 h after which they were cooled to room temperature in desiccators and weighed.

2.4.2.4 Determination of crude fibre content

The crude fibre content of the samples was determined using the standard method [29]. N-Hexane was used to de-fat 2 g of sample, added in oiled 200 ml of 1.25% H_2SO_4 and boiled for 30 minutes, filtered, washed with 1% HCl and boiling water. The residues were returned into 200 ml boiling NaOH and allowed for 30 minutes. The final residues were drained and transferred to the silica ash crucible (porcelain crucible), dried in an oven at 100°C for 2 hours and cooled until a constant weight obtained. and incinerated (ashed) in a muffle furnace at 600°C for 5 hours, cooled in a desiccator and weighed.

2.4.2.5 Determination of fat content

The fat content of the samples content (1g was extracted for ether extract determination using petroleum ether as solvent) was determined using the standard Soxhlet method [28].

2.4.2.6 Determination of carbohydrate content

The carbohydrate content of the sample was determined as nitrogen free extraction calculation by difference [28].using the formula below:

% Carbohydrate = 100 – (% moisture + % protein + % ash + % crude fibre + % fat)

2.4.2.7 Determination of energy value / caloric content

The caloric content was calculated using the standard method [28]. as follows:

Calorie (kcal / 100 g) = (4 × % carbohydrate) + (4 × % protein) + (9 × % fat)

2.4.3 Determination of micronutrient

2.4.3.1 Determination of β-carotene content

The β – carotene content of the samples was determined using the method [30]. The samples were weighed, W_1 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

2.4.4.1 Determination of water absorption capacities

Water absorption capacity was determined by modifying the method [31]. 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 [32]. 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 [33]. 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 [33]. 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

Cooking quality of pasta was the most important aspect from the consumer's point of view, including optimal cooking time, swelling or water uptake during cooking, the texture of the cooked product, stickiness, aroma and taste. These cooking factors of pasta were related to the gelatinization rates and chemical composition of the pasta used. Cooking time, cooking quality, solid loss and water absorption were studied as per the methods described by American Association of Cereal Chemists [29].

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. [34]. One hundred grams of pasta 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 ([29].

2.4.6 Total Viable and Mould Count (TVC)

The total viable count was determined according to the method [35]. 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 ^oC using a colony counter (Gallenkamp colony counter, 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 ^oC, 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 [36]. where 9 signifies 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 randomised. 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 $p < 0.05$ [37].

3. RESULTS AND DISCUSSION

Plates 4 to 6 show the processed flours from rice (plate 4), cowpea (plate 5) and orange-fleshed sweet potato (Plate 6).

Plate 4. Picture of rice flour

Plate 5. Picture of cowpea flour

Plate 6. Picture of orange-fleshed sweet potato flour

3.1 Proximate Composition (%) and the Caloric Content (Kcal/G) of the Local Rice, White Cowpea Beans and Orange-fleshed Sweet Potato Flours

The proximate composition (%) and the caloric content (kcal/g) of the raw materials (local rice, fermented white cowpea beans and orange-fleshed sweet potato flours are shown in Table 3.

The protein content of the fermented white cowpea beans "akidi charamanya" flour (26.98%) was higher than that of local rice flour (8.73%) and orange-fleshed sweet potato flour (3.33%) which makes it a good protein supplement. The protein content of the cowpea flour compared well with 28% obtained by Khalid et al. [38]. Fermented white cowpea beans flour had the highest fat content (0.98%) which was higher than that of local rice flour (0.75%) and orange-fleshed sweet potato flour (0.49%). Fat plays a role in the texture and sensory quality of food product. It also determines the processing temperatures as well as auto-oxidation which could lead to rancidity. The low fat content of orange-fleshed sweet potato flour showed that the orange-fleshed sweet potato flour would not be easily susceptible to rancidity. Local rice flour contains the highest ash content (2.49%) which is higher than that of white cowpea beans flour (2.19%) and orange-fleshed sweet potato flour (1.79%). This would probably increase the mineral and vitamin content of the blend since ash is an index of mineral content. Also, the addition of orange-fleshed sweet potato, which is genetically modified with a high amount of ß-carotene in the blend, would increase the vitamin and mineral content of the blend. The ß-carotene in the orange-fleshed sweet potato flour would help to solve the problem of poor sight in developing countries like Nigeria.

It was observed that orange-fleshed sweet potato flour had the highest crude fibre (2.58%) which was higher than that of white cowpea beans flour (2.39%) and local rice flour (1.04%), although the crude fibre content of orange-fleshed sweet potato flour and that of white cowpea beans flour were not significantly ($p<0.05$) different. The crude fibre content was similar to 3.0% reported by Mohammad et al. [39]. The fibre content would be effective in the delay of gastric

Table 3. Proximate composition of local rice, white cowpea beans and orange-fleshed sweet potato flours

Composition (%)	Local rice flour	White cowpea flour	Orange-fleshed sweet potato flour
Protein	8.73[b] ± 0.04	26.98[a] ± 0.04	3.33[c] ± 0.01
Fat	0.75[b] ± 0.01	0.98[a] ± 0.03	0.49[c] ± 0.01
Ash	2.49[a] ± 0.01	2.19[b] ± 0.02	1.79[c] ± 0.01
Fibre	1.04[a] ± 0.01	2.39[a] ± 0.02	2.58[a] ± 2.16
Moisture	6.85[b] ± 0.01	6.15[c] ± 0.01	8.09[a] ± 0.02
Carbohydrate	80.14[b] ± 0.01	61.31[c] ± 0.04	83.72[a] ± 0.04
Calorie (kcal/g)	358.45[a] ± 0.01	357.25[b] ± 0.01	344.23[c] ± 0.04

Values are means ± standard deviation of 2 replications. Means within a row with the same superscript were not significantly (p<0.05) different

emptying [39]. and a reduction in serum cholesterol [40]. The moisture contents of local rice flour (6.85%), white cowpea beans flour (6.15%) and orange-fleshed sweet potato flour (8.09%) was within the 10% stipulated standard for foods [41]. The high moisture content of food is an index of spoilage since moisture enhances chemical and biochemical reactions that could lead to spoilage. The carbohydrate content of the flours was 80.11, 67.43 and 82.28% for local rice, white cowpea and orange-fleshed sweet potato flours respectively. Orange-fleshed sweet potato flour had the highest carbohydrate content while white cowpea beans had the lowest. The solar drying technique employed during the processing of the flour helped in the retention of the nutrients present in the flour. The proximate composition of the flours compared favourably well with the values reported by other researchers [42,43].on the chemical composition of rice, cowpea and sweet potato.

3.2 Functional Properties of Local Rice Flour, White Cowpea Beans Flour and Orange-fleshed Sweet Potato Flour

Table 4 shows the functional properties of local rice flour, white cowpea beans flour and orange-fleshed sweet potato flour.

