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Production, Quality Evaluation and Acceptability of Bread from Wheat, Bambara Groundnut and Yellow Root Cassava Flours

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Abstract

The study was carried out to produce and evaluate the quality of wheat, yellow root cassava, and Bambara groundnut-based bread. The flours were blended in varying ratios of 100:0:0, 90:5:5, 80:10:10, 70:15:15 and 60:20:20 coded as WF_1 (control), WBC_2, WBC_3, WBC_4 and WBC_5 respectively. The proximate composition, β -carotene, physical and sensory properties of the samples were evaluated. The moisture, crude protein, crude fat, crude fibre and ash contents were significantly ($p<0.05$) higher in samples WBC_2, WBC_3, WBC_4 and WBC_5 compared to sample WF_1. The crude protein, fat, ash and crude fiber ranged from 12.73 to 16.22%, 2.62 to 5.60%, 1.89 to 2.51% and 0.19 to 0.71% respectively. While the moisture and carbohydrate contents significantly ($p>0.05$) decreased from 30.18 to 23.78% and 52.39 to 51.18% respectively due to the increase in the level of yellow root cassava and Bambara groundnut flours. There was a significant ($p<0.05$) increase in the β -carotene content of the samples which ranged from 0.14 to 0.45 mg/100gm, with WF_1 having the least mean value (0.45 mg/100gm) compared to the fortified samples. The physical properties ranged from 6.18-7.43 cm, 151.72-181.92 gm and 1.13-3.31 cm for height, weight and oven spring respectively. It was observed that in terms of the overall acceptability, sample WF_1 had the highest mean value of 7.15 whereas sample WBC_5 had the least mean value of 3.55. Thus, there was a significant ($p<0.05$) difference between sample WF_1 and samples WBC_2, WBC_3, WBC_4 and WBC_5. However, sample WF_1 was the most preferred of all other samples.

Keywords: Bambara groundnut, Bread, β -carotene, Flour, Wheat, Yellow root cassava.

Introduction

The popularity of bakery products has contributed to increased demand for ready-to-eat, convenience food products, such as biscuits, bread, cake, chin-chin, cookies and other pastry products [1]. The consumption of bread in Nigeria is on a steady increase because it is convenient and ready-to-eat food normally consumed at breakfast, lunch and sometimes dinner. Bread is one of the most important staple foods and the second most widely consumed non-indigenous food products after rice in Nigeria [2]. It is consumed by people in every socioeconomic class and is acceptable to both adults and children. The word bread is used to describe the whole range of different bread varieties which may vary in weight, shape, crust hardness, crumb cell structure, softness, colour and eating quality [3].

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Bread is generally made by baking dough which has wheat flour, water, yeast and salt as its main ingredient [4]. These ingredients undergo a series of a process involving weighing, mixing, kneading, shaping, proofing and baking before the product is ready-to-eat [5]. Other ingredients which may be added include flours of other cereals, fat, malt flour, soy flour, emulsifiers, milk, sugar, fruits, among others. Nutritionally, bread contains a high percentage of carbohydrate and fat both of which are needed for energy [6], while vitamins, minerals, protein, and other nutrients are relatively in a small portion. Bread is, however, relatively expensive, being made from wheat grains which are imported from foreign countries. The importation of wheat, therefore, causes an immense drain on the economic effect on agricultural and technological development. Wheat is the grain of choice in bread making due to its high gluten content, though, there have been reports of bread made from flours of other cereals grains such as maize, oats, rye, and barley; roots like cassava in combination with wheat flour.

According to FAO [7], flour from indigenous raw materials could be added in proportions that will not affect the original and intended color, flavor and the particle size of the product adversely. However, there have been several attempts at partial substitution of wheat flour with flour from readily available, cheap, indigenous crops like cassava, cocoyam, maize, breadfruit, sorghum, among others. Furthermore, very little information is available on the use of composite flour of yellow root Cassava-Bambara groundnut-wheat flour in bread production. Composite flour has many advantages among which are; its vital role complementing the deficiency of essential nutrients. It promotes high yielding local plant species and enhances the overall use of domestic agriculture. Also, it saves the hard currency.

