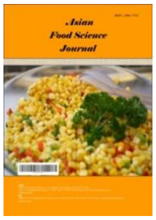

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Quality Evaluation of Yam (*Dioscorea rotundata*) and carrot (*Daucus carota* L.) Flour Blends for Production of Stiff Dough and Biscuits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study evaluates the quality of yam and carrot flour blends for the production of stiff dough and biscuits. Flour samples were prepared from yam tubers and carrot flours .The carrot flour was used to substitute 5, 10, 15, and 20 of the yam flour on the stiff dough. Biscuits were prepared from various blends of wheat flour, carrot flour and yam flours. The proximate composition, functional properties, vitamin, minerals and sensory attribute of the flour blends were carried out using appropriate standard methods for the analysis. The sensory properties of the stiff dough and biscuits were determined. The proximate composition of the flour blends were significantly (P< 0.05) different for the moisture (7.52.-6.89%), ash (2.00-2.36%), protein (4.90-4.55%), fat (1.41-1.25%) and carbohydrate (82.09-77.73%). The water absorption (2.53 – 4.10%) and least gelation concentration(6.43-12.03%) of the blends increased while the bulk density (0.65-0.53 g/ml), dispersibility (1.49 -2.50%), swelling capacity(2.59 -3.83%) and foaming capacity (26.73-6.44 g/ml).The blends were rich in iron(8.43-19.22 mg/100g), zinc (7.43-18.11 mg/100g), magnesium (94.54-170.49 mg/100g) and phosphorus (30.63-84.01 mg/100g). The blends were rich in pro-

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vitamin A (5.51-17.42). Vitamin B_1 (0.43-0.84) and vitamin C (4.81-17.81 mg/100g). The sensory scores recorded on the flour blends for appearances (7.10- 8.50), texture (7.40 -8.10), taste (7.10 - 7.85), aroma (6.70 -7.60) and acceptability (6.35-7.70) decreased with increasing level of carrot flour in the blends. The biscuits containing 75% wheat flour, 20% yam flour and 5% carrot flour was the most preferred.

Keywords: Proximate; functional; minerals; yam and carrot flour blends.

1. INTRODUCTION

Yam is a tuber crop belonging to the (*Dioscorea*) family. It has been reported to have nutritional superiority when compared with other tropical root crops [1]. Yam is an annual root tuber bearing plants with more than 600 species which are economically important in terms of food, income and medicine [2]. Yams are the most important staple food in West Africa, after cereals [3]. Africa accounts for about 94% of the world production of yams with Nigeria as the leading producer in the continent [4]. Fresh yams are difficult to store and are subject to deterioration during storage. Carrot *(Daucus carota* L) is one of the popular root vegetables grown throughout the world and is the most important source of dietary carotenoids in Western countries including the United States of America [5] Carrot (*Daucus carota*) is a root vegetable, usually orange in color, though, purple, black, red, white, and yellow varieties also exist. Carrots are a domesticated form of the wild carrot, *Daucus carota*, native to Europe and south-western Asia.

Biscuit are snacks that are popular and widely consumed all over the world by people of all ages. They are traditionally made from soft wheat, a cereal, which is cultivated in many parts of the world, but imported by countries with unfavourable climatic conditions. Such importing countries spend a lot of foreign exchange on importation of wheat. Hence a compelling need to develop an adequate substitute for wheat. Biscuits have the potential to be significant contributor of essential nutrients in the human diet. This is primarily because biscuits are very popular and well accepted by consumers including children, youths, women etc. [6] so biscuits can be a good source of nutrients for all. A successful way to improve the nutritional aspect of biscuits is by preparing cookies/biscuits with enriched flours (composite flour) which contain a significant amount of nutrient such as protein, vitamins and minerals [7]. This has increase the quest for a wheat substitute. Flours with better nutritional quality than wheat would be highly desirable, especially in developing countries where malnutrition is prevalent. Hence, the need for composite flours. Usually, the aim of producing composite flour is to get a product that is better than the individual components.

2. MATERIALS AND METHODS

2.1 Sample Collection

The yam tuber variety *Dioscorea rotundata*, carrot and wheat were purchased from Makurdi, township Benue State, Nigeria. Reagents used were of analytical grade and were obtained from recognized local suppliers

2.2 Preparation of Yam Flour

Yam flour was produced following the method described by Enwere [8]. The yam tubers are washed to remove sand, dirt and other adhering materials. The yam tubers were peeled manually with sharp stainless kitchen knife, sliced into small pieces of 0.02 mm thickness and thereafter steeped in water containing sodium metabisulphite of 0.2% for 5 min (so as to arrest the browning reaction) after which the yam pieces were removed and placed in a sieve to remove excess water, then were cooked for 10 min at 10^{o}C. The yam pieces were oven-dried at 70˚C for 10 h, milled using hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, serial No. 950401), resulting flour passed through a 250 µm sieve (Endecotts Ltd, England) and packed in polythene bags prior to use. The flow chart of the preparation of yam flour is shown in Fig. 1.

