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PHYSICOCHEMICAL PROPERTIES OF PRO-VITAMIN A CASSAVA-WHEAT COMPOSITE FLOUR BISCUIT

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Summary

In this research work, the physicochemical properties of biscuit made from wheat flour and pro-vitamin A cassava flour mixed in different ratios of 100:0, 90:10, 80:20, 70:30 and 60:40 (w/w) was investigated. The addition of pro-vitamin A flour to wheat flour influenced the functional properties such as water absorption, swelling and pasting properties. Peak, trough, breakdown and final viscosities of 100% wheat flour was generally lower than the mixes. However, the setback viscosity of the mixes were lower than that of wheat flour. This was attributed to possible complex formation between the starch components of the flours and the carotenoid. Protein (10.80-15.45%), fat (11.87-21.35%) and carbohydrate (60.08-70.99%) were the major components of the biscuits. The protein and fat contents of the biscuit decreased with increasing proportions of pro-vitamin A cassava flour. But, the carotenoid contents of the biscuits increased. Sensory results showed that biscuit prepared from wheat flour and pro-vitamin A cassava flour in ratio 90 to 10 had similar overall acceptability rating (6.50) and total rating score (31.8) to the control (Overall acceptability rating; 6.50 and total rating score; 32.5). The research has established that acceptable biscuits which could be potentially used to address protein, energy and vitamin A challenges in developing nations of the world.

Keywords: biscuit, cassava, physicochemical properties, pro-vitamin A, pasting

Introduction

Biscuit is a ready to eat, convenient and inexpensive food products (Kulkarni, 1997). In many parts of the world including Nigeria, biscuit is one of the confectioneries consumed mostly by children. It is produced essentially from wheat flour, fat, sugar and water, but other ingredients may be added to enhance desired sensory attributes (Oyeyinka et al., 2014). Wheat flour is the most widely used flour for making biscuit. However, flours from other tuber crops such as cassava have also found application in the biscuit industry. These non-conventional flours have been used either singly or in combination with wheat flour as composites in making bread (Eriksson, 2013; Eriksson et al., 2014) and biscuits (Akubor and Ukwuru, 2003; Oluwole and Karim, 2005; Akingbala et al., 2011; Oluwamukomi et al., 2011; Osundahunsi et al., 2012; Thomas, 2012; Obadina et al., 2014; Oyeyinka et al., 2014). The use of composite flours in biscuit production has several implications. It may result in the reduction of importation cost for wheat flours to developing nations, promote the use of lesser known or neglected food crops and may facilitate the delivery of important micronutrients such as vitamin A to the desired population.

Micronutrient deficiency such as Vitamin A deficiency is one of the major challenge facing developing nations. Vitamin A deficiency can lead to night blindness and other acute diseases. In many parts of the world, several intervention programmes aimed at reducing the associated menace caused by Vitamin A deficiency and other micronutrients deficiencies have been suggested. One of such interventions is the use of staples and snacks such as biscuits as a medium to reach the vulnerable groups, which in most cases are the pregnant women and infants.

Cassava (*Manihot esculenta crantz*) with improved nutritional value such as pro-vitamin A cassava is currently been used as an aid in reducing the prevalence of dietary Vitamin A deficiency due to its high content of β-carotene (Omodamiro et al., 2012). According to Aniedu and Omodamiro (2012), pro-vitamin A cassava have the potential of providing up to 25% of daily vitamin A requirements of children and women. These authors reported the use of 10% high quality cassava flour made from pro-vitamin A cassava root in the production of bread, chin-chin, cakes, strips and salad cream (Aniedu and Omodamiro, 2012). Whole cassava flour has also been successfully used in the production of biscuit

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with comparable sensory qualities to that of wheat biscuit (Akingbala et al., 2011). However, the nutritional quality in terms of protein content of the wheat biscuit was more than double those of the cassava flour biscuits (Akingbala et al., 2011). The replacement of wheat flour with flours from other food crops in the production of biscuit may influence the physicochemical properties of the biscuit. For example, Oluwamukomi et al. (2011) found that biscuit weight increased with increase in the levels of added cassava flour. The protein content of biscuit made from 90% wheat flour and 10% cassava flour was not significantly different from that produced from 100% wheat flour (Oluwamukomi et al., 2011). The incorporation of different ingredient may influence functional and nutritional properties of the resulting products. In this study, the physicochemical properties of biscuit produced from varying ratios of wheat and pro-vitamin A cassava flour was investigated.