Cassava (*Manihot esculanta Crantz*) is cultivated in the tropical regions and was originated from North-East Brazil [8]. It is a dicotyledonous plant belonging to the family *Euphorbiaceae*. Cassava comprises of the peel (10-20%) and the edible fleshy portion (80-90%). The roots are used for human consumption, animal feed and raw materials in many industries. Cassava is drought tolerant, requires limited land preparation and grows well in poor soil, all these attributes make it an extremely adapted crop. Cassava tubers generally possess a cream or white flesh color and do not contain a legible amount of carotenoids. Vitamin A remains a very important component of human nutrition, as it aids in vision, cell differentiation, synthesis of glycoprotein, reproduction and overall growth and development. Vitamin A deficiency (VAD) and the severity of the consequences, prevention, and therapy become a ubiquitous concern.

However, the development and dissemination of yellow root cassava will complement current efforts to address VAD by delivering vitamin A through a staple food which consumers eat every day. Cassava roots are rich in carbohydrates but deficient in proteins and many other essential micronutrients. The recent introduction of yellow root cassava or β -carotene cassava varieties is ideal and proper [9]. Since the presence of pro-vitamin A (β -carotene) in the new cassava would improve the nutritional status of the consumer; there is therefore need to evaluate various food forms from these newly bred crops for value addition to enhance better and wide range utilization of the crop. Since cassava is a major staple food crop in Nigeria, consumption of this β -carotene cassava can help in combating vitamin A deficiency, which is a serious public health problem in many parts of the world [10].

Bambara groundnut (*Vigna subterranean*) belongs to the Leguminosae family of flowering plant. It is an important legume grown in the northern part of Nigeria but mostly consumed in the eastern part of Nigeria especially Enugu State. Bambara groundnut is high in carbohydrates (65%), protein (16.0%), but low in fat content (5.9%), crude ash (2.9%) and moisture (9.7%). However, bambrara groundnut dishes are favored as nutritious because of their protein and energy content [11].

Materials and Methods

Procurement of raw materials

Wheat (golden penny), Bambara groundnut (*Vigna subterranean (L.) Verdc),* salt, sugar (sucrose) eggs, margarine, and dry baker's yeast were purchased from Ogige main market in Nsukka Local Government Area, Enugu State. The yellow root cassava (*Manihot esculenta Crantz*) was purchased from National Root Crops Research Institute (NRCRI), Umuahia, Abia State.

Preparation of samples

Processing of Bambara groundnut into flour: The method described by [11] was used in the processing of Bambara groundnut into flour. Bambara groundnut was sorted to remove extraneous materials such as stone and dirt and to separate insect-infested seeds from desirable ones. Broken, wrinkles and immature seeds were also sorted out. The seed coats were partially removed by splitting the seed in an attrition mill, winnowing to remove loosen test and converting the cotyledon into fine flour by milling several times using the attrition mill. The flour was sieved using a muslin cloth. The unit operations involved in the processing of bambara groundnut into flour was shown in Figure 1.

Processing of yellow root cassava into flour: The method described by [12] was used in the processing of yellow root cassava into flour. Yellow root cassava tubers were peeled manually using knives, washed, grated into a mesh using hammer mill and then bagged to dewater. After dewatering, a cake was formed which was broken into small particles, oven dried and milled into flour. The flour was sieved with a muslin cloth to obtain a fine yellow-root cassava flour. The unit operations involved in the processing of yellow root cassava into flour was shown in Figure 2.

