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Evaluation of the breakfast cereal produced from maize and African yam bean composite flour enriched with purple joy leaf powder

Nwanagba NL[1], Obeta NA[2], Obi UA[3], Oga M[4]
[1] Department of Food Science and Technology, Michael Okpara. University of Agriculture, Umudike, Abia State, Nigeria
[2] Department of Food Science and Technology, University of Nigeria Nsukka, Nigeria
[3] Department of Home Sciences, Michael Okpara. University of Agriculture, Umudike, Abia State, Nigeria

Abstract
Breakfast cereal produced from maize and African yam bean composite flour enriched with purple joy leaf powder was evaluated. Five samples were generated by mixing different proportions of maize and African yam bean flour with the same quantity of purple joy leaf powder in the following manner, (90:10:0, 80:15:5, 70:25:5, 60:35:5. 50:45:5). These five samples were subjected to vitamins and sensory analyses. The vitamin composition results showed that vitamin A ranged from 202.390 to 321.920mg/100g, B_2 content ranged from 0.410 to 0.620mg/100g, B_3 content ranged from 3.970 to 7.140mg/100g, B_6 content ranged from 0.050 to 0.180mg/100g and C ranged from 3.060 to 11.580mg/100g.The sensory results revealed that the samples were generally liked by the panelists although sample 119 was preferred most in terms of overall acceptability.

Keywords: breakfast cereal, maize, African yam bean, enrichment, purple joy leaf

1. Introduction
Breakfast cereal is defined as dry cereal eaten at breakfast which has been processed into different forms by soaking, swelling, roasting, grinding, rolling or flaking, shredding or puffing of any cereal and is eaten as breakfast [1, 2]. Breakfast cereals due to their limitations of essential amino acids are often supplemented by other food classes. In recent times food product developers have incorporated legumes into traditional cereal formulations as nutrient diversification strategy as well as efforts to reduce the incidence of malnutrition among vulnerable groups [3].
Malnutrition is a common dietary problem that is said to be endemic and is mostly characterized by micro-nutrient deficiency and protein-energy malnutrition [4, 5]. Micro-nutrient deficiency occurs mostly as a result of processing. Most micronutrients are reduced either by leaching or physical separation involved during processing operations e.g. minerals and vitamins. This escalates micronutrient deficiency on population that relies mostly on processed food like breakfast cereal [2].
Among the cereals, Maize **(***Zea mays)* represents the staple food for most part of the population of Africa, Nigeria inclusive. The kernel is used both for human consumption and for livestock feed [6, 7]. Maize grains are rich in vitamins A, C, and E, carbohydrates, essential minerals, dietary fiber and contains 9% protein [8].
African yam bean (*Sphenostylis stenocarpa*,), Legumes or pulses are edible fruits or seeds of pod bearing plants [9, 2]. Their seeds are put to a myriad of uses, both nutritional and industrial, and in some parts of the developing world they are the principal source of protein for humans [10]. African yam bean has high protein content, in the range of 20-40%; about twice that of cereals and several times that in root tubers [9, 11].
A. brasiliana belongs to the Family Amaranthaceae commonly known in Brazil as Purple joy weed or Joseph's coat. It is widely used as a medicinal agent to cure different diseases, such as inflammation, wound healing, analgesic, antitumor activity, immune modulator and lymphocyte proliferation [12, 5]. Dietary diversification has been suggested by many workers as the ultimate solution to malnutrition. Most micronutrients e,g iron and zinc requirements are difficult to meet from non-fortified foods [13].
Moreso, fortification/ enrichment/restoration of plant-based breakfast/complementary foods with vitamin and mineral pre-mix or animal supplements such as milk makes the foods expensive for low-income earners who earn less than 300 naira (1.5 USD) per day [14, 5]. Moreso, breakfast cereal made from Maize and African yam bean enriched with purple joy leaf powder, will solve the problems of protein-energy malnutrition and ensure food security. This study aimed at evaluating the breakfast cereal produced from Maize and African yam bean composite flour enriched with purple joy leaf powder.