Materials and methods

Materials

Pro-vitamin A cassava (TMS 01/1368 variety) was obtained from Oyo State Agricultural Development Farm, Ogbomoso, Nigeria, while wheat flour, sugar, salt, fat and baking powder were purchased from a local market in Ogbomoso, Nigeria.

Flour production, formulation of composite flour and biscuit production

Flour was produced from freshly harvested pro-vitamin A cassava roots according to the modified method of Onabolu et al. (1998). The resulting flour was sieved (sieve size: 200 μm) and mixed with wheat flour sieved with the same sieve size. The ratio of wheat flour and pro-vitamin A cassava flour was 100:0, 90:10, 80:20, 70:30 and 60:40 w/w). Other ingredients used in biscuit production were added as described previously (Akinwande et al., 2008).

Functional and pasting properties of composite flour

Water absorption capacity, swelling power and bulk density was done as described by (Oyeyinka et al., 2014). The pasting properties of wheat-pro-vitamin A composite flour was determined using a Rapid Visco Analyzer (Newport Scientific, Australia), according to the method described by Oyeyinka et al. (2016a).

Chemical composition of flour and biscuits

Moisture, fat and ash contents of flour and biscuit was determined using AOAC (2000) methods. Protein content was determined by Kjeldahl method (6.25×N) and total carbohydrate was calculated by difference. Total cyanide (mg/kg) was determined as reported by Oluwamukomi et al. (2011) while carotenoid analysis was carried out as described previously (Aniedu and Omodamiro, 2012).

Physical properties of biscuit

The diameter and thickness of biscuits were measured with a venire caliper. Spread ratio was calculated from the ratio of diameter to thickness as described by Gains (1991) method. The average of weight biscuit (5 pieces) was measured in (g).

Sensory evaluation of biscuit

Consumers acceptability of biscuits was conducted using semi-trained panelist (N=50) consisting of students in the Department of Food Science and Engineering, Ladoke Akintola University of Technology, Nigeria. Most panelists were between the ages: 18–30 and these were regular consumers of biscuits. A 7 point hedonic scale (1- extremely dislike; 7- extremely like) was used.

Statistical analysis

Experiments were conducted in triplicate. Data were analyzed using analysis of variance and means were compared using Fischer's Least Significant Difference Test ($p<0.05$).

Results and discussion

Carotenoid and cyanide content of pro-vitamin A cassava-wheat composite flour

The carotenoid and cyanide contents of freshly harvested pro-vitamin A cassava tuber were 7.54 μg/g and 24.99 mg/kg respectively (Table 1). Composite flour prepared from wheat flour and pro-vitamin A cassava flour had carotenoid content ranging between 4.09 and 6.84 μg/g, while the cyanide content varied between 0.08 and 0.34 mg/kg. Expectedly, as the amount of pro-vitamin A cassava flour increased in the mix, both carotenoid and cyanide contents increased. The cyanide and the carotenoid in the cassava variety used may explain the increase in these components in the composite flour mix.

Table 1. Carotenoid and cyanide content of pro-vitamin A cassava tuber and its composite flour

Wheat flour	Cassava flour	Carotenoid Content (μg/g)	Cyanide Content (mg/kg)
100	0	4.02 ±0.01[e]	0.02 ±0.14[d]
90	10	4.09 ±0.01[d]	0.08 ±0.02[d]
80	20	5.14 ±0.12[c]	0.12 ±0.01[c]
70	30	5.76 ±1.20[c]	0.13 ±0.02[c]
60	40	6.84 ±1.20[b]	0.34 ±0.01[b]
Raw cassava tuber		7.54 ±0.01[a]	24.99 ±0.12[a]

Mean ± SD. Mean with different superscript letters along the same column are significantly different ($p<0.05$).