2.3 Preparation of Carrot Flour

The method described by Yuanjuan [9] was adopted for the preparation of carrots flour. Fresh carrot roots were sorted, washed with water and peeled manually with knife to remove the outer skin, then blanched in a water solution of potassium metabisulphite (0.2%), at 92 ^{o}C for 3 min. The blanched carrots were drained and sundried for 10 h, milled and sieved through 250 µm sieve. The carrot powder was packaged in a polyethylene bag prior to use. The flow chart of the preparation of carrot flour is shown in Fig. 2.

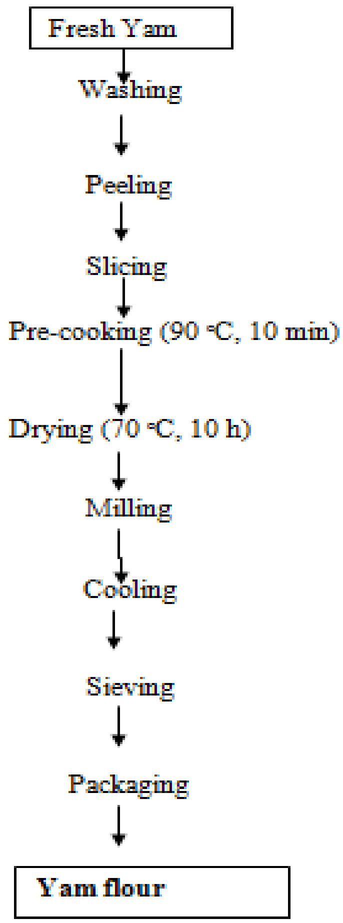

Fig. 1. Flow chart for yam flour production
Source: Adapted by Enwere [8]

2.4 Preparation of Biscuit

The biscuit was produced using the formulation given by Iwe [10]. Which consist of flour 100kg, butter 20g, sugar 20g, 1.5g baking powder, 0.5g salt and 10g egg. The method used for the preparation of biscuits was thoroughly mixed in a bowl after which wheat flour, yam and carrot flour mixed with water were then form dough. The dough was shaped using the coca-cola bottle top and baked on a greased tray at 160 °C for 15 min. The biscuits were cooled to ambient temperature and then packaged in high-density polyethylene bags prior to use. The flow chart of the preparation of biscuits is shown in given in Fig. 3.

2.5 Analysis of Samples

2.5.1 Determination of Proximate Composition

The proximate composition of the blends was determined by the AOAC [12] methods.

2.5.2 Evaluation of functional properties

The bulk density of the flour blends was determined by the method of [13] while the method of [12] was adopted in the determination of the swelling capacity. The dispensability of the flour blends was determined by [13]. The forming capacity and the least gelation concentration were determined by [14] and [15] respectively.

2.5.3 Determination of vitamin composition

The method described by [16] was used to determine the vitamin A, B_1 content of the sample while that of [17] was used to determine the vitamin C.

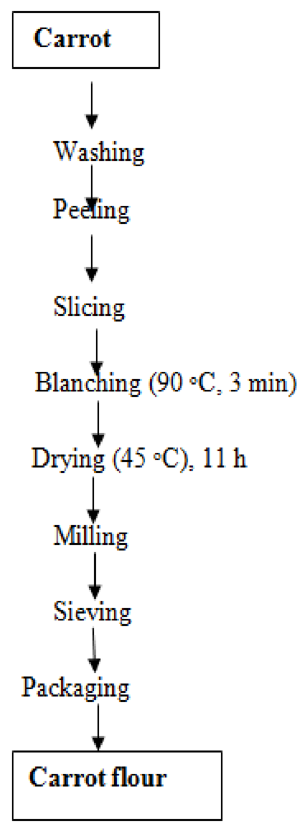

Fig. 2. Flow chart for carrot flour production
Source: Yuanjuan [9] was adopted

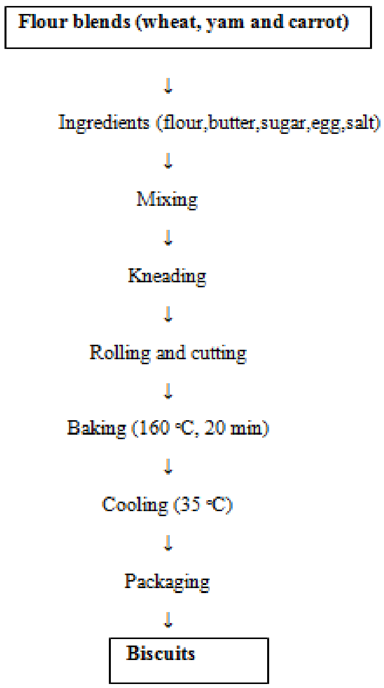

Fig. 3. Flow chart for production of biscuit
Source: Agu [11] was adopted

2.5.4 Determination of mineral content

The mineral contents of the formulated samples were evaluated using the method of [18].