2. Materials and Methods
2.1 Sample Collection
The African yam beans (*Sphenostylis stenocarpa*) and yellow Maize grains (*Zea mays L)* were purchased from Orie Ngodo market Isuochi, Umunneochi, Abia state, Nigeria. Other ingredients such as sugar, salt etc. used for this work were purchased from Town gate market, Umuahia Abia state, Nigeria. All the chemical reagents used were obtained from National Root crop Research Institute, Umudike. Purple joy leaves were locally harvested from a farm in Amuda Isuochi, Umunneochie Local Government Area of Abia State.

2.2 Sample Preparation
Maize grains and African yam bean seeds were properly cleaned and sorted to remove stones, dirt, chaff, weevil

infested seeds and other extraneous matters before they were used for further processing.

2.2.1 Processing of Maize Grains into Flour

The modification method described by [2] was used. The purchased maize grains were cleaned and sorted after which it was milled into flour using hammer mill and packaged.

2.2.2 Preparation of African Yam Bean Flour

The African yam bean flour was prepared using the method described by [15]. The purchased African yam bean seeds were sorted to remove contaminants and the spoilt seeds, the seeds were soaked in cold water for 14 h to loosen the seed coats and the water changed after each 45 min to prevent development of unpleasant odour. The seeds were manually de-hulled by rasping them in-between the palms and the loosened seed coat was removed by floatation in water. The de-hulled seeds were drained and dried in a hot air oven at 60 ℃ for 1 h and then milled into flour using a hammer mill before sieving using a sieve size of 0.4 mm. The African yam bean flour obtained was packaged in an airtight container and kept for further analysis.

2.2.3 Preparation of Purple Joy leaf Powder

The Purple joy leaf powder was processed by a slight modification of method described by [12]. The Purple joy leaf after harvesting was cleaned, washed, dried in an oven at 40 ^{o}C for 36 h and then pulverized to powder in a hammer mill. The flour obtained was sieved using 0.4 mm mesh size to obtain fine powder extract. The Purple Joy leaf powder was packaged in an airtight polyethylene bags prior to analysis.

2.3 Formulation Composition of the Sample Flour Blends

Whole yellow Maize flour, African yam bean flour and Purple joy weed leaf Powder (A.*brasilliana)* were blended at different ratios to obtain five samples as indicated in Table 2.1.

2.4 Production of Breakfast Cereal

The breakfast cereal was produced by modification of the method of [3]. The ratio of ingredients used for the production of breakfast cereal is shown in Table 2.2 and the flowchart for breakfast cereal production is shown in Figure 2.1. Firstly, the flours were blended. It was conditioned with water; Sugar and a pinch of salt was added to modify the taste. The mixture was steam cooked for 10 min and was allowed to age for 10 min at room temperature (25 ^{0}C -30 ^{0}C). This was followed by flaking/Rolling, and toasting at 120 ^{0}C for 30 min followed by cooling and packaging with polypropylene container prior to analysis.

Table 1: Formulation of composite flour with whole maize flour and African yam beans with Purple joy leaf powder.

Sample WHMF/AYBF/PJWLP	% Whole Maize flour (WMF)	%African Yam Bean flour (AYBF)	% Purple joy weed Leaf Powder (PJWLP)
119(90:10:0)	90	10	0
229(80:15:5)	80	15	5
339(70:25:5)	70	25	5
449(60:35:5)	60	35	5
559(50:45:5)	50	45	5

Table 2: Ingredients for the production of Breakfast cereal samples

Ingredients	Quantity
Composite Flour	95 g
Purple joy leaf powder	5 g
Granulated sugar	15 g
Salt	0.5g
Water	15 ml

(Mbaeyi, 2005) [3]