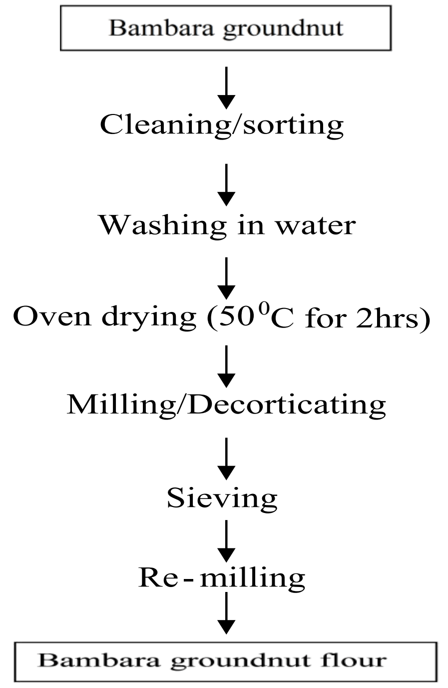

Figure 1: Production of flour from Bambara groundnut [11].

Formulation of composite flour for bread production (Figure 2)

Production of wheat, bambara groundnut and yellow root cassava-based bread (Table 1)

Five (5) different samples of bread were produced using the straight dough method. The method described by [13] was used in the production of bread. The weighed ingredients (flour, salt, sugar, water, yeast, among others) were added at the mixing stage and kneaded to obtain a dough. The dough was cut, weighed, molded and placed in baking pans smeared with the mixture of vegetable oil and margarine. The dough was covered to proof for 1 hour and then baked in the oven at the temperature of 180 ^{0}C for 30 minutes. The baked loaves were carefully removed from the pans, allowed to cool for 15 minutes and packaged in polyethylene bags for further study.

Recipe to produce bread from the flour blends of wheat, yellow root cassava and Bambara groundnut

The recipe to produce wheat, yellow root cassava and Bambara groundnut-based bread is shown in Table 2.

Determination of physical properties of bread samples

The loaf weight was determined by simple weighing using an electronic balance. The height of the bread was also determined by measuring with a meter rule. Oven spring was determined by the difference in the height of the dough before baking and height of the bread after baking [15].

Proximate analysis of the samples

The proximate composition of the samples for crude protein, ash, crude fiber, fat, and moisture was determined using [16], while carbohydrates content was obtained by difference.

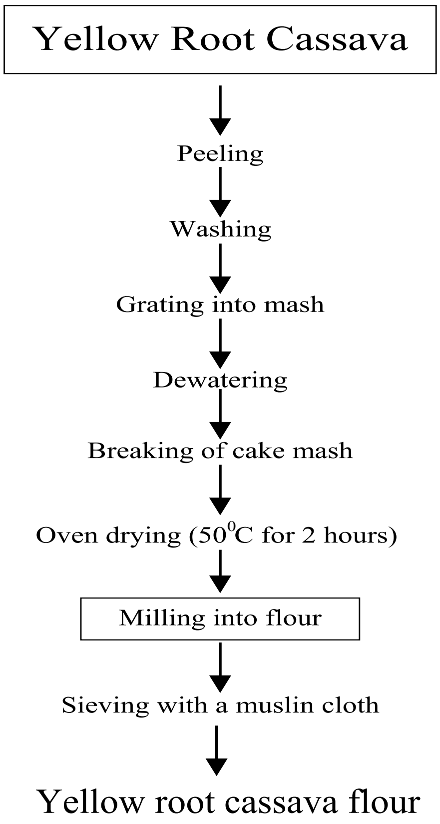

Figure 2: Processing of yellow root cassava into flour [12].

Table 1: Formulation of flour blends of wheat, bambara groundnut and yellow root cassava for bread production.

Sample/blends	WF	BGF	YRCF
WF_1 (Control)	100	0	0
WBC_2	90	5	5
WBC_3	80	10	10
WBC_4	70	15	15
WBC_5	60	20	20

WF=Wheat Flour, BGF=Bambara Groundnut Flour, YRCF=Yellow Root Cassava Flour, WF_1=wheat flour (100 g), bambara groundnut flour (0 g), and yellow root cassava flour (0 g), WBC_2=Wheat flour (90 g), bambara groundnut flour (5 g) and yellow root cassava flour (5 g), WBC_3=Wheat flour (80 g), bambara groundnut flour (10 g) and yellow root cassava flour (10 g), WBC_4=Wheat flour (70 g), bambara groundnut flour (15 g) and yellow root cassava flour (15 g), WBC_5=Wheat flour (60 g), bambara groundnut flour (20 g) and yellow root cassava flour (20 g).