2.5.5 Sensory evaluation

Biscuits samples were evaluated for taste, flavor, texture, appearance, as well as general acceptability using a 20-member untrained panelists 9 point hedonic scale.

2.6 Statistical Analysis

All Analyses were carried out in triplicates. The results obtained were subjected to analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 17.0.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Biscuits Samples

The proximate composition of the yam carrot flour blends are presented in the Table 3. Moisture content of the flour blends ranged between 6.91-7.57%. There is a significant decrease ($p<0.05$) in moisture content with increase in level of substitution of carrot flour which is an indicator of long shelf life/ storage stability since moisture and water activity of a product determines greatly the keeping quality of foods. These moisture content values were minimal and may not have adverse effect on the quality attributes of the product [19]. The lower the moisture contents of the food the better the storage stability of food as reported by Wireko-manu [20]. Ash content which gives a measure of the mineral content of food material increased significantly ($p<0.05$) as the amount of carrot flour inclusion increased. The Ash content ranged from 2.00% to 3.50%. Sample E had the value of 2.65% and sample A had the lowest ash content value of 2.00% and the 100% carrot had the highest ash content of 3.50%.

Table 1. The yam and carrot flour blends for the preparation of stiff dough

Number of flours blends	Yam flour (g)	Carrot flour (g)
1	100	0
2	95	5
3	90	10
4	85	15
5	80	20
6	0	100

Table 2. Recipe for the preparation of biscuits

Wheat (g)	Yam (g)	Carrot (g)	Fat (g)	Sugar (g)	Baking Powder (g)	Salt (g)	Eggs (g)
100	-	-	20	20	1.5	0.5	10
85	10	5	20	20	1.5	0.5	10
80	15	5	20	20	1.5	0.5	10
75	20	5	20	20	1.5	0.5	10
70	25	5	20	20	1.5	0.5	10

Source: Iwe [10]

These values were similar to that reported by kanu [21] from production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults. The ash content increases with increase substitution of soy beans flour. Ash content level as reported by Alinor [22] was regarded as a measure of the quality grade of the flour and often a useful criterion in identifying the authenticity of food. Protein content ranged from 3.01 to 4.90% The protein content for the flour blends was significantly different ($p<0.05$) amongst the samples with Sample A having the highest protein content of 4.90% while 100% carrot flour had the lowest of 3.01%. The protein content of the flour blends increased with increase in carrot flour inclusion. This is in conformity with the work reported by [23] where an increase in protein content (7.28%) and ash (3.58%) was observed when yam flour was substituted with 40% cowpea flour and an increase in protein content from 3.5% in the control (yam flour) to 19.7% for yam flour fortified with 40% soybeans flour respectively. But the result is in contrast with the work of Olaoye [24] who reported a decrease with increase in the proportion of breadfruit flour used to supplement wheat flour, in the percentages of 0, 5, 10, 15, 20 and 25 for biscuit production. The protein content of wheat has been reported to be higher than its breadfruit counterpart and this could be responsible for the lower values of crude proteins in the biscuit samples, as the amount of bread fruit flour increases [25] As an extension, the proximate composition of carrot is slightly higher than that of yam hence the increase in its value as it was been supplemented with carrot flour.The crude fibre ranged between 1.60, 4.50and 4.65% and this showed a corresponding significant increase ($p<0.05$) with increased in the proportion of carrot flour. it was observed that sample E had 4.50% , sample A had 1.60% and the 100% carrot blend had the highest 0f 4.65%. Carrot has relatively higher crude fibre than Yam and this could justify the result obtained for the different samples. Crude fibre is known to aid the digestive system of human as described by AOAC [26], indicating that the carrot supplemented yam flour could attract good acceptability by many people as well as health organizations. Fat content of blends ranged from 1.18 to 1.41% to 1.25%. E has the value of 1.25% and sample A had the highest 1.41% ,the 100% carrot flour blend had the lowest value of 1.18%, though the incremental values were minimal but significantly different ($p>0.05$) from each other. According to AOAC [26] fat plays a significant role in the shelf life of food products and as such relatively high fat content could be undesirable in baked food products. This is because fat can promote rancidity in foods, leading to development of unpleasant and odorous compounds.Carbohydrate content varied significantly ($p>0.05$) and decreased with addition of carrot flour. The value ranges from 82.09% to 71.25%. Sample A was significantly higher ($p<0.05$) with 82.09% while, the 100% carrot blend lowest value of 71.25%, sample E was 77.73%. This was in agreement with the findings of Jimoh [27] who reported a decrease in carbohydrate content with increase in soybean flour fortification. The result implies that yam is rich source of carbohydrate. Carbohydrate plays a vital role in supply of energy to cell such as brain, muscle and bloods [28].

