QUALITY EVALUATION OF NOODLES PRODUCED FROM UNRIPE PLANTAIN FLOUR USING XANTHAN GUM

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ABSTRACT

This study was conducted in Ogun State, Nigeria to evaluate the quality of noodles produced from unripe plantain flour using xanthan gum. About 25kg of unripe (green) plantain (*Musa paradisiacal normalis)* variety was obtained. The fruits chosen were of grade 1 maturity stage (unripe) and with acceptable appearance for consumption and Xanthan gum were purchased from Chemicals' market. Plantain noodles have ash content (2.40%), moisture content (8.20%), fat content (1.72%), crude fibre (1.62%), carbohydrate content (88.20%), protein content (3.60%), energy value of 345.2 kJ/g and Ph to be 5.8. Mean cooking time for PN3 was 7.62minutes, while that of PN2 is 7.10minutes, PN1 was cooked for 5.10minutes and PNO for 4.5minutes but the branded commercial noodles were cooked for 8.21 and 8.29minutes. Percentage cooking losses for the noodles were 6.60, 7.60, 8.40, 10.40, 6.52 and 6.39 for PN3(Plantain flour with 3.5xantham gum), PN2(Plantain flour with 2.5xantham gum), PN1(Plantain flour with 1.5xantham gum), PN0(Plantain flour without xantham gum), BN1(branded noodles 1) and BN2(branded noodles 2) respectively. PN3, PN2, PN1, PN0, BN1 and BN2 had 124.20, 115.25, 113.50, 105.50, 112.58, 111.30 rate of water absorption respectively. There was significant difference ($p<0.05$) in the colour, starchy mouth coating, stickiness, firmness and smoothness of the cooked samples of noodles. In colour, both branded noodles 1 and 2 were found to have light yellow colour while noodles produced from plantain flour with or without xanthan gum (PNO) had the least colour grey (1.2). In terms of smoothness, the range was 1.5-4.2 but PN3 was found to be very smooth. The range of firmness values was (2.2-4.1) and PN3 was adjudged to be very firm among the noodle samples from plantain flour. The range of values for stickiness was (1.4-4.3), also PN3 was found not to be as sticky as other noodle samples produced from plantain flour. The range of values for starchy mouth feel was (1.6-4.2), moreover, PN3 was found to have the least starch mouth feel. The result showed that there was no significant difference ($p>0.05$) in all the sensory attributes (appearance, flavour, taste, texture and colour) examined among the noodles produced from plantain flours but significant difference ($p<0.05$) existed between the plantain noodle samples and the commercial branded noodles. The range of mean scores for taste was (1.0-4.7), flavour (1.5-4.6), texture (2.0-4.4), colour (1.2-4.2) and acceptability (2.0-4.6). It can therefore be concluded that plantain noodles using 3.5% of xantham gum stand a good product at the end if other products can be incorporated (wheat, soya bean etc), so that attributes like flavor and taste will not only be improved but the product also will be nutritionally balanced.

Keywords: *Nigeria, Xantham gum, Noodles, Sensory attributes.*

1. INTRODUCTION

Plantain *(Musa paradisica)* belongs to the family of banana and is popularly called cooking banana, since it is seldom eaten raw. Banana plants are monocotyledonous perennial and important crops in the tropical and subtropical world regions [29]. They include dessert banana, plantain and cooking bananas. Plantain and cooking bananas are very similar to unripe dessert bananas in exterior appearance, although often larger; the main difference being that the flesh of the plantain is starchy rather than sweet and also requires cooking while dessert bananas are consumed usually as ripe fruits.

In Nigeria plantains and bananas are both important staples and as sources of income for subsistence farm families. There has been increasing trend towards large-scale production of the crop [22] in the traditional humid rainforest production zone, and some emergent production zones are located in the sub-humid areas of South Eastern Nigeria [6].

Presently plantains are of less importance than banana in terms of world trade in the genus but in West and Central Africa about 70 million people are estimated to derive more than one quarter of their food energy requirement from plantains. The plantain fruit is an excellent source of nutrient when eaten as food [21]. Furthermore, plantain has a high carbohydrate content (31g/100g) and low fat content (0.4 g/100g). They are good sources of vitamins and minerals, particularly iron (24 mg/kg), potassium (9.5 mg/kg), calcium (715mg/kg), vitamin A, ascorbic acid, thiamine, riboflavin and niacin. The sodium content (351mg/kg) is low in dietary terms hence recommended for low sodium diets [29]. It is recommended to produce plantain flour from green fruits, since it has high starch content of about 35% on wet weight basis [21].

Noodle products are staple food in many parts of Asia, especially throughout South East Asia. Almost 40% of wheat products in Asian countries are consumed in the form of noodles [8,19]. Traditional noodle is made from simple ingredients (wheat flour, water and salt) can be a complete meal since it contains carbohydrates, protein and trace amount of saturated fatty acids. Besides, noodles are often used as a convenience food due to its simple preparation, low cost and fast cooking characteristics. However, composition of noodles appears to have limited attention and there is little data available on nutritional value of noodle products [31]. Moreover, some reports even claimed that noodle lacks other essential nutritional composition such as dietary fibre, vitamins especially B group vitamins) and minerals which were lost during wheat flour refinement. Thus,this study is to evaluate the quality of noodles produced from unripe plantain flour using xanthan gum.

2. MATERIALS AND METHOD

Materials:

About 25kg of unripe (green) plantain (*Musa paradisiacal normalis)* variety was obtained at Bena farm in Ilese-ijebu, Ogun state. The fruits chosen were of grade 1 maturity stage (unripe) and with acceptable appearance for consumption [9]. Iodised salt and Vegetable oil was purchased from ijebu ode market. Xanthan gum (Grindsted® Xanthan 200, Danisco USA, Inc., New Century, KS) was purchased from Chemicals' market, Lagos State, Nigeria.

