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Quality Characteristics of Cookies Prepared from Unripe Plantain and Defatted Sesame Flour Blends

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ABSTRACT

The cookie making potentials of unripe plantain and defatted sesame flours blended at different proportions were evaluated. The peak viscosity, trough, final viscosity and setback values of composite blends were higher than 100% wheat flour. The protein, fat, ash and crude fiber contents of unripe plantain-defatted sesame cookies were significantly ($p \leq 0.05$) higher than control while carbohydrate contents decreased. The composite cookies had low total sugar (11.59 to 12.97%) than control (14.35%), low *in vitro* starch digestibility (32.68 to 43.39%) than wheat cookie (53.42%) and high protein digestibility (70.28 to 80.11%) than control (72.05%). The iron and magnesium contents of composite cookies were significantly ($p \leq 0.05$) higher with low sodium content than control. The diameter and thickness of composite cookies were not significantly ($p \geq 0.05$) different from control while weight of former was significantly higher than latter. There were no significant ($p \geq 0.05$) differences in sensory properties between composite cookies and control.

Key words: Cookies, unripe plantain-defatted sesame flour, pasting properties, nutritional, physical and sensory properties

INTRODUCTION

Cookies are a form of confectionery product dried to a low moisture content (Okaka, 2009). Compared to biscuits, cookies tend to be larger with a softer chewier texture (IFIS, 2005). Cookies are consumed extensively all over the world as a snack food and on a large scale in developing countries where protein and caloric malnutrition are prevalent (Chinma and Gernah, 2007). With the increased advocacy on the consumption of functional foods by World nutrition bodies due to different health problems related with food consumption such celiac disease (life-long intolerance to wheat gluten, characterized by inflammation of the proximal small intestine), diabetes and coronary heart diseases, the recent WHO recommendations to reduce the overall consumption of sugars and foods that promote high glucose responses (WHO/FAO, 2003). A current trend in nutrition is the consumption of low-carbohydrate diets, including slowly digested food products, as well as an increased intake of functional foods (Hurs and Martin, 2005). The food professionals/industries are faced with the challenge of producing food products containing functional ingredients in order to meet the nutritional requirements of individuals with health challenges.

Therefore, cookies can serve as vehicle for delivery of important nutrients if made readily available to the population (Chinma and Gernah, 2007). This partly stimulated research into the production of cookies using from non-wheat flour blends containing functional ingredients (principally those with high dietary fiber and resistant starch). Dietary fiber in human diets lowers serum cholesterol, reduces the risk of heart attack, colon cancer, obesity, blood pressure, appendicitis and many other disease (Rehinan *et al.*, 2004). On the other hand, resistant starch is part of some ingredients that assist in preventing and managing prediabetes and type 2-diabetes (Jideani and Jideani, 2011). Resistant starch have interesting functional properties for use in foods such as formation of products with high fiber content and low volume with improved sensory properties such as texture and appearance when compared to products rich in traditional fiber (Nugent, 2005). Therefore, there is the need to develop cookies containing functional ingredients with high nutritional quality.

Unripe plantain is rich in dietary fiber (8.82%) and resistant starch (16.2%), micronutrients and helps to reduce the blood sugar level; and low in protein and fat (Ayodele and Erema, 2011). In contrast, defatted sesame flour contains protein (55.70%), ash (9.83%), crude fiber (1.64%), total carbohydrate (29.40%) and high in sulphur- containing amino acids (El-Adawy, 1997). Sesame increases plasma gamma-tocopherol and enhances vitamin E activity which is known to prevent cancer and heart diseases (Hui, 1996). Considering the health benefits of unripe plantain and sesame flour, their incorporation as composite blends in the preparation of cookies may enhance the nutritional and health status of the consumers, reduce total dependence on wheat flour and prevalent incidence of celiac disease.

