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QUALITY CHARACTERISTICS OF BISCUITS PREPARED FROM COMPOSITE FLOUR OF YELLOW FLESHED CASSAVA AND QUALITY PROTEIN MAIZE

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Abstract: *Protein and vitamin A deficiencies are two public health concerns in Nigeria. This study investigated the quality attributes of biscuits prepared from yellow fleshed cassava flour (YFCF) and quality protein maize flour (QPMF). The proximate, mineral and antinutrient composition, β-carotene content and color attributes of the composite flour and biscuits were determined. Data were subjected to analysis of variance and the means separated by Duncan's Multiple Range Test. The protein and β-carotene contents of the flour blends ranged from 5.69 to 8.54% and 1.45 to 2.76 µg/g, respectively. On the other hand, the biscuits contained 11.38 to 14.6% protein and 1.35 to 1.82 µg/g β-carotene. The protein, ash, crude fiber, spread ratio and mineral composition of biscuits increased as QPMF increased. The hardness of the biscuits decreased with increase in QPMF. Furthermore, the mean sensory scores of the biscuits revealed that they were liked moderately. However, the most acceptable biscuit was the one prepared from 20% YFCF and 80% QPMF.This study has demonstrated the possibility of producing acceptable biscuit from quality protein maize, which could be used in school feeding programmes in Nigeria.*

Keywords: *Biscuit, Nutrient composition, Quality protein maize, Sensory attributes, Yellow fleshed cassava*

1. Introduction

Biscuits are popular food items among Nigerians, may be as a result of their work schedule where there is little or no time to cook main dishes. Biscuit was reported as being the most consumed snack among young Nigerians [1]. The versatility of biscuit thus makes it a suitable vehicle in ameliorating cases of malnutrition in Nigeria. The major raw material in biscuit manufacture is the flour. The conventional flour in biscuit manufacture is the one obtained from wheat. However, flours obtained from other crops are being used, depending on such factors as availability, affordability, accessibility and nutritional need [2, 3]. Type of flour has been reported to influence the quality attributes of biscuit. For example, Agiriga and Iwe [1] reported that composite flour of cassava, groundnut and corn starch affected the thickness and spread ratio of cookies. Many authors also reported that flours affected the functional, acceptability and nutritional value of biscuits [3, 4, 5, 6].

Cassava (*Manihot esculenta*Crantz) has been recognised as the world's sixth most important crop (after wheat, rice, maize, potato, and barley) and the most widely cultivated root crop in the tropics [7]. Nigeria is the world's largest producer of cassava roots. Its potential in improving food insecurity and socioeconomic well-being of Nigerian citizens have been documented [7]. Cassava root, though rich in starch, is poor in protein [8]. New varieties of cassava with low in cyanide content, drought-resistant, high yielding, disease- and pest-resistant, and early maturing have been developed. Of particular note is the yellow fleshed cassava (or vitamin A biofortified cassava) variety which is of relevance in solving the endemic vitamin A deficiency in Nigeria [9]. The typical composition of yellow fleshed cassava flour is 23.18 to 53.56% starch, 0.62 to 1.74% crude fibre, 0.93 to 1.85% ash, 0.146 to 0.877 μg/g β-carotene, 2.43 to 3.4 mg/kg HCN [9, 10]. These varieties could supply about 25% of daily vitamin A requirements of children and women [9]. Cassava flour has been advocated as an ideal substitute to wheat flour in the production of pastries due to its availability and low cost of production [8, 11].Previous studies [12,13] have shown that 40% partial substitution of wheat flour with cassava flour for bread production is possible while complete 100% substitution of wheat flour with cassava for biscuit manufacture has been reported by Oyewoleet al [14].