Functional properties are those characteristics that govern the behaviour of nutrients in food during processing, storage and preparation as they affect food quality and acceptability [44].

The water absorption capacity is the ability of a product (such as flour) to absorb water. Orange-fleshed sweet potato flour had the highest water absorption capacity (253.90%) and was followed by local rice flour (181.70%). White cowpea flour had the least water absorption capacity (148.00%) among the flour samples. Water absorption capacities of flours depend on several factors such as the size of granules, amylose/ amylopectin ratio, and intra and inter molecular forces [45]. Water absorption capacity gives the indication of the amount of water available for gelatinization. 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 white cowpea beans flour could be attributed to the presence of low amount of hydrophilic constituents in these flours [45].

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 also increases the mouth feel of foods especially bread and other baked foods [46]. The orange-fleshed sweet potato had the highest oil absorption capacity of 143.61% while local rice flour had had the least oil absorption capacity (69.88%). The higher oil absorption capacity of orange-fleshed sweet potato indicated the presence of polar amino acids in the flour [47].

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 [48]. The bulk densities of local rice, white cowpea beans and orange-fleshed sweet potato flours were 0.76, 0.59 and 0.62 g/cm^3 respectively. The differences in the bulk densities of the flours may probably be due to their different particle sizes (300, 500 and 300 µm for local rice, white cowpea beans and orange-fleshed sweet potato, respectively [49,50,51,52]. It was observed that the bulk density of local rice flour was the highest,

Table 4. Functional properties of local rice, white cowpea beans and orange-fleshed sweet potato flours

Property	Rice flour	White cowpea flour	Orange-fleshed sweet potato flour
Water Absorption capacity (%)	$181.70^b \pm 0.35$	$148.00^c \pm 0.35$	$253.90^a \pm 0.01$
Oil Absorption capacity (%)	$69.88^c \pm 0.04$	$130.01^b \pm 0.01$	$143.2^a \pm 0.02$
Bulk density (g/cm$^{3)}$	$0.76^a \pm 0.01$	$0.59^c \pm 0.01$	$0.62^b \pm 0.01$
Swelling capacity (ml)	$8.53^b \pm 0.04$	$9.05^a \pm 0.07$	$4.26^c \pm 0.01$

Values are means ± standard deviation of 2 replications. Means within a row with the same superscript are not significantly (p<0.05) different

followed by that of orange-fleshed sweet potato flour. White cowpea flour had the least bulk density which 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.

Swelling capacity is an indication of the water absorption index of the granules during heating [53]. The swelling capacity of local rice flour, white cowpea beans flour and orange-fleshed sweet potato flour was 8.53, 9.05 and 4.26 ml, respectively. This shows that white cowpea beans flour had the highest swelling capacity (9.05 ml) which is significantly (p<0.05) different from local rice and orange-fleshed sweet potato flours. The values obtained for all the functional properties evaluated on the flours compared favourably well with the values reported by Khalid et al. [37].using cowpea flour (*Vigna ungiculata* (L) Walp), [38], different varieties of orange-fleshed sweet potato flours and Aromatic rice flour [54].

3.3 Sensory Scores of the Pasta Formulated from Local Rice and Fermented White Cowpea Beans Flour Blends

The results of the sensory scores of the pasta formulated from the blends of local rice flour and fermented white cowpea beans flour for preliminary studies are shown in Table 5.

The colour of the formulated samples was yellow. According to Garsa [55], traditional pasta consumers prefer cooked pasta to have a bright yellow colour. The sensory scores for colour varied from 5.80 to 6.85 with sample RF + CF (0:100) having the lowest score while sample RF + CF (100:0) and RF + CF (70:30) had the highest score. There was no significant ($p < 0.05$) difference in colour of all the samples.

The flavour score ranges from 5.65 to 6.90 with sample RC + CF (0:100) having the least score while sample RF + CF (70:30) had the highest score. There were no significant ($p < 0.05$) different among samples RF + CF (100:0), RF + CF (90:10), RF + CF (80:20), RF + CF (60:40) and RF + CF (50:50), Samples RF + CF (100:0), RF + CF (0:100), RF + CF (80:20), RF + CF (60:40) and RF + CF (50:50) showed no significant ($p < 0.05$) difference in flavour.

The sensory score for taste varies from 5.60 to 6.90 with sample RF + CF (100:0) and RF + CF (0:100) having the least score while sample RF + CF (70:30) had the highest score. There were no significant ($p < 0.05$) difference among samples RF + CF (90:10), RF + CF (80:20), RF + CF (70:30), RF + CF (60:40) and RF + CF (50:50). It was also observed that there were no significant ($p < 0.05$) difference among samples RF + CF (100:0), RF + CF (0:100), RF+ CF (90:10), RF + CF (60:40) and RF +CF (50:50).

The texture score ranged from 5.50 to 6.40 with sample RF + CF (0:100) having the least score while sample RF + CF (90:10) had the highest value. There was no significant ($p < 0.05$) difference in the texture scores of the sample.

The score for the overall acceptability varied from 5.75 to 6.60 with sample RF + CF (0:100) having the least score while sample RF + CF (80:20) had the highest score. There were no significant ($p < 0.05$) difference among all the samples but based on the overall acceptability, the sample containing 80% rice and 20% cowpea 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 80% rice and 20% cowpea flours) with orange-fleshed sweet potato flour. The panellists preferred pasta sample obtained by blending 90% of rice/cowpea flour blend and 10% orange-fleshed sweet potato

Table 5. Sensory scores of pasta produced from blends of local rice and fermented white cowpea beans flour blends

Sensory attributes	RC + CF (100:0)	RF + CF (0:100)	RF + CF (90:10)	RF + CF (80:20)	RF + CF (70:30)	RF + CF (60:40	RF + CF (50:50)
Colour	$6.85^{a}\pm2.03$	$5.80^{a}\pm1.36$	$6.30^{a}\pm1.17$	$6.75^{a}\pm1.65$	$6.85^{a}\pm1.04$	$6.55^{a}\pm1.43$	$6.65^{a}\pm1.42$
Flavour	$5.85^{ab}\pm1.81$	$5.65^{b}\pm2.45$	$6.20^{ab}\pm1.61$	$6.50^{ab}\pm1.28$	$6.90^{a}\pm1.67$	$6.15^{ab}\pm1.39$	$6.10^{ab}\pm1.83$
Taste	$5.60^{b}\pm1.82$	$5.60^{b}\pm1.61$	$6.25^{ab}\pm2.05$	$6.80^{a}\pm1.51$	$6.90^{a}\pm1.21$	$6.20^{ab}\pm1.54$	$6.15^{ab}\pm1.73$
Texture	$5.75^{a}\pm1.71$	$5.50^{a}\pm1.93$	$6.40^{a}\pm1.50$	$6.10^{a}\pm1.21$	6.10 ± 1.21	$5.90^{a}\pm1.71$	$5.85^{a}\pm1.42$
Overall acceptability	$5.90^{a}\pm1.80$	$5.75^{a}\pm1.74$	$6.50^{a}\pm1.47$	$6.60^{a}\pm1.81$	$6.45^{a}\pm0.69$	$6.40^{a}\pm1.64$	$6.15^{a}\pm1.79$

Values are mean ± standard deviation of 20 panellists. Means within a row with the same superscript were not significantly (p < 0.05) different.