Functional properties of pro-vitamin A cassava-wheat composite flour

Bulk density of the flours varied slightly (0.72-0.76 g/cm^3) with the addition of pro-vitamin A cassava flour to wheat flour (Fig. 1). But the water absorption capacity decreased (approx. 25%) with the addition of up 40% pro-vitamin A cassava flour. Differences in the size of starch granules in the respective flours used in the formulation may have accounted for the variation in water absorption capacity of the composite flours. Similar conclusion was reported by previous researchers (Oyeyinka et al., 2014). Further, the presence of different hydrophilic carbohydrates as previously reported (Maninder et al., 2007) and the reduction in proteins due to decrease in the amounts of wheat flour may also explain the variations in the water absorption capacity of the composite flours. The swelling power of the 100% wheat flour was significantly ($p<0.05$) lower than those of the composite flours (Fig. 1). Cereal flours including wheat flour contain endogenous lipids which are known to restrict swelling of starch in foods. The restriction in swelling is associated with the formation of complexes between amylose in starch and the lipids (Putseys et al., 2010; Oyeyinka et al., 2016b). Lipids may also cover the surface of starch with film preventing hydration and swelling (Kim and Walker, 1992).

Pasting properties such as peak viscosity, pasting temperature and setback viscosity of the composite flours varied significantly (Table 2). The peak viscosity of the flours generally increased with increase in the pro-vitamin A cassava flour. Wheat flour (100%) showed the lowest peak viscosity, while that of composite flour i.e. 60% wheat and 40% cassava flour was the highest. Peak viscosity of flours is influenced by many factors including amylose content, starch granule size, presence of lipids and proteins. During cooking of flours, amylose in starch leaches out into the surrounding medium to forms a viscous paste. The degree of interaction between the various components of the flours may explain the variation in the paste peak viscosity. High starch content in cassava flour may have enhanced the increased peak viscosity of the composite flours. Pasting temperature provides an indication of the minimum temperature required to cook the flour and also represent the ease of cooking. The pasting temperature (87.25 °C) of wheat flour (100%) was higher than the composite flours, which showed approximately 74 °C (Table 2). High pasting temperature in the control wheat flour could be due to the presence of endogenous lipids, which may interact with starch in the flour to form amylose-inclusion complex. These complexes are known to be resistant to swelling and rupturing during cooking. Previous studies associated high pasting temperature with the presence of starch which is highly resistant to swelling and rupturing (Maninder et al., 2007). This explanation is in agreement with the swelling power result (Fig. 1), where 100% wheat flour showed restricted swelling when compared with the composite flours.

The setback viscosity of the flour decreased from 1255 to 890 RVU with increase in the levels of cassava pro-vitamin A. Setback viscosity is an indication of the retrogradation tendencies of cooked starch, which is dependent on the extent of re-association of leached amylose. The reduction in setback viscosity following the addition of pro-vitamin A cassava flour suggest low retrogradation tendencies of the composite flours. Nwokocha et al. (2009) reported lower setback viscosity for cassava starch compared to cocoyam starch.

