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Evaluation of Wheat and Orange-fleshed Sweet Potato Composite Flour Fortified with African Yam Bean Flour for Instant Noodle Production

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Authors' contributions

This work was carried out in collaboration between all authors. Author BNE designed the study and supervised the laboratory work. Author AGE managed analyses of the study and literature searches. Author NM performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study is aimed at evaluating instant noodles produced using a composite mixture of wheat and orange-fleshed sweet potato (OFSP) flour fortified with African yam bean (AYB) flour.
Study Design: This was an analytical study done in replicates and sensory evaluation by 20 panelists.
Place and Duration of Study: This study was conducted in Food Science and Technology Laboratory, the University of Uyo between June-August, 2017.
Methodology: Wheat, OFSP, and AYB flour were prepared and subsequently mixed as composite flour in different ratio. They are (80 W: 10 OFSP: 10 AYB); (70 W: 15 OFSP: 15 AYB); (60 W: 20 OFSP: 20 AYB) and (50 W: 20 OFSP: 30 AYB). The control was 100% wheat flour. A nutritional composition including vitamin A and gluten content of individual flour samples and the composite

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were determined. Composite flour samples were used for noodle production. Previous analysis except gluten content was repeated on the noodle samples including cooking time, water absorption capacity (WAC) and microbial quality assessment using standard methods while sensory acceptability was based on nine points hedonic scale.
Results: Moisture, ash, fat, protein, fibre, carbohydrate and vitamin A content of the noodles produced ranged from (11.53-12.40%), (1.35-2.11%), (1.70-2.19%), (11.67-13.04%), (2.13-3.38%), (67.90-70.90%) and (218.03-288.14%), respectively. Noodles produced using (50 W: 20 OFSP: 30 AYB) had the highest protein, fat, fiber and vitamin A content. The other samples compared favorably with the control. Product acceptability based on sensory score showed that the control (wheat noodle) was most preferred while OFSP and AYB supplemented noodles were above average. Cooking time and WAC of the noodle samples ranged between 7.33-10.33 min. and 135.32-154.87%, respectively. Microbiological analysis revealed that the products were within acceptable limits.
Conclusion: Instant noodles produced from the composite flour compared favorably with that produced from 100% wheat flour. Among the noodle samples prepared from composite flour, that which comprise 50 W: 20 OFSP: 30 AYB is recommended for noodle industries in Nigeria.

Keywords: Noodles; African yam bean; Orange-fleshed sweet potato; wheat flour; fortification.

1. INTRODUCTION

Instant noodle is a breakfast cereal produced from the mixture of flour, water, and alkaline solution. This meal is enjoyed by children and adults. According to [1] noodle consumption in China could be traced as far back as 5000 BC which later spread to other Asian countries and the rest of the world. Noodle is rich in carbohydrate and contains some level of protein and vitamins [2]. Hard wheat flour constitutes the major raw material for noodle production. Different noodle types exist based on colorant or flavor added. Noodles could be dried or pre-cooked, fused with oil and sold with packaged flavoring agent [3].

In the last two decades, noodle consumption in Nigeria is increasingly gaining acceptability which relies majorly on imported wheat. Due to increasing cost of this raw material which results in high cost of noodles, sourcing flour locally from different sources has become imperative. To promote utilization of cassava flour, Nigerian government has come up with a policy that encourages blending 100% wheat flour with locally sourced flour obtained from cassava which is a tuber crop [4].

Sweet potato (*Ipomoea batatas*) is a starch-rich tuber crop. It is a staple food consumed across Nigeria. Potato flour has many food applications [5]. Majority of sweet potato varieties are less nutritive, but the orange-fleshed sweet potato (OFSP) variety rich in beta-carotene is considered as a very cheap source of vitamin A especially for young children. Therefore, consumption of OFSP could be useful in combating widespread of vitamin A deficiency (VAD) in children which results in blindness and death of 250-500, 000 African children yearly [6]. Apart from being a food source, OFSP also exerts several health-promoting effects in humans [7,8,9,10].

Food fortification is an important strategy usually adopted to improve the nutritive value of foods rich in carbohydrate content. Legume such as African yam bean (*Sphenostylis stenocarpa*) is very rich in protein and amino acids. African yam bean (AYB) has been used by many researchers for food fortification. Although the usefulness of AYB and orange-fleshed sweet potato has been documented, its utilization in Nigeria is still largely on a small scale. There is a limited study that involves the application of AYB and OFSP flour in industrial food processing [11,12].

Therefore, this study is aimed at evaluating noodles prepared using wheat and OFSP flour composite fortified with AYB flour which could be scaled up for useful application in Nigeria noodle industries.

2. MATERIALS AND METHODS

Wheat flour and iodized salt were purchased from Akpan-andem market; African yam bean (AYB) from the Fiongaran market in Akwa Ibom state while orange-fleshed sweet potato (OFSP) was from Fedica farms Markurdi, Benue State. Premix C, iodized salt, and riboflavin were obtained from a very reputable noodle manufacturer in Nigeria.