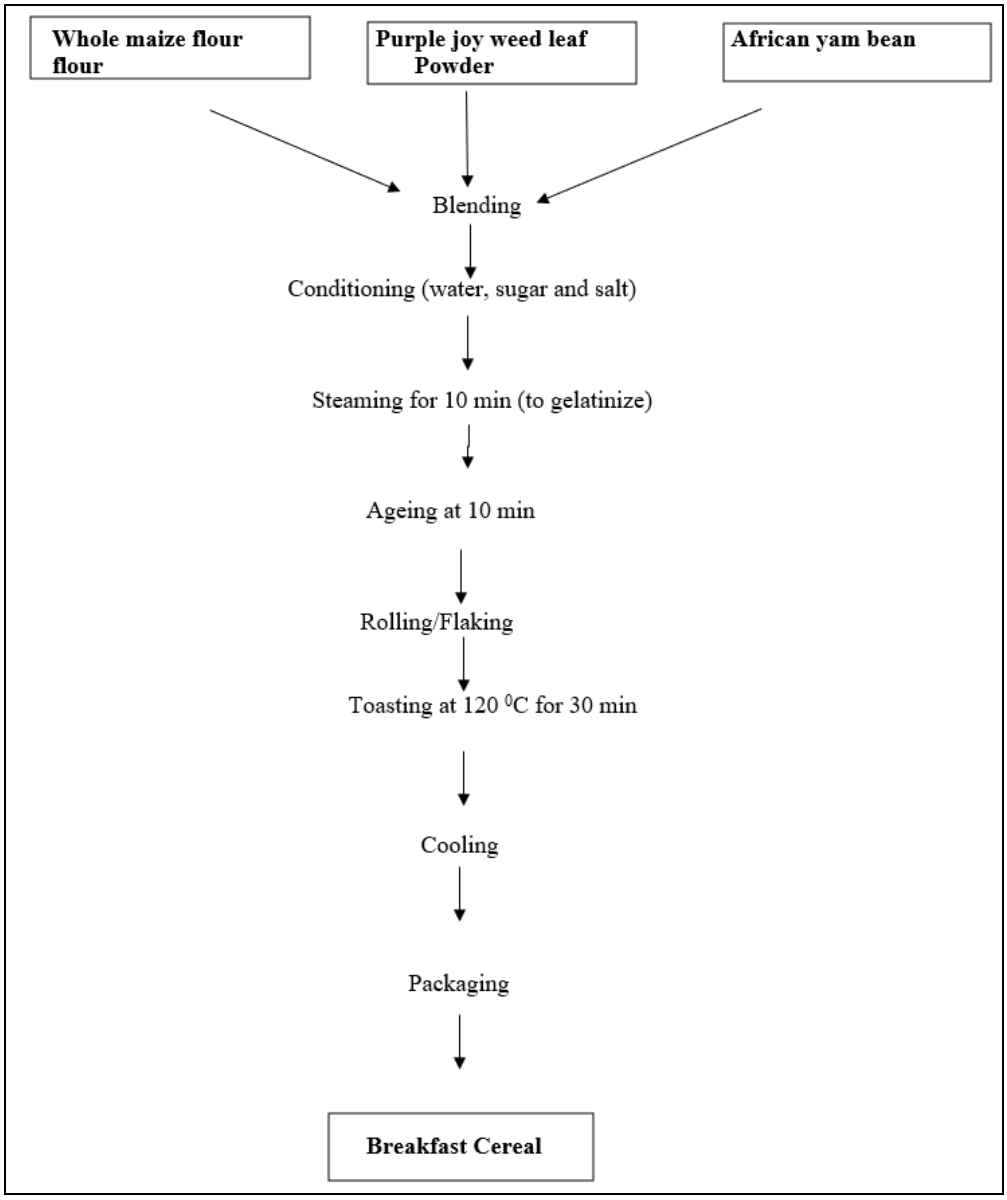

Fig 1: The flowchart for the production of breakfast cereal.