3.2 Functional Properties of Yam and Carrot Flour Blends

The bulk density of the samples were significantly ($P>0.05$) different. The bulk density values ranged from 0.49 to 0.65 g/ml. It was observed that 100% carrot blend the lowest value and sample A had highest value of 0.65 g/cm^3 and sample E had 0.53 g/cm^3. The bulk density according to Ajanaku [29] is generally affected by the particle size and the density of flour or flour blends and it is very important in determining the packaging requirement, raw material handling and application in wet processing in the food industry. The bulk density is a reflection of load the sample can carry if allowed to rest directly on one another. Onimawo [30] reported that the lower the bulk density levels, the higher the amount of flour particle that can stay together thus increase the energy content that could be derived by Padmashree [31] from his work reported that higher bulk density is desirable for greater ease of dispensability of flour since it helps to reduce the paste thickness, which is an important factor in convalescent and child feeding. Hence, sample A can be use in the preparation of convalescent and child food, while sample E with the lowest bulk density will find use in the formulation of complementary foods as reported by Akpata [32].

Swelling capacity increased with increased in carrot flour. The swelling capacity values ranged from 2.59 to 3.95 g/ml. It is clear that lowest value of swelling capacity was observed in sample A whereas the maximum in sample E. Sample A had the lowest value of 2.59 g/ml and sample E had the of 3.83 g/ml then the 100% carrot flour had the highest of 3.95 g/ml. The values were significant different from each other ($P<0.05$). The swelling powers of the flours in this study were higher to that of tiger nut flour (2.47) g/ml reported by Oladele [33] but lower than for cereal starches (24 to 42) as reported by Apiah [34]. The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations. Swelling capacity of composite flours carrot supplemented yam flour blends increased with increase in the level of incorporation ratio of carrot flour. It is explicit that the swelling capacity of composite flours was highly affected by the level of carrot flour. The swelling capacity of flour samples is often related to their protein and starch content higher protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and restricts the swelling power.

The water absorption capacity for carrot supplemented yam flour composite flours is given in Table 4. The Water Absorption capacity of the flour blends were significantly different ($P>0.05$) and ranged from 2.53 to 4.40 g/ml for all flours. The water absorption of the 100% carrot flour blend had highest value of 4.40 g/ml and lowest in sample A (2.53 g/ml). The result suggests that addition of carrot flour to yam flour affected the amount of water absorption. This could be due to molecular structure of the carrot flour which encourages water absorption, as could be seen from the higher values of WAC, with increase in proportions of yam flours. Contrary observation was reported by [35]. The increase in WAC of blends after incorporating carrot flour may be due to increase in the amylose leaching and solubility and loss of starch crystalline structure. High WAC of composite flours suggests that the flours can be used in formulation of some foods such as sausage, dough, processed cheese and bakery products. The increase in the WAC has always been associated with increase in the amylose leaching and solubility, and loss of starch crystalline structure. The flour with high water absorption may have more hydrophilic constituents such as polysaccharides. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods. The good WAC of composite flour (E) may prove useful in products where good viscosity is required such soups and gravies. The observed variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics [36].

The least gelation concentration which is defined as the lowest protein concentration at which gel remained in the inverted tube was used as index of gelation capacity. The data for LGC of different carrot supplemented yam flour blends are given in Table 4 blends were significantly different ($P>0.05$) and ranged from 6.43% to 12.03% with A recording the lowest value of 6.43% and E with highest value of 12.03%. Sample A formed gel quickly at a very low concentration of 6.43%. [37] Reported that the lower the LGC, the better the gelating ability of the protein ingredient and the swelling ability of the flour was enhanced. [38] Reported that protein gelation was significantly affected by exposed hydrophobicity and square of sulfhydryls of proteins. As the percentage of incorporation of carrot flour in yam flour (composite flour) increased, gelling properties decreased.

