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Physicochemical and Sensory Properties of Cookies Produced from Cassava/Soyabean/Mango Composite Flours

[1]C.E. Chinma and [2]D.I. Gernah
[1]Department of Food Science and Nutrition, Federal University of Technology Minna, Nigeria
[2]Department of Food Science and Technology, University of Agriculture, Makurdi, P.M.B. 2373 Makurdi, Nigeria

Abstract: The physicochemical and sensory properties of cookies produced from cassava/soyabean/ mango Composite flours were studied. Cassava, soyabean and moderately ripe mango fruits were processed into flours. Chemical composition of the flours was determined. Cookies comprising different compositions of wheat, cassava, soyabean and mango flours were prepared. One hundred percent wheat flour served as control. Cookies were subjected to chemical, sensory and physical analyses. Cookies made from composite blends had higher protein, fat, ash, crude fibre, energy and β-carotene (Provitamin A) than cookies from 100% wheat flour. There was significant difference ($p \leq 0.05$) in moisture content and cyanide level between cookies prepared from composite flours and control. There was significant difference ($p \leq 0.05$) in thickness, diameter and spread ratio. There was no significant difference ($p \geq 0.05$) in weight between cookies made from composite flours and the control. As the level of substitution of cassava flour with soyabean and mango flour increases from 10%, cookies made from composite blends enjoyed higher rating in terms of internal crumb colour, surface colour, flavour and overall acceptability.

Key words: Physicochemical, sensory properties, cookies, provitamin A, cyanide content

INTRODUCTION

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 particularly among women and children. Cookies can serve as a vehicle for important nutrients if made readily available to the population. The increasing importance of snack foods such as cookies in today's eating habit has not been fully exploited. This could be as a result of the high cost of wheat in tropical areas leading to importation. This leads to economic drain and increased prices of baked goods in these countries. Thus much research involving the use of non-wheat flour has been carried out to substitute wheat in baked products in developing countries (UNECA, 1985). These flour mixes used are generally referred to as composite flours (Akubor, 2004a). According to Syder and Kwon (1987) partial substitution does in fact save foreign exchange but it is obviously not the solution to the problem of wheat importation. For most countries, the solution will be total substitution of wheat flour. This reason has also resulted in the use of local raw materials that could combine optimum nutritive value with good processing characteristics.

Cassava (*Manihot esculenta* Crantz) is an important source of calories to millions of people particularly in the tropics (Lasekan *et al*., 2004). The major limitations of cassava include low protein, low mineral and vitamin contents together with cyanide toxicity (Ihekoronye and Ngoddy, 1985). The cassava amino acid such as methionine, lysine and tryptophan are also low in quality (Badifu *et al*., 2000). Therefore, incorporation of soyabean and mango flour into cassava flour for the production of cookies will increase the protein, caloric value and micronutrients since such flour samples are good sources of such nutrients (FAO, 1986; Badifu *et al*., 2000).

Soyabean (*Glycine max*) a grain legume is one of the richest and cheapest sources of plant protein. The seeds (beans) of the high yielding variety contain about 18% oil and 38% protein (IITA, 1990).

Mango fruit is a good source of provitamin A (with reported concentration of 2,400 mg 100 g^{-1}) and vitamin C (Badifu *et al*., 2000).

Given the above information on the nutritional contents of mango, soyabean and cassava, this study was undertaken to produce cookies of high and good nutritional quality from cassava-soyabean-mango composite flours.

Corresponding Author: C.E. Chinma, Department of Food Science and Nutrition, Federal University of Technology Minna, Nigeria

MATERIALS AND METHODS

Source of raw material: The following materials were purchased from Wurukum Market in Makurdi, Benue State: wheat flour (Golden Penny), Wiekfield baking powder, granulated sugar, margarine (Romi) and eggs. Cassava (TMS 30470) tubers (*Manihot esculenta* Crantz) and soyabean (TGX 1448-2E) (*Glycine max*) were purchased from University of Agriculture, Makurdi Teaching and Research Farm. Moderately-ripe mango (*Mangifera indica* L.) fruits of local variety were purchased from Gboko Market, Benue State.

Cassava flour preparation: The method of IITA (1990) was adopted. Three kilogram of cassava roots were washed, manually peeled with knife, washed again and cut into chips. The chips were soaked for 9 h in tap water at ambient conditions. The water was changed at intervals of 3 h after which the chips were rinsed and dried in an air-oven at 60°C for 24 h. The dried chips were milled into flour using hammer mill (8" LAB MILL) and the resultant flour was sieved into a particle size of 100 μm. The flour was packaged in low-density polyethylene bags and stored using covered plastic containers in a freezer maintained at -18°C from where samples were taken for use.

Soyabean flour preparation: The method of Ihekoronye and Ngoddy (1985) was used. Three kilogram of soyabean grains were soaked in tap water for 12 h at ambient conditions and the water was changed at 3 h intervals. The soaked beans were dehulled manually and then boiled for 30 min, drained and dried in an air oven at 60°C for 24 h. The dried beans were then cooled, milled using hammer mill (8" LAB MILL) and sieved to a particle size of 100 μm to obtain soyabean flour. The flour was packaged in low-density polyethylene bags and stored using covered plastic container in a freezer maintained at -18°C, from where samples were taken for use.