2.5 Chemical Analysis

2.5.1 Determination of vitamin content

2.5.1.1 Determination of β-carotene

The spectrophotometric method described by [16] was employed in the determination of β-carotene contents of the breakfast cereal samples. A quantity of the sample was measured into beaker. 80 ml of acetone added into the beaker and filtered if necessary. Separating funnel was set up and 20 ml of petroleum ether was added into the separating funnel. The filtrate was poured into the separating funnel with the petroleum ether. Distilled water was slowly introduced to fill the funnel to the brim (this leads to the formation of two layers with lower layers being aqueous) using a wash bottle. The tap was opened and the aqueous layer was allowed to run off. The procedure was repeated for about four [4] times until the aqueous layer becomes clear. The clear lower layer was drained/ ran off. A cotton wool was plugged into a funnel and added anhydrous Sulphate salt (this helps to remove residual water gas). The funnel was placed in a measuring cylinder and the remaining sample from the separating funnel was collected. The collected sample is made-up to 25 ml using petroleum ether (used in washing the separating funnel). The spectrophotometric reading was read at 450 nm using a spectrophotometer.

$$\beta\text{-carotene } (\mu g/100g) = \frac{100}{W} \times \frac{Au}{As} \times C \times \frac{Vf}{Va} \times D$$

Where W = weight of sample used
A_u = Absorbance of test sample
A_s = Absorbance of standard solution
C = Concentration of the standard solution
V_f= Total filtrate volume
V_a = Volume of filtrate analysed
D = Dilution factor, where applicable.

2.5.1.2 Determination of Vitamin B2 (Riboflavin)

The vitamin B2 content of the breakfast cereal samples was determined by the method of [17]. A quantity of each of the formulated samples was placed in a conical flask and 50 ml of 0.2 N HCl added. The solution was boiled for 1 h, and cooled. The pH was adjusted to 6.0 using sodium hydroxide. One N HCl was added to the sample solution to lower the pH to 4.5. The solution was then filtered into 100 ml volumetric flask and made up to volume with distilled

water. In order to remove interference, two tubes were taken and labeled 1 and 2. About 10 ml of water was added to tube 1. Another 10 ml of filtrate and 1 ml riboflavin standard was added to test tube 2. One ml of glacial acetic acid was added to each tube and mixed. Then, 0.5 ml 3% $KMnO_4$ solution was added to each tube. The test tube was allowed to stand for 2 min, after which 0.5 ml 3% H_2SO_4 was added and solution mixed well. The flourimeter was adjusted to excitation wavelength of 470nm and emission wavelength of 525nm. The flourimeter was also adjusted to zero deflection against 0.1 N H_2SO_4 and 100 against tube 2 (standard). The fluorescence of tube 1 was added to both tubes and the fluorescence measured within 10 sec. Riboflavin was then calculated as follows:

$$\text{Riboflavin (mg/g)} = \frac{Y}{Y} — X \times \frac{1}{W}$$

Where:
W = weight of sample,
X = reading of sample – blank reading,
Y = reading of sample + standard (tube 2)- reading of sample - standard blank.

2.5.1.3 Determination of Vitamin B3 (Naicin)
The vitamin B3 content of the breakfast cereal was determined by spectrophotometric method described by [18]. A quantity of the sample was treated with 50 ml of 1 N H_2SO_4 and shaken for 30 min, 3 drops of ammonia solution was added to the sample and filtered into a 50 ml volumetric flask and 5 ml of Potassium ferrocyanide was added. This was acidified with 5 ml of 0.02 N sulphuric acid and absorbance was measured in the spectrometer at 470nm wavelength. A standard Niacin solution was prepared and diluted. Ten ml of the solution was analyzed as discussed above. The reading was made with reagent blank at zero.
The Niacin content was calculated as follows:

$$[\text{mg}/100\text{g}] = \frac{100}{W} X \frac{Au}{As} X\ C\ X \frac{Vf}{Va} X\ D$$

Where:
W = weight of sample analyzed
A_u =Absorbance of the test sample
As = Absorbance of the standard solution
V_f = Total volume of filtrate
V_a = Volume of filtrate analyzed
C = Concentration of the standard
D = Dilution factor where applicable.