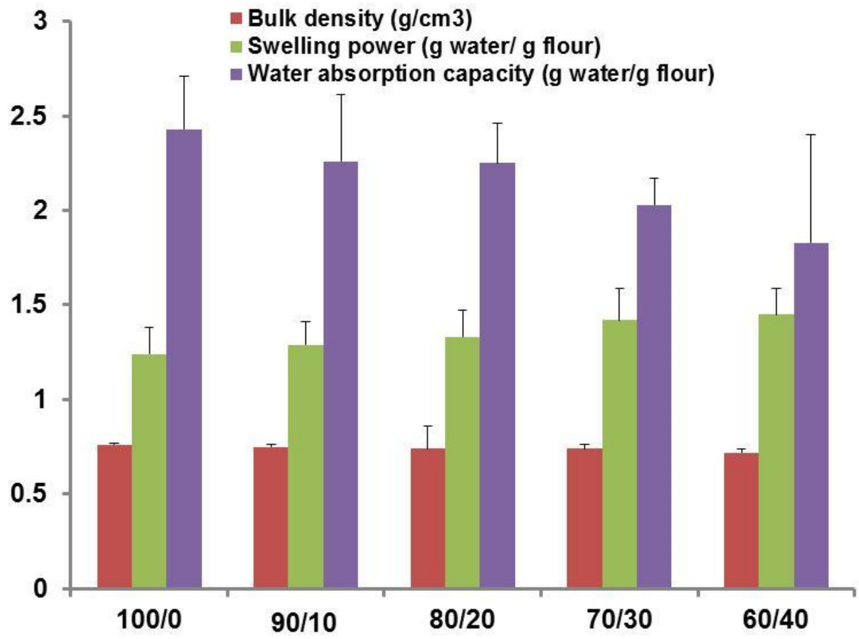

Fig. 1. Selected functional properties of wheat-pro-vitamin A cassava composite flour

Table 2. Pasting properties of wheat-pro-vitamin A cassava composite flour

Wheat flour	Cassava flour	PV (RVU)	TV (RVU)	BV (RVU)	FV (RVU)	SV (RVU)	Peak Time (min)	PT (°C)
100	0	2100[b]	1234[c]	799[b]	2489[b]	1255[a]	6.1[a]	87.2[a]
90	10	2323[a]	1437[b]	866[ab]	2572[a]	1135[b]	6.0[a]	75.1[b]
80	20	2344[a]	1511[a]	833[ab]	2532[a]	1021[b]	5.9[a]	73.4[c]
70	30	2293[b]	1494[ab]	886[a]	2429[b]	935[c]	5.8[b]	73.4[c]
60	40	2407[a]	1521[a]	888[a]	2411[bc]	890[cd]	5.5[bc]	73.5[c]

Mean with different superscript letters along the same column are significantly different ($p<0.05$).
PV: Peak viscosity, TV: Trough viscosity, BV: Breakdown viscosity, FV: Final viscosity, SV: Setback viscosity, PT: Pasting temperature

Physical properties of biscuit

The physical properties including weight, diameter, thickness, and spread ratio of biscuit made from wheat and pro-vitamin A composite flour are presented in Table 3. With increasing levels of pro-vitamin A cassava flour, the weight and spread ratio increased from 5.46 to 6.49 g and 7.44 to 8.27 respectively while diameter and thickness decreased from 4.91 to 4.63 cm and 0.66 to 0.56 cm respectively. Aly and Seleem (2015) similarly reported increase in weight and spread ratio and a decrease in diameter and thickness of gluten-free biscuits made from cassava and extruded soy and pumpkin powder. The diameter of the biscuit in this study is within the range reported for biscuit made from wheat-cassava composite flour (Akingbala et al., 2011; Oluwamukomi et al., 2011; Aly and Seleem 2015).

Table 3. Physical property of wheat-pro-vitamin A cassava composite biscuit

Wheat flour	Cassava flour	Weight (g)	Diameter (cm)	Thickness (cm)	Spread Ratio
100	0	5.46 ± 0.01[b]	4.91± 0.01[a]	0.66 ± 0.01[a]	7.44 ± 0.18[bc]
90	10	5.67 ± 0.02[b]	4.85 ± 0.01[a]	0.65 ± 0.01[a]	7.46 ± 0.18[bc]
80	20	5.88 ± 0.01[b]	4.81 ± 0.01[ab]	0.64 ± 0.07[a]	7.58 ± 0.06[b]
70	30	6.18 ± 0.04[a]	4.65 ± 0.01[c]	0.59 ± 0.07[b]	7.95 ± 0.12[ab]
60	40	6.49 ± 0.01[a]	4.63 ± 0.01[c]	0.56 ± 0.01[b]	8.27 ± 0.18[a]

Mean ± SD. Mean with different superscript letters along the same column are significantly different ($p<0.05$).