2.1 Preparation of Orange-fleshed Sweet Potato (OFSP) Flour

A slightly modified method described by [13] was used to prepare OFSP flour. The potato tubers were sorted, washed and manually peeled into thin pieces. The sliced potatoes were blanched at 65ºC for 15 mins to prevent browning reactions. The blanched slices were dried in a hot air oven set at 55ºC until constant weight was achieved. Subsequently, attrition mill was used to mill the dried sliced potatoes. The potato flour obtained was sieved using 2 mm mesh and then packaged inside a plastic container.

2.2 Preparation of African Yam Bean (AYB) Flour

A slight modification of the procedure described by [14] was used to prepare AYB flour. Brown African yam bean seeds were sorted to remove foreign materials. The seeds were thoroughly washed with clean tap water and subsequently soaked for 24 hr in ash solution to soften the seed coat for easy dehulling. After dehulling, the seeds were dried in a hot air oven set at 55ºC until constant weight was achieved. Attrition mill was subsequently used to mill the seeds. The flour obtained was sieved using 2 mm mesh sieve and packaged.

2.3 Preparation of African Yam Bean, Orange-fleshed Sweet Potato and Wheat Composite Flour Samples for Instant Noodle Production

Uniform blending of wheat, OFSP, and AYB flour composite in the ratio 100:0:0, 80:10:10, 70:15:15, 60:20:20 and 50:20:30 were achieved using a mechanical blender. The control is 100:0:0.

2.4 Production of Instant Noodle

The first stage involves alkaline salt preparation which comprises of riboflavin, salt and premix C dissolved in water using a slightly modified method described by [15] similar to the formulation adopted by a very reputable leading noodle manufacturer in Nigeria. The next stage involved the transfer of 1 Kg flour sample into 1-litre alkaline salt solution and continuously stirred for 15 min to ensure homogeneity was achieved and crumbled dough formed. Manual rollers were used to roll the dough into sheets and subsequently slit into strands using manual pasta maker and after that cut into shapes using a knife. The noodles placed inside a deep stainless steel pan were steamed at 100 C for 3 min using water bath and subsequently dried in a hot air oven set at 65 C for two hr. The hot dried instant noodles were allowed to cool to room temperature (28±2ºC) and then packaged.

2.5 Determination of Nutritional and Physicochemical Properties of Composite Flour and Their Noodle Product

Moisture, crude fat, crude protein, total ash, crude fiber, carbohydrate and gluten content of the blended flour of different ratio were determined using [16] methods with slight modification. The cooking time and water absorption of the noodles produced were determined using the methods described in [17].

2.5.1 Determination of moisture content

Cleaned crucibles were dried in a hot air oven at 100ºC for one hr and then allowed to cool in a desiccator to obtain a constant weight. Two grams (2 g) of each sample was weighed into the crucibles and dried at 105ºC until constant weight was obtained. This procedure was carried out for all the samples.

$$\% \text{ Moisture content} = \frac{W2 - W3}{W2 - W1} \times 100$$

Where:

W_1 = Initial weight of the empty crucible
W_2 = Weight of crucible + sample before drying
W_3 = Weight of crucible + sample after drying

2.5.2 Determination of crude fat content

Soxhlet extraction method was used to determine the fat content of the samples. A Soxhlet extractor with a reflux condenser and a 250 ml round bottom flask was used for the analysis. Three granules of glass beads (anti-bumping agent) were dropped into the round bottom flask and weighed. Two grams (2 g) of the sample was then weighed into a labeled thimble. A volume of 100 ml petroleum ether was poured into the flask, and extractor thimble was sealed with cotton wool. The soxhlet apparatus was then allowed to reflux for four hr after which the thimble was removed. Petroleum ether inside the flask was carefully collected leaving behind extracted fat inside the flask which was dried for one hr inside an oven set at 105ºC after which the flask was allowed to cool and weighed. This procedure was carried out for all the samples.

$$\% \text{ Fat content} = \frac{W3 - W2}{W1} \times 100$$

Where:

W_1 = Weight of sample
W_2 = Weight of flask + anti-bumping granules + sample before extraction
W_3 = Weight of flask + anti-bumping granules + sample after extraction

2.5.3 Determination of crude protein content

This was determined using Micro-Kjeldahl method. The first stage of the process involved digestion of the sample. One gram (1 g) of each sample was weighed into 100 ml Kjeldahl flask followed by addition of 2.5 g anhydrous Na_2SO_4, 0.5 g $CuSO_4$ and 5 ml concentrated H_2SO_4. The content of the flask was allowed to stand for 2-3 hr after which the flask was heated in a fume cupboard. Initial heating of the flask was gentle to allow fume to appear and subsequently intensified until the solution was clear. After the flask was allowed to cool, the content was transferred to a 100 ml volumetric flask and made up to mark with repeated washing using distilled water. At the distillation stage, 5 ml boric acid and three drops of methyl red were added to the 100 ml conical flask. The content of the flask was steam distilled into conical flask using 100 ml of 60% NaOH. The distillation process lasted for 5 min when the color changed from purple to green. Titration being the last stage involved using 5 ml distillate to titrate against 0.01 N HCl until a purple colored endpoint was observed. The percentage protein was calculated using the expression:

$$\% \text{ Nitrogen} = \frac{T \times 14.01 \times 0.01 \times 20 \times 100}{1.0 \times 100}$$