2.5.1.4 Determination of Vitamin B6 (Pyridoxine)
The vitamin B2 content of the breakfast cereal samples was determined by the method of [17]. Two g portion of each of the formulated samples was weighed into 500 ml Erlenmeyer flask and 200 ml 0.4 M HCl added. The solution was autoclaved for 2 h at 121^{0}C, cooled to room temperature and pH adjusted to 4.5 with 6 M KOH. The solution was diluted to 250 ml with water in volumetric flask and filtered through Whatman No. 40 paper. A quantity of filterate was taken for chromatography analysis. Desired amount of the filtered extract was placed on ion exchange column in 50 ml portions and allowed to pass completely through with no flow regulation. Beaker and column were washed 3 times with 5 ml portions hot 0.02 CH_3COOH (pH 5.5). Pyridoxal was eluted with two 50 ml portion boiling 0.04 M CH_3COOH (pH 6.0) using 100 ml volumetric flask as receiver. Pyridoxine was eluted with two, 50 ml portions boiling 0.1 M CH_3COOH (pH 7.0), using 100 ml volumetric flask as receiver. Pyridoxamine was eluted with two 50 ml boiling $KClK_2HPO_4$ (pH 8.0) solution, using 250 ml beaker as receiver and the pH adjusted to 4.5. Pyridoxine and pyridoxal eluates were diluted to 100 ml and pyridoxamine to 200 ml with water. A Ten ml each of the standard pyridoxine, pyridoxal and pyridoxamine solution was then neutralized with KOH and adjusted pH 4.5 with CH_3COOH. The resulting solutions were each put on column, washed and eluted as above. Eluted pyridoxine and pyridoxal standards were diluted to 100 ml and pyridoxamine to 200 ml with water. Each standard was diluted to 1.0 mg/ml with water.

Assay
Clean tubes and glass beads were heated at 260^{0}C for 2 h. Two 4 mm glass beads were placed in each 16 x 150 mm screw-cap glass culture tube. For standard curve, freshly prepared standard working solutions was pippetted into triplicate tubes to give 0.0, 0.1, 2.0, 3.0, 4.0, and 5.0mg pyridoxine, pyridoxal, or pyridoxamine/tube respectively. Similarly test tubes for eluted standards were prepared, omitting blanks. Test eluates from chromatographic column were diluted to contain 1ng vitamin B6 component/ml 1,2,3,4 and 5 ml diluted eluates were pipepetted into triplicate tubes. Tubes were capped with plastic caps with 3 mm (1/8 inch) hole through top. Entire set were autoclaved for 10 min at 121 ^{0}C and cooled to room temperature. Using automatic pipette with sterilized attachments, 5ml steamed medium (previously prepared) was pipetted through hole in the cap. Tubes were covered with sterile cheese cloth and placed in refrigerator for 1 h followed by inoculation. Aseptically, 1 drop assay inoculum of *S. uvarum* suspended cells was inoculated through cap of each tube, except for first set of 0.0 level standard curves. Tubes were then inoculated on constant rotary shaker for 22 h in a temperature-regulated room (30 h). Tubes were steamed in an autoclave for 5 min, cooled, and the caps removed. % T at 550nm was read on spectrophotometer. 100% T was set with water to read inoculated blank. 100% T was set with un- inoculated blank to read inoculated blank. Nine inoculated blank tubes were mixed, and with this mixture set at 100% Ton instrument, all other tubes were read. Readings in triplicate tubes were averaged and % T plotted against ng eluted standard pyridoxine, pyridoxal, or pyridoxamine/tube was determined by interpolation and µg pyridoxine, pyridoxal and pyridoxamine per g sample reported.

2.5.1.5 Determination of Vitamin C (Ascorbic Acid)
The method described by [19] was used. Ten g of the sample was extracted with 50 ml EDTA/ TCA extracting solution for 1h and filtered through a whatmann filter paper into a 50 ml volumetric flask and made up to the mark with the extracting solution. Twenty ml of the extract was pipetted into a 250 ml conical flask and 10 ml of 30% KI as well as 50 ml of distilled where added, followed by 2 ml of 1% starch indicator. The solution obtained was titrated against 0.01 M $CuSO_4$ solution to a dark end point.

$$\text{Vit C [mg/100g]} = 0.88\ X\ \frac{100}{5} X \frac{Vf}{20} X \frac{T}{1}$$

Where: V_f = Volume of the extract,T = Sample titre - blank titre.

2.6 Sensory Evaluation

Sensory evaluation of the flaked breakfast cereal samples were prepared using method as described by [20]. A total of 25 semi panelists who were familiar with the quality attributes of the flaked breakfast cereal were selected from students of the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike.