Methods:

1. Chemical characterization of unripe plantain fruits

Determination of pH

About 5g of the plantain sample was thoroughly mixed with 50ml of distilled water in a glassware. The pH of the slurry was determined using a digital pH meter (model METTLER DELTA 340) after calibration using pH 4.0 and pH 7.0 buffers.

Determination of moisture content

The moisture content of the plantain was determined according to AOAC (2000) method. 5g of the plantain samples was accurately weighed into an evaporating dish and dried in an oven at 105^{0}C for 3h. The samples were cooled in a dessicator and weighed. The process of heating cooling and weighing was repeated after every 30 minutes interval until a constant weight was obtained. The moisture content was then calculated as follows:

$$\% \text{ moisture content} = \frac{W_1 - W_2}{W_1 - W_0} \times \frac{100}{1}$$

Where:

W_0 = weight of petri dish in grams

W_1 = weight of petri dish in grams and sample before drying

W_2 = weight of petri dish in grams and sample after drying

Determination of crude fibre

About 5g of the sample was weighed into a 500 ml Erlemeyer flask and 100ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes from the time boiling commenced. The flask was removed from the heater, cooled a little and filtered through a 15.0 cm No. 4 Whatman paper. The residue was removed with a spatula and transferred to a porcelain dish. The sample was dried overnight at 150 ^{0}C. After drying, it was transferred to a dessicator and weighed after cooling. It was ashed in a muffle furnace at 500 ^{0}C for 6 hours, allowed to cool and reweighed [2].

$$\% \text{ Crude Fibre} = \frac{W_1 - W_2}{W_0} \times \frac{100}{1}$$

where:

W_1 = Weight of dried sample + dish

W_2 = Weight of dish

W_0 = Weight of sample initially

Determination of ash content

The ash content of the sample was determined by using [2] method. About 5g of the plantain samples was weighed into crucible in triplicate. The sample was placed in the muffle furnace at 550^{0}C until a light grey ash was observed and constant weight obtained. The sample was cooled in the dessicator to avoid absorption of moisture and weighed. The ash content was calculated as follows:

$$\text{Percentage ash content} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

where:
W_2 = Weight of sample and crucible before ashing
W_1 = Weight of sample and crucible after ashing
W = Weight of sample

Determination of Fat content

Fat content was determined using the method described by [2]. 10g of the plantain samples was weighed and wrapped up in a filter paper. It was then placed in the extraction thimble. Fat extraction unit was cleaned, dried in an oven and cooled in the dessicator before weighing. Petroleum ether (25 ml) was measured into the flask and the fat extracted with solvent. After extraction, the solvent was evaporated by drying in the oven. The flask and the content were then cooled in a dessicator and weighed. The fat content was calculated as follows:

$$\% \text{ Fat Content} = \frac{X - Y}{Z} \times \frac{100}{1}$$

where:
X = Weight of fat + flask
Y = Weight of flask
Z = Weight of sample

Determination of crude protein

The protein content determination of the samples were carried out using micro kjedhal method as described by [2] which consists of wet digestion, distillation and titration. The protein content was determined by weighing 3g of sample into boiling tube with 25ml concentrated sulphuric acid and one catalyst tablet (5g K_2SO_4, 0.15g $CUSO_4$, 0.15g T_1O_2). They were heated at low temperature for digestion to take place. The digest was diluted with 100 ml of distilled water , 10 ml of 40% NaOH and 5 ml of $Na_2S_2O_3$ anti-bumping agent were added, after which the component was diluted into 10 ml of Boric acid.

$$\% \text{ Protein} = \frac{(\text{Actual Titre Value} - \text{Titre of Blank}) \times 0.1\text{N of HCl} \times 0.014 \times \text{Conversion Factor} \times 100}{\text{Weight of Sample}}$$

Determination of Total carbohydrate content

The total carbohydrate content was determined by difference between 100 and total sum of the percentage of fat, moisture, ash, crude fibre and protein content [2].

2. Processing mature unripe plantain fruits into flour.

Plantain flour was produced by adopting the method of [9] as shown in fig.1. The plantain fruits were washed, peeled and sliced to about 5 mm diameter using a slicer. The slices were steamed for 15 min to inactivate enzymes. The pulp was drained and dried in a cabinet drier at 60°C for 24 h. After which the dried plantain slices was milled into flour. The flour was screened through a 0.25 mm sieve and packed in high density polyethylene (HDPE) until use.

Mature green plantain
↓
Washing
↓
Peeling
↓
Slicing (5mm)
↓
Blanching
↓
Drying (60^0 for 24hr)
↓
Dry milling (hammer mill)
↓
Screening (0.25mm)
↓
Plantain flour

Figure 3: Flow chart for production of plantain flour

3. Analyses of unripe plantain flours

Physical Analyses

Percentage yield and Pulp to Peel ratio of plantain flours

The percentage yield of the plantain flours was measured as the weight of final sample obtained over the total weight of the plantain sample multiplied by 100.

$$\frac{\text{Final weight of sample}}{\text{Total weight of plantain}} \times 100$$

Pulp ⁄ peel Ratio

Total weight of fingers (pulp + peel) = W_1
Weight of pulp = W_2
Weight of peel = W_3
% of pulp in fingers (W_4) = W_2 x 100 ⁄ W_1
% of peel in fingers (W_5) = W_3 x 100 ⁄ W_1
Pulp ⁄ peel ratio = W_4 ⁄ W_5

4. Nutritional Composition

Determination of moisture content

The moisture content of the plantain was determined according to [3] method. 5g of the plantain samples was accurately weighed into an evaporating dish and dried in an oven at 105^0C for 3h. The samples were cooled in a dessicator and weighed. The process of heating cooling and weighing was repeated after every 30 minutes interval until a constant weight was obtained. The moisture content was then calculated as follows:

$$\% \text{ moisture content} = \frac{W_1 - W_2}{W_1 - W_0} \times \frac{100}{1}$$