Key: RF + CF (100:0) = 100 % Local rice flour and 0% cowpea flour; RF + CF (0:100) = 0% Local rice flour and 100% Fermented white cowpea flour; RF + CF (90:10) = 90% of local rice flour and 10% fermented white cowpea flour; RF + CF (80:20) = 80% Local rice flour and 20% fermented white cowpea flour; RF + CF (70:30) = 70% Local rice flour and 30% fermented white cowpea flour; RF + CF (60:40) = 60% Local rice flour and 40% fermented white cowpea flour; RF + CF (50:50) = 50% Local rice flour and 50% Fermented white cowpea flour

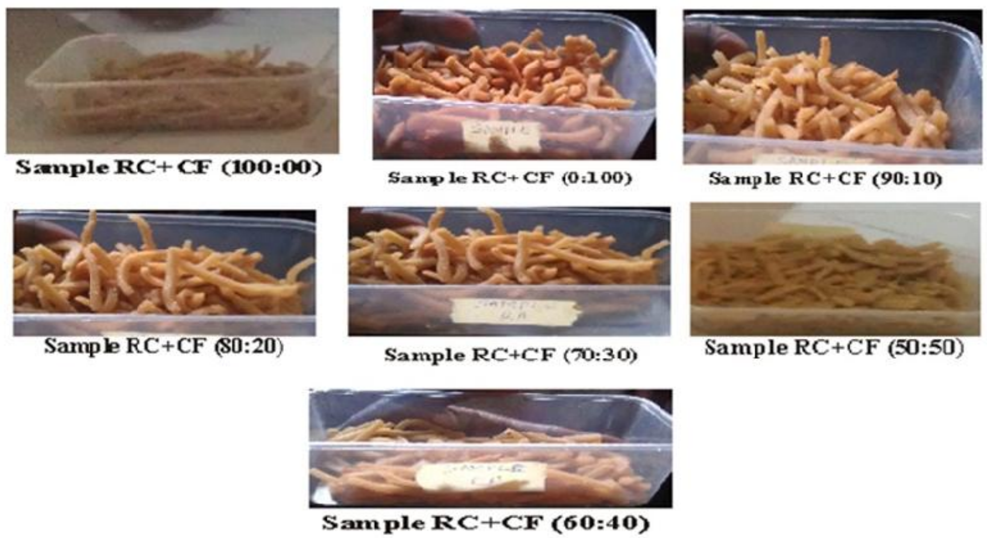

Plate 7. Pictures of the pasta samples formulated with rice and white cowpea beans flour at different ratios

Table 6. Physical characteristics of pasta formulated from local rice, white cowpea beans and orange-fleshed sweet potato flour blends

Property	Control 100% rice	RC/Pa (90:10)	RC/Pb (80:20)	RC/Pc (70:30)	RC/Pd (60:40)	RC/Pe (50:50)
Width (cm)	$0.83^{a}\pm0.35$	$0.63^{c}\pm0.01$	$0.74^{b}\pm0.02$	$0.57^{d}\pm0.01$	$0.79^{a}\pm0.14$	$0.82^{a}\pm0.01$
Height (cm)	$1.58^{c}\pm0.04$	$1.71^{ab}\pm0.01$	$1.78^{a}\pm0.04$	$1.64^{bc}\pm0.01$	$0.95^{d}\pm0.07$	$0.88^{d}\pm0.28$
Length (cm)	$2.35^{c}\pm0.21$	$2.59^{b}\pm0.21$	$3.48^{a}\pm0.35$	$2.78^{b}\pm0.04$	$2.28^{c}\pm0.04$	$2.24^{c}\pm0.01$

Values are means ± standard deviation of 2 replications. Means within a row with the same superscript were not significantly (p<0.05) different.

Key: RC/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd (60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; RC/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour.

in terms of colour, texture and overall acceptability. The result of the sensory scores was different from the values reported by Akubeze [56] which showed sample wheat-maize/cowpea (70:30) as the best blend.

3.4 Physical Characteristics of Pasta Formulated from Local Rice, Fermented White Cowpea Beans and Orange-fleshed Sweet Potato Flour Blends

The physical characteristics of pasta formulated from local rice flour, fermented white cowpea flour and orange-fleshed sweet potato flour blends at different ratios were shown in Table 6.

The width of the pasta produced from blends of local rice, white cowpea beans and orange-fleshed sweet potato flour varies from 0.57 to 0.82 cm with sample RC/Pe (50:50) having the highest value while sample RC/Pc (70:30) had the least value. The width of samples RC/Pd (60:40) and RC/Pe (50:50) were not significantly (p<0.05) different from the control (100% rice noodle) while samples RC/Pa (90:10), RC/Pb (80:20) and RC/Pc (70:30) were significantly (p<0.05) different from the control (100% rice).

The height of the pasta varied from 0.88 to 1.78 cm with sample RC/Pe (50:50) having the lowest value while sample RC/Pb (80:20) having the highest value. There were no significant (p<0.05) different between sample RC/Pa (90:10) and RC/Pc (80:20). The heights of samples RC/Pa (90:10) and RC/Pc (70:30) were not significantly (p<0.05) different, samples RC/Pd (60:40) and RC/Pe (50:50) were also not significantly (p<0.05) different. Sample RC/Pc (70:30) showed no significant (p<0.05) difference from the control (100% rice).

The length of the pasta varied from 2.24 to 3.48 cm with sample RC/Pb (80:20) having the highest value while sample RC/Pe (50:50) had the least value. Sample RC/Pa (90:10) and RC/Pc (70:30) were not significantly (p<0.05) different. Also, samples RC/Pd (60:40) and RC/Pe (50:50) were not significantly (p<0.05) different from the control (100% rice) while sample RC/Pb (80:20) 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 [56] whereas the values for the length and height of the samples were found to be different.

3.5 Proximate Composition of Pasta Formulated from Local Rice, Fermented White Cowpea Beans and Orange-fleshed Sweet Potato Flour Blends

The proximate composition of pasta produced from local rice, fermented white cowpea beans and orange-fleshed sweet potato flour blends are shown in Table 7.