The low gelation concentration of sample A may be an added asset for the formation of curd or as an additive to other gel forming materials in food products. The variation in the gelling properties may be ascribed to ratios of the different constituents such as protein, carbohydrates and lipids in the blends. This suggests according to [39] that interaction between such components may also have a significant role in functional properties. Least gelation concentration values were in contrast with those reported for African yam bean (16 to 20%) by [40]. However, lower values were recorded for several species and Lab bean by [41] and [42]. [43] Also reported a LGC of 12% for black gram flour. The LGC for other flour such as lupin [44], cowpea [45] safflower and maize flour [46] were 14, 6.6, 8 and 6% (w/v) respectively. The CSYF would be useful in food system such as puddings, sauce and other foods which require thickening and gelling [47].

Dispersibility of the flour sample increased significantly ($P<0.05$). With increased in carrot content in the blends can be seen in the Table 4. The flour blends content ranged from the 1.49 to 2.50 (g/mL) it was observed that there was significant differences ($p>0.05$) in the CSYF samples. Sample A had the lowest value of 1.49 and sample E had the highest value of 2.50 (g/mL).The dispersibility of the sample A was lower than that of the other CSYF samples. However, the values of dispersibility are relatively high for all the composite flour samples hence;

they will easily reconstitute to give fine consistency dough during mixing as reported by [48].

Foaming capacity of protein refers to the amount of interfacial area that can be created by the protein [49]. Foam is a colloidal of many gas bubbles trapped in a liquid or solid. Small air bubbles are surrounded by thin liquid films as can be seen on Table 4 forming capacity decreased from 26.73(g/mL) to 6.44(g/mL). Foaming capacity of each of the CSYF varied significantly ($P>0.05$) from each other. While, sample A had the highest foaming capacity of 26.73(g/ml), sample E foaming ability (6.44 g/mL) was the least.

3.3 Mineral Contents of Samples

The result of the mineral composition of CSYF as shown in Table 5 revealed a corresponding increment in concentration of mineral contents with increase in substitution with carrot flour. There was significant difference ($p>0.05$) among the samples for iron (Fe), zinc (Zn), phosphorous (P) and magnesium (Mg). The presence of iron (8.43, 19.89), zinc (7.43-20.05), phosphorus (94.54-178.35) and magnesium (30.63-90.01) mg/100g signifies that the flour blends is capable of providing essential mineral nutrients that are needed in the body to facilitate proper functioning of certain organs in the body as reported by Oh [50].

Iron content increased with increased in carrot flour supplementation percentage. The 100% carrot flour blend had the highest value of 19.89 mg/100g and sample A had the lowest value of 8.43 mg/100g. The recommended dietary allowance for iron in adult and children is 10 mg/day while female adult is 15 mg/day. Iron is required for blood formation. The composite flour studied could therefore contribute to iron needs of consumers. Zinc is important in diet for many protein and enzymes synthesis, growth and base balance in the body as reported by Osganian [51]. The zinc value increased with increased in carrot flour ranged from (7.43-20.05) mg/100g. Zinc aids in the growth and repair of tissues, boosts the immune system and plays an important role in sperm survival. WHO recommend Zinc intake of 15 and 10 mg/day, respectively for adult and children as described by FNB [52].

Magnesium helps regulates diverse biochemical reaction in the body, including the protein synthesis, muscles and nerve function blood pressure regulation it also keeps bones strong. The 100% carrot flour blends had the highest value of 178.35 mg/100g and the 100% yam flour had 94.54 mg/100g.

Phosphorus is an essential component of phospholipids, bones and teeth, its deficiency can lead to bone, loss, weakness and loss of appetite. The phosphorus content of the flour blends increased from (94.54-178.35) mg/100g.

3.4 Vitamins Content of Flour Blends

The vitamin C, beta carotene (pro-vitamin A), vitamin $B_1$and composition in mg/100 g is presented in Table 6. For vitamin C, $B_{1,}$ D and beta carotene (vitamin A) the values ranged from between (4.81, 0.43, 5.51) and (17.81, 0.84, 17.42), respectively. The values were significantly different ($p<0.05$) from each other for vitamin C, $B_{1,}$ and Beta carotene respectively. According to [53], Minerals and vitamins are essential, but in small amounts, for the regulation of normal metabolism and as an antioxidant. Vitamin A and C were significantly high ($p<0.05$) in the CSYF than vitamin B_1. Beta carotene is known for its role in preventing cardiovascular disease in individuals at high risk [54].

Vitamin C is an essential nutrients for human, because the body cannot synthesizes it must be obtained from the dietary sources .it is required several metabolic reactions, including the biosynthesis of collagen and neurotransmitters as well as for the conversion of cholesterol to bile acids.