2.7 Statistical Analysis

The data obtained from the vitamin and sensory analyses were subjected to analysis of variance of a completely randomized design (C.R.D) using the SPSS procedure version 22 for personal computers while treatment mean were separated using Duncan's multiple range test at significant difference at 95% confidence level (p<0.05).

3.1 Vitamin Composition of Breakfast Cereal Samples

Table 3.1 shows the vitamin composition of the breakfast cereal samples. The results for the β-carotene content of the breakfast cereal samples ranged from 202.390 to 321.920 µg/100g. There were significant differences (p<0.05) between the samples. The sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest value for β-carotene content while sample 559 (: 50% whole maize flour; 45% African yam bean flour and 5% Purple joy weed leaf powder) had the least β-carotene value. The values for β-carotene decreased with decrease in quantity of The whole maize flour [5]. Reported a high β-carotene value of (6996.00 µg/kg) for the Purple Joy leaf analyzed. However, Purple joy leaf powder could be responsible for the high β-carotene values of the sample with decreasing quantity of whole maize flour. β-carotene is one of the precursor Vitamin A and Vitamin A helps to maintain healthy and smooth skin, improves resistance to infection, keeps the inner lining of mouth, ear, nose, lung and digestive tract healthy [22, 23].

The values for the riboflavin (Vitamin B_2) content of the breakfast cereal samples ranged from 0.410 to 0.620 mg/100g. There were significant differences (p<0.05) between the samples. Sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest Riboflavin value while sample 559 (50% whole maize flour; 45% African yam bean flour and 5% Purple joy weed leaf powder) had the least Riboflavin value. The result shows a decrease in the value of riboflavin for the breakfast cereal samples. This could be attributed to the decrease in the quantity of the whole maize flour in the formulation. However, Purple joy leaf which was reported to contain 654.10 mg/kg Riboflavin [5] could have made a significant contribution on the vitamin B_2 content of the breakfast cereal samples with low whole maize flour. Riboflavin acts as a coenzyme in the breakdown of fats, proteins, carbohydrates and other nutrients. It also helps fatty acid reduction and is necessary for catabolism of nutrients in the liver [2].

The result for the niacin (vitamin B_3) content of the breakfast cereal samples as shown in the Table 3.1 ranged from 3.970 to 7.140 mg/100g. There were significant differences (p<0.05) between the samples. Sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest niacin value while sample 559 (50% whole maize flour; 45% African yam bean flour and 5% Purple joy weed leaf powder) had the least niacin value. A decrease in the Niacin content was observe as quantity of the whole maize flour in formulation reduces. Purple joy weed leaf powder might have contributed to the niacin content of the breakfast cereal samples with reduced quantity of whole maize flour. Niacin was reported to be present up to 4184.40 mg/kg in purple joy weed leaf [5]. However, this could be enough to make an important contribution to the niacin content of the breakfast cereal samples. Niacin assists the release of energy from fat, carbohydrates and protein. It is also responsible for preventing the incident of pellagra [21].

Table 3: Vitamin Compositions of the Breakfast Cereal

Breakfast cereal Samples WMF: AYBF: PJWLP	β-carotene (µg/100g)	Vitamin B_2 (mg/100g)	VitaminB_3 (mg/100g)	VitaminB_6 (mg/100g)	vitamin C (mg/100g)
119 (90:10:0)	$321.920^{a} \pm 0.014$	$0.620^{a} \pm 0.014$	$7.140^{a} \pm 0.014$	$0.050^{c} \pm 0.014$	$3.060^{e} \pm 0.014$
229 (80:15:5)	$289.830^{b} \pm 0.014$	$0.560^{b} \pm 0.014$	$6.410^{b} \pm 0.014$	$0.130^{b} \pm 0.000$	$4.180^{d} \pm 0.014$
339 (70:25:5)	$260.780^{c} \pm 0.014$	$0.510^{c} \pm 0.014$	$5.630^{c} \pm 0.014$	$0.140^{b} \pm 0.014$	$6.610^{c} \pm 0.014$
449 (60:35:5)	$231.740^{d} \pm 0.014$	$0.460^{d} \pm 0.014$	$4.760^{d} \pm 0.014$	$0.160^{ab} \pm 0.014$	$9.110^{b} \pm 0.014$
559 (50:45:5)	$202.390^{e} \pm 0.424$	$0.410^{e} \pm 0.014$	3.970e ± 0.014	$0.180^{a} \pm 0.014$	$11.580^{a} \pm 0.000$