Table 2: Recipe formulation to produce wheat, yellow root cassava and bambara groundnut-based bread.

Ingredients	WF_1	WBC_2	WBC_3	WBC_4	WBC_5
Wheat Flour (g)	100	90	80	70	60
Bambara Groundnut Flour (g)	0	5	10	15	20
Yellow Root Cassava Flour (g)	0	5	10	15	20
Yeast (g)	2.5	2.5	2.5	2.5	2.5
Sugar (g)	2	2	2	2	2
Salt (g)	1.5	1.5	1.5	1.5	1.5
Fat (g)	2	2	2	2	2
Water (mL)	55	55	55	55	55

Source: [14] with slight modification

WF_1=wheat flour (100 g), bambara groundnut flour (0 g), and yellow root cassava flour (0 g), WBC_2=Wheat flour (90 g), bambara groundnut flour (5 g) and yellow root cassava flour (5 g), WBC_3=Wheat flour (80 g), bambara groundnut flour (10 g) and yellow root cassava flour (10 g), WBC_4=Wheat flour (70 g), bambara groundnut flour (15 g) and yellow root cassava flour (15 g), WBC_5=Wheat flour (60 g), bambara groundnut flour (20 g) and yellow root cassava flour (20 g).

Determination of β -carotene content of the samples

The β -carotene content was determined using the method of [17].

Sensory evaluation of the samples

The samples were coded and presented to twenty (20) untrained panelists for sensory evaluation. The panelists scored the crust, color, flavor, taste, aroma, texture and overall acceptability of the samples using a nine-point Hedonic scale, where 9 indicates extremely like and 1 extremely dislike [18].

Experimental design and statistical analysis

The experimental design was Completely Randomised Design (CRD). Data obtained were subjected to analysis of variance (ANOVA) at $p<0.05$. Duncan's New Multiple Range Test (DNMRT) was used to compare the treatment means using the Statistical Product for Service Solution (SPSS) version 20 [19].

Results and Discussion

Proximate composition and β -carotene content of the samples

The results of the proximate composition and β -Carotene content of the bread samples produced from wheat-yellow root Cassava-Bambara groundnut are shown in Table 3.

The crude protein content of the samples ranged from 12.73-16.22%. Sample WF_1 (control) had the lowest protein content of 12.73% while WBC_5 had the highest value of 16.22%. There was a significant ($p<0.05$) increase with an increase in the levels of inclusion of yellow root cassava and bambara groundnut flours. This was expected because bambara groundnut is a legume while wheat is a cereal grain, naturally, legumes have more protein than cereals although the prevalent protein in wheat occurs as gluten which is needed in baking. The high crude protein content of food legumes generally constitutes the natural protein supplements to the staple diet. This agrees with the work of [20] and [21], who enriched the crude protein content of "Ojojo" and cookies using rice-bean flours and African yam bean seeds respectively.

The moisture content of the samples ranged from 23.78-30.18%. Sample WF_1 had the highest moisture content of 30.18% while WBC_5 had the lowest value of 23.78%. The moisture content of the samples decreased significantly ($p<0.05$) from 30.18-23.78% with increasing levels of yellow root Cassava/Bambara groundnut flours. It was observed that sample WF1 had the highest level (30.18%) of moisture content while sample WBC_2 had the least value (23.78%). The decrease in the moisture content of the samples may be attributed to the functional properties of the protein of the bambara groundnut flour such as water sorption. The successive decrease in the moisture content of the samples with increased levels of composite flours may increase the shelf life of the bread. There was a significant ($p<0.05$) difference between sample WF_1 and samples WBC_2, WBC_3, WBC_4, and WBC_5 (Table 3).