3.5 Means Sensory Scores from Yam and Carrot Flour Blends

The Results of sensory evaluation of flour blends samples containing different level of carrot-flour substitution as compared to the control (yam flour) is shown in Table 7. The results of the CSYF appearances did not show a consistent pattern for all the samples, and there was significant difference ($p>0.05$) in the appearances of the CSYF samples and the control sample (A). The change in the colour of the Carrot Supplemented Yam Flour from white to orange colour as a result of the addition of the carrot flour which is orange in colour. The control sample A was scored higher (8.05) by the panellist while sample C and E had the lowest scores (7.10).

The scores for texture (softness and chewiness) of the CSYF samples decrease with increase in carrot flour substitution, when compared to the yam flour (control sample A). Sample A, which is the control had the best texture score of 8.10, follow by sample B (7.75), while sample E had the lowest score of 7.40 as the supplementation of yam flour with carrot flour reduces the gelling ability of the resulting flour blends. The incorporation of carrot flour into yam flour resulted in poor flavour (taste and aroma) scores. The results show that decrease in the scores as the yam flour was substituted with carrot flour. Sample C record the lowest value 7.20 and 6.70 for taste and aroma respectively. Most of the panellist complained of flavour and aroma from the carrot flour in the Carrot Supplemented Yam Flour, since they are more conversant with the yam flour flavor and aroma.

The sensory evaluation also revealed that CSYF with carrot-flour substitution of 5% and that of 20% with scores of 7.10 respectively were overall acceptable, even though yam flour which is the control with score of 7.70 was still preferred.Sensory evaluation results showed that yam flour was more accepted in terms of appearances, texture, taste, aroma and general acceptability. This outcome was however expected because the panelist are used to yam flour.

3.6 Sensory Mean Scores of Biscuits

The flours: wheat, yam and carrot were mixed together at different ratio (A-100% wheat,B-85% wheat,10%Yam and 5%Carrot,C-80% wheat, 15%Yam and 5% Carrot,D-75% wheat, 20% Yam and 5% Carrot, E -70% wheat 25% Yam and 5% Carrot) to make biscuit. Results of the sensory evaluation of the biscuit made from different level of wheat, carrot and yam flour blends as compared with the control 100% wheat flour are shown in Table 8 The result of the colour of the biscuit made from the blends does not show any distinct or consistent pattern. There was significant difference ($p<0.05$) in the colour of sample C and D as compared to the control sample A. The colour of the biscuit which range from white to light orange is as a result of the orange colour of carrot flour added which is orange in colour. The control biscuit sample A and C were scored higher (8.15) by the panellist followed by sample D (8.14), while sample E had the lowest score of 7.75.

Table 3. Proximate composition of yam and carrot flour blends

Sample	Moisture%	Protein%	Ash%	Fibre%	Fat%	Carbohydrate
100:0	7.52 ^{e} ±0.04	4.90 ^{e} ±0.01	2.00 ^{a} ±0.02	1.60 ^{a} ±0.01	1.41 ^{e} ±0.02	82.09 ^{e} ±0.00
95:5	7.39 ^{d} ±0.01	4.84 ^{d} ±0.02	2.11 ^{a} ±0.04	2.50 ^{b} ±0.01	1.37 ^{d} ±0.02	80.81 ^{d} ±0.02
90:10	7.13 ^{c} ±0.02	4.80 ^{c} ±0.01	2.18 ^{b} ±0.14	3.34 ^{c} ±0.04	1.36 ^{c} ±0.01	79.78 ^{c} ±0.03
85:15	7.04 ^{b} ±0.01	4.72 ^{b} ±0.01	2.36 ^{b} ±0.03	4.14 ^{d} ±0.03	1.30 ^{b} ±0.03	78.61 ^{b} ±0.01
80:20	6.89 ^{a} ±0.01	4.55 ^{a} ±0.05	2.36 ^{b} ±0.03	4.50 ^{e} ±0.02	1.25 ^{a} ±0.04	77.73 ^{a} ±0.05
0:100	6.32 ^{a}±0.01	3.01 ^{a} ±0.01	3.50 ^{d} ±0.01	4.65 ^{e} ±0.01	1.18 ^{e} ±0.01	71.25 ^{a} ±0.01

Values are means ± standard deviation of 2 replicates. Means within column with the same superscript were not significantly different at (p>0.05). Keys; A= 100% yam flour, B= 95% yam and 5% carrot flour, C= 90% yam and 10% carrot flour, D= 85% yam and 15% carrot flour, E= 80% yam and 20% carrot flour, F= 100% carrot flour