Several studies have reported the use of wheat-based composite flour in cookies production (Ajanaku *et al.*, 2011; Kamaljit *et al.*, 2010; Nasir *et al.*, 2010; Onoja *et al.*, 2010; Gernah *et al.*, 2010; Arshad *et al.*, 2007; Giami *et al.*, 2005; McWatters *et al.*, 2003; Shrestha and Noomhorm, 2002). Due to increased interest in the consumption of functional foods, cookies with high nutritional and sensory properties have been produced from non-wheat-based composite flour (Okpala and Okoli, 2011; Agriga and Iwe, 2009; Chinma and Gernah, 2007; Akubor and Ukwuru, 2003; Singh *et al.*, 2003). To the best of our knowledge, there is paucity of information in literature on unripe plantain and defatted sesame flour cookies. Therefore, the objectives of the study was to evaluate the chemical composition and pasting properties of unripe plantain and defatted sesame flour blends and the chemical, physical and sensory properties of cookies prepared from the flour blends.

MATERIALS AND METHODS

Source of raw material: Unripe plantain, sesame seeds and other baking ingredients such as butter, salt, sugar, honey, ginger, baking powder and egg were obtained from Minna central market, Minna, Nigeria.

Preparation unripe plantain flour: The method of Akubor and Ukwuru (2003) was adopted in the preparation of unripe plantain flour. Matured unripe plantain fruits were washed in tap water hand peeled and the edible portion (pulp) was sliced with a stainless knife into 2.5 cm-thick slices (6.0×4.0 cm). The slices were immersed in 0.25 g L^{-1} sodium metabisulphite at 30°C for 10 min. The slices were dried at 60°C in an air-draft oven (Gallenkamp 300 plus series, England) and then ground into flour using attrition mill (Globe P 44, China). The flour samples were passed through a 0.45 mm mesh size sieve to obtain the flour and stored in plastic containers with lids at 4°C in a refrigerator from where samples were drawn for analysis.

Preparation of defatted sesame flour: The method of El-Adawy (1997) was adopted in the preparation of defatted sesame flour with slight modification. Dehulled sesame seeds were sorted to remove bad seeds and other foreign materials. The seeds were soaked overnight in cold tap water at ambient temperature and the hulls were completely removed by floatation technique through hand rubbing. The dehulled seeds were blanched in water for 5 min, washed in cold tap water and dried at 60°C in an air-draft oven (Gallenkamp 300 plus series, England) and then milled into flour using attrition mill (Globe P 44, China) to obtain the full fat sesame flour. The flour samples were passed through a 0.45 mm mesh size sieve. A 500 g of full fat sesame flour was poured in a white muslin cloth and immersed in a medium sized aluminum pan containing 1 L of petroleum ether for Ihr to extract the oil. The defatted sesame flour was air dried for 30 min and milled into fine powder using a blender (Philips, model HR 1702) and stored in plastic containers with lids at 4°C in a refrigerator from where samples were drawn for analysis.

Formulation of blends: Unripe plantain and defatted sesame flours were mixed at different proportions (100:0%; 90:10%; 80:20% and 70:30%) while 100% wheat flour served as standard. A Kenwood mixer was used for mixing samples at speed 6 for 3 min to achieve uniform blending.

Chemical analysis: Moisture, protein, crude fiber, fat, ash, carbohydrate, energy and mineral (iron, magnesium and sodium) contents of flour blends and cookie samples were determined as described by AOAC (1995). The *in vitro* protein digestibility of cookie samples were determined using the procedure described by Mertz *et al.* (1984) and Aboubacar *et al.* (2001) while *in vitro* starch digestibility was determined as described by Shekib *et al.* (1988). The total sugar contents of cookies were determined as describe by Moorthy and Padmaja (2002).

Determination of pasting properties: Pasting parameters was determined using rapid visco analyzer (Newport Scientific Pty. Ltd., Warrie-wood NSW 2102, Australia). A 2.5 g of starch samples were weighed into a dried empty canister; then 25 mL of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed and the canister was fitted into the rapid visco analyzer. Each suspension was kept at 50°C for 1 min and then heated up to 95 at 12.2°C min^{-1} and held for 2.5 min at 95°C. It was then cooled to 50 at 11.8°C min^{-1} and kept for 2 min at 50°C.