The fat content of the samples ranged from 2.62-5.60%. Sample WF_1 had the lowest fat content of 2.62% while WBC_5 had the highest value of 23.78%. The fat content of the samples increased from 2.62-5.60% with increased levels of yellow root cassava and bambara groundnut flours. The increased fat content could be attributed to the fat content in bambara groundnut flour. There was a significant ($p<0.05$) difference between WF_1 and all other fortified samples.

The ash content of the samples ranged from 1.89-2.51.60%. Sample WF_1 had the lowest ash content of 1.89 while WBC_5 had the highest value of 2.51%. The ash content could come from both yellow root cassava and bambara groundnut flours. The ash content increased from 1.89-2.51% with an increased level of yellow root cassava and bambara groundnut flours. The high ash content of the samples could be an indication of an increase in the mineral content as reported by [22]. A similar result was also reported by [23].

The crude fiber content of the samples ranged from 0.19-0.71%. Sample WF_1 had the lowest ash content of 0.19% while WBC_5 had the highest value of 0.71%. It was observed that there was an increase in the crude fiber content as the level of addition of yellow root cassava and bambara groundnut flours increased. This increase could be attributed to the yellow root cassava and bambara groundnut flours which are reported to be high in fiber content [23]. There was a significant ($p<0.05$) difference between sample WF_1 and all other fortified samples.

The carbohydrate content of the samples ranged from 51.18-53.48%. Sample WF_1 had the highest carbohydrate content of 53.48% while WBC_5 had the lowest value of 51.18%. It was observed that there was a decrease in the carbohydrate content as the level of addition of yellow

Table 3: Proximate composition and β -carotene content of the samples.

Samples	Protein (%)	Moisture (%)	Fibre (%)	Fat (%)	Ash (%)	CHO (%)	β-carotene (mg/100g)
WF_1	$12.73^d±0.64$	$30.18^a±0.01$	$0.19^d±0.01$	$2.62^e±0.02$	$1.89^d±0.01$	$53.48^a±0.63$	$0.14^e±0.06$
WBC_2	$13.72^c±0.62$	$29.41^b±0.01$	$0.38^c±0.01$	$2.87^d±0.01$	$1.98^c±0.01$	$53.18^c±0.60$	$0.20^d±0.06$
WBC_3	$14.78^b±0.48$	$25.70^c±0.01$	$0.58^c±0.01$	$3.63^c±0.01$	$2.02^c±0.03$	$52.39^b±0.51$	$0.24^c±0.12$
WBC_4	$15.90^a±0.10$	$24.75^b±0.11$	$0.59^b±0.06$	$4.44^b±0.01$	$2.24^b±0.05$	$51.64^{bc}±0.12$	$0.32^b±0.12$
WBC_5	$16.22^a±0.10$	$23.78^e±0.01$	$0.71^a±0.00$	$5.60^a±0.01$	$2.51^a±0.01$	$51.18^c±0.12$	$0.45^a±0.12$

Values are means ± SD of duplicate replications. Means within the same column with different superscripts were significantly ($p<0.05$) different. WF_1 (100% wheat flour ± 0% bambara groundnut flour ± 0% yellow root cassava flour), WBC_2 (90%) wheat flour ± 5% Bambara groundnut four ± 5% bambara groundnut flour ± 5% yellow root cassava flour), WBC_4 (70% wheat flour ± 15% bambara groundnut flour ± 15% yellow root cassava flour) and WBC_5 (60% wheat flour ± 20% Bambara groundnut flour ± 20% yellow root cassava four).

root cassava and bambara groundnut flours increased. The decrease in carbohydrate content from 53.48-51.18% could be due to the high level of yellow root cassava and bambara groundnut flours. To correlate it with protein, the carbohydrate content decreased as the protein content of from bambara groundnut flour increased. Thus, there was a significant (p<0.05) difference between sample WF_1 and all other fortified samples. [24] reported that a high level of carbohydrate implies that the bread would be a source of high energy and nutrients dense.