In terms of cultivation areas and total production, maize (*Zea mays*) has been reported as the third most important cereal (after wheat and rice) in the world [3]. It is a major food commodity for the teeming population of developing countries. Varieties of maize include pop, flint, dent, floury and sweet cultivars. Quality protein maize (QPM) is a biofortified cultivar with twice the amount of lysine and tryptophan than the conventional maize and a protein bio-availability that rivals milk casein [15, 16, 17]. Average composition of QPM has been given as 10% moisture, 10% protein, 3.06% crude fat, 1.2% ash, 2.38% crude fibre and 85.75% carbohydrate [18]. The total phenolic content and antioxidant activity of QPM are

1.38 mg $GAEg^{-1}$ and 68% DPPH inhibition, respectively. Biscuits have been produced from QPM-wheat, QPM-wheat-oat-maize-soybean, QPM-pumpkin leaves-cocoa powder flour blends [18, 19, 20, 21].

2. Materials and methods

2.1 Materials

The yellow fleshed cassava flour (YFCF) was obtained from the Institute of Food Security, Environmental Resources and Agricultural Research, Federal University of Agriculture, Abeokuta, Nigeria. The cassava variety used in preparing the flour was TMS 01/1412. QPM grains (ART 98/Swi-Y) were purchased from the seed store of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Nigeria. Sugar, salt, margarine, sodium bicarbonate (baking powder), milk (skimmed milk powder), eggs, and vanilla flavour were sourced from a local market in Ogun State.

2.2 Preparation of quality protein maize flour (QPMF)

QPMF was prepared according to the method described by Mesfin and Shimelis[22]. Sorting was done by removing the undesirable seeds and other foreign materials from QPM by the principle of flotation. Then the seeds were sundried and dry milled. The resultant flour was sieved with a mesh size of 250μm, and packaged in a polyethylene bag.

2.3 Formulation of blends

The composite blends were formulated (Table 1) after a preliminary screening experiment using paired preference test. The upper limit of substitution of YFCF with QPMF was set at 80% due to the results and observations obtained from the preliminary experiment.

2.4 Preparation of biscuit

The composite flour and the other ingredients (as presented in Table 2) were weighed using the ingredient formulation by Oyewoleet al [14]. The main stages of the biscuit preparation were mixing, rolling and cutting. Baking was done at 160 ^{0}C for 20 minutes.

2.5 Determination of proximate composition

The proximate composition of the composite flours and biscuits was determined using the methods stated by AOAC [23]. Moisture content was determined using a digital moisture analyser in which about 0.5 g of ground sample was spread in the drying pan after cleaning and tarring the weight of the pan. The Soxhlet method of solvent extraction was used to determine the crude fat content. The weight of the filter paper was noted and about 2 g of ground sample was measured into the filter paper. The summation of the weights of the filter paper and sample was denoted as W_1.The filter paper was well tied to avoid the spilling out of the content. Then the filter paper was put into the thimble. The thimbles with the samples were attached to the extraction apparatus. Then diethyl ether was poured into a boiling flask after which set up of the extraction apparatus was done. The apparatus hot plate was set on to allow for the extraction process to take place for minimum of 6 h. Then the recycling process made by the diethyl ether was stopped to let the solvent to evaporate from the boiling flask with the extract. In the process, the evaporated solvent was recovered in the apparatus. The filter paper was removed from the thimble and was allowed to dry in the oven for 30 min at 150°C to evaporate the remaining solvent in the sample. Then, it was removed from the oven, cooled in a desiccator for 30 min. Thereafter, the filter paper was weighed and recorded as W_2. The percentage fat was then calculated.

Then, 20 ml of sulphuric acid was added to the samples in the digestion tubes and about half of a Kjeldahl tablet was added to facilitate the digestion process by catalysing and raising the boiling point temperature of sulphuric acid. After this, the mixture was placed in the digester at a temperature of about 370 °C for 1.5 h. On completion of the digestion the digested sample was cooled and made up to 100 ml by adding distilled water. About 20 ml of the solution was then poured into the distillation flask and distillation was done using 40% NaOH. The ammonia was then distilled into a receiving flask that contained solution of excess boric acid (4%) for reaction with ammonia. Titration was carried out with 0.1 N of HCl using methyl red as an indicator. In determining the crude fibre content of sample, about 1.0 g of defatted samples was measured and transferred into a round-bottomed flask. Then 50 ml of trichloroacetic acid was added to the sample in the round-bottomed flask and boiled.