Where: T = Titre value; 1.0 g = Weight of sample; 20 = Dilution factor; 0.01 = Normality of HCl; 14.01 = Atomic mass of nitrogen.

Percentage protein = % Nitrogen x 6.25 (where 6.25 is conversion factor of protein).

2.5.4 Determination of total ash content

Two grams (2 g) of the well-blended sample was weighed into a crucible previously dried in a hot air oven at 100ºC for one hr and then allowed to cool inside a desiccator to obtain a constant weight. Both the crucibles and their content were transferred into a muffle furnace ignited at 550ºC. Ashing of the samples lasted for four hr. The samples were removed from muffle furnace, cooled in a desiccator for 30 mins and weighed. Percentage ash was calculated using the expression:

$$\% \text{ Ash} = \frac{W3 - W1}{W2 - W1} \times 100$$

Where; W_1 = Weight of empty crucible; W_2 = Weight of empty crucible + Sample before ashing W_3 = Weight of empty crucible + Sample after ashing.

2.5.5 Determination of crude fiber content

Two grams (2 g) of the sample was weighed and poured into a boiling 200 ml of 1.25% H_2SO_4 and allowed to boil for 30 min. Muslin cloth fixed to a funnel was used to filter the solution and then washed with boiling water until it was completely free from acid. The residue was returned into 200 ml NaOH and allowed to boil for 30 min and then further washed with 1% HCl. The final residue was drained and transferred into a silica ash crucible dried in the oven to a constant weight and allowed to cool. The percentage crude fiber was calculated using the expression:

$$\% \text{ Crude fiber} = \frac{Loss\ in\ weight\ on\ ignition}{weight\ of\ food\ sample} \times 100$$

2.5.6 Determination of gluten content

The initial weight of dry filter paper was taken followed by addition of 25 g of flour sample on the empty filter paper. The weighed flour was transferred into a ceramic mortar and 15 ml distilled water was added. A spatula was used to thoroughly mix the flour and water until the homogenous dough was formed. The dough was removed from the mortar without any particle left behind, knead into a ball and soaked in water at room temperature (28±2ºC) for one hr. The dough soaked in water was removed and washed in a slowly running tap until starch and soluble matters were completely removed after which the dough was spread on the initial filter paper the weight had been taken. The dough placed on filter paper was put in an oven set at

105ºC for three hr, then transferred into a desiccator and left for 30 mins. The filter paper containing dried dough was reweighed.

$$\% \text{ Gluten content} = \frac{W3-W1}{W2-W1}$$

Where: W_1 = Weight of empty filter paper; W_2 = Weight of blank filter paper + sample before drying; W_3 = Weight of empty filter paper + sample after drying.

2.5.7 Determination of carbohydrate content

The carbohydrate content of each sample was estimated by the difference method which involves subtracting the sum of moisture, fat, protein, crude fiber and ash content from 100%.

2.5.8 Determination of vitamin A content

Two gram (2 g) of each sample was poured into a beaker followed by addition of 10 ml chloroform solution. The chloroform layer was transferred to another test tube. A saturated solution of antimony trichloride reagent was added to the tube, and blue coloration was observed. The spectrophotometer was adjusted to read the absorbance of the resulting solution at 620 nm against a reagent blank. The result was calculated as follows:

$$\frac{Ast\ x\ Ctd\ x\ D.F}{Atd\ \ X\ \ W} = \text{mg/100 g of vitamin A}$$

Where:

A_{st} = Absorbance of test
C_{td} = Concentration of standard
D.F = Dilution factor
A_{td} = Absorbance of standard
W = Weight of the sample

2.5.9 Determination of cooking time

Ten gram of each noodle sample was cooked using 300 ml of boiling potable water. Cooking time of the noodle sample was determined by removing a piece of the noodle being cooked and placed between 2 pieces of the watch glass. The softness of the noodle was determined based on hand-feel. The time taken for the uncooked noodle to become fully hydrated and soft is the optimum cooking time.

2.5.10 Determination of water absorption

Water absorption is the difference in weight between cooked and uncooked noodles expressed as a percentage. The initial weight of uncooked noodle was taken after which it was cooked. The cooked noodles were rinsed with water, then drained for 30 sec and then reweighed.