The β -carotene content of the samples ranged from 0.14-0.45 mg/100 gm as shown in Table 4. Sample WF_1 had the lowest β -carotene content of 0.14 mg/100g while WBC5 had the highest value of 0.45 mg/100 gm. It was observed that the β -carotene content of the fortified samples significantly (p<0.05) increased with increase in the levels of yellow root cassava/Bambara groundnut flour. The increased β -carotene may be attributed to the yellow root cassava flour incorporation to the samples since it was biofortified with β -carotene. It was also observed that sample WF_1 had the lowest value (0.14 mg/100 gm) of β -carotene while sample WBC_2 had the highest value (0.45 mg/100 gm). Thus, there was a significant (p<0.05) difference between sample WF_1 and other fortified samples. β -carotene is an essential nutrient required for maintaining the immune function of the body as reported by [25]. It also helps in the maintenance of healthy teeth, skeletal and soft tissue, mucous membranes and skin.

Physical properties of wheat, yellow root Cassava-Bambara groundnut flour-based bread samples

The results of the physical characteristics of the wheat-yellow root Cassava-Bambara groundnut-based bread are shown in Table 5.

The height of the samples ranged from 6.18-7.43 cm. Sample WF_1 had the highest value of 7.43 cm while WBC_5 had the lowest value of 6.18 cm. It was observed that the height of the loaves decreased significantly (p<0.05) with increased substitution with yellow root cassava and bambara groundnut flours from 7.43-6.18 cm. This could be attributed to the reduction in the level of wheat flour as the substitution with yellow root Cassava/Bambara groundnut flours increased hence, decrease in the gluten content which helps to improve the elasticity or extensibility of bread [26] also reported a similar observation. There was a significant (p<0.05) difference between sample WF_1 and all other fortified samples.

The gluten fraction is responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide produced during fermentation. [27] attributed decreased in the loaf volume, specific volume and height of wheat-sorghum composite bread to lower levels of gluten network in the dough and consequently, less ability of the dough to rise due to the weaker cell wall structure (Table 4).

The weight of the samples ranged from 151.72-181.92 gm. Sample WF_1 had the lowest value of 151.72 gm while WBC5 had the highest value of 181.92 gm. The weight of wheat-yellow root Cassava-Bambara groundnut-based bread samples significantly (p<0.05) increased with increase in the levels of yellow root Cassava and Bambara groundnut flours. It was observed that the weight of all the fortified samples was significantly higher than sample WF_1. Thus, there was a significant (p<0.05) between sample WF_1 and all other fortified samples. [28-30] also reported an increase in weight in bread production from different composite flours.

The oven spring of the samples ranged from 1.13-3.31 cm. Sample WF_1 had the highest value of 3.31 cm while WBC_5 had the lowest value of 1.13 cm. The oven spring measured decreased significantly (p<0.05) with increased substitution with yellow root Cassava and Bambara groundnut flours. This could be attributed to the decrease in the structure forming proteins in wheat which lowered the ability of the dough to rise extensively during proofing leading to a reduction in the bread volume. However, there was a significant (p<0.05) difference between sample WF_1 and samples WBC_2, WBC_3, WBC_4, and WBC_5.

Sensory scores of the samples from the blends of wheat, yellow root Cassava and Bambara groundnut flours

The results of the sensory scores of the samples from the blends of wheat, yellow root Cassava, and Bambara groundnut flours are shown in Table 5.

Colour: The mean scores of colour varied from 6.15-7.65 with the pictures of the samples shown in Plate 1. There was a decrease in the scores as Bambara groundnut and yellow

Table 4: Physical properties of the bread samples from the blends of wheat, yellow root cassava, and bambara groundnut flours.