The protein content of pasta formulated from the blend of local rice, fermented white cowpea beans and orange-fleshed sweet potato flour varies from 10.91 to 18.80% with sample RC/Pe (50:50) having the lowest value and sample RC/Pa (90:10) had the highest protein content. The results showed that the blending ratios influence the protein content of the pasta. 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 white cowpea beans flour in the blends. It could be deduced that fermentation increased the nutritional properties

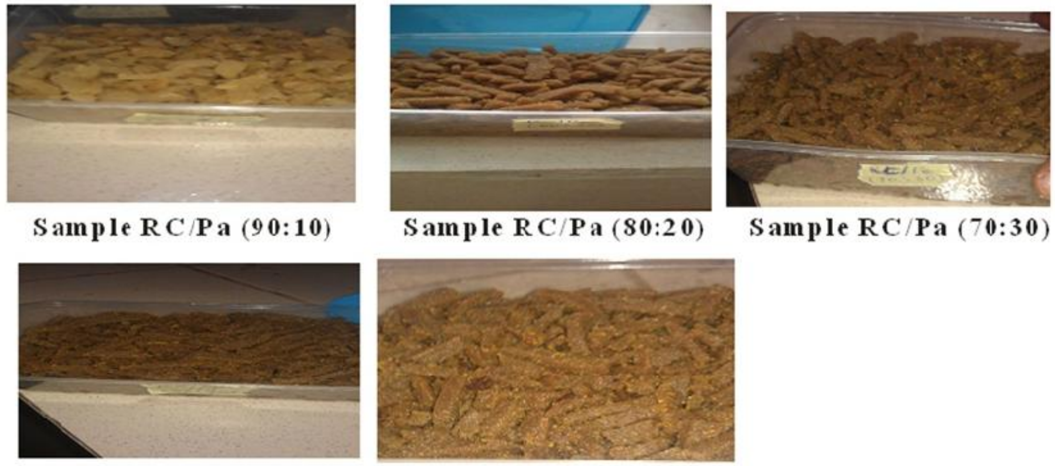

Plate 8. Pictures of pasta formulated from local rice, fermented white cowpea and orange-fleshed sweet potato flour blends

Table 7. Proximate composition of pasta formulated from local rice, fermented white cowpea beans and orange-fleshed sweet potato flour blends

Composition (%)	Control (100% rice)	RC/Pa (90:10)	RC/Pb (80:20)	RC/Pc (70:30)	RC/Pd (60:40)	RC/Pe (50:50)
Protein	8.68^{e}± 0.25	18.80^{a}± 0.28	11.90^{c}± 0.14	15.30^{b}± 0.28	12.19^{c}± 0.16	10.91^{d}± 0.13
Fat	1.21^{d}± 0.78	2.70^{a}± 0.28	2.23^{bc}± 0.35	2.23^{bc}± 0.35	1.95^{c}± 0.64	2.51^{ab}± 0.51
Ash	2.73^{b}± 0.35	2.48^{c}± 0.35	1.74^{e}± 0.14	1.82^{d}± 0.21	1.81^{d}± 0.01	3.43^{a}± 0.64
Fibre	1.59^{c}± 0.41	3.29^{a}± 0.21	2.70^{b}± 0.38	1.53^{c}± 0.35	2.58^{b}± 0.35	1.52^{c}± 0.21
Moisture	5.03^{e}± 0.35	11.63^{c}± 0.18	14.32^{b}± 0.02	11.67^{c}± 0.03	14.63^{a}± 0.01	11.09^{d}± 0.02
Carbohydrate	80.47a± 0.03	60.95^{f}± 0.01	67.01^{d}± 0.01	67.69^{c}± 0.01	66.89^{e}± 0.01	70.61^{b}± 0.01
Calorie (kcal/g)	362.43^{a}± 0.04	329.78^{d}± 0.03	339.91^{e}± 0.01	324.09^{b}± 0.01	323.85^{f}± 0.01	335.81^{c}± 0.01

Values are means ± standard deviation of 2 replications. Means within a row with the same superscript were not significantly ($p<0.05$) different.
Key: RC/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; RC/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour

of food products [57]. The high protein content could be used to eradicate the protein-energy malnutrition especially in the developing country like Nigeria [58].

The fat content of the pasta formulated from the blends of local rice, white cowpea beans and orange-fleshed sweet potato flour varied from 1.95 to 2.70% with sample RC/Pa (90:10) having the highest value and RC/Pd (60:40) having the least fat content. The fat contents of samples RC/Pa (90:10) and RC/Pe (50:50) were not significantly ($p<0.05$) different. There were no significant ($p<0.05$) difference among samples RC/Pb (80:20), RC/Pc (70:30) and RC/Pe (50:50). Samples RC/Pb (80:20), RC/Pc (70:30) and RC/Pd (60:40) were also not significantly ($p<0.05$) difference but the fat content of all the samples were significantly ($p<0.05$) different from the control (100% rice). The fat contents of all the samples were found to be generally low. This result was not in agreement with the findings of Umego [59]. Using wheat-sweet potato-soybean flour blends. The results of the fat content obtained by Umego [59]. 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 [60].

The ash content of the pasta varied from 1.74 to 3.43% with sample RC/Pe (50:50) having the highest ash content while sample RC/Pc (80:20) 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 [60]. This result showed that sample RC/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 RC/Pc (70:30) and RC/Pd (60:40) 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 pasta varied from 1.52 to 3.29% with sample RC/Pa (90:10) having the highest fibre content and sample RC/Pe (50:50) having the lowest value. The fibre contents of the blends were observed to be higher than that of the control (100% rice) which was not significantly ($p<0.05$) different from the fibre contents of samples RC/Pc (70:30) and RC/Pe (50:50). The fibre contents of samples RC/Pc (80:20) and RC/Pd (60:40) were not significantly ($p<0.05$) different. The increase in the fibre contents of the blends was due to the high contents of fibre in white cowpea 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 [60].

The moisture content of the pasta ranged between 11.09 to 14.63% with sample RC/Pd (60:40) having the highest value and RC/Pe (50:50) having the lowest moisture content. The moisture contents of sample RC/Pa (90:10) and RC/Pc (70:30) were not significantly ($p<0.05$) different. The moisture content of all the blends was shown to be significantly ($p< 05$) different

Table 8. The pro-vitamin-A content of pasta formulated from local rice, fermented white cowpea beans and orange-fleshed sweet potato flour blends

Samples code	Pro-vitamin A compositions (mg/100g)
Control (100% rice)	ND
RC/Pa (90:10)	$0.93^{e}±0.01$
RC/Pb (80:20)	$1.72^{d}±0.01$
RC/Pc (70:30)	$2.50^{c}±0.35$
RC/Pd (60:40)	$3.29^{b}±0.01$
RC/Pe (50:50)	$4.07^{a}±0.01$

Values are means ± standard deviation of 2 replications. Means within a column with the same superscript were not significantly (p<0.05) different. ND = Not detected

Key: RC/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; RC/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour.

from the control (100% rice). The relatively high moisture contents of the blends could be attributed to their relatively high fibre content. Fibrous food products have the ability to trap more moisture than their less fibrous counterparts [60]. Low moisture content enhances the storage stability of foods. This is because moisture enhances the biochemical reactions that would lead to food spoilage. A similar result was reported by David [61].using maize and cowpea flour blends.