2.6 Sensory Evaluation of Noodles Produced Using Composite Flour Formulations

Sensory evaluation of the products was determined using a similar method described by [18]. Twenty sensory panelists familiar with noodles were given the samples to evaluate using a nine-points hedonic scale which ranges from 1 (dislike extremely) to 9 (like extremely).

2.7 Microbial Quality Assessment of Noodle Produced from the Composite Flour

A slightly modified method described by [19] was adopted to determine total bacterial count, total coliform count as well as population of *Staphylococcus* sp, yeast and mould in noodle samples produced from composite flour formulations using standard plate count agar, violet red bile agar, Baird-parker agar base and malt extract, respectively prepared in accordance with manufacturers' instructions.

2.8 Statistical Analysis

All the data obtained from this study were subjected to statistical analysis using analysis of variance (ANOVA). Using statistical package for the social sciences (SPSS) 20.0 software, Duncan multiple range tests (DMRT) was used to separate the means obtained from replicate analysis.

3. RESULTS AND DISCUSSION

Results from nutritional composition and physicochemical properties of composite flour made up of wheat, orange-fresh sweet potato (OFSP) and African yam bean (AYB) flour and that of noodle samples produced using composite flour subjected to sensory evaluation and microbial analysis were obtained from this study.

3.1 Nutritional Composition of Composite Flour Formulations

Fig. 3 shows the proximate composition and dry gluten content of OFSP and AYB flour. According to [20] beta-carotene content of sweet potato positively correlated with fresh orange intensity (r ¯0.99). Proximate composition of OFSP flour reported by [21] is similar to the results obtained from this study. Fig. 3 shows that protein content of AYB flour is higher than OFSP flour. The higher protein content of AYB flour could be as a result of AYB being a typical legume known for its rich protein content compared to starch-rich foods such as OFSP. However, the carbohydrate content of OFSP flour is higher than that of AYB flour. Bartova and Barta [22] reported that potato is not rich in protein content. According to [23] sweet potato like other tubers is known for its low-fat content. Being a root tuber, potato contains a higher proportion of carbohydrate than legumes such as African yam bean. The proximate composition of OFSP and AYB flour reported in this study is similar to that reported by [24] with some variations which could be attributed to processing methods, agro-ecological conditions, the extent of drying, test methods and laboratory condition as at the time of analyses. Shown in Figure 1 and two is the dough sheet of wheat and composite flour, respectively used for noodle production.

Table 1 depicts the vitamin A content of OFSP and AYB flour. Although OFSP flour contains a lower quantity of most constituents except carbohydrate content based on the result presented in Fig. 3 it is interesting to report that its vitamin A content is higher than that of AYB flour as shown in Table 1. Therefore, consumption of OFSP flour is likely to supply needed quantity of vitamin A to the body especially children who are likely to suffer vitamin A deficiency.

Table 1. Vitamin A (mg/100 g) of orange-fleshed sweet potato and African yam bean flour

Constituent	OFSP flour	AYB flour
Vitamin A	439.80	0.17

Table 2 shows the nutritional composition of five different flour combinations separately used to produce noodles. The results obtained indicate that there was a significant difference at ($P<0.05$) observed between the composite flour samples and control. The moisture content of the samples ranged between 11.40-13.95%. The values are within recommended 15% maximum moisture content for long-term storage of grains [25]. The higher moisture content of flour samples encourages the growth of microorganisms which drastically shortens its shelflife. However, the relatively low moisture content of the flour samples is preferable because it helps to extend its shelflife.

Fig. 1. Dough sheet of wheat flour (control)

Fig. 2. Dough sheet of composite flour

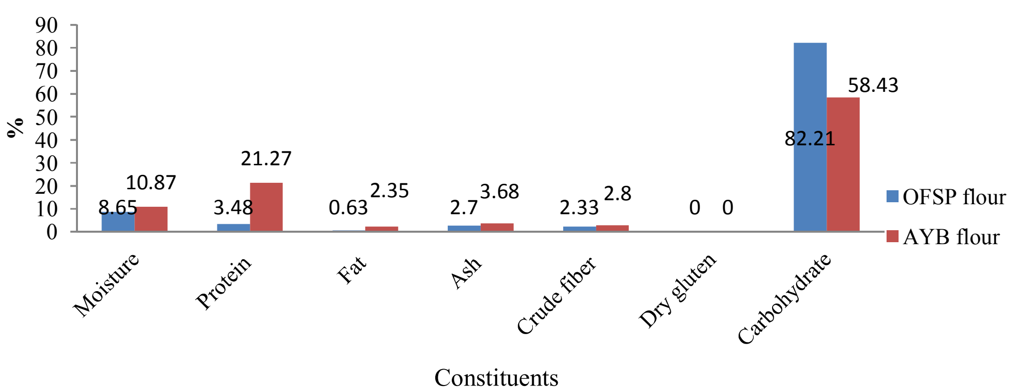

Fig. 3. Proximate composition and gluten content of Orange-fleshed sweet potato (OFSP) and African yam bean (AYB) flour

Results obtained from this study show that ash content of the composite flour and the control ranged between 0.59-1.39% the sample with the highest proportion of AYB (S. *stenocarpa*), sample E (50W+20 OFSP+30 AYB) had the highest ash content. Table 2 shows that ash content of the flour combinations increased as the proportion of AYB flour added to the composite increased. This could be as a result of a high proportion of AYB in the composite flour which is rich in a mineral such as iron, calcium, copper, manganese, and phosphorus. The mineral content of AYB flour is required for human health sustainability [26].