Samples	Height (cm)	Weight (g)	Oven Spring (cm)
WF_1	$7.43^a±0.04$	$151.72^e±1.44$	$3.31^a±0.01$
WBC_2	$7.05^b±0.00$	$163.12^d±1.42$	$2.18^b±0.04$
WBC_3	$6.91^c±0.01$	$169.54^c±0.66$	$2.01^c±0.01$
WBC_4	$6.83^c±0.10$	$172.88^b±1.41$	$1.66^d±0.01$
WBC_5	$6.18^d±0.04$	$181.92^a±0.72$	$1.13^e±0.11$

Values are means ± SD of duplicate replications. Means within the same column with different superscripts are significantly (p<0.05) different. WF_1 (100% wheat flour ± 0% bambara groundnut flour ± 0% yellow root cassava flour), WBC_2 (90%) wheat flour ± 5% bambara groundnut four ± 5% bambara groundnut flour ± 5% yellow root cassava flour), WBC_4 (70% wheat flour ± 15% bambara groundnut flour ± 15% yellow root cassava flour) and WBC_5 (60% wheat flour ± 20% bambara groundnut flour ± 20% yellow root cassava four).

Table 5: Sensory scores of the samples from the blends of wheat, yellow root cassava, and bambara groundnut flours.

Samples	WF1	WBC2	WBC3	WBC4	WBC5
Colour	$7.65^a±1.09$	$6.95^{ab}±1.57$	$6.90^{ab}±1.62$	$6.70^{ab}±1.54$	$6.15^b±1.98$
Aroma	$6.55^a±1.79$	$5.55^b±1.32$	$5.30^b±1.13$	$5.35^b±1.46$	$3.55^c±1.61$
Texture	$7.05^a±1.19$	$6.60^a±1.31$	$6.80^a±1.11$	$6.45^a±1.32$	$5.55^b±1.88$
Mouthfeel	$6.75^a±1.45$	$6.00^{ab}±1.26$	$5.40^b±1.27$	$5.45^b±1.10$	$4.00^c±2.00$
Taste	$6.50^a±1.57$	$5.30^b±1.08$	$5.15^b±1.42$	$5.05^b±1.19$	$3.15^c±1.63$
After test	$6.30^a±1.22$	$5.80^{ab}±1.15$	$5.15^b±1.35$	$5.05^b±1.39$	$3.75^c±2.02$
Overall acceptability	$7.15^a±1.09$	$6.30^b±0.98$	$5.75^b±1.12$	$5.55^b±1.23$	$3.55^c±1.43$

Values are means ± SD of duplicate replications. Means within the same row with different superscripts were significantly (p<0.05) different. WF_1 (100% wheat flour ± 0% bambara groundnut flour ± 0% yellow root cassava flour), WBC_2 (90%) wheat flour ± 5% bambara groundnut four ± 5% bambara groundnut flour ± 5% yellow root cassava flour), WBC_4 (70% wheat flour ± 15% bambara groundnut flour ± 15% yellow root cassava flour) and WBC_5 (60% wheat flour ± 20% bambara groundnut flour ± 20% yellow root cassava four).

Figure 3: The pictures of the wheat, yellow root cassava, and bambara groundnut-based bread are shown in Plate 1.

Plate 1: Bread samples produced from the blends of wheat, yellow root cassava, and bambara groundnut flours.
WF_1=wheat flour (100 g), Bambara groundnut flour (0 g), and yellow root cassava flour (0 g), WBC_2=Wheat flour (90 g), Bambara groundnut flour (5 g) and yellow root cassava flour (5 g), WBC_3=Wheat flour (80 g), bambara groundnut flour (10 g) and yellow root cassava flour (10 g), WBC_4=Wheat flour (70 g), bambara groundnut flour (15 g) and yellow root cassava flour (15 g), WBC_5=Wheat flour (60 g), bambara groundnut flour (20 g) and yellow root cassava flour (20 g).

root Cassava flours were added, however, the decrease was not significant (p>0.05). It was observed that sample WF_1 had the highest mean score (7.65) while sample WBC_5 had the least mean score. There was no significant (p>0.05) difference between sample WF_1 and samples WBC_2, WBC_3 and WBC_4, but a significant (p<0.05) difference was observed between samples WF_1 and WBC_5.