Preparation of cookies: Cookies was prepared according to the method of AACC (2000) with some modifications in the recipe: flour 100 g, honey 50 mL, corn starch 10 g, vegetable shortening 2.5 g, baking powder 1 g, one egg, salt 1 g and the quantity of water added varies. The dry ingredients (flour, sugar, salt and baking powder) were thoroughly mixed in a bowl by hand for 3 min. Vegetable shortening was added and mixed until uniform. Egg was then added and the mixture kneaded. The batter was rolled and cut with a 50 mm diameter cookie cutter. The cookies was placed on baking trays, leaving 25 mm spaces in between and was baked at 180°C for 10 min in the baking oven. Following baking, the cookies was cooled at ambient temperature, packed in polyethylene bags and stored at 23°C prior to subsequent analysis and sensory evaluation.

Sensory properties of cookies: Sensory properties of cookies were determined using a twenty-member panelist consisting of students and members of Food Science option, Department of Animal Production Federal University of Technology, Minna, Nigeria. Cookie samples prepared from each flour blend were presented in coded white plastic plates. The order of presentation of samples to the panel was randomized. Tap water was provided to rinse the mouth between evaluations. The panelists were instructed to evaluate the coded samples for aroma, taste, crispiness, colour, texture and overall acceptability. Each sensory attribute was rated on a 9-point Hedonic scale (1 = disliked extremely while 9 = liked extremely).

Determination of physical properties of biscuits: The diameter (D) and thickness (T) of the cookies were measured to calculate the spread factor (SF) according to AACC method 10-50D AACC (2000). The diameter of the cookies was measured by placing six cookies edge-to-edge horizontally and rotating at 90° angle for a duplicate reading. The thickness of cookies was measured by placing six cookies on top of each other, followed by a duplicate reading recorded by shuffling cookies. All the measurements were done in two replicates of six cookies each and all the readings were divided by six to get the values per cookie. The SF was calculated according to the following formula:

$$SF = (D/T \times CF) \times 10$$

where, CF is the correction factor, at constant atmospheric pressure (1.0 in the present study).

RESULTS AND DISCUSSION

Proximate composition of flour blends: The proximate composition of wheat, unripe plantain and defatted sesame flour blends is presented in Table 1. The moisture, protein, fat , crude fiber, ash and carbohydrate and oxalate contents of the flour blends ranged from 7.81 to 10.33%, 2.03 to 17.95%, 1.20 to 1.71%, 0.90 to 3.74%, 2.12 to 5.94%, 65.15 to 82.41% and 0.17 to 0.26%, respectively. Addition of defatted sesame flour to unripe plantain flour increased moisture, protein and ash contents while fat and carbohydrate contents decreased. The composite blends had higher protein, ash, fat and crude fiber contents than 100% wheat flour. The moisture contents of the composite blends were below the 10% moisture level recommended for safe keeping of flour samples (SON, 2007). The increase in protein, ash and crude fiber contents of unripe plantain flour due to defatted sesame flour addition may be attributed to addition effect caused by defatted sesame flour since defatted sesame flour contains higher amounts of protein, ash and crude fiber (El-Adawy, 1997). The oxalate contents of the composite blends were lower than the permissible limits for composite flour as reported by SON (2007). Sesame contains oxalate but processing steps such as dehulling and blanching have been reported to lower their oxalate contents (Alobo, 2001; Badifu and Akpagher, 1996). The chemical composition of unripe plantain-defatted sesame flour blends obtained in this study is in agreement with those of Akubor and Ukwuru (2003) for plantain-cowpea flour blends.