The fat content of the flour samples ranged between 1.41-1.96%. Sample E (50 W+20 OFSP + 30 AYB) and Sample a (100% W) had the highest and lowest fat content 1.96% and 1.41%, respectively. The fat content of the various composite flour combinations is similar to the trend of the ash content of the composite flour samples earlier reported. The higher fat content of Sample E compared with others could be as a result of a high proportion of AYB flour in the composite flour combinations. The fat content of bread made from wheat, potato, and cocoyam ranged between 1.1-1.6% is lower than that of African yam bean [27]. According to [28] flour blended with OFSP flour resulted in low-fat content of the food material.

Table 2 shows there were significant differences ($P<0.05$) in crude protein content of control (100% W) and other composite flour combinations. The values ranged from 11.61-12.85%. The protein content of wheat flour reported by [29,30] is higher than that reported in this study. However, the value reported by [31] in a related study is close to the result obtained from this study. The variations in protein content could be as a result of geographical location, since soil with high nitrogen levels can influence protein content of the grains [32]. Sample E (50 W+20 OFSP+30 AYB) had the highest protein content compared with other composite flour combinations. Therefore, the use of Sample E to produce ready-to-eat noodles could be of immense benefit to many citizens in developing countries like Nigeria who cannot afford processed foods high in protein content. Interestingly, the protein content of the composite flour combinations compared favorably with the control.

The crude fiber content of all the composite flour combinations shown in Table 2 ranged between 2.03-3.16%. The control had the lowest crude fiber content (2.03%) while Sample E (50% W+20% OFSP+30% AYB) had the highest crude fiber content. The results in Table 2 revealed that fiber content of the composite flour samples increased with the increased addition of OFSP flour. This result trend could be as a result of fiber content of orange-fleshed sweet potato [33,13] and African yam bean [34]. According to [35] the high fiber content of foods consumed is important because it reduces bowel disorder and constipation.

The carbohydrate content of composite flour samples including the control varied from 69.23-70.39%. Sample E (50% W+20% OFSP+30% AYB) had the lowest carbohydrate content compared with that of other samples. The difference in carbohydrate contents of the control and composite flour samples could be attributed to differences in their protein, fat, fiber, ash and gluten content. The high carbohydrate content of wheat and OFSP flour could also have contributed significantly to the high carbohydrate content of the composite flour samples. Results obtained from this study revealed that composite flour sample used for noodle production could be considered as a cheap source of energy for the human body.

Gluten content of both the control (100% W) and other composite flour samples ranged from 2.84 to 12.26%. Among all the flour samples, the control and Sample B (80% W+10% OFSP+10% AYB) had the highest and least gluten content, respectively. According to [36], dry gluten content of semolina from North America is 11%. This value is close to the result obtained from this study. The results in Table 2 showed that gluten content of the composite flour samples decreased with increase in the proportion of OFSP and AYB flour in the composite sample. This could be as a result of the absence of gluten in both OFSP and AYB flour.

3.2 Nutritional Composition of Noodle Samples Prepared Using Composite Flour

Table 3 depicts the nutritional composition of noodle samples produced using composite flour that comprises wheat, AYB and OFSP flour in different proportion. Traditional noodle made from wheat, alkaline, salt or without salt is rich in carbohydrates but low in other essential nutrients such as dietary fiber, vitamins, and minerals which are usually lost during flour refinement

Table 2. Nutritional composition of composite flour

Sample code	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrate (%)	Gluten (%)
A	13.95±0.02^{b}	0.59±0.00^{d}	1.41±0.08^{d}	11.61±0.02^{d}	2.03±0.01^{d}	70.39±0.09^{b}	12.26±0.07^{a}
B	12.83±0.01^{b}	0.91±0.00^{c}	1.75±0.03^{b}	11.79±0.01^{c}	2.34±0.03^{c}	70.35±0.07^{b}	12.11±0.07^{a}
C	12.18±0.04^{b}	1.04±0.04^{b}	1.66±0.03^{c}	12.10±0.02^{b}	2.41±0.01^{b}	70.59±0.03^{a}	7.52±0.04^{b}
D	12.41±0.04^{b}	0.57±0.01^{d}	1.82±0.02^{b}	12.12±0.08^{b}	3.10±0.01^{a}	69.96±0.08^{c}	3.97±0.08^{c}
E	11.40±0.01^{b}	1.39±0.01^{a}	1.96±0.05^{a}	12.85±0.03^{a}	3.16±0.06^{a}	69.23±0.09^{d}	2.84±0.04^{d}