Values are means ± SD of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Keys: WMF = Whole Maize Flour, AYBF= African Yam Bean Flour and PJWLP= Purple Joy leaf Powder (A. brasiliana

The result for pyridoxine content of the breakfast cereals showed values ranging from 0.050 to 0.180 mg/100g. There were significant differences (p<0.05) between the samples. The sample 559 (50% whole maize flour; 45% African yam bean flour and 5% Purple joy weed leaf powder) had the highest pyridoxine content while sample 119 (90% whole maize flour and 10% African yam bean flour) had the least pyridoxine value. The result showed a uniform increase in the pyridoxine content of the breakfast cereal samples. The increase could be attributed to increase in African yam bean quantity in the formulations. Also, addition of the purple joy weed leaf powder could be partly responsible for the increase [5]. Reported a pyridoxine value of (21.01 mg/kg) for the purple joy weed leaf. This result is not in agreement with the work of [2] who recorded a low pyridoxine value (0.13 to 0.26 mg/100g) for breakfast cereal produced from African yam bean, maize and defatted coconut. Pyridoxine acts as a co-enzyme for approximately 100 essential chemical reactions. They include protein and glycogen metabolism, proper action of steroid hormones, pyruvate production, production of red blood cells and much more. It is also of great use to immune system as it helps hemoglobin production and increases the amount of oxygen carried by it [2].

The result for Vitamin C content of the formulated breakfast cereal samples ranged from 3.060 to 11.580 mg/100g. There were significant differences ($p<0.05$) between the samples. The sample 559 (50% whole maize flour; 45% African yam bean flour and 5% Purple joy weed leaf powder) had the highest vitamin C value while sample 119 (90% whole maize flour and 10% African yam bean flour) had the least Vitamin C value. The result shows an increase in Vitamin C content of breakfast cereal samples [5]. recorded a high vitamin C value of (238.36mg/kg) for purple joy weed leaf. This could be partly responsible for the significant increase in Vitamin C value of the breakfast cereal samples. Also, due to the controlled drying at 40 ºC in an electric oven used for processing the purple joy weed leaf powder, Most of the Vitamin C was been retained. The result was not in agreement with the work of [2] who reported a low vitamin C content (1.70 to 2.65 mg/100g) for breakfast cereal sample produced from African yam bean, maize and defatted coconut. Vitamin C are good anti-oxidant in the blood and cells, helps functional activity of immune cells and assist collagen and adrenaline production [22]. However, variations in the vitamin values of the breakfast cereal samples could be attributed to the difference in proportion in the formulation.

3.2 Sensory Characteristics of the Breakfast Cereal Samples

Table 3.2 shows the sensory characteristics of the breakfast cereal samples. The appearance values showed that sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest mean value of 7.760. This could be as a result of using higher proportion of whole maize flour (90%) and low African yam bean (10%) used for the formulation. However, sample 339 (70% whole maize flour; 25% African yam bean flour and 5% Purple joy leaf powder) and sample 449 (60% whole maize flour; 35% African yam bean flour and 5% Purple joy leaf powder) had the least value.

The aroma value of the breakfast cereal samples ranged from 5.080 to 6.720. Sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest value (6.720) followed by sample 559 (50% whole maize flour; 45% African yam bean flour and 5% Purple joy leaf powder) while sample 449 (60% whole maize flour; 35% African yam bean flour and 5% Purple joy leaf powder) had the least aroma value (5.080). The decrease in the aroma score could be due to increase in proportion of African yam bean flour and also due to the addition of the purple Joy leaf powder. African yam bean are characterized by the presence of beany off flavor, which are objectionable by the consumers.