Where:

W_0 = weight of petri dish in grams
W_1 = weight of petri dish in grams and sample before drying
W_2 = weight of petri dish in grams and sample after drying

Determination of crude fibre

About 5g of the sample was weighed into a 500 ml Erlemeyer flask and 100ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes from the time boiling commenced. The flask was removed from the heater, cooled a little and filtered through a 15.0 cm No. 4 Whatman paper. The residue was removed with a spatula and transferred to a porcelain dish. The sample was dried overnight at 150 ^{0}C. After drying, it was transferred to a dessicator and weighed after cooling. It was ashed in a muffle furnace at 500 ^{0}C for 6 hours, allowed to cool and reweighed [2].

$$\% \text{ Crude Fibre} = \frac{W_1 - W_2}{W_0} \times \frac{100}{1}$$

where:

W_1 = Weight of dried sample + dish
W_2 = Weight of dish
W_0 = Weight of sample initially

Determination of ash content

The ash content of the sample was determined by using [2] method. About 5g of the plantain samples was weighed into crucible in triplicate. The sample was placed in the muffle furnace at 550^0C until a light grey ash was observed and constant weight obtained. The sample was cooled in the dessicator to avoid absorption of moisture and weighed. The ash content was calculated as follows:

$$\text{Percentage ash content} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

where: W_2 = Weight of sample and crucible before ashing
W_1 = Weight of sample and crucible after ashing
W = Weight of sample

Determination of Fat content

Fat content was determined using the method described by AOAC [2]. 10g of the plantain samples was weighed and wrapped up in a filter paper. It was then placed in the extraction thimble. Fat extraction unit was cleaned, dried in an oven and cooled in the dessicator before weighing. Petroleum ether (25 ml) was measured into the flask and the fat extracted with solvent. After extraction, the solvent was evaporated by drying in the oven. The flask and the content were then cooled in a dessicator and weighed. The fat content was calculated as follows:

$$\%\ \text{Fat Content} = \frac{X - Y}{Z} \times \frac{100}{1}$$

where:
X = Weight of fat + flask
Y = Weight of flask
Z = Weight of sample

Determination of protein

The protein content determination of the samples were carried out using micro kjedhal method as described by [2] which consists of wet digestion, distillation and titration. The protein content was determined by weighing 3g of sample into boiling tube with 25ml concentrated sulphuric acid and one catalyst tablet (5g K_2SO_4, 0.15g $CUSO_4$, 0.15g T_1O_2). They were heated at low temperature for digestion to take place. The digest was diluted with 100 ml of distilled water , 10 ml of 40% NaOH and 5 ml of $Na_2S_2O_3$ anti-bumping agent were added, after which the component was diluted into 10 ml of Boric acid.

$$\%\ \text{Protein} = \frac{(\text{Actual Titre Value} - \text{Titre of Blank}) \times 0.1\text{N of HCl} \times 0.014 \times \text{Conversion Factor} \times 100}{\text{Weight of Sample}}$$

5. Processing of plantain flour into noodles

The noodle sample will be produced as shown in the fig.5 below. Plantain noodle was produced by adopting the method of [20] with slight modification. 200g of organic and inorganic plantain flours were separately mixed with 130ml distilled water, 0.3% NaCl, 5ml vegetable oil (GOYA en Espana, Sevilla Spain) and 2.5-3.5% xanthan gum (Grindsted® Xanthan 200, Danisco USA, Inc., New Century, KS). The resultant dough was kneaded with hand for 5mins and allowed to rest for 20mins, then folded and sheeted through a noodle machine (VillaWare classic Italian Kichenware, Cleveland, OH) with the gap set at 4 (plate 5). The sheet was cut into strips (plate 6). The noodle strips were dried in the cabinet dryer at 60^{o}C for 12hrs, packed and sealed in high density polyethylene film and kept for further analyses (plates 7 and 8).

Plantain flour noodles were produced using the method of Nagao [20] with slight modification as shown in figure2

Plantain flour (200g flour/150ml distilled water)
↓
Mixing (0.2-5% NaCl, 0.3-4%Oil, 0.02-3%emulsifier)
Kneading
↓
Resting (20mins.)
↓
Sheeting
↓
Rolling
↓
Cutting in sizes
↓
Drying (39^{0}C for 6-8hrs)
↓
Dried Noodles

Fig. 4: Processing unripe plantain flour into noodles (Nagao,1996)

6. Analyses of noodles produced from unripe plantain flours

Nutritional Composition

Determination of moisture content

The moisture content of the plantain was determined according to [3] method. 5g of the plantain samples was accurately weighed into an evaporating dish and dried in an oven at 105^{0}C for 3h. The samples were cooled in a dessicator and weighed. The process of heating cooling and weighing was repeated after every 30 minutes interval until a constant weight was obtained. The moisture content was then calculated as follows:

$$\%\ \text{moisture content} = \frac{W_1 - W_2 x}{\quad} \quad \frac{100}{\quad}$$

$$W_1 - W_0 \qquad 1$$

Where:

W_0 = weight of petri dish in grams

W_1 = weight of petri dish in grams and sample before drying

W_2 = weight of petri dish in grams and sample after drying

Determination of crude fibre

About 5g of the sample was weighed into a 500 ml Erlemeyer flask and 100ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes from the time boiling commenced. The flask was removed from the heater, cooled a little and filtered through a 15.0 cm No. 4 Whatman paper. The residue was removed with a spatula and transferred to a porcelain dish. The sample was dried overnight at 150 ^{0}C. After drying, it was transferred to a dessicator and weighed after cooling. It was ashed in a muffle furnace at 500 ^{0}C for 6 hours, allowed to cool and reweighed [2].

$$\% \text{ Crude Fibre} = \frac{W_1 - W_2}{W_0} \times \frac{100}{1}$$

where:

W_1 = Weight of dried sample + dish

W_2 = Weight of dish

W_0 = Weight of sample initially

Determination of ash content

The ash content of the sample was determined by using [2] method. About 5g of the plantain samples was weighed into crucible in triplicate. The sample was placed in the muffle furnace at 550^{0}C until a light grey ash was observed and constant weight obtained. The sample was cooled in the dessicator to avoid absorption of moisture and weighed. The ash content was calculated as follows:

$$\text{Percentage ash content} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

where:

W_2 = Weight of sample and crucible before ashing

W_1 = Weight of sample and crucible after ashing

W = Weight of sample

Determination of Fat content

Fat content was determined using the method described by [2]. 10g of the plantain samples was weighed and wrapped up in a filter paper. It was then placed in the extraction thimble. Fat extraction unit was cleaned, dried in an oven and cooled in the dessicator before weighing. Petroleum ether (25 ml) was measured into the flask and the fat extracted with solvent. After extraction, the solvent was evaporated by drying in the oven. The flask and the content were then cooled in a dessicator and weighed. The fat content was calculated as follows:

$$\% \text{ Fat Content} = \frac{X - Y}{Z} \times \frac{100}{1}$$

where:

X = Weight of fat + flask

Y = Weight of flask

Z = Weight of sample

Determination of protein

The protein content determination of the samples were carried out using micro kjedhal method as described by [2] which consists of wet digestion, distillation and titration. The protein content was determined by weighing 3g of sample into boiling tube with 25ml concentrated sulphuric acid and one catalyst tablet (5g K_2SO_4, 0.15g $CUSO_4$, 0.15g T_1O_2). They were heated at low temperature for digestion to take place. The digest was diluted with 100 ml of distilled water, 10 ml of 40% NaOH and 5 ml of $Na_2S_2O_3$ anti-bumping agent were added, after which the component was diluted into 10 ml of Boric acid.

$$\% \text{ Protein} = \frac{(\text{Actual Titre Value} - \text{Titre of Blank}) \times 0.1\text{N of HCl} \times 0.014 \times \text{Conversion Factor} \times 100}{\text{Weight of Sample}}$$

Determination of Quality attributes of Noodles

Cooking characteristics

Cooking time

About 10g of noodles was cooked in 300ml of deionised water in a covered 500ml beaker. Cooking time was determined by the removal of a piece of noodle every 2mins and pressing the noodle between 2 pieces of watch glasses. Optimum cooking was achieved when the center of the noodles became transparent or when the noodle was fully hydrated. Cooking was stopped by rinsing briefly in deionised water [1].

Cooking loss

Approximately 10g noodles were cooked in 300mL of distilled water in a 500 mL beaker until the central opaque core in the noodle strand disappeared. Cooking loss (%) was measured by transferring the cook water to a pre-weighed beaker and evaporating the water in a conventional oven overnight at 100℃, then reweighing the beaker with left over solids. Cooking quality analysis was performed in triplicate [1].

Cooking Loss (%) = (dried residue in cooking water/noodle weight before cooking**)×**100

Water absorption

Water absorption (%) is the difference in weight of cooked noodles and uncooked noodles, expressed as the percentage of the weight of uncooked noodles. Cooked noodles were rinsed with water and drained for 30seconds then weighed to determine the gain in weight. This analysis indicates the amount of water absorbed by the noodles during cooking process [1].

Sensory evaluation of plantain noodles

Sensory evaluation was conducted by the Method described by Bhat and Sharma, (1989). Samples were presented to a panel of 10 trained judges selected from Departments of Nutrition and Dietetics, Ogun State College of Health Technology, Ilese-ijebu, Ogun State, Nigeria.

Descriptive profiling

Organoleptic characteristics of the dried and cooked noodles were assessed by descriptive sensory profile on colour, roughness, firmness, stickiness and starchy mouth coating using a 5-point attribute scale formulated by the 10 trained judges. Also, appearance, taste, colour, aroma and texture were evaluated.

Overall acceptability

Overall acceptability of the noodles was evaluated by 10 panelists to indicate their preference for the samples on a nine point hedonic scale, where 1 and 9 represent dislike extremely and like extremely respectively.

Statistical analysis

Data obtained in this research work were subjected to Student t- test (used to measure the significant level of differences observed in the case of small samples) and ANOVA and the means of values were separated by Duncan range test using SPSS software (16.0 version) where necessary.

3. RESULTS AND DISCUSSION

This section shows the result obtained from unripe plantain processed into noodles with certain amount of xantham gum used as a binder.

Chemical Composition of fresh plantain pulp, plantain flour and noodles

Table 2 shows the data on the chemical composition of the fresh plantain pulp. The table shows that the fresh pulp of plantain has ash content (1.8%), moisture content (68.5%), fat content (1.22%), crude fibre (0.8%), carbohydrate content (29.2%), protein content (2.40%).

It also shows the chemical composition of the plantain flour. The plantain flour had ash content (2.20%), moisture content (8.80%), fat content (1.35%), crude fibre (1.40%), carbohydrate content (89.5%), protein content (3.40%). Table 2 shows the chemical composition of plantain noodles. The result showed that the plantain flour has ash content (2.40%), moisture content (8.20%), fat content (1.72%), crude fibre (1.62%), carbohydrate content (88.20%), protein content (3.60%).

Microbiological properties of plantain flour, plantain noodles

The microbiological nmproperties of the plantain flour are presented on table 3. Total plate count of the plantain flour was observed to be 2.1×10^2cfu/g and fungal count was observed to be 1.1×10^2cfu/g. No coliform or staphylococcus was detected in the plantain flour.

The microbiological properties of plantain noodles are presented on table 3. Total plate count, fungi count, coliform count and staphylococcal were not detected in both samples of plantain noodles.