Values are means ± SD of triplicate determination. Means in the column with different superscript are significantly different at (P<0.05). A depicts 100% W; B depicts 80% W+10% OFSP+10% AYB; C depicts 70% W+15% OFSP+15% AYB; D depicts 60% W+20% OFSP+20% AYB; E depicts 50% W+20% OFSP+30% AYB
Key: W = Wheat; OFSP = Orange fleshed sweet potato; AYB = African yam bean

Table 3. Nutritional composition of noodle products

Sample code	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrate (%)	Vitamin A (mg/100 g)
A	12.40±0.03^{b}	1.35±0.02^{c}	1.85±0.05^{a}	11.67±0.00^{c}	2.13±0.01^{d}	70.90±0.09^{a}	218.03±0.05^{c}
B	13.24±0.03^{a}	1.49±0.04^{bc}	1.88±0.04^{a}	11.86±0.03^{d}	2.47±0.02^{c}	69.04±0.05^{b}	224.17±0.01^{d}
C	12.61±0.05^{b}	1.83±0.07^{ab}	1.70±0.03^{a}	12.06±0.01^{c}	2.33±0.02^{cd}	69.36±0.08^{b}	248.09±0.01^{c}
D	12.12±0.02^{b}	1.70±0.05^{bc}	1.94±0.05^{a}	12.25±0.04^{b}	2.90±0.01^{b}	69.08±0.06^{b}	261.03±0.05^{b}
E	11.53±0.03^{b}	2.11±0.01^{a}	2.19±0.07^{a}	13.04±0.05^{a}	3.38±0.01^{a}	67.90±0.09^{c}	288.14±0.05^{a}

Values are means ± SD of triplicate determination. Means in the column with different superscript are significantly different at (P<0.05). A depicts 100% W; B depicts 80% W+10% OFSP+10% AYB; C depicts 70% W+15% OFSP+15% AYB; D depicts 60% W+20% OFSP+20% AYB; E depicts 50% W+20% OFSP+30% AYB.
Key: W = Wheat; OFSP = Orange fleshed sweet potato; AYB = African yam bean

[37]. Potentially, animal sources such as egg, dairy products, calf liver as well as sea foods and plant sources such as legumes, cereals, vegetables and vegetable oils can be used to supplement the nutrient loss in traditional noodles [38]. Results depicted in Table 3 show that nutritional composition of noodles prepared from wheat, OFSP and AYB composite flour in different proportion is significantly different (P<0.05) from the wheat noodle (control sample).

The moisture content of noodle samples produced from various composite flour samples ranged from 11.53-13.24%. Generally, the shelf life of edible products including noodles is dependent on its moisture content because of microbial activities in the products which result in spoilage. Among the noodle samples, moisture content 13.24% of Sample B (80% W+10% OFSP+10% AYB) and 11.53% for Sample E (50% W+20% OFSP+30% AYB) is the highest and lowest values, respectively.

Regarding the fat content of the noodle samples, the values obtained in this study is lower than that reported by [39] which ranged between 0.71-8.33%. The wide variation in fat content in both studies could be as a result of ingredients used, processing methods and type of flour used for the noodle production. The relatively low-fat content recorded in the noodle samples is beneficial to human health because it could significantly reduce the rate of cholesterol accumulation in the human body. Related studies revealed that addition of soybean flour to wheat flour increased the fat content of cookies. Similarly, addition of amaranthus flour to buckwheat and addition of cowpea to cocoyam flour for pasta production resulted in increased fat content [40,41,42]. It could be that amaranthus, cowpea, and soybean have higher fat content than some legumes such as AYB.

The results obtained from this study revealed that protein content of noodle samples ranged from 11.67-13.04%. Comparable results were reported from noodles produced from wheat and nettle leaves which results ranged from 9.89-13.40%. Regarding other related flour products such as pasta obtained from wheat, chickpea and defatted soya, the protein content range between 9.17-11.33%. Different researchers reported that protein content of pasta produced from 100% wheat is 11.3%, 11.8%, 11.7%, 11.97%) and macaroni produced from wheat, barley, and soybeans ranged between 9.61-11.51% [43,44,45].

Table 3 shows that dietary fiber of the noodle samples increased as the proportion of OFSP and AYB flour in the composite increased. This could be as a result of higher fiber content of orange-fleshed sweet potato and African yam bean compared with wheat flour [40,43,46]. The crude fiber of the noodle samples ranged from 2.13-3.38%. According to FAO/WHO, the recommended fiber contents of food products consumed by children and adults should not exceed 5%.