The taste sensory result for the breakfast cereal sample ranged from 5.320 to 7.000 with sample 119 (90% whole maize flour and 10% African yam bean flour) having the highest value and sample 339 (70% whole maize flour; 25% African yam bean flour and 5% Purple joy leaf powder) with the least value. The high taste value of the sample 119 could be attributed to the absence of purple joy leaf powder.

The texture of the breakfast cereal reflects to the mouth feel. Sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest value of 6.800 followed by sample 229 (80% whole maize flour; 15% African yam bean flour and 5% Purple joy weed leaf powder) and sample 559(50% whole maize flour; 45% African yam bean flour and 5% Purple joy weed leaf powder). Sample 449 (60% whole maize flour; 35% African yam bean flour and 5% Purple joy leaf powder) had the least value 5.040.

Crispness is the desirable quality of breakfast cereal samples. The crispness value ranged from 4.760 to 7.200. Sample 119 (90% whole maize flour and 10% African yam bean flour) had the highest value of 7.200 while sample 339 (70% whole maize flour; 25% African yam bean flour and 5% Purple joy leaf powder) had the least value of 4.760. The lower value of sample 339 could be attributed to uneven heat circulation during oven roasting.

The overall acceptability level of the breakfast cereal ranged from 5.520 to 7.820. Sample 119(90% whole maize flour and 10% African yam bean flour) had the highest value 7.820 while sample 449 (60% whole maize flour; 35% African yam bean flour and 5% Purple joy leaf powder) had the least value. Sample 119 is significantly different ($p<0.05$) from the other samples (229,339,449 and 559). There was no significant difference between sample 559(50% whole maize flour; 45% African yam bean flour and 5% Purple joy leaf powder) and 229(80% whole maize flour; 15% African yam bean flour and 5% Purple joy leaf powder). The result showed that sample 119 was preferred most followed by samples 229 and 559

Table 3: Sensory Characteristics of the Breakfast Cereal Samples

Breakfast cereal Samples WHF: AYBF: PJWLP	Appearance	Aroma	Taste	Texture	Crispiness	Overall acceptability
119 (90:10:0)	$7.760^{a} \pm 1.091$	$6.720^{a} \pm 1.621$	$7.000^{a} \pm 1.414$	$6.800^{a} \pm 1.291$	$7.200^{a} \pm 1.384$	$7.840^{a} \pm 1.106$
229 (80:15:5)	$5.840^{bc} \pm 1.841$	$5.840^{abc} \pm 1.463$	$6.320^{ab} \pm 1.930$	$6.520^{a} \pm 1.262$	$7.120^{a} \pm 1.481$	$6.680^{b} \pm 1.492$
339 (70:25:5)	$5.400^{c} \pm 1.500$	$5.440^{bc} \pm 1.530$	$5.320^{b} \pm 1.842$	$5.280^{b} \pm 1.646$	$4.760^{b} \pm 1.921$	$5.640^{c} \pm 1.350$
449 (60:35:5)	$5.400^{c} \pm 1.683$	$5.080^{c} \pm 1.631$	$5.680^{b} \pm 1.909$	$5.040^{b} \pm 1.567$	$5.200^{b} \pm 2.062$	$5.520^{c} \pm 1.531$
559 (50:45:5)	$6.360^{b} \pm 1.381$	$6.200^{ab} \pm 1.528$	$6.320^{ab} \pm 1.819$	$6.520^{a} \pm 1.418$	$7.120^{a} \pm 1.481$	$7.000^{b} \pm 1.080$

Values are means ± SD of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$). Keys: WMF = Whole Maize Flour, AYBF= African Yam and PJWLP= Purple Joy Weed leaf Powder (*A.brasiliana*)

4. Conclusion

The study has revealed that acceptable ready-to eat breakfast cereal samples could be produced from flour blends of maize, African yam bean and purple joy weed powder leaf powder. The study also showed that breakfast cereal enriched with purple joy leaf powder has a good sensory appeal and enhancement in the vitamin contents especially vitamin C, vitamin B_2, B_3 and B_6,

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