The carbohydrate content of the control (100% rice) was higher (80.47%) than that of the blends while sample RC/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 decrease in the carbohydrate contents could be due to the fact that carbohydrate by difference depended on the other nutrients.

The calorie content for the pasta varied from 323.85 to 339.91 kcal/100g with sample RC/Pd (60:40) having the least calorie value while sample RC/Pc (70:30) had the highest calorie value. The caloric values of all the samples were significantly ($p<0.05$) different from the control (100% rice). The high calorie content of the control (100% rice) could be attributed to the high carbohydrate content of the pasta.

The values obtained for the proximate compositions compared favourably well with the values reported by David [61].using maize and cowpea flour blends and that of Akubeze [56]. using wheat/maize and mungbean flour blends.

3.6 Pro-Vitamin a Content of Pasta Formulated from Local Rice, Fermented White Cowpea Beans and Orange-fleshed Sweet Potato Flour Blends

The Vitamin A contents of pasta produced from the blends of local rice, white cowpea beans and orange-fleshed sweet potato flours were shown in Table 8.

The pro-vitamin A content (mg/100 g) of pasta formulated from local rice, white cowpea beans and orange-fleshed sweet potato flour blends varied from 0.93 to 4.07 mg/100 g with sample RC/Pa (90:10) having the least pro-vitamin A content while sample RC/Pe (50:50) had the highest pro-vitamin A content. The control (100% rice) was found to contain no 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 pro-vitamin A in the pasta 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) [17]. 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. The values obtained for the pro-vitamin A content compared favourably well with the values reported by Mohammad [38]. using different varieties of orange-fleshed sweet potato.

3.7 Cooking Characteristics of Pasta Formulated from Local Rice, Fermented White Cowpea Beans and Orange-fleshed Sweet Potato Flour Blends

The results of the cooking characteristics of the pasta produced from blends of local rice, white cowpea beans and orange-fleshed sweet potato flours were shown in Table 9.

The cooking time of the pasta formulated from blends of local rice, white cowpea beans and orange-fleshed sweet potato flours varied from 7.55 to 15.05 min with sample RC/Pe (50:50) having the lowest cooking time while sample RC/Pa (90:10) having 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 70.13 to 95.15% with sample RC/Pa (90:10) having the least cooking yield while sample RC/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 white cowpea beans flours. Also, the low cooking loss would give rise to high cooking yield.

Table 9. Cooking characteristics of pasta formulated from local rice, white cowpea beans and orange-fleshed sweet potato flour blends

Cooking characteristics	Control (100% rice)	RC/Pa (90:10)	RC/Pb (80:20)	RC/Pc (70:30)	RC/Pd (60:40)	RC/Pe (50:50)
Cooking time (min)	$20.51^{a}\pm0.01$	$15.05^{b}\pm 0.07$	$9.31^{d}\pm0.01$	$10.51^{c}\pm0.01$	$8.28^{e}\pm0.04$	$7.55^{f}\pm0.07$
Cooking yield (%)	$60.51^{f}\pm0.01$	$70.13^{e}\pm 0.04$	$80.96^{d}\pm0.14$	$85.31^{c}\pm0.01$	$90.48^{b}\pm0.04$	$95.15^{a}\pm0.21$
Cooking loss (%)	$39.25^{a}\pm0.35$	$29.80^{b}\pm 0.14$	$19.04^{c}\pm0.01$	$14.58^{d}\pm0.04$	$9.48^{e}\pm0.28$	$4.68^{f}\pm0.35$

Values are means ± standard deviation of 2 replications. Means within a row with the same superscript were not significantly (p<0.05) different.
Key: RC/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; RC/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour.

Table 10. Total viable and mould counts of pasta formulated from local rice, white cowpea beans and orange-fleshed sweet potato flours

Samples	Total viable count (CFU/g)	Mould count (CFU/g)
Control (100% rice)	2.0×10^{4}	ND
RC/Pa (90:10)	4.8×10^{4}	ND
RC/Pb (80:20)	4.2×10^{4}	ND
RC/Pc (70:30)	3.3×10^{4}	ND
RC/Pd (60:40)	6.2×10^{4}	4.0×10^{1}
RC/Pe (50:50)	2.2×10^{5}	ND

***Key:** RC/Pa (90:10) = 90% of the best blend flour and 10% of orange-fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; RC/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour. ND = Not detected.*

Table 11. Sensory score of pasta formulated from local rice, fermented white cowpea beans and orange-fleshed sweet potato flour blends

Sensory attributes	100% Rice (control)	RC/Pa (90:10)	RC/Pb (80:20)	RC/Pc (70:30)	RC/Pd (60:40)	RC/Pe (50:50)
Colour	$6.75^{a}\pm 1.89$	$6.35^{a}\pm1.27$	$5.70^{ab}\pm1.17$	$4.90^{bc}\pm1.12$	$4.80^{bc}\pm1.85$	$4.10^{c}\pm2.22$
Flavour	$6.45^{a}\pm 1.43$	$6.10^{ab}\pm0.91$	$5.70^{ab}\pm1.26$	$5.45^{ab}\pm1.39$	$5.40^{b}\pm1.57$	$5.25^{b}\pm2.15$
Taste	$6.50^{a}\pm1.47$	$5.95^{a}\pm1.43$	$5.70^{a}\pm1.45$	$5.30^{a}\pm1.45$	$5.35^{a}\pm1.79$	$5.45^{a}\pm2.48$
Texture	$6.40^{a}\pm 1.27$	$5.75^{ab}\pm1.25$	$4.90^{bc}\pm1.21$	$4.95^{bc}\pm1.90$	$4.15^{c}\pm2.13$	$4.35^{c}\pm2.18$
Aftertaste	$6.40^{a}\pm 1.08$	$5.75^{ab}\pm1.07$	$5.00^{ab}\pm1.29$	$4.85^{ab}\pm2.06$	$4.60^{c}\pm2.26$	$4.60^{c}\pm2.19$
Overall Acceptability	$6.57^{a}\pm1.07$	$6.45^{ab}\pm1.28$	$5.15^{bc}\pm1.27$	$5.60^{c}\pm1.69$	$4.85^{c}\pm1.89$	$4.75^{c}\pm2.24$

Values are means ± standard deviation of 20 panellists. Means within a row with the same superscript were not significantly (p<0.05) different.
Key: RC/Pa (90:10) = 90% of the best blend flour and 10% of orange – fleshed sweet potato flour; RC/Pb (80:20) = 80% of the best blend flour and 20% of orange-fleshed sweet potato flour; RC/Pc (70:30) 70% of the best blend flour and 30% of orange-fleshed sweet potato flour; RC/Pd(60:40) = 60% of the best blend and 40% of orange-fleshed sweet potato flour; RC/Pe (50:50) = 50% of the best blend flour and 50% of orange-fleshed sweet potato flour.