Cooking characteristics of plantain and branded noodles

Table 4 shows the mean values of the cooking characteristics of plantain and branded noodles and the variables considered includes cooking time, cooking loss and water absorption. Various combination of plantain noodles and xantham gum in different proportions were used, plantain noodles with 3.5% xantham gum was tagged PN3, PNO is plantain noodles without xanthan gum, PN2 is plantain noodles with 2.5% xanthan gum, PN1 is Plantain noodles with 1.5% xanthan gum and also some branded commercial noodles were used as control and tagged BN1 and BN2. Mean cooking time for PN3 was 7.62minutes, while that of PN2 is 7.10minutes, PN1 was cooked for 5.10minutes and PNO for 4.5minutes but the branded commercial noodles were cooked for 8.21 and 8.29minutes. Percentage cooking losses for the noodles were 6.60, 7.60, 8.40, 10.40, 6.52 and 6.39 for PN3, PN2, PN1, PN0, BN1 and BN2 respectively. The percentage rate of water absorption is shown on table 4, it shows that PN3, PN2, PN1, PN0, BN1 and BN2 had 124.20, 115.25, 113.50, 105.50, 112.58, 111.30 rate of water absorption respectively.

PNO: Plantain noodles without xanthan gum
PN3: Plantain noodles with 3.5% xanthan gum
PN2: Plantain noodles with 2.5% xanthan gum
PN1: Plantain noodles with 1.5% xanthan gum
BN1: Branded commercial noodle1
BN2: Branded commercial noodle2

Table 2: Chemical Composition of fresh plantain pulp, plantain flour and plantain noodles

Parameters (%)	Fresh plantain pulp	Plantain flour	Plantain noodles
Moisture content	68.5 ± 1.2	8.80 ± 0.6	8.20 ± 0.2
Ash	1.80 ± 0.3	2.20 ± 0.4	2.40 ± 0.1
Fat	1.22 ± 0.4	1.35 ± 0.2	1.72 ± 0.2
Crude protein	2.40 ± 0.2	3.40 ± 0.4	3.60 ± 0.4
Crude fibre	0.80 ± 0.2	1.40 ± 0.1	1.62 ± 0.1
Carbohydrate	29.2 ± 0.2	89.5 ± 0.2	88.20 ± 0.2
Energy (kJ/g)	125.8 ± 0.4	361.2 ± 0.4	345.2 ± 0.4
PH	-	6.10± 0.1	5.8± 0.1

Results are expressed as mean values and standard deviation of three replicates

Table 3: Microbiological composition of Plantain Flour and plantain noodles

Parameters (cfu/g)	Plantain flour	Plantain noodles
Total plate count	$2.1 \times 10^2 \pm 0.01$	ND
Fungi count	$1.1 \times 10^2 \pm 0.00$	ND
Coliform count	ND	ND
Staphylococcal count	ND	ND

Results are expressed as mean values and standard deviation of three replicates
ND – Not detected

Table 4: Mean values of the cooking characteristics of plantain and branded noodles

Noodle Samples	Cooking Time (mins.)	Cooking Loss (%)	Water Absorption (%)
PN3	7.62 ± 0.01^d	6.60 ± 0.02^c	124.20 ± 0.01^f
PN2	7.10 ± 0.10^c	7.60 ± 0.01^d	115.25 ± 0.01^e
PN1	5.10 ± 0.10^b	8.40 ± 0.01^e	113.50 ± 0.01^d
PNO	4.5 ± 0.10^a	10.40 ± 0.01^f	105.50 ± 0.01^a
BN1	8.21 ± 0.05^e	6.52 ± 0.02^b	$112.58. \pm 0.01^c$
BN2	8.29 ± 0.04^f	6.39 ± 0.04^a	111.30 ± 0.10^b

Results are expressed as mean values and standard deviation of three replicates

Sensory attributes of noodles

Fig. 4 represents the Spider web plot of the sensory attributes of colour, starchy mouth coating, firmness and smoothness of the cooked samples of noodles. There was significant difference ($p<0.05$) in the colour, starchy mouth coating, stickiness, firmness and smoothness of the cooked samples of noodles and also among the samples of noodles produced from plantain flours. In colour, both branded noodles 1 and 2 were found to have light yellow colour while noodles produced from plantain flour with without xanthan gum (PNO) had the least colour grey (1.2). In terms of smoothness, the range was 1.5-4.2 and among the samples of noodles produced from plantain flour, PN3 was found to be very smooth. The range of firmness values was (2.2-4.1) and PN3 was adjudged to be very firm among the noodle samples from plantain flour. The range of values for stickiness was (1.4-4.3), also PN3 was found not to be as sticky as other noodle samples produced from plantain flour. The range of values for starchy mouth feel was (1.6-4.2), moreover, PN3 was found to have the least starch mouth feel.

Fig 5 represents the Spider web plot of acceptability test of cooked plantain and branded noodles**.** The result showed that there was no significant difference ($p>0.05$) in all the sensory attributes (appearance, flavour, taste, texture and colour) examined among the noodles produced from plantain flours but significant difference ($p<0.05$) existed between the plantain noodle samples and the commercial branded noodles. The range of mean scores for taste was (1.0-4.7), flavour (1.5-4.6), texture (2.0-4.4), colour (1.2-4.2) and acceptability (2.0-4.6).

The mean scores of the acceptability test of cooked plantain and branded noodles are shown in Fig 6**.** The result showed that there was significant difference ($p<0.05$) in all the sensory attributes (appearance, flavour, taste, texture and colour) examined among the noodles produced from plantain flours with different levels of xanthan gum and the commercial branded noodles. The range of mean scores for appearance was (5.8-7.2) but the apperance of PN3 was preferred to all other samples made from plantain flour while PNO is the least, flavour (5.6-7.2) and PN3 flavour was preferred to other samples, taste (5.0-6.4) but PN0 and PN1 had the taste that was least while majority preferred the taste of PN3, texture (4.6-7.2) and PN3 texture was the best when rated, colour (5.8-6.2) with PN3 having highest number and acceptability (4.8-7.0). The result showed that PN3 was preferred among all the noodles sample made from plantain flour and among all the samples of noodles, the BN1 and BN2 were preferred but PN3 compared favourably with the branded noodles.