Pasting properties of flour blends: The pasting properties of wheat, unripe plantain and defatted sesame flour blends are presented in Table 2. The peak viscosity, trough, break down, final

Table 1: Chemical composition of wheat, unripe plantain and defatted sesame flour blends

Flour blends, UP:DS	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)	Oxalate (%)
100% wheat	10.33±0.45^{a}	11.97±0.76^{c}	1.33±0.10^{a}	0.90±0.10^{b}	2.12±0.13^{d}	73.35±0.51^{c}	ND
100:0	7.81±0.19^{c}	2.03±0.45^{e}	1.71±0.03^{a}	3.74±0.27^{a}	2.30±0.09^{d}	82.41±0.51^{a}	0.17±0.63^{a}
0:100	9.54±0.32^{b}	47.74±0.81^{a}	1.05±0.20^{a}	3.00±0.18^{a}	5.94±0.43^{a}	32.73±0.51^{f}	0.26±0.63^{a}
90:10	8.03±0.97^{bc}	6.06±0.20^{d}	1.20±0.15^{a}	3.17±0.31^{a}	2.85±0.15^{cd}	78.69±0.97^{b}	0.21±0.91^{a}
80:20	8.28±0.55^{c}	11.80±0.72^{c}	1.32±0.40^{a}	3.20±0.15^{a}	3.03±0.60^{c}	72.37±0.97^{d}	0.21±0.91^{a}
70:30	8.37±0.11^{c}	17.95±0.57^{b}	1.41±0.12^{a}	3.32±0.79^{a}	3.80±0.85^{b}	65.15±1.43^{e}	0.24±1.43^{a}

Values are mean and standard deviation of three determinations, Values followed by different superscript in a column are significantly ($p \leq 0.05$) different, UP: Unripe plantain flour DS: Defatted sesame flour, ND: Not determined

Table 2: Pasting properties of wheat, unripe plantain and defatted sesame flour blends

Flour blends UP:DS	Peak viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Set back (RVU)	Peak time (min)	Pasting temperature (°C)
100% wheat	61.42±0.05[e]	33.47±0.62[e]	27.95±0.11[d]	90.15±0.56[e]	56.75±0.56[e]	5.24±0.01[a]	85.10±0.56[a]
100:0	385.09±0.83[a]	215.50±0.10[a]	169.59±0.49[a]	340.82±0.64[a]	125.32±0.42[a]	5.09±0.01[a]	81.35±0.39[c]
90:10	170.72±0.44[d]	157.30±0.57[d]	13.42±0.72[e]	228.40±0.71[d]	71.10±0.30[d]	5.11±0.04[a]	83.40±0.24[b]
80:20	229.50±0.67[c]	170.84±0.25[c]	58.66±0.90[b]	260.75±0.84[c]	89.91±0.37[c]	5.19±0.01[a]	81.65±0.66[c]
70:30	240.28±0.91[b]	186.00±0.13[b]	54.28±0.47[c]	283.11±0.91[b]	97.11±0.45[b]	5.27±0.01[a]	83.79±0.54[b]

Values are mean and standard deviation of three determinations, Values followed by different superscript in a column are significantly ($p \leq 0.05$) different from each other, UP: Unripe plantain flour, DS: Defatted sesame flour

Table 3: Proximate composition of cookies prepared from wheat, unripe plantain and defatted sesame flour blends

Flour blends UP:DS	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%)	Energy value (kcal)	Oxalate (mg/100 g)
100% wheat	5.33±0.25[b]	12.40±0.90[c]	9.07±0.57[c]	1.44±0.11[c]	2.98±0.30[b]	68.78± 1.19[b]	406.35± 1.80[b]	ND
100:0	5.57±0.81[b]	7.05±0.63[e]	8.95±0.24[c]	3.01±0.16[b]	3.15±0.51[ab]	75.42±1.23[a]	410.43±2.05[a]	ND
90:10	6.69±0.20[a]	11.81±0.57[d]	9.97±0.13[b]	3.26±0.45[b]	3.32±0.28[a]	64.95±0.98[c]	396.77±1.24[c]	ND
80:20	6.42±0.52[a]	14.57±0.81[b]	9.16±0.48[c]	3.70±0.90[ab]	3.57±0.15[a]	62.58±1.45[d]	391.04±1.93[e]	0.10±0.05[a]
70:30	6.48±0.10[a]	19.80±1.03[a]	10.49±0.11[a]	4.24±0.68[a]	3.96±0.74[a]	55.03±0.87[e]	393.73±2.56[d]	0.13±0.10[a]