Table 4. Functional properties of yam and carrot flour blends

Sample Yam: carrot	Bulk density (g/cm^3)	Swelling capacity (g/ml)	Water absorption (g/ml)	Least Gelation concentration (%)	Dispensability	Foaming (g/ml)
100:0	0.65^{a}±0.04	2.59^{e}±0.01	2.53^{e}±0.04	6.43^{e}±0.04	1.49^{d}±0.01	26.73^{a}±0.04
95:5	0.64^{b}±0.05	3.20^{d}±0.01	2.69^{d}±0.04	8.04^{d}±0.04	1.94^{c}±0.02	11.13^{b}±0.04
90:10	0.61^{c}±0.01	3.44^{c}±0.01	3.03^{d}±0.72	10.09^{c}±0.01	2.29^{b}±0.01	10.29^{c}±0.01
85:15	0.61^{c}±0.01	3.70^{b}±0.01	3.50^{b}±0.01	10.13^{b}±0.04	2.50^{a}±0.01	10.09^{d}±0.01
80:20	0.53^{c}±0.04	3.83^{a}±0.04	4.10^{a}±0.14	12.03^{b}±0.04	2.50^{a}±0.01	6.44^{e}±0.06
0.100	0.49^{d}±0.01	3.95^{e}±0.01	4.40^{e}±0.01	12.30^{a}±0.02	2.62^{a}±0.01	5.34^{e}±0.04

Values are means ± standard deviation of 2 replicates. Means within column with the same superscript were not significantly different at (p>0.05). Keys: A= 100% yam flour, B= 95% yam and 5% carrot flour, C= 90% yam and 10% carrot flour, D= 85% yam and 15% carrot flour, E= 80% yam and 20% carrot flour, F= 100% carrot flour

Table 5. Minerals content of samples

Sample Yam: carrot	Iron (mg/ 100 g)	Zinc (mg/ 100 g)	Magnesium (mg/ 100 g)	Phosphorus (mg/ 100 g)
100:0	$8.43^{a} \pm 0.04$	$7.43^{a} \pm 0.04$	$94.54^{a} \pm 0.05$	$30.63^{a} \pm 0.04$
95:5	$9.07^{b} \pm 0.09$	$9.05^{b} \pm 0.07$	$114.32^{b} \pm 0.03$	$41.71^{b} \pm 0.01$
90:10	12.43 ± 0.04^{c}	$11.42^{c} \pm 0.02$	$124.81^{d} \pm 0.01$	$48.23^{d} \pm 0.04$
85:15	$14.81^{d} \pm 0.01$	$15.62^{d} \pm 0.02$	$114.92^{c} \pm 0.03$	$43.05^{c} \pm 0.06$
80:20	$19.22^{e} \pm 0.02$	$18.11^{e} \pm 0.01$	$170.49^{d} \pm 0.01$	$84.01^{e} \pm 0.01$
0:100	$19.89^{e} \pm 0.04$	$20.05^{e} \pm 0.01$	$178.35^{e} \pm 0.04$	$90.01^{e} \pm 0.02$

Values are means ± standard deviation of 2 replicates. Means within column with the same superscript were not significantly different at (p>0.05). Keys: A= 100% yam flour, B= 95% yam and 5% carrot flour, C= 90% yam and 10% carrot flour, D= 85% yam and 15% carrot flour, E= 80% yam and 20% carrot flour, F= 100% carrot flour

Table 6. Vitamins content of flour blends

Sample Yam: carrot	Vitamin A (Beta- carotene) (mg/100 g)	Vitamin B (Thiamine) (mg/100 g)	Vitamin C (mg/100 g)
100:0	$5.50^{a} \pm 0.01$	$0.43^{a} \pm 0.04$	$4.81^{a} \pm 0.02$
95:5	$6.43^{b} \pm 0.04$	$0.45^{b} \pm 0.02$	$10.04^{b} \pm 0.06$
90:10	$7.83^{c} \pm 0.04$	$0.52^{c} \pm 0.02$	$13.04^{c} \pm 0.06$
85:15	$13.13^{d} \pm 0.04$	$0.71^{d} \pm 0.01$	$15.24^{d} \pm 0.05$
80:20	$17.42^{e} \pm 0.02$	$0.84^{e} \pm 0.05$	$17.81^{e} \pm 0.02$
0:100	$18.03^{e} \pm 0.02$	$0.96^{e} \pm 0.02$	$19.05^{e} \pm 0.02$

Values are means ± standard deviation of 2 replicates. Means within column with the same superscript were not significantly different at (p>0.05). Keys: A= 100% yam flour, B= 95% yam and 5% carrot flour, C= 90% yam and 10% carrot flour, D= 85% yam and 15% carrot flour, E= 80% yam and 20% carrot flour, F= 100% carrot flour