Table 1.

Composite blends of yellow fleshed cassava flour and quality protein maize flour

Flour blends	YFCF (%)	QPMF (%)
Control	100	0
CM-1	90	10
CM-2	70	30
CM-3	50	50
CM-4	30	70
CM-5	20	80

YYFCF= yellow fleshed cassava flour; QPMF= quality protein maize flour

Table 2.

Biscuit ingredients

Ingredients	Quantity
Flour	200g
Fat	100g
Salt	0.2g
Vanilla flavor	0.2g
Baking powder	2g
Powder milk	3 tablespoons
Egg	1 whole
Granulated sugar	70g

Source: Oyewole et al (1996)

3. Results and discussion

3.1 Quality attributes of composite flour of yellow fleshed cassava flour and quality protein maize flour

The quality attributes of the composite flour are presented in Table 3. The moisture, fat, protein, crude fibre, ash and carbohydrate of the blends ranged from 9.25 to 10.04%, 0.80 to 3.87%, 5.9 to 8.54%, 1.20 to 3.30%, 0.78 to 1.22%, and 75.98 to 81.02%, respectively. The moisture contents of the blends were lower than 14% recommended for safe storage of flour foods [30]. Similar ranges of values were reported by Thariseet al[30], for cassava-based composite blends. The protein, crude fibre, ash and mineral contents of the blends increased while the carbohydrate energy and cyanide contents decreased as the maize flour increased. The hydrogen cyanide, which decreased as the maize flour increased in the blend, ranged between 1.08 and 1.62 mg/kg. The cyanide content ranged from 1.08 to 1.62 mg/kg and increased as QPMF increased in the blend. The β-carotene contents of the composite flour ranged from 1.40 to 1.87 µg/g, and decreased with increase in QPMF. The quantity of β-carotene in the biscuit samples is much lower than the daily recommended values of 750µg and 400 to 600 µg for women and children, respectively [10]. The lightness (L*), redness (a*) and yellowness (b*) increased as the content of QPMF increased in the blends. This observation contradicts the findings of Bolade and Adeyemi [31] who reported that the L* value of cassava-maize flour blend increased with increase in cassava flour. The difference may be due to the varieties of maize and cassava used in the two studies.

Table 3.

Quality attributes of composite flour of yellow fleshed cassava and quality protein maize

Quality attributes	CM-1	CM-2	CM-3	CM-4	CM-5
Proximate composition (%)					
Moisture	10.03^{b}	10.04^{b}	9.81^{b}	9.26^{a}	9.25^{a}
Fat	0.80^{a}	3.87^{e}	3.13^{c}	1.97^{b}	3.43^{d}
Protein	5.9^{ab}	6.35^{ab}	6.79^{bc}	7.66^{cd}	8.54^{d}
Crude fibre	1.20^{a}	1.90^{ab}	2.65^{bc}	3.15^{c}	3.30^{c}
Ash	1.04^{ab}	0.78^{a}	1.14^{b}	1.22^{b}	1.20^{b}
Carbohydrate	81.02^{b}	77.05^{a}	76.48^{a}	76.73^{a}	75.98^{a}
Mineral composition (mg/100g)					
Calcium	0.10^{a}	1.17^{b}	1.46^{c}	1.67^{d}	1.92^{e}
Sodium	0.29^{a}	0.41^{c}	0.37^{b}	0.42^{d}	0.47^{e}
Magnesium	0.21^{a}	0.22^{b}	0.24^{c}	0.26^{d}	0.27^{e}
Zinc	0.11^{a}	0.12^{b}	0.13^{c}	0.16^{d}	0.17^{e}
Iron	0.11^{a}	0.12^{b}	0.17^{c}	0.17^{d}	0.21^{e}
Energy (kcal/g)	354.90^{a}	368.48^{b}	361.21^{ab}	355.34^{a}	367.80^{b}
β-carotene (µg/g)	1.87^{b}	1.58^{ab}	1.45^{a}	1.51^{a}	1.40^{a}
HCN (mg/kg)	1.62^{d}	1.60^{d}	1.41^{c}	1.30^{b}	1.08^{a}
Colour					
L*	91.43^{d}	87.30^{bc}	85.15^{bc}	82.39^{ab}	79.33^{a}
a*	-0.005^{a}	0.085^{ab}	0.135^{ab}	0.370^{bc}	0.560^{c}
b*	12.40^{b}	15.50^{c}	18.82^{d}	23.62^{e}	25.22^{f}