Values are mean and standard deviation of three determinations, Values followed by different superscript in a column are significantly ($p \leq 0.05$) different from each other, UP: Unripe plantain flour, DS: Defatted sesame flour, ND: Not determined

viscosity, set back value, peak time and temperature values of flour samples ranged from 61.42 to 385.09 RVU, 33.47 to 215.50 RVU, 27.95-169.59 RVU, 90.15 to 340.82 RVU, 56.75 to 125.32 RVU, 5.09 to 5.27 min and 81.35 to 85.10°C, respectively. The RVA properties of flour samples showed that unripe plantain-defatted sesame flour blends had higher peak viscosity, trough, final viscosity and setback value than wheat flour. Also, addition of defatted sesame flour to unripe plantain flour reduced its peak viscosity, trough, break down, final viscosity and set back value. This could be attributed to the reduction in starch for gelatinization. Gomez *et al.* (2008) reported a decrease in peak viscosity; break down, set back value when wheat flour was substituted with chickpea flour due to decreased carbohydrate content and different protein content affecting the viscosity parameters. Protein forms complexes with the starch granule surface preventing the release of exudates and lowering the viscosity (Olkku and Rha, 1978). The increase in peak viscosity, trough, break down, final viscosity and set back value among composite blends with increasing level of defatted sesame flour could be attributed to reduction in amylose content in blends since unripe plantain flour contain higher amylose content than sesame flour. Low amylose content has been reported to be associated with a higher peak viscosity and a lower pasting temperature (Zaidul *et al.*, 2007). The pasting results obtained in this study was in line with those of Zaidul *et al.* (2007) for wheat flour-cassava starch blends and (Dachana *et al.*, 2010) for dried moringa leaf-wheat flour blends.

Proximate composition of cookies: The proximate composition of cookies prepared from 100% wheat flour, unripe plantain and defatted sesame flour blends are presented in Table 3. The moisture, protein, fat, crude fiber, ash, carbohydrate, energy value and oxalate contents ranged from 5.33 to 6.69%, 11.81 to 19.80%, 8.95 to 10.49%, 1.44 to 4.24%, 3.15 to 3.96%, 55.03 to 75.42%, 391.04 to 406.35 kcal and 0.10 to 0.13 mg/100 g, respectively. The moisture, protein, fat, ash, crude fiber and oxalate contents of cookies prepared from unripe plantain and defatted sesame flour blends were significantly ($p \leq 0.05$) higher than control cookies. The increase in protein, ash and crude fiber values of composite cookies may be attributed to addition effect caused by defatted sesame flour due to the complementation of unripe plantain flour with defatted sesame flour that contain higher amount of protein, ash and crude fiber. Defatted sesame flour contain 55.7% of protein, 1.64% of fat, 3.41% of crude fiber, 9.83% of ash and 29.40% of carbohydrate (El-Adawy, 1997). The higher ash, crude fiber, protein and low carbohydrate of cookies prepared from unripe plantain-defatted sesame flour has nutrition advantage over 100% wheat cookies especially for individuals with health problems that may require foods rich in protein, fiber and low in carbohydrate. The reduction in oxalate contents of the cookies compared to the flour blends (Table 1) may be attributed to effect of heat during baking. The oxalate contents of the cookies were lower than the permissible limits (SON, 2007).