The cooking loss varied from 4.68 to 29.80% with sample RC/Pe (50:50) having the least cooking loss while sample RC/Pa (90:10) had the highest cooking loss. The cooking loss of the blends was not 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, cowpea and orange-fleshed sweet potato flour blends. The overall network that holds the noodle structure might consist primarily of protein and starch matrices [62].

The values obtained for the cooking time and cooking loss of the pasta was higher than that reported by Akubeze [56] using wheat/maize and mungbean flour blends, but the cooking yield was similar.

3.8 Microbiological Content of Pasta Formulated from Local Rice, White Cowpea Beans and Orange-fleshed Sweet Potato Flour Blends

The total viable count and mould count of pasta formulated from blends of local rice, white cowpea beans and orange-fleshed sweet potato flours are shown in Table 10.

The total viable count of the pasta ranged from 3.3×10^4 to 2.2×10^5 CFU/g with sample RC/Pc (70:30) having the least value and sample RC/Pe (50:50) had the highest value. The mould count was not detected on other samples except sample RC/Pe (60:40) which had the 4.0×10^1. This could be because of its high moisture content. Microorganisms play a significant role in the determination of the shelf life of products. Microorganisms are usually responsible for spoilage of many food items. A high total viable count could indicate the presence of a mixed population of microorganisms, which may consist of spoilage types. The total viable count and mould count of the samples were not high when assessed using the guidelines for microbiological quality of pasta products [63] which indicated 10^4 CFU/g for satisfactory, 10^4 to 10^5 CFU/g acceptable and 10^6 CFU/g and above as being of unsatisfactory quality. The total bacterial and fungal counts in the food product may be a consequence of fermentation of the white cowpea flour and low level of hygiene maintained during processing of the product. Limits of microbial counts have been recommended in most foods to keep them safe for consumption [64]. Thus, it is preferable to utilize these flours as soon as possible especially the fermented white cowpea beans flour because of the high protein content which might cause spoilage.

3.9 Sensory Scores of Pasta Formulated from Local Rice, Fermented White Cowpea Beans and Orange-fleshed Sweet Potato Flour Blends

The sensory scores of the pasta formulated from local rice, fermented white cowpea beans and orange-fleshed sweet potato flour blends are shown in Table 11.

The sensory scores for colour varied from 4.10 to 6.35 with sample RC/Pa (50:50) having the least score while sample RC/Pa (90:10) had the highest score. There were no significant ($p<0.05$) difference in colour between samples RC/Pa (90:10), RC/Pb (80:20) and the control (100% rice). Also, there was no significant ($p<0.05$) difference among samples RC/Pb (80:20), RC/Pc (70:30) and RC/Pd (60:40). It was also observed that there was no significant ($p<0.05$) difference in colour among samples RC/Pc (70:30), RC/Pd (60:40) and RC/Pe (50:50), while the control (100% rice) were significantly ($p<0.05$) different from samples RC/Pc (70:30), RC/Pd (60:40) and RC/Pe (50:50). Transparency in colour has also used an indicator in assessing the quality of pasta [65]. The appearance/colour of the noodles became darker (from light brown to dark brown) with increasing level of orange-fleshed sweet potato in the blend. The increasing substitution level of the orange-fleshed sweet potato may be caused a significant decrease in scores. This could probably be because potatoes were 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 pasta products contained a high amount of reducing sugar. This discolouration could be due to the reactions involving amino acids and reducing sugars [66]. A similar result was obtained by Umego [59] using wheat-sweet potato-soy bean flour blends and wheat pasta substituted with hull-less barley [55].

The sensory score for flavour ranged from 5.25 to 6.10 with sample RC/Pe (50:50) having the least score and sample RC/Pa (90:10) having the highest score. There were no significant ($p<0.05$) different in flavour among samples RC/Pa (90:10), RC/Pb (80:20) and RC/Pc (70:30) and the control (100% rice). Also, there was no significant ($p<0.05$)difference in flavour among samples RC/Pa (90:10), RC/Pb (80:20), RC/Pc

(70:30), RC/Pd (60:40) and RC/Pe (50:50), while the control (100% rice) was significantly (p<0.05) different in flavour from samples RC/Pd (60:40) and RC/Pe (50:50). The desirable flavour attributes of the samples could be due to the effect of fermentation on the organoleptic properties of foods [57].

The sensory scores for taste varied from 5.30 to 5.95 with sample RC/Pc (70:30) having the lowest score and sample RC/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 high reducing sugar content of the orange-fleshed sweet potato flour and the effect of fermentation on the organoleptic properties of the fermented white cowpea beans flour [57, 65]. A similar result was obtained by Umego [59].

The sensory scores for texture varied from 4.15 to 5.75 with sample RC/Pd (60:40) having the least score and sample RC/Pa (90:10) having the highest score. The low texture score of sample RC/Pd (60:40) 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). Also, the smooth texture of sample RC/Pa (90:10) could be due to the high amount of fermented cowpea beans flour in the sample which had the finest particle size (500 µm), and low amount of orange-fleshed sweet potato flour. There were no significant (p<0.05) difference between the control (100% rice) and sample RC/Pa (90:10). Also, there were no significant (p<0.05) difference among samples RC/Pa (90:10), RC/Pb (80:20) and RC/Pc (70:30). Samples RC/Pb (80:20), RC/Pc (70:30), RC/Pd (60:40) and RC/Pe (50:50) were not significantly (p<0.05) different, while samples RC/Pb (80:20), RC/Pc (70:30), RC/Pd (60:40) and RC/Pe (50:50) were significantly (p<0.05) different from the control (100% rice).

The sensory score for the aftertaste varied from 4.60 to 5.75 with sample RC/Pd (60:40) and RC/Pe (50:50) having the lowest score while sample RC/Pa (90:10) had the highest score. There were no significant (p<0.05) different among samples RC/Pa (90:10), RC/Pb (80:20) and RC/Pc (70:30) and the control (100% rice). Samples RC/Pd (60:40) and RC/Pe (50:50) were also not significantly (p<0.05) different from each other but significantly (p<0.05) different from the control (100% rice).