CM-1= 90% cassava flour + 10% QPM; CM-2=70% cassava flour+ 30% QPM;
CM-3=50% cassava flour+50% QPM; CM-4=30% cassava flour + 70% QPM;
CM-5=20% cassava flour + 80% QPM. Means with same superscripts within a row are not significantly different at P > 0.05

3.2 Physical and chemical attributes of biscuits prepared from composite flour of yellow fleshed cassava and quality protein maize

The physical and chemical attributes of the biscuits are presented in Table 4. The weight, diameter, thickness and spread ratio of the biscuits, which varied significantly, were 6.64 to7.93g, 4.51to 4.56 cm, 0.622 to 0.767 cm, and 5.93 to 7.33, respectively. The weight, thickness and diameter of the biscuits increased as the proportion of QPMF increased in the flour blend. Similar trend was reported by previous workers [20, 25, 21]. This may be due to the additional protein from QPMF. Proteins (especially the polar amino acids) have been reported to enhance binding of biscuit components due to their high water absorption capacity [21]. Bolade and Adeyemi [31] reported that the water holding capacity of maize flour (2.09 g/g) was higher than cassava flour (1.87 g/g). The authors further reported that the water holding capacity of maize-cassava flour blend decreased with increase in the level of cassava flour. Except for the biscuits prepared from flour blend containing 20% yellow fleshed cassava and 80% quality protein maize, other samples had spread ratio higher than the control. The spread ratio has been referred to as spread in another publication [32]. It depends on the available moisture to act as solvent and the dough strength, among other factors. Increased availability of water has been reported to result in a decrease in dough viscosity and increase in spread ratio [32]. Increased spread is generally desirable in biscuit making; exception however is ginger nut biscuit where increased thickness (height) is required to develop its desirable porous and soft crumb [32]. The spread ratio tended to increase with increase in QPMF. Significant ($P < 0.05$) differences occurred in the colour attributes of the biscuit samples. There was a decrease in the lightness (L* value) and increase in the redness (a* value) and yellowness (b* values) as the level of QPMF increased in the blend. The textural properties of a food refer to those properties impacted by the structural elements of the food. They are objectively measured by the sense of touch in relation to the deformation, disintegration and flow of food under a force and are functions of time, mass and distance [33]. Changes in ingredients and processing can cause variations in texture [34]. The peak force of the QPM-based biscuits was lower than the control. Taiwo et al [21] reported similar results. The high the peak force the harder the cookies; harder cookies are undesirable [35].