Nutritional properties of cookies: The nutritional composition of properties of cookies prepared from unripe plantain and defatted sesame flour blends as well as 100% wheat flour is presented in Table 4. The total sugar ranged from 11. 59 to 14.35%, with control cookies having higher sugar content than composite cookies. The sugar content of unripe plantain-defatted sesame cookies decreased with increasing level of defatted sesame flour in the blend. Among the composite cookies, the 70:30 (unripe plantain: defatted sesame) ratios had the lowest sugar content. The sugar content of composite cookies obtained in this study was lower than the range (21.20 to 26.26%) reported by Jisha *et al.* (2010) for dietary fiber-enriched and cassava flour muffins and biscuits, 16.80 to 23.80% reported by Jisha and Padmaja (2011) for whey protein concentrate-cassava flour biscuit and 13.20 to 16.00% reported by Hooda and Jood (2005) for wheat-fenugreek biscuits.

The *in vitro* starch digestibility of cookies ranged from 32.68 to 53.42% with 100% wheat flour cookies having higher value than unripe plantain-defatted sesame flour cookies. The *in vitro* starch digestibility of composite cookies decreased with increase in defatted sesame flour addition in the blend. The decrease in *in vitro* starch digestibility of composite biscuits as the level of defatted sesame flour increased in the blend may be attributed to increased crude fiber content which perhaps caused a reduction in starch digestibility by trapping starch granules within a viscous protein-fiber-starch network (Chinma *et al.*, 2011). Also, the presence of protein bodies around starch granules (due to increased protein content) may restrict granule swelling and starch gelatinization and hence, reduces the susceptibility to enzymatic attack (Aarathi *et al.*, 2003); thereby reducing *in vitro* starch digestibility of unripe plantain-defatted sesame cookies. The poor starch digestibility values of the composite cookies is an indication that the cookies may serve as a functional food for groups with special caloric and glycemic requirements such as obese or diabetic people. The *in vitro* starch digestibility values obtained in this study is in close agreement with 25.43 to 57.25% reported by Chinma *et al.* (2011) and 36.08 to 52.36% reported by Jisha and Padmaja (2011) for whey protein concentrate -cassava flour biscuit.

In vitro protein digestibility is an important criterion for evaluation of protein quality as well as an indicator for protein bioavailability in foods (Chinma *et al.*, 2011). The *in vitro* protein digestibility of cookie samples ranged from 70.28 to 72.05%. The *in vitro* protein digestibility of cookies prepared from unripe plantain and defatted sesame flour blends were significantly ($p \leq 0.05$) higher than 100% wheat cookies. Addition of defatted sesame flour to unripe plantain increased the *in vitro* protein digestibility of composite cookies and could be attributed to increased protein content. This observation is in line with that of El-Adawy (1997) whom reported that addition of sesame flour to bread improved its protein digestibility over the control. which confirm that these composite cookies have better nutritional value than 100% wheat cookies. This author further stated that the low protein digestibility of wheat can be improved by mixing with sesame products. Therefore addition of up to 10% defatted sesame flour to unripe plantain may improve the nutritional quality of the cookies compared to control cookies, since foods with high protein digestibility is potentially of a better nutritional value than the one of low digestibility because the former provides more amino acids on proteolysis (Ali *et al*., 2010). The *in vitro* protein digestibility of unripe plantain-defatted sesame flour cookies obtained in this study is in close agreement with the value (71.20 to 80.60%) reported by El-Adawy (1997) for wheat-sesame flour bread higher than the values (60.20 to 71.57%) reported by Chinma *et al*. (2011) for tigernut-pigeon pea biscuit.