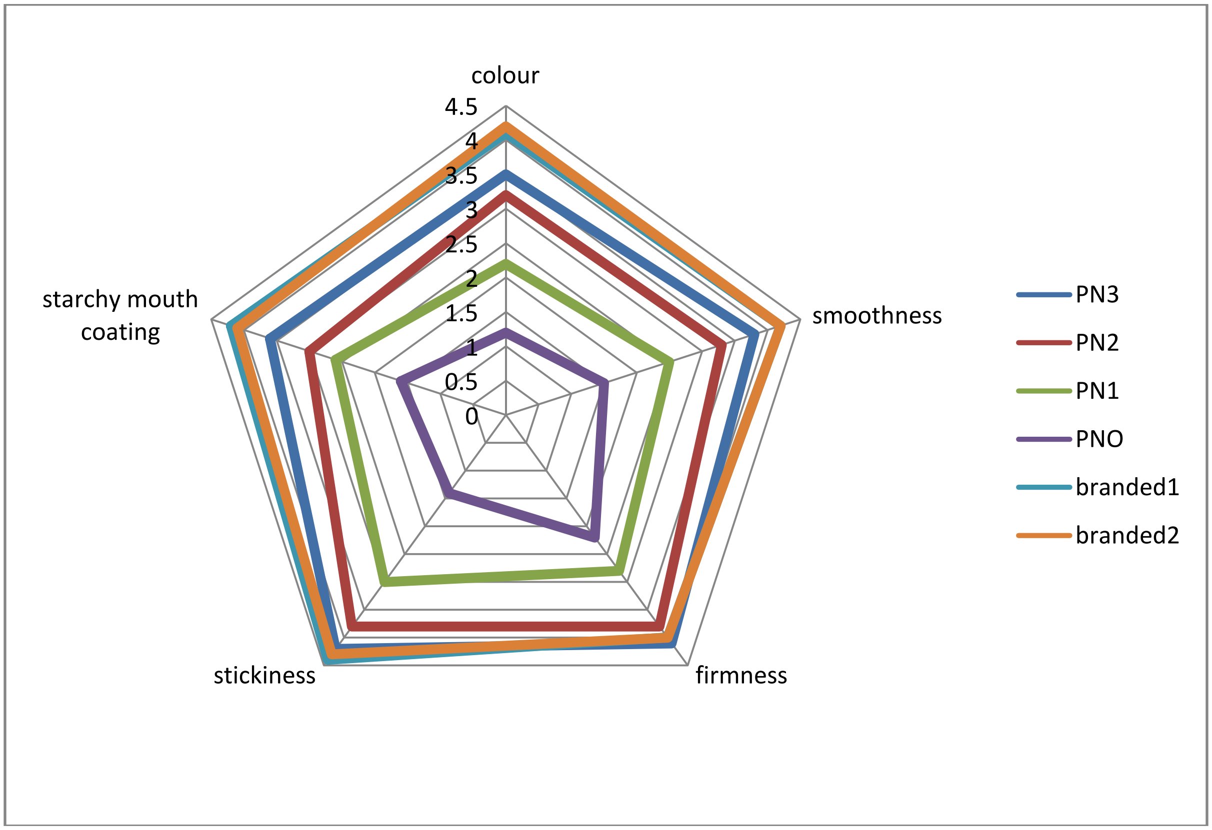

Fig. 4: Spider Web Plot on Sensory Descriptive profiling of cooked plantain and branded noodles