There were significant ($P < 0.05$) differences in the proximate composition of the biscuits. The moisture contents of the biscuit samples were between 5.57 and 6.51%, which is higher than the level (1.60 to 1.19%) reported by Taiwo et al [21] and the 5% limit given by the Nigerian Industry Standard. The importance of moisture content in the storability of biscuit cannot be overemphasized as it affects the biochemical activity of foods. The range of values of protein, moisture, ash, fat, fibre and carbohydrates of the biscuit samples were 11.38 to 14.67%, 1.57 to 2.51%, 0.66 to 1.48%, 25.10 to 28.22%, 1.60 to 2.89% and 52.59 to 58.45%, respectively. The protein, ash, fat and crude fibre contents of the biscuits increased while the moisture and carbohydrate decreased with increase in QPMF level. Similar results were reported by Olapade and Ogunade [36] and Amir et al [37]. Foods containing high amount of protein, fat, ash and crude fibre tended to have lower amount of carbohydrate [21]. Kaur et al [18] associated increase in spread ratio with increase in crude fibre. The authors further submitted that high-fibre flours produce weaker dough than refined flours, which results in greater flow of cookie dough and larger cookie diameter.

There were significant ($P < 0.05$) differences in the mineral composition of the biscuits. The mineral contents increased with increase in QPMF level. The energy content decreased the QPMF level increased.

Table 4.
Physical and chemical attributes of biscuits prepared from biofortified cassava-maize composite flour

Quality attributes	CM-1	CM-2	CM-3	CM-4	CM-5	Control*
Physical attributes						
Weight (g)	6.88^{b}	6.64^{a}	7.18^{c}	7.43^{d}	7.93^{e}	7.34^{d}
Diameter (cm)	4.51^{a}	4.56^{c}	4.53^{b}	4.55^{bc}	4.55^{bc}	4.51^{a}
Thickness (cm)	0.639^{ab}	0.622^{a}	0.645^{c}	0.767^{b}	0.767^{b}	0.675^{c}
Spread ratio	7.05^{c}	7.33^{d}	6.74^{b}	7.04^{c}	5.93^{a}	6.67^{b}
Colour						
L*	58.82^{d}	55.95^{c}	50.82^{b}	51.24^{b}	46.79^{a}	63.82^{e}
a*	7.23^{b}	7.75^{c}	9.06^{d}	8.91^{d}	10.32^{e}	5.59^{a}
b*	21.75^{c}	21.94^{e}	21.24^{b}	22.83^{d}	20.87^{a}	21.74^{c}
Peak force (N)	58.65^{e}	32.70^{d}	29.27^{c}	13.19^{a}	22.10^{b}	93.10^{f}
Proximate composition (%)						
Moisture	6.01^{c}	5.74^{ab}	5.81^{ab}	5.57^{a}	5.93^{c}	6.51^{d}
Fat	25.65^{a}	28.22^{a}	25.10^{a}	27.20^{a}	26.83^{a}	27.81^{a}
Protein	12.92^{b}	12.48^{b}	11.38^{a}	14.67^{c}	14.67^{c}	12.92^{b}
Crude fibre	1.60^{a}	2.89^{c}	2.15^{ab}	2.15^{ab}	2.50^{bc}	1.60^{a}
Ash	0.82^{a}	0.66^{a}	1.10^{b}	0.82^{a}	1.48^{c}	1.10^{b}
Carbohydrate	57.01^{ab}	54.01^{ab}	58.45^{b}	53.58^{ab}	52.59^{a}	54.06^{ab}
Mineral composition (mg/100g)						
Calcium	0.85^{b}	0.87^{c}	1.46^{d}	1.67^{e}	1.92^{f}	0.77^{a}
Sodium	0.29^{b}	0.41^{d}	0.37^{c}	0.42^{e}	0.47^{f}	0.23^{a}
Magnesium	0.21^{b}	0.22^{b}	0.24^{bc}	0.26^{c}	0.27^{d}	0.16^{a}
Zinc	0.11^{b}	0.12^{bc}	0.13^{c}	0.16^{d}	0.17^{d}	0.09^{a}
Iron	0.11^{a}	0.12^{a}	0.17^{b}	0.17^{b}	0.21^{c}	0.10^{a}
Energy (kcal/g)	510.53^{a}	519.92^{a}	505.26^{a}	517.82^{a}	510.48^{a}	518.21^{a}
β-carotene (µg/g)	0.045^{a}	0.819^{b}	1.45^{c}	2.82^{a}	2.17^{d}	1.51^{c}
HCN (mg/kg)	1.41^{a}	1.19^{b}	1.22^{b}	1.12^{b}	1.09^{b}	1.62^{a}