The mineral contents of cookies prepared from unripe plantain-defatted sesame flour blends such as such as sodium, iron and magnesium ranged from 81.12 to 472.35 mg/100 g, 3.03 to 4.78 mg/100 g and 57.19 to 289.30 mg/100 g, respectively. The iron and magnesium contents of composite cookies were significantly ($p\geq 0.05$) higher than wheat cookies while sodium content of composite cookies were significantly ($p\leq 0.05$) lower than control. Addition of defatted sesame flour to unripe plantain flour increased the iron and magnesium content of composite while the sodium content decreased. The higher contents of iron and magnesium and low sodium content in composite cookies than 100% wheat cookies may be attributed to high contents of iron and magnesium and low sodium in plantain and or defatted sesame flour. Supplementation of wheat flour with defatted flour in wheat based bread has been reported to increase the macro and micronutrient composition of the bread (El-Adawy, 1997). The high iron and magnesium and low contents of unripe plantain-defatted cookies make them suitable as a nutrition therapy for hypertensive and diabetic patients considering the role these minerals play in nutrition.

Physical properties of cookies: The physical properties of cookies prepared from unripe plantain and defatted sesame flour blends as well as 100% wheat flour is presented in Table 5. The diameter, thickness, weight and spread ratio of cookies ranged from 4.16 to 5.07 cm, 1.82 to 1.98 cm, 19.45 to 20.81 g and 21.12 to 27.42, respectively. There was no significant ($p\geq 0.05$) difference in diameter and thickness between composite cookies and 100% wheat cookies. The weight of composite cookies differed significantly ($p\leq 0.05$) with 100% wheat flour cookies. Addition of defatted sesame flour to unripe plantain flour slightly increased the thickness and weight of composite cookies while the diameter and spread factor decreased. This could be attributed to higher contents of starch in unripe plantain and low crude fiber contents in 100% unripe plantain cookie than composite cookies (Table 3). According to Altan *et al*. (2009), potential factors contributing to smaller dimensions of cookies may include the lower amounts of starch and higher amounts

Table 4: Nutritional properties of cookies prepared from wheat, unripe plantain and defatted sesame flour blends

Flour blends UP:DS	Total sugar (%)	*In vitro* starch digestibility (%)	*In vitro* protein digestibility (%)	Sodium (mg/100 g)	Iron (mg/100 g)	Magnesium (mg/100 g)
100 % wheat	14.35 ± 0.94^{a}	53.42 ± 1.01^{a}	72.05 ± 1.14^{d}	472.35 ± 1.12^{a}	3.03 ± 0.33^{b}	57.19 ± 0.84^{e}
100:0	12.97 ± 0.72^{b}	40.85 ± 1.33^{c}	70.28 ± 1.29^{e}	92.45 ± 0.09^{b}	0.67 ± 0.16^{c}	289.30 ± 0.91^{a}
90:10	12.55 ± 0.29^{b}	43.39 ± 0.99^{b}	74.60 ± 0.86^{c}	89.73 ± 0.03^{c}	4.50 ± 0.20^{a}	281.86 ± 0.63^{b}
80:20	12.10 ± 0.50^{bc}	38.31 ± 1.05^{d}	77.04 ± 1.01^{b}	86.25 ± 0.18^{d}	4.62 ± 0.37^{a}	277.25 ± 0.39^{c}
70:30	11.59 ± 0.68^{c}	32.68 ± 1.67^{e}	80.12 ± 1.43^{a}	81.10 ± 0.47^{e}	4.78 ± 0.19^{a}	265.13 ± 0.77^{d}

Values are mean and standard deviation of three determinations, values followed by different superscript in a column are significantly ($p\leq 0.05$) different from each other

Table 5: Physical properties of cookies prepared from wheat, unripe plantain and defatted sesame flour blends

Blends, UP:DS	Diameter (cm)	Thickness (cm)	Weight (g)	Spread factor
100% wheat flour	5.07±0.03[a]	1.96±0.04[a]	19.63±0.20[b]	25.87±0.20[b]
100:0	4.99±0.01[a]	1.82±0.12[a]	19.45±0.14[b]	27.42±0.20[a]
90:10	4.75±0.02[a]	1.98±0.05[a]	20.75±0.30[a]	24.00±0.20[c]
80:20	4.30±0.01[a]	1.96±0.08[a]	20.81±0.08[a]	21.94±0.20[e]
70:30	4.26±0.00[a]	1.97±0.11[a]	20.51±0.03[a]	21.62±0.20[e]