Aroma: It was observed from the result that there was a significant (p>0.05) decrease in the mean values (6.55-3.55) of the aroma of the samples as the level of inclusion of bambara groundnut and yellow root cassava flours to wheat flours increased. This decrease may be attributed to the beany flavor from bambara groundnut flour with which the bread was fortified, which is quite different from the usual bread that is produced solely from wheat flour. Sample WF_1 had the highest mean score (6.55) while sample WBC_5 had the least mean score (3.55). There was a significant (p<0.05) difference between sample WF_1 and samples WBC_2, WBC_3, WBC_4, and WBC_5.

Texture: In terms of texture, the mean scores of the samples decreased from 7.05-5.55 as the level of addition of bambara groundnut flour and yellow root cassava increased. It was observed that sample WF_1 had the highest value (7.05) while sample WBC_5 had the least value (5.55). Thus, there was a significant (p<0.05) difference between sample WF_1 and samples WBC_2, WBC_3, WBC_4 but there was no significant (p>0.05) difference between samples WF_1 and WBC_5.

Mouthfeel: The mouthfeel had the mean scores varying from 4.00-6.75. Sample WF_1 had the highest mean score (6.75) while sample WBC_5 had the least score (4.00). A significant (p<0.05) difference was observed in sample WF_1 and samples WBC_3, WBC_4 and WBC_5, but no significant (p>0.05) difference was observed between samples WF_1 and WBC_2.

Taste: The taste results show a decrease in the values from 6.50-3.15 as the levels of addition of both bambara groundnut and yellow root cassava in the bread increased. Sample WF_1 had the highest mean score of 6.50 and sample WBC_5 had the least value 3.15. However, there was a significant (p<0.05) different between sample WF_1 and all other fortified samples.

Aftertaste: Aftertaste had the mean scores varying from 3.75-6.30 as the increase in the level of the yellow root cassava and bambara groundnut flours increased in the fortified samples. It was observed that sample WF_1 had the highest score (6.30) while sample WBC_5 had the least score (3.75). Also, a significant (p<0.05) difference was observed between sample WF_1 and samples WBC_3, WBC_4 and WBC_5, but there was no significant (p>0.05) difference between samples WF_1 and WBC_2.

Overall acceptability: The results of the overall acceptability of the samples decreased from 7.15-3.55 as the level addition of bambara groundnut flour and yellow root cassava increased. Sample WF1 had the highest value (7.15) while sample WBC_5 had the least value (3.55). Sample WF_1 was the most accepted followed by samples WBC_2, WBC_3, WBC_4, and WBC_5. However, there was a significant (p<0.05) difference between sample WF_1 and all fortified other samples.

Pictures of the samples from blends of wheat, yellow root cassava and bambara groundnut flours (Figure 3)

Conclusion and Recommendation

Conclusion

Incorporation of yellow root cassava and bambara groundnut flours to the samples had a significant effect on the proximate composition, β -carotene content, physical and sensory properties of the fortified samples. Although, the inclusion of yellow root cassava and bambara groundnut flours to the bread improved the nutrient compositions of all the fortified samples, sample WF_1 which had no yellow root Cassava and Bambara groundnut flours added had the highest level of acceptability by the panelists and was the most preferred followed by samples WBC_2 and WBC_3. This may be that the panelists are more conversant with the sample (WF_1) which was not fortified with yellow root cassava and bambara groundnut flours.

Recommendation

Therefore, it is recommended that either sample WBC_2 or WBC_3 should be produced in place of sample WF_1 because they contain more nutrients and closer to sample WF_1 in terms of physical characteristics.

Also, it is recommended that yellow root cassava flour can be incorporated to wheat flour to ameliorate the excessive use of wheat and improve the use of root and tuber crops without significant change in the quality of the product. This will also increase National Gross Profit, income for rural farmers and improve the production of yellow root cassava and bambara groundnut.

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