Table 7. Sensory attribute of stiff porridge from yam and carrot flour blends

Sample	Appearance	Texture	Taste	Aroma	Acceptability
100:0	$8.05^{a} \pm 1.19$	$8.10^{d} \pm 1.02$	$7.85^{a} \pm 0.93$	$7.60^{a} \pm 0.9$	$7.70^{a} \pm 2.06$
95:5	$7.35^{b} \pm 1.14$	$7.75^{b} \pm 1.02$	$7.40^{b} \pm 1.14$	$7.35^{b} \pm 1.18$	$7.10^{b} \pm 2.17$
90:10	$7.10^{d} \pm 0.85$	$7.55^{c} \pm 0.83$	$7.20^{d} \pm 1.06$	$6.70^{e} \pm 1.03$	$6.35^{d} \pm 1.96$
85:15	$7.30^{c} \pm 1.03$	$7.45^{d} \pm 1.01$	$7.30^{c} \pm 1.42$	$6.80^{d} \pm 1.67$	$6.65^{c} \pm 1.80$
80:20	$7.10^{d} \pm 1.52$	$7.40^{e} \pm 1.54$	$7.10^{c} \pm 1.94$	$7.05^{c} \pm 2.06$	$7.10^{b} \pm 2.22$

Values are means ± standard deviation of 2 replicate. Means within column with the same superscript were not significantly different at (p>0.05).Keys: A= 100% yam flour, B= 95% yam and 5% carrot flour, C= 90% yam and 10% carrot flour, D= 85% yam and 15% carrot flour, E= 80% yam and 20% carrot flour, F100% carrot flour

Table 8. Means sensory scores from wheat, yam and carrot flour blends on the biscuits

Sensory Attribute	A	B	C	D	E
Colour	$8.15^{a} \pm 0.93$	$7.95^{b} \pm 0.68$	$8.15^{a} \pm 0.74$	$8.14^{b} \pm 0.59$	$7.15^{c} \pm 0.55$
Texture	$7.95^{a} \pm 0.68$	$7.60^{a} \pm 0.68$	$7.85^{a} \pm 0.81$	$8.15^{a} \pm 0.67$	$7.75^{a} \pm 0.85$
Taste	$7.90^{a} \pm 1.09$	$7.60^{a} \pm 1.27$	$7.90^{a} \pm 0.78$	$8.15^{a} \pm 0.74$	$7.45^{a} \pm 0.82$
Flavor	$7.60^{a} \pm 1.42$	$7.80^{a} \pm 0.52$	$7.85^{b} \pm 0.74$	$7.55^{b} \pm 0.99$	$7.90^{a} \pm 0.71$
Generally acceptability	$8.15^{a} \pm 0.81$	$7.85^{b} \pm 0.87$	$7.95^{b} \pm 0.75$	$8.25^{a} \pm 0.78$	$7.65^{b} \pm 0.67$

Values are means ± standard deviation of duplicate determination. Means in the same column with common superscript letter are not significantly (p>0.05) different. Keys: A= Yam flour 100%, B= Yam flour 95% and carrot 5%, C= Yam flour 90% and carrot 10%, D= Yam flour 85% and carrot 15%, E= Yam flour 80% and carrot 20%

The scores for texture (softness and chewiness) of the biscuit made from the flour blend ranged from 7.60 to 8.15 with sample D having the highest scores and sample B the lowest. It was only sample D that was significantly different (p<0.05) from the control (sample A) in terms of texture. There was no significant difference (p<0.05) in the taste and aroma of the biscuit samples when compare with that of the control, except for sample D for taste. For taste, the score range from 7.45 to 8.15 where sample E was the lowest and sample D the highest. For aroma, sample D had the least score (7.55) while sample E had the highest score of 7.90. The high aroma of sample E could be as a result of the strong aroma of the carrot flour. Sample D with a score of 8.25 was the most acceptable follow by sample A, the control with a score of 8.15 and sample E was the least acceptable with a score of 7.65. Sensory evaluation results show that biscuit sample D produced from flour blends (wheat, yam and carrot at ratio 75:20:5) was the most preferred in terms of texture, taste and general acceptability.

4. CONCLUSION

Based on the results of this study, it is concluded that carrot flour had higher fat, ash, crude fiber, mineral, vitamin content and functional properties than the yam flour. However, the scores for appearance, texture, taste, aroma and general acceptability of the stiff dough prepared from yam flour supplemented carrot flour were inferior to that of yam flour stiff doughThe flour yam-carrot flours are shelf stable with higher nutritional content when compared to 100% yam flour thus addition of carrot to yam flours will increase ones nutritional intake and also create diversity in areas predominantly known for high intake of yam dough such Benue, Taraba and Nasarawa states where micro nutrient malnutrition is also high as carrot is a good house of many micronutrients.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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