Values are mean and standard deviation of three determinations, Values followed by different superscript in a column are significantly ($p\geq 0.05$) different from each other, UP: Unripe plantain flour DS: Defatted sesame flour

Table 6: Sensory properties of cookies prepared from wheat, unripe plantain and defatted sesame flour blends

Flour blend	Aroma	Colour	Taste	Texture	Overall acceptability
100% wheat UP:DS	6.9±0.11[ab]	7.0±0.05[a]	7.2±0.10[a]	7.7±0.03[a]	7.3±0.06[a]
100:0	7.5±0.21[a]	6.8±0.11[a]	6.7±0.14[a]	7.1±0.16[a]	6.7±0.03[a]
90:10	7.3±0.09[a]	7.0±0.02[a]	6.9±0.05[a]	7.0±0.08[a]	6.9±0.10[a]
80:20	7.1±0.00[a]	6.9±0.15[a]	7.1±0.08[a]	7.2±0.02[a]	7.2±0.19[a]
70:30	7.1±0.04[a]	6.8±0.07[a]	6.9±0.20[a]	7.0±0.05[a]	7.1±0.23[a]

Values are mean and standard deviation of three determinations, Values followed by different superscript in a column are significantly ($p\leq 0.05$) different from each other, UP: Unripe plantain flour, DS: Defatted sesame flour

of fiber. The increase in weight of composite cookies due to addition of defatted sesame flour could be attributed to high bulk density of defatted sesame flour than unripe plantain flour. The higher bulk density of unripe plantain-defatted sesame flour blends could also account for higher weight of composite cookies than 100% wheat cookies. The decrease in spread factor of composite cookies with increased level of defatted sesame flour addition could be attributed to higher protein content of defatted sesame flour (Table 1). According to Nasir *et al.* (2010), the increased number of hydrophilic sites available due to increased protein content competes for the limited free water in cookie dough, resulting to a decrease in spread factor. Nasir *et al.* (2010), Hooda and Jood (2005) and Singh *et al.* (1993) have reported a decrease in spread with increased protein in the cookies. Our results obtained for physical properties of unripe plantain-defatted sesame cookies are in close agreement with those of Nasir *et al.* (2010) and Toma *et al.* (2009) but higher than the values reported by Akubor and Ukwuru (2003) for plantain-cowpea cookies.

Sensory properties of cookies: Table 6 shows the sensory properties of cookies prepared from unripe plantain and defatted sesame flour blends and 100% wheat cookies. There was no significant ($p\geq 0.05$) difference in aroma, colour, taste, texture and overall acceptability of cookies prepared from 100% wheat flour and composite blends. This result implies that the evaluated sensory properties of 100% wheat cookies are not different from the developed cookies. Cookies prepared from 100% wheat flour and unripe plantain and defatted sesame flour blend had higher acceptability score than cookies made from 100% unripe plantain flour. Though there was no significant difference in texture between 100% wheat flour and composite cookies, the 100% wheat flour cookie had higher texture score than composite cookies. This could be attributed to the presence of gluten in wheat flour that resulted in the formation of elastic dough which was hard during handling, resulting to cookies with higher texture after baking than non-wheat composite cookies. From the overall acceptability scores, it was concluded that unripe plantain and defatted sesame flour could be incorporated up to 70:30 ratios in the preparation of cookies without affecting the sensory properties of the cookies.

CONCLUSIONS

The use of unripe plantain and defatted sesame composite flours in the production of cookies with improved nutritional and sensory quality without adversely affecting most baking characteristics is possible. Cookies prepared from such composite flour could help in combating protein- energy malnutrition; have the potential as a functional food especially for celiac, hypertensive, diabetic and obese patients considering their poor starch and high protein digestibility, relative high crude fiber, iron and magnesium, low carbohydrate and sodium contents than 100% wheat flour cookies.

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