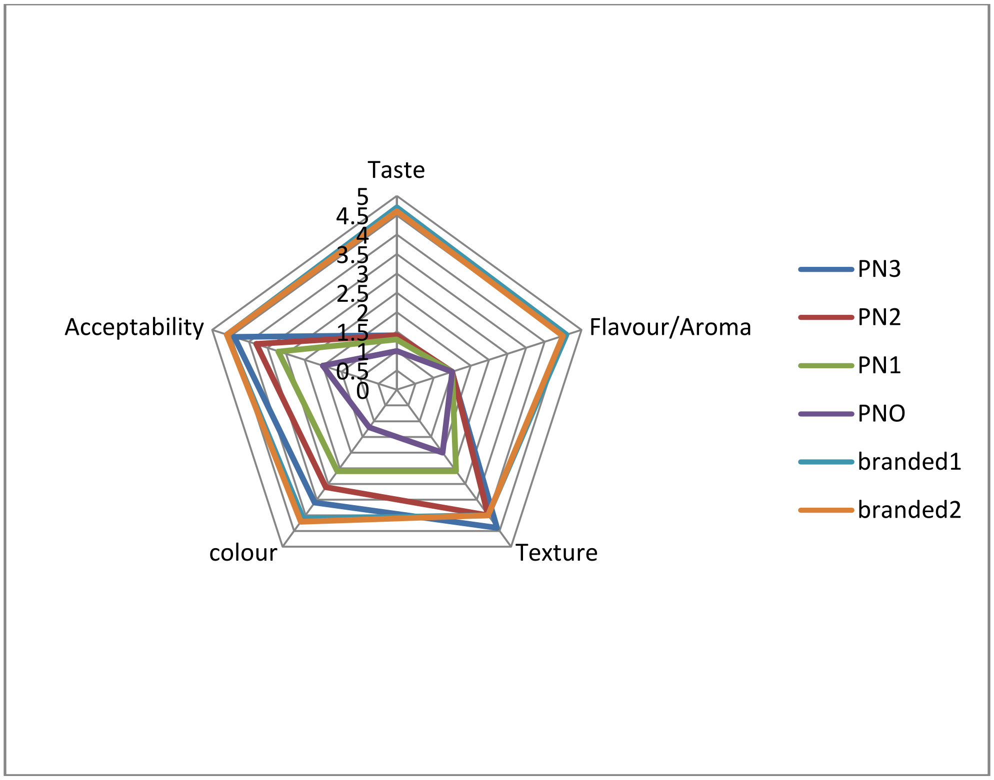

Fig 5: The mean values of acceptablity of cooked noodles

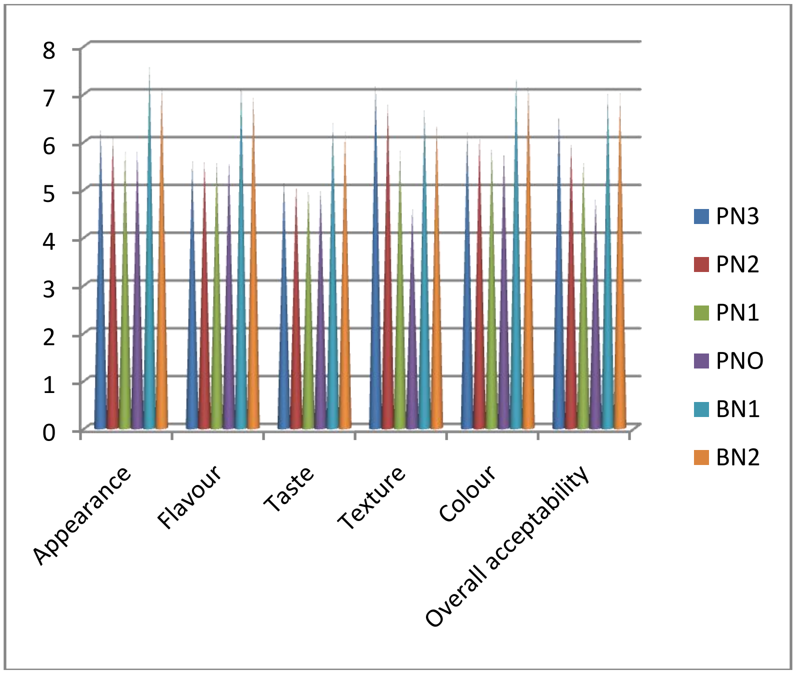

Fig 6: The mean values of acceptablity of noodles

4. DISCUSSION

The plantain is extensively produced in Africa, the Caribbean and Latin America [5]. New economical strategy to increase utilization of plantain includes the production of plantain flour when the fruit is unripe, and to incorporate the flour into various innovative products such as slowly digestible cookies [4], high-fiber bread and edible films. The clear advantage presented by green plantain flour includes a high total starch; resistant starch and dietary fiber content [13]. Due to the high content of these functional ingredients, regular consumption of green plantain flour can be expected to confer beneficial health benefits for human [25]. It would be possible to utilize the green pulp as a functional ingredient in starch-rich products such as the noodles [26].

Traditional noodle made from simple ingredients (plantain flour, water and salt) can be a complete meal since it contains carbohydrates, protein and trace amount of saturated fatty acids. Besides, noodles are often used as a convenience food due to its simple preparation, low cost and fast cooking characteristics. However, composition of noodles appears to have limited attention and there is little data available on nutritional value of noodle products [31]. Moreover, some reports even claimed that noodle is lack of other essential nutritional composition such as dietary fibre, vitamins (especially B group vitamins) and minerals which were lost during processing. Thus, this work evaluates the quality of noodles produced from unripe plantain flour using xanthan gum.

The results of the chemical analysis indicate that the chemical composition for plantain vary in proportion to their maturity. Hence, Unripe plantain flour can be used as a composite flour in baking industry and can be better stored because of its low moisture contents (8.80%) compared to that ripe plantain flour which had high moisture contents thereby limiting its usage in food industry.

Quality of noodle is evaluated in term of colour [17], texture [25] and cooking characteristic [23]. Qualities of the noodles are determined by the raw materials, ingredients and process technology in which starch and protein play the major roles. Plantain noodles produced in this study were considered different from noodles that are typically produced in the industry. These plantain noodles were grey in color, and had distinctive banana aroma. Noodles were cooked in the same way as might be done by a normal consumer in the home.

The result reflected that plantain noodles are a good source of energy because the flour contains 361.2 kJ/g while the plantain noodles contain 345.2 kJ/g of energy. The implication is that plantain noodles will be a good source of food for all individuals in need of more steady energy and it is line with the study of [7], on utilization of matured green banana (*musa paradisiaca var. awak*) flour and oat beta glucan as fibre ingredients in noodles that reported 340kJ/g. Percentage of fibre was found to 1.62 in plantain noodles and fibre is a food material that resists the hydrolysis by alimentary tract enzymes but form viscous solution and will be highly fermented by microflora in human large intestine. Fibre mainly consists of β-glucan, pectins and variety source of gums [12]. By forming a viscous gel matrix, soluble fibre has been shown to be able to bind bile salts which may reduce blood cholesterol levels. It also may slow the absorption of glucose from the intestine, thereby requiring less insulin secretion. Therefore, fibre is effective in delay gastric emptying [12], reducing serum cholesterol [10], insulin contents and prostprandial blood glucose in human body. Consequently, help to reduce the risk of colon cancer, diverticulosis diabetes and coronary heart disease.

The protein content of plantain noodles in this study were low (3.60%) when compared with that of the noodles made from cassava with certain proportion of wheat and soya bean as reported by [27] in the study "Production of instant cassava noodles" . Other researches have been carried out by incorporating legume flour [10] and barley flour enriched with β-glucan [15] in the production of pasta and noodle products. Besides, Collado and Corke (1996) also reported that sweet potato, potato and waxy corn have been used to improve eating quality of white salted noodle (WSN) is common practice in Japan. There may be a need to add other products like soya bean in subsequent noodles that may be produced with plantain to enhance or improve the protein content of the noodles since protein according to Webmd (2012), helps in building and repairing of tissues. Protein makes enzymes, hormones, and other body chemicals and also an important building block of bones, muscles, cartilage, skin, and blood. Plantain noodles with different concentration of xantham gum contain little amount of fat (1.72%) which may be another good attribute of this product because of the low lipid and high energy value, plantain noodles are recommended for obese and geriatric patients (10). Plantain noodles are useful for persons with peptic ulcer, for treatment of infant diarrhea, in celiac disease and in colitis . Many studies proven that plantain noodles was anti-ulcerogenic against aspirin-induced ulceration and was effective in prophylactic treatment and in healing ulcers (Dunjic *et al.*, 1993).