Regarding the carbohydrate content of noodle samples produced using composite flour the values were lower than that produced using 100% wheat flour. It could be that addition of OFSP and AYB flour to wheat flour resulted in lower carbohydrate content of noodles produced using the composite flour. Carbohydrate content of all the noodle samples produced ranged from 67.90-70.90%. In a related study [47] reported that carbohydrate content of biscuits reduced with increasing substitution of soybean flour.

This study revealed that vitamin A content of noodle produced from 100% wheat is higher than that produced using wheat, OFSP, and AFB flour composite. It could be that vitamin A content of the noodles increased as the proportion of OFSP flour blended with the composite flour increased. There is an indication that OFSP flour is rich in beta-carotene. In fact, OFSP flour can retain beta-carotene which determines the quantity of vitamin A available in the flour despite being subjected to different processing methods such as blanching and drying as well as different storage conditions. The result from this study is consistent with that of [48,49].

3.3 Cooking time of Noodle Samples Prepared from Composite Flour Formulations

The optimum cooking time of noodles produced using composite flour of different proportion as well as that of 100% wheat flour which is the control is presented in Table 4. The values ranged from 7:33-10:33 minutes. The results show that optimum cooking time for control (100% W) is longer than that of noodles produced using composite flour mixture. Table 4 further revealed that noodle samples prepared using composite flour that contain the highest proportion of OFSP and AYB flour (Sample E) had the shortest cooking time of 7:33 minutes. Chillo [50,51] and [52] reported that optimum cooking time of drum spaghetti was longer than that of base quinoa, broad beans, and chickpea flours. In a related study, the cooking time of noodles reduced with an increase in defatted lupine meal and whole lupine meal in the production of noodles.

Table 4. Cooking properties of noodle products

Sample code	Cooking time (min.)	WAC (%)
A	10.33±0.07[a]	154.87±0.09[a]
B	8.00±0.00[b]	135.83±0.04[c]
C	7.66±0.07[b]	135.32±0.04[c]
D	7.66±0.07[b]	142.36±0.07[b]
E	7.33±0.07[b]	142.84±0.06[b]

Values are means ± SD of triplicate determination. Means in the column with different superscript are significantly different at (P<0.05). A depicts 100% W; B depicts 80% W+10% OFSP+10% AYB; C depicts 70% W+15% OFSP+15% AYB; D depicts 60% W+20% OFSP+20% AYB; E depicts 50% W+20% OFSP+30% AYB

Key: W = Wheat; OFSP = Orange fleshed sweet potato; AYB = African yam bean

3.4 Water Absorption of Noodles Prepared from Composite Flour

Table 4 shows that water absorption capacity (WAC) of the control sample (154.87%) was the highest compared with that of noodles produced using composite flour. Studies conducted by [53] relate decreased WAC to shorter cooking time. Longer cooking time and higher WAC of Sample A noodles (control) compared with that of other samples could be attributed to a higher quantity of cereal starch in the wheat flour. Similar observations were made by [54] for maize-based noodles. The water absorption capacity for extruded snacks prepared from the varied proportion of foxtail millet based composite flour was in the range of 440%, 420%, and 400%, respectively for 70, 60 and 50% of foxtail millet respectively [55].

3.5 Sensory Evaluation of Noodles Prepared from Composite Flour

Presented in Table 5 are the average sensory score of noodle produced from composite flour sample as well as that of 100% wheat. In the present study, it was revealed that average sensory score of the noodle samples based on color reduced with an increased proportion of OFSP and AYB in the composite flour used in producing the noodles. This could be attributed to the deep orange color of potato which affected conventionally accepted and preferred bright yellow translucent appearance of noodles [44].

Regarding aroma, Sample A had the highest score 8.15 compared with that of other noodle samples. Table 5 revealed that no significant difference exists among the noodles produced from different composite flour samples but the sensory scores are significantly different from Sample A (control). Smell is an important and integral part of taste and general acceptability of food before it is put in the mouth [56].

Considering average sensory score based on noodle texture, Table 5 shows that Sample A (control) was most preferred compared with other noodle samples produced from composite flour. This could be as a result of gluten content of flour. In terms of noodle texture, it was observed that average sensory score reduced with increased proportion of OFSP and AYB in the composite flour except that of Sample E. Despite the effect of low gluten content of composite flour used to prepare Sample E, it is interesting to note that average sensory score for texture of Sample E was higher than that of other noodle samples prepared using composite flour. The texture of food is the prevailing structural characteristics considered shortly before the product is consumed. This property will determine if such food is chewable or easily swallowed [57,58]. In a related study [39] reported similar results for noodles produced from cassava/wheat flour as well as that of wheat, ‘acha’ and soybean.

Based on the average sensory score for a taste of the noodle samples, the panelist assigned highest sensory score 8.20 to the control followed by 7.95 for Sample E, while the rest of the samples were comparable. Taste is an important parameter when evaluating sensory attribute of food. The food might be appealing and have a high nutritional composition, but if it does not have a good taste, the product is likely to be unacceptable [56].

Regarding flavor which is generally understood as aroma and taste, the samples were not significantly different at (P<0.05) from the control.