Mango flour preparation: The method of Badifu *et al.* (2000) was adopted. Five kilogram of moderately-ripe mangoes were washed, peeled with a sharp kitchen knife and the mesocarp was sliced off the hard nut. The slices were trimmed and spread on metal trays in a cabinet dryer maintained at 60-65°C. During the drying process, mango slices were occasionally turned to enhance even drying. The process of drying was continued and samples were taken at 2½- h intervals for determination of moisture until they dried to the moisture content of (8-10%). The dried mango slices were milled using hammer mill and sieved into particle size of 100 μm. The mango flour was packaged in low density polyethylene bags and stored using covered plastic container in a freezer maintained at -18°C from which samples were taken for use.

Table 1: Formulation of composite flours (%) for cookie production

Flour blend	Wheat flour	Cassava flour	Soyabean flour	Mango flour
A (control)	100	-	-	-
B	-	100	-	-
C	-	80	10	10
D	-	70	15	15
E	-	60	20	20
F	-	50	25	25

Formulation of composite flours: Composite flours with different proportions of cassava, soyabean and mango mesocarp flour were prepared as shown in Table 1, with 100% wheat flour serving as control. A digital weighing balance and a blender (Philips, HR 1702) were used for weighing and mixing the flours, respectively.

Preparation of cookies: Cookies were prepared using the method of Nishiber and Kawakishi (1990) with slight modifications. Instead of glucose and butter in the original formular, granulated sugar (sucrose) and margarine were used in this preparation. Cookies formulation include, flour (49.50 %), margarine (20.00 %), beaten whole egg (10.00 %), sugar (20.00 %) and baking powder (0.50 %). The flour, sugar and baking powder were manually mixed inside a bowl (500 cm^3) because the quantity of mixture was too small to use a laboratory mixer. Margarine and beaten whole egg were well creamed for 60 sec then the dried ingredients were added at once and mixed for another 60 sec. The batter was shaped using tomato tin (0.25×35mm) and baked in an air oven at 180°C for 8 min. They were allowed to cool on a rack after which they were packaged in low-density polyethylene bag and kept in a plastic container.

Determination of physical properties of cookies: Cookies Diameter (D) and Thickness (T) were determined using a vernier calliper while cookies weight was determined using an electronic weighing balance. Spread was calculated as D/T×10 (Akubor, 2004a).

Determination of chemical properties of flour samples and cookies: Protein, fat, crude fibre, ash, moisture, β-carotene (Provitamin A) were determined using the AOAC (1995) method. The carbohydrate content was calculated by difference. The energy value was estimated from Atwater factors (Protein×4 + carbohydrate×4 + fat×9). Hydrogen cyanide value was determined as described by Indira and Singha (1969).

Sensory evaluation: Coded samples of cookies were presented to twenty panellists. They were instructed to score the following attributes: texture, internal crumb colour, surface colour, flavour, taste and overall acceptability of the products using a 5-point hedonic scale, in which 1 represented extreme dislike and 5 represented like extremely. The 100% wheat flour cookie was used as control.

Statistical analyses: All analytical determinations were conducted in triplicates. The means were calculated and the data were subjected to analysis of variance (Steel and Torrie, 1980). Where significant difference existed, Turkey's test was used in separating the means as described by Ihekoronye and Ngoddy (1985).

RESULTS AND DISCUSSION

The chemical composition of flour samples is shown in Table 2. The soyabean flour had high protein, fat and energy content followed by wheat flour. Cassava flour had the least protein and fat content but had the highest carbohydrate, crude fibre and cyanide content. However, mango flour had the highest β-carotene (Provitamin A) content and the least cyanide content.

The chemical composition of cookies is shown in Table 3. Protein, fat, ash, moisture, energy value and β-carotene content increased with increasing levels of soyabean and mango flours in the composite flours while crude fibre and carbohydrate values decreased with increasing levels of soyabean and mango flours. There was significant difference ($p\leq 0.05$) between cookies made from control and composite flours in terms of moisture, protein, fat, ash, crude fibre, carbohydrate, energy value, β-carotene and cyanide values.

The physical properties of cookies are presented in Table 4. There was significant difference ($p\leq 0.05$) between cookies made from 100% wheat flour and composite flour blends in terms of thickness, diameter and spread ratio. Cookies thickness and diameter increased slightly as the proportion of soyabean and mango flours increased in the blends. However, spread ratio showed a slight decrease as the proportion of soyabean and mango flours increased. There was no significant difference ($p\geq 0.05$) in weight between cookies made from 100% wheat flour and composite flours. There was however slight decrease in weight of cookies made from composite flours as the proportion of soyabean and mango flour increased.

The sensory characteristics of cookies are shown in Table 5. Significant difference ($p\leq 0.05$) was observed between cookies made from composite flours and the 100% wheat flour cookies with respect to internal crumb colour, surface colour, flavour, taste, texture and overall acceptability as the level of substitution of cassava flour with soyabean and mango flour increases from 10%. It was observed that there were increases in the scores for these attributes when the proportion of soyabean and mango flours increased in the blends with the exception of texture. Flavour and taste were found to be determining factors in the acceptability of cookies. When mango flour was increased to higher levels, flavour, taste and colour acceptability dropped.

Table 2: Chemical composition of flour samples

Flour sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Energy value (