The moisture content of noodles did not exceed the level of 8.20%, and the minimal cooking time from 4.5 to 7.62 minutes which deviates totally from the study of [9]. The diameter of noodles samples after cooking was similar, which implies that none of the ingredients even xantham gum does not have any effect on the weight of the noodles. The result reflected sample with more xantam gum having longer cooking time with lowest cooking loss, though the effect of xantham gum on the cooking time and loss has not been evaluated but after each time of cooking, the plantain noodles with 3.5% xantham gum were characterised by the statistically significantly lower cooking losses than the noodles with less xantham gum. Cooking losses are one of the main parameters taken into consideration during the assessment of pasta quality [9]. The result showed less cooking losses in a sample of noodles with more xantham gum but with higher water absorption.

Sensory attributes of colour, starchy mouth coating, firmness and smoothness of the cooked samples of noodles showed a significant difference ($p<0.05$). There was significant difference ($p<0.05$) in the colour, starchy mouth coating, stickiness, firmness and smoothness of the cooked samples of noodles and also among the samples of noodles produced from plantain

flours. In colour, both branded noodles 1 and 2 were found to have light yellow colour while noodles produced from plantain flour with or without xanthan gum (PNO) had the least colour grey, it was reported by [16] that the colour of noodle is one the most important quality parameter perceived by consumer. Each type of noodle has its own unique colour and the preference varies with the region [28]. The colour grey of all the samples (PNO, PN1, PN2 and PN3) was different from that of the commercially branded noodles and the one reported by [15].
Texture is one of the critical characteristics in quality evaluation of noodle. Elasticity, adhesiveness and firmness are the main parameters that are measured in texture evaluation of noodle [8,18]. In Japan, noodle should be smooth, soft and elastic in texture while noodle with firmer texture is preferred in China and Korea [18]. Though all the samples with xantham gum are fair considering firmness, smoothness and stickiness of the noodles but PN3 compete favourably with the commercially branded noodles. The result also showed significant difference ($p<0.05$) in all the sensory attributes (appearance, flavour, taste, texture and colour) examined among the noodles produced from plantain flours with different levels of xanthan gum and the commercial branded noodles, PN3 was rated high for appearance, texture, colour and acceptability alongside the branded noodles except for taste and flavour that was rated low which may be due to the fact that it is blanched and there is need to include more ingredient to enhance the flavor and taste. It can therefore be concluded that plantain noodles using 3.5% of xantham gum stand a good product at the end if other products can be incorporated (wheat, soya bean etc), so that attributes like flavor and taste will not only be improved but the product also will be nutritionally balanced.

5. CONCLUSION

The results of the study suggest that temperature and pretreatment have an impact on the air drying characteristics and some functional properties of the plantain flour. As expected the increase in drying temperature resulted in an increase in drying rate and the blanching of the product also bleaches some of the nutrient content of product. The moisture diffusivity values were affected by the pretreatments as well as temperature as they increased with increasing temperature for all pretreatments. The chemical composition of plantain pulp when compared with the flour showed high moisture content with less carbohydrate which means most of the water content were lost during processing whereby increasing the energy level.

The proximate analysis of the noodles showed a high carbohydrate content with more fibre and low water content when compared with plantain flour. The implication is that temperature and treatment can be varied to produce the desired moisture content for a particular usage. Plantain noodles with different xantham gum combination and the branded noodles used as control exhibit variable characteristics for cooking characteristics, sensory descriptive profiling and the acceptability test carried out on the noodles. Desirable cooking time increase with the amount of xantham gum in the noodles with lower cooking losses in that order and higher absorption rate but when compared with the branded noodles, it showed that desirable cooking time increase with low losses and rate of absorption is also low, the implication is that apart from absorption power of plantain flour, xantham gum also affects it. The sensory and acceptability test showed that the plantain noodles with 3.5% xantham gum compete favourably with the branded noodles for all the factors considered except for flavor and taste that need more improvement.
From this work, it can be concluded that instant noodles produced from plantain flour with different proportion of xantham gum were different from each other. It was observed that as xantham gum in the noodle samples increased, there was an improvement in their smoothness, firmness, stickiness and starchy mouth coating for the Descriptive analysis of cooked noodles while acceptability test for cooked noodles also buttress the fact because samples with more xantham gum were choose to be better in colour and texture. The noodle sample with 3.5% xanthan gum was highly accepted closely followed by noodle samples with 2.5% xanthan gum but the taste and flavour of the samples has to be improved because the rating was very low compared to that of branded noodles used as control.

6. RECOMMENDATIONS

Based on the work of this study, the following recommendations are neccessary :

I. Thickness of plantain slices would need to be differentiated in other to find out the optimum drying rate and its effect on the thin layer modeling of the drying process.
II. There is need to determine the effect of xantham gum on the proximate composition of plantain flour by determining the chemical composition of xantham gum itself, so that it will assist in knowing the relationship and the amount of xantham gum that will give the best result when producing plantain noodles.
III. Incorporation of other food products like soybean and wheat in little proportion is necessary to boost the protein content of the product, so that it will be a food product that supplies all classes of nutrients in right proportion.
IV. Taste and flavor of food determines the acceptability of that food product, more effort should be annexed towards improving the taste and flavor of the product by adding more ingredients to supplements for the loss during processing and to enhance the quality of that unripe plantain used putting into consideration the amount that will not pose any threat to the outcome of the product.

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