The highest score for flavor 7.9 was assigned to Sample E.

Table 5 revealed that there is no significant difference ($p<0.05$) between the overall acceptability of the control sample and Sample E which was assigned average score 8.35 and 8.30, respectively by the sensory panelist. This was not the case with other noodle samples, which were significantly different from the control and Sample E. Based on the sensory evaluation of all the noodle samples, this study revealed that noodles produced using composite flour compared favourably with the control (wheat noodle) which had already gained popular acceptability as observed in terms of colour, taste, aroma, flavor, and texture. Furthermore, this study has demonstrated that noodles from wheat, OFSP, and AYB flours have good organoleptic acceptability and the flour samples could be used for other products like complementary baby foods and biscuits.

3.6 Assessment of Microbial Quality of Noodles Prepared from Composite Flour

The microbial properties of the noodle products are shown in Table 6. Total bacterial count of the control was observed to be 5.0×10^1 CFU/g while Sample E (50% W+20% OFSP+30% AYB) was 2.0×10^1 CFU/g. Microorganisms were not detected in other noodle samples. The microbial dose of the noodle samples based on total bacterial plate counts was observed to be within acceptable limits set by International microbiological standards recommended units for foods which should be less than 10^3 CFU/g. International Commission for the microbiological specification for foods, [59] states that ready-to-eat foods with plate counts between 0-10^3 CFU/g are acceptable while between 10^4-10^6 CFU/g is tolerable. Ojure and Quadri [46] reported comparable results with that obtained from this study. Microbial count recorded in both the control and Sample E could be as a result of

Table 5. Average sensory score of noodle produced from composite flour sample

Sample code	Taste	Colour	Flavor	Aroma	Texture	Overall acceptability
A (510)	8.20 ± 0.69^a	8.20 ± 0.95^a	7.75 ± 1.16^a	8.15 ± 0.67^a	7.70 ± 1.26^a	8.35 ± 0.93^a
B (511)	7.10 ± 1.11^c	6.75 ± 1.01^b	7.35 ± 0.93^a	7.30 ± 1.26^b	6.60 ± 1.23^b	7.55 ± 0.68^b
C (512)	7.60 ± 0.94^{bc}	7.25 ± 1.06^b	7.60 ± 1.09^a	7.35 ± 0.98^b	6.70 ± 0.92^b	7.60 ± 0.68^b
D (513)	7.25 ± 1.06^c	7.00 ± 1.25^b	7.35 ± 0.98^a	7.00 ± 1.07^b	6.75 ± 1.29^b	7.45 ± 0.99^b
E (514)	7.95 ± 0.51^{ab}	7.30 ± 1.12^b	7.90 ± 0.64^a	7.45 ± 0.82^b	7.05 ± 1.14^{ab}	8.30 ± 0.57^a

Values are means of 20 members sensory panelist score ± SD. Means in the column with different superscript are significantly different at (P<0.05). A depicts 100% W; B depicts 80% W+10% OFSP+10% AYB; C depicts 70% W+15% OFSP+15% AYB; D depicts 60% W+20% OFSP+20% AYB; E depicts 50% W+20% OFSP+30% AYB.
Key: W = Wheat; OFSP = Orange fleshed sweet potato; AYB = African yam bean

Table 6. Microbial analysis of noodles produced from composite flour samples

Sample code	TBC (CFU/g)	TCC (CFU/g)	Y/M (CFU/g)	*Staphylococcus* sp (CFU/g)	*Salmonella* sp (CFU/g)
A	5.0×10^1	ND	ND	ND	ND
B	ND	ND	ND	ND	ND
C	ND	ND	ND	ND	ND
D	ND	ND	ND	ND	ND
E	2.0×10^1	ND	ND	ND	ND

Values are means ± SD of triplicate determination. Means in the column with different superscript are significantly different at (P<0.05). A depicts 100% W; B depicts 80% W+10 % OFSP+10% AYB; C depicts 70% W+15% OFSP+15% AYB; D depicts 60% W+20% OFSP+20 % AYB; E depicts 50% W+20 % OFSP+30% AYB.
Key: W = Wheat; OFSP = Orange fleshed sweet potato; AYB = African yam bean; ND = Not detected; TBC = Total bacterial count (1000 CFU/g, standard); TCC = Total coliform count (10 CFU/g, Standard) Y/M = Yeast/mould (100 CFU/g, standard)

Fig. 4. Noodle sample after drying

improper handling during processing of the product.

4. CONCLUSION

This study has demonstrated that composite flour which comprises of wheat supplemented with orange-fleshed sweet potato and African yam bean flour up to 20% and 30%, respectively used for noodle production resulted in a nutritious and well acceptable instant noodles shown in Fig. 4 above which also meets microbiological criteria. This result could have useful application in noodle industries in Nigeria because the product had comparable quality with conventional noodle produced from 100% wheat flour.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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