Proximate composition and carotenoid content of biscuit

Proteins, fats and carbohydrates were the major components of biscuit made from wheat-pro-vitamin A cassava composite flour (Table 4). The protein content of biscuit prepared from the control 100% wheat flour was the highest (approx. 16%), while that of biscuit prepared from composite flour (60% wheat and 40% pro-vitamin A flour) was the lowest (approx. 11%). Addition of pro-vitamin A cassava flour to wheat flour resulted in a reduction in protein and fat contents of the biscuits, while ash, fibre and carbohydrate contents increased. The observed composition of the formulated biscuit is similar to values reported in other studies on composite biscuits (Hooda and Jood, 2005; Oluwamukomi et al., 2011; Oyeyinka et al., 2014). Decrease in protein and fat contents of the biscuit could be attributed to the reduction in the ratio of wheat flour in the biscuit formulation. Wheat flour is a richer source of protein and fat compared to cassava flour, which has the bulk of nutrient as carbohydrate. The carotenoid contents of the formulated biscuits increased with increasing amounts of pro-vitamin A cassava flour in the formulation from 246.80 to 352.40 µg/100 g (Table 4). These values are within the carotenoid content range (219-428 µg/100 g) reported for biscuit prepared from sweet potato flour and mango mesocarp flour (Sengev et al., 2016) and bread with added mango mesocarp (Badifu et al., 2006). Sengev et al. (2016) found that biscuit formulated from 60% sweet potato flour and 40% mango mesocarp flour showed the highest carotenoid content of 428 µg/100 g. Both sweet potato and mango are relatively good source of beta carotene, which may explain the higher values reported by this authors compared to values in this study.

Table 4. Chemical composition of biscuit from wheat-pro-vitamin A cassava composite flour

Parameters	Samples				
	100:0	90:10	80:20	70:30	60:40
Moisture (%)	3.26 ± 0.01^{bc}	3.99 ± 0.01^{a}	3.70 ± 0.03^{ab}	3.51 ± 0.01^{b}	3.07 ± 0.10^{c}
Protein (%)	15.47 ± 1.07^{a}	13.00 ± 0.66^{b}	10.93 ± 0.74^{c}	10.80 ± 0.74^{c}	10.87 ± 0.28^{c}
Fat (%)	21.35 ± 1.21^{a}	20.02 ± 0.01^{ab}	17.54 ± 0.01^{c}	12.49 ± 0.01^{d}	11.87 ± 1.12^{d}
Ash (%)	0.61 ± 0.07^{cd}	0.75 ± 0.01^{c}	1.29 ± 0.01^{b}	1.39 ± 0.01^{b}	1.79 ± 0.02^{a}
Fibre (%)	0.23 ± 0.01^{cd}	0.28 ± 0.10^{c}	0.33 ± 0.01^{b}	0.28 ± 0.01^{c}	0.41 ± 0.17^{a}
CHO (%)	60.08 ± 0.53^{d}	60.96 ± 0.76^{d}	64.21 ± 0.98^{c}	68.53 ± 0.09^{b}	70.99 ± 1.47^{a}
Carotenoid (µg/100 g)	246.80 ± 0.04^{d}	303.60 ± 0.24^{c}	334.00 ± 0.42^{b}	331.60 ± 1.12^{b}	352.40 ± 1.83^{a}

Mean ± SD. Mean with different superscript letters along the same row are significantly different ($p<0.05$).

Sensory properties of biscuit

Sensory properties of the biscuit were slightly affected by the added pro-vitamin A cassava flour (Fig. 2). In general, the ratings recorded for the sensory attributes of the biscuit decreased with increase in the level of pro-vitamin A cassava flour. Colour is an important sensory attribute of any food because of its influence on acceptability. The brown colour resulting from maillard reaction is always associated with baked goods. Biscuit made from wheat flour (100%), which served as the control had the highest rating for colour, aroma, texture and overall acceptability. The higher rating observed for the control sample may be due to the fact that panel members are familiar with wheat biscuit and this could have influenced their rating for the control sample. Obviously, the added pro-vitamin A cassava flour changed the sensory properties of the biscuit as evident in the rating recorded by the panellist. The total rating score obtained for the control biscuit was 32.5 out of a maximum score of 35. Biscuit prepared from wheat flour and pro-vitamin A cassava flour in ratio 90 to 10 had similar overall acceptability rating (6.50) and total rating score (31.8) to the control (Overall acceptability rating; 6.50 and total rating score; 32.5).