Based on the overall acceptability, the control (100% rice) had the highest score (6.57) followed by sample RC/Pa (90:10) which scored 6.45, while sample RC/Pe (50:50) had the least score (4.75). There were no significant (p<0.05) difference between the control (100% rice) and sample RC/Pa (90:10). Also, there was no significant (p<0.05) difference between samples RC/Pa (90:10) and RC/Pb (80:20). Samples RC/Pb (80:20), RC/Pc (70:30), RC/Pd (60:40) and RC/Pe (50:50) were not significantly (p<0.05) different from each other but significantly (p<0.05) different from the control (100% rice). 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 [59] using wheat-sweet potato-soy bean flour blends and orange-fleshed sweet potato and rice-field bean gluten-free pasta improved by the addition of hydrothermally treated rice flour [67]. From the sensory scores, it showed no significant difference (p>0.05) in taste, colour and flavour between the control and the optimum pasta. The obtained results showed that the optimal formulation of pasta was significantly better with the highest scores for all the attributes. Moreover, the selected optimum pasta gathered superior scores (values above 5 on a 9-point Hedonic scale) in the overall acceptability in comparison with the control sample without the addition of orange-fleshed sweet potato.

4. CONCLUSION AND RECOMMENDATION

From the study, it has shown that acceptable pasta could be produced from blends of local rice, white cowpea beans and orange-fleshed sweet potato flour. The result showed that the addition of white cowpea beans and orange-fleshed sweet potato in the pasta formulation affected the chemical, cooking and sensory properties of the pasta. Addition of white cowpea beans improved the protein content of the rice pasta. The use of orange-fleshed sweet potato improved the pro- vitamin A content of the pasta, 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-cowpea-orange-fleshed sweet potato pasta would help to alleviate problems of protein-energy malnutrition and micro-nutrient deficiency in Nigeria and other developing countries. Also, the sample obtained by blending 90% of rice/cowpea flour blend and

10% orange-fleshed sweet potato 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 white cowpea beans "akidi charamanya" 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 pasta formulated from the flour blends.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. McClatchey C. How pasta became the world's favourite food; 2011. Available:http//www.bbc.com (Accessed November 12th, 2016)
2. Sui Z, Locas P, Corke H. Optional cooking time of noodles related to their notch sensitivity. Journal of Texture Studies. 2006;37:428–441.
3. Owen G. Cereals processing technology. england, cambridge. Woodhead Publishing Limited. 2008;131-151.
4. World Instant Noodle Association. Instant Noodle Facts Worldwide; 2001. Available:http//www.Instant%20noodle%20-%20Wikipedia.mht (Accessed on November 20th, 2016)
5. Mearim ML, Invarsson A, Dickey W. Celiac disease: Is it time for mass screening? Best Practice and Research Clinical Gastroenterology. 2005;19(13):41-452.
6. Tongpun N. Formulation of soy protein-enriched instant noodles. Master of Science Dissertation (Nutrition), Faculty of Graduate Studies, Mahidol University, Bangkok, Thailand; 2006.
7. Flodin NW. The metabolic roles, pharmacology and toxicology of lysine. The Journal of the American College of Nutrition. 1997;16(1):7-21.
8. Kumara D. Routledge studies in the modern world economy: Poverty, Inequality, and growth in developing countries: Theoretical and empirical approaches edited by Atsushi Maki. Canada: Routledge Publishers. 2015;130.
9. Wa sche A Muller, K Knauf U. New processing of lupin protein isolates and functional properties. Nahrung/Food. 2001; 45:393-395.
10. Duranti M. Grain legume proteins and nutraceutical properties. Fitodorapia. 2006; 77:67-82.
11. Haard NF, Chism GW. Characteristics of edible plant tissues. In: Food chemistry. New York Marcel Dekker, Inc. 1996;943-1001.
12. Raymond N, Heap J, Case S. The gluten-free diet: An update for health professionals. Practice. Gastroenterology. 2006;30(9):67–69.
13. Amussen HW, Sharp RN, Sharp CK. The feasibility of making soups from rice flour and hydrolyzed rice. Journal of American Dietetic Association. 1990;90(7):991-993.
14. Leardkamolkarn V, Thongthep W, Suttiarporn P, Kongkachuichai R, Wongpornchai S, Wanavijit A. Chemopreventive properties of the bran extracted from a newly-developed Thai rice: The riceberry. Food Chemistry. 2011;125: 978-985.
15. Frei M, Becker K. Agro-biodiversity in subsistence-oriented farming systems in a Philippine upland region: Nutritional considerations. Biodiversity and Conversion. 2004;13:1591-1610.
16. Ju ZY, Hettiarachchy NS, Path N. Extraction, denaturation and hydrophobic properties of rice flour proteins. Journal of Food Science. 2001;66(2):229-232.
17. Inagabire MR, Hilda V. Comparison of the nutrient composition of flour sweet potato varieties cultivated in Rwanda. American Journal of Food and Nutrition. 2011;13:35-38.
18. Laurine SM, Van Jaarsveld PJ, Faber M, Philpott MF, Labuschagne MT. Trans-β-carotene, selected mineral content and potential nutritional contrition of 12 sweet potato varieties. Journal of Food Composition Analysis. 2012;27:151-159.
19. Oloo BO, Shitandi A, Mahungu S, Malinga JB, Ogata BR. Effects of lactic acid