CM-1= 90% cassava flour + 10% QPM; CM-2=70% cassava flour+ 30% QPM;
CM-3=50% cassava flour+50% QPM; CM-4=30% cassava flour + 70% QPM;
CM-5=20% cassava flour + 80% QPM. Means with same superscripts within a row are not significantly different at P > 0.05, *biscuit prepared from 100% biofortified cassava flour

However, except for the two samples obtained from YFCF:QPMF (70:30) and YFCF:QPMF (20:80), there was no significant (P > 0.05) difference between the energy content of the QPM-based biscuits and control. The low energy value of the control compared to the other flour blends could be as a result of the higher protein and fat contents of QPM-based biscuits since dietary fat is the most concentrated source of energy. The β-carotene content of the biscuits, which varied significantly from 1.08 to 1.62 µg/g, decreased with increase in QPMF. There was a reduction in the hydrogen cyanide content of the biscuit samples. The hydrogen cyanide content ranged between 1.09 and 1.62 mg/kg.

3.4 Sensory attributes of biscuits prepared from composite flour of yellow fleshed cassava and quality protein maize

In terms of colour, no significant (P > 0.05) difference was observed between the control and the biscuit samples containing ≤ 50% maize flour (Table 5). There was no significant (P > 0.05) difference in the taste, crunchiness and aroma of biscuits prepared from the composite flour and 100% cassava flour. On the other hand, biscuits prepared from composite flour containing ≥ 50% maize flour were rated higher than control in terms of overall acceptability. However, biscuit prepared from composite flour of 20% cassava and 80% high quality protein maize were the most accepted. Olapade and Ogunade [36] also reported that the addition of maize flour enhanced the sensory attributes of crunchy snacks made from sweet potato flour.

Table 5.

Sensory attributes of biscuits prepared from composite flour yellow fleshed cassava and quality protein maize

Quality attributes	CM-1	CM-2	CM-3	CM-4	CM-5	Control*
Colour	6.86^{a}	7.32^{ab}	7.32^{ab}	7.54^{b}	7.58^{b}	6.74^{a}
Taste	6.40^{a}	6.88^{a}	7.20^{a}	6.68^{a}	6.74^{a}	6.94^{a}
Crunchiness	6.38^{a}	6.72^{a}	6.82^{a}	6.78^{a}	7.12^{a}	6.64^{a}
Aroma	6.54^{a}	7.00^{a}	7.00^{a}	7.16^{a}	6.86^{a}	6.62^{a}
Overall acceptability	6.70^{c}	7.02^{c}	7.34^{b}	7.40^{a}	7.42^{b}	7.08^{d}

CM-1= 90% cassava flour + 10% QPM; CM-2=70% cassava flour+ 30% QPM;
CM-3=50% cassava flour+50% QPM; CM-4=30% cassava flour + 70% QPM;
CM-5=20% cassava flour + 80% QPM. Means with same superscripts within a row are not significantly different at P > 0.05, *biscuit prepared from 100% biofortified cassava flour

4. Conclusion

The study investigated the nutrient composition, physical and sensory attributes of biscuit from composite flours of yellow fleshed cassava flour and quality maize. The protein, fat and crude fibre and mineral (Ca, Na, Mg, Zn and Fe) contents of the biscuit samples increased with increased substitution with quality maize flour. The study has indicated that acceptable and nutritious biscuit could be obtained from composite flour of 20% yellow fleshed cassava and 80% quality maize flour.

5. References

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