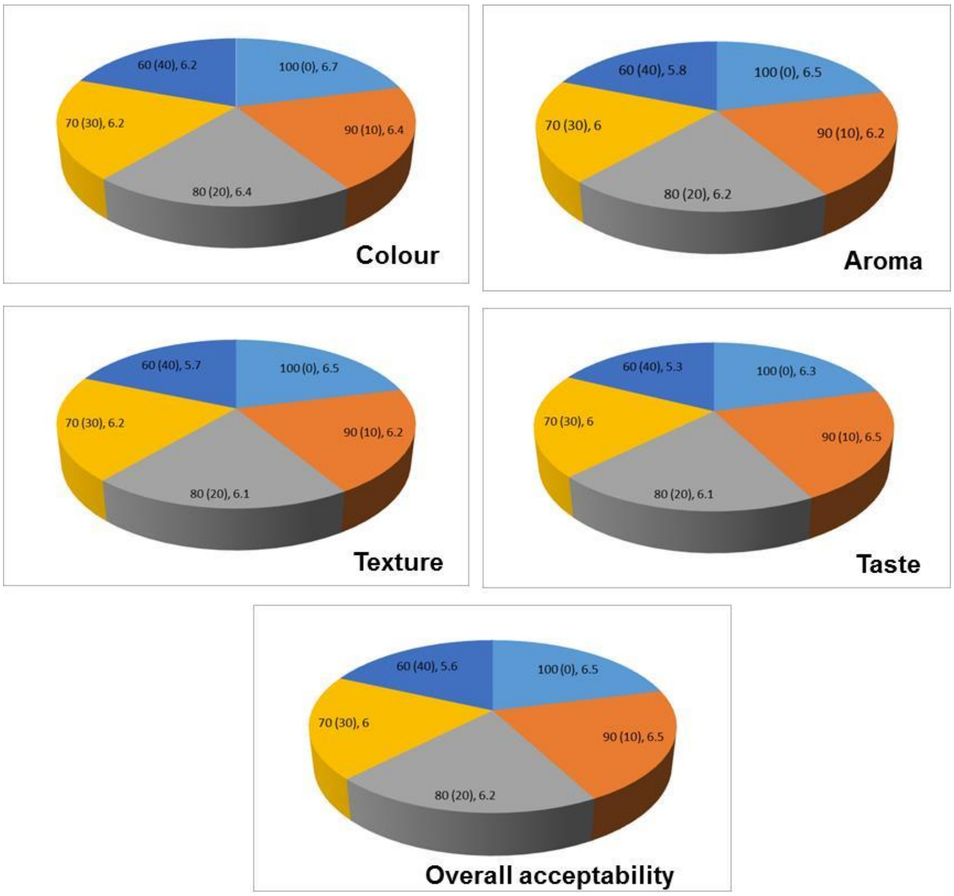

Fig. 2. Plot of mean sensory scores of biscuit from wheat-pro-vitamin A cassava composite Flour
Values before the bracket: Percentage of wheat flour
Values in the bracket: Percentage of pro-vitamin A cassava
Values after the bracket: Mean sensory scores

Conclusions

Biscuits with improved nutritional and sensory qualities can be prepared from a mixture of pro-vitamin A cassava flour and wheat flour at ratio 10 to 90 respectively. Functional properties of wheat flour was affected by addition of pro-vitamin A cassava flour. The formulated biscuits are good sources of proteins, energy and carotenoids, which can be potentially used to address protein-energy malnutrition and vitamin A deficiency among vulnerable groups especially in developing countries.

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