fermentation on the retention of β-carotene content in orange-fleshed sweet potato. International Journal of Food Studies. 2014;3:13–33.
20. Ellong EN, Billard C, Adenet S. Comparison of physiochemical, organoleptic and nutritional abilities of eight sweet potato (*Ipomoea batatas* L) varieties. Food and Nutrition Science. 2014;5(2):196.
21. Fetuga G, Tomlins K, Henshaw F, Idowu M. Effect of variety and processing method on functional properties of traditional sweet potato flour ('elubo') and sensory acceptability of cooked paste ('amala'). Food Science and Nutrition. 2014;2(6): 682-691.
22. Mwanri A, Kogi-Makanu W, Laswai H. Nutrients and anti-nutrients composition of raw, cooked and sun-dried sweet potato leaves. African Journal of Food and Agricultural Nutrition Development. 2011; 11(5):5142-5156.
23. Low J, Lynam J, Lemaga B, Crissman C, Bakr I, Thece G. Sweet potato in sub-Sahara Africa. Netherlands; Springer. 2009;359-390.
24. Iwe MO, Onyeukwu U, Agiriga AN. Proximate, functional and pasting properties of FARO44 rice, African yam bean and brown cowpea seeds composite flour. Journal of Food and Agriculture; 2016.
Available:http:dxdoi.org/10.1080/23311932.2016.1143409
25. Onoja US, Akubor PI, Njoku I, Atama CI, Onyishi GC, Ekeh FN, Eyo JE, Ejere VC. 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. 2014;9(24):1119–1026.
DOI: 10.5897/SRE2014.6104
26. Hagenimana V, Owori C. Process of producing sweet potato flour; 2016.
Available:http//www. R7036 – sweet potato flour.pdf
(Accessed December 22nd, 2016)
27. Hou G. Oriental noodles. Advances in Food and Nutrition Research. 2011;43: 141-193.
28. AOAC. Association of official analytical chemist, official methods of analysis. 18th edition, Washington DC, USA; 2010.
29. AACC. Approved methods of American association of cereal chemists (10th edition). Minnesota: American Association of Cereal Chemists. St. Paul. 2000;276–280.
30. Onyeka EU, Nwabekwu IO. Phytochemical profile of some leafy vegetables dried using solar dryer. Nigeria Food Journal 2007;1:72-82.
31. Philips RD, Chinnan MS, Branch AL, Miller J, Mcwatters KH. Effects of pre – treatment on functional and nutritional properties of cowpea meal. Journal of Food Science. 1998;53:805–809.
32. Beuchat LR. Functional and electro-phoretic characteristics of succinylated peanut flour protein. Journal of Agricultural Food Chemistry. 1977;25:258–261.
33. Onwuka GI. Food analysis and instrumentations theory and practice. 1st edition. Lagos; Naphtali Prints. 2005;29–73.
34. Schoenlechner R, Drausinger J, Ottenschlaeger V, Jurackova K, Berghofer E. Functional properties of gluten-free pasta produced from amaranth, quinoa and buckwheat. Plant Foods of Human Nutrition. 2010;65(4):339-349.
35. Prescott LM, Harley JP, Kelein OA. Microbial nutrition: Types of media. In: Microbiology, Sixth edition. New York; McGrawill. 2005;93–105.
36. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for tropics. Macmillian education Ltd, London. 1985; 10–77.
37. Steel RG, Torrie JH. Principles and procedures of statistics: A biometrical approach. 2nd Edition. New York: McGraw Hill; 1980.
38. Khalid I, Elhardallou S, Elkhalifa E. Compostion and functional properties of cowpea *(Vigna unguiculata* L. Walp) flour and protein isolates. American Journal of Food Technology. 2011;7:113–122.
39. Mohammad K, Ziaul H, Sheikh N. Comparison of the proximate composition, total carotenoids and total polyphenol content of nine varieties of orange-fleshed sweet potato grown in Bangladesh. Institute of Nutrition and Food Science, University of Dhaka, Dhaka, Bangladesh; 2016.
40. Kure OA, Bahago EJ, Daniel EA. 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. 1998;3(2):17-22.

41. Hou G, Kruk M. Asian noodle technology. AIB Research Department, Technical Bulletin. 2008;20:12.
42. Standard Organization of Nigeria (SON), Nigeria Industrial Standard for Pasta Products. 2014;188–189.
43. Mepba DH, Eboh L, Nwaojigwa SU. Chemical composition, functional and baking properties of wheat – plantain composite flours. African Journal of Food and Agriculture nutrition and Development. 2007;7(1):40–45.
44. Enwere NJ. Foods of plant origin: Nsukka Nigeria: Afro-Orbis publications limited. 1998;24–106.
45. Matil KF. Functional requirement of proteins for foods. Journal of American Oil Chemistry Society. 2007;48: 477-480.
46. Akubor PI, Badifu GIO. Chemical composition, functional properties and baking potential of African bread fruit kernel and wheat flour blends. International Journal of Food Science and Technology. 2001;39:223-229.
47. Kinsella E. Functional properties of proteins in foods: Critical review. Food Science and Nutrition Journal. 1976;1(3): 219–280.
48. Taira H. Buckwheat introduction. Encyclopaedia of Food Technology. 2010;139.
49. ASABE Standards S319.4: Method of determining and expressing fineness of feed materials by sieving. St. Joseph, Michigan: ASABE; 2008.
50. AACC. AACCI method 55-60.01- guideline for determination of particle size distribution. Approved methods- Physical Tests of American Association of Cereal Chemists (11^{th} edition). Minnesota: American Association of Cereal Chemists. St. Paul; 2011.
51. Sonaye SY, Baxi RN. Particle size measurement and analysis of flour. International Journal of Engineering Research and Applications (IJERA). 2012; 2(3):1839-1842.
52. Patwa A, Malcolm B, Wilson J, Ambrose K. Particle size analysis of two distinct classes of wheat flour by sieving. Transactions of the ASABE (American Society of Agricultural and Biological Engineers). 2014;57(1):151-159.
53. Kanura D, Noel D, Dilip K. Significance of the functional properties of plant products. Food and Nutrition Bulletin. United Nation University. 1996;17(2).
54. Adeleke RO, Odedeji JO. Functional properties of wheat and sweet potato flour blends. Pakistan Journal of Nutrition. 1974; 9(6):535–538.
55. Garsa AAS. Preparation and quality evaluation of pasta substituted with hull-less barley. Australian Journal of Basic and Applied Sciences. 2017;11(1):98-106.
56. Akubeze VO. 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; 2015.
57. Hutkin RW. Microbiology and technology of fermented foods. London; Blackwell Publishing. 2006;12-13
58. Ghasemzadeh R. Processing and assessment of quality characteristic of cereals – legumes composite weaning foods. International conference on Bioscience, Biochemistry and Bioinformatics. 2011;5:357–359.
59. Umego E. 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; 2012.
60. Jeckins DJA. Dietary fibre, Lente carbohydrates and the insulin resistant diseases. British Journal of Nutrition 2000; 83:157-163.
61. David O. Development of instant noodles from maize and cowpea. An M.Sc. dissertation, Kwame Nkrumah University of Science and Technology, Kumesi, Ghana; 2015.
62. Saifullah R, Abbas FM, Yeoh SY, Azhar ME. Utilization of green banana flour as a functional ingredient in yellow noodle. International Food Research Journal. 2009;16:373–379.
63. International commission on microbiological specifications for foods. ICMSF. Microorganisms in Foods 2, Sampling for Microbiological Analysis: Principles and Specific Applications; 1986.
64. Anon. Microbiological guidelines for pasta products. Recommendations for food safety monitoring in Hong Kong by the expert panel on microbiological safety of food, Hong Kong. 2016;7.

65. Jane J, Kasemsuwan T, Chen JF. Phosphorous in rice and other starches. Cereal Food World. 1996;41:827e–832e.
66. Tewe OO, Ojeniyi FE, Abu OA. Sweet potato production, utilization and marketing in Nigeria. Department of Social Sciences, International Potato Centre (CIP), Lima, Peru; 2003.
67. Dib A, Wójtowicz A, Benatallah L, Zidoune MN, Mitrusb M, Sujak A. Optimization of rice-field bean gluten-free pasta improved by the addition of hydrothermally treated rice flour. Italian Journal of Food Science. 2018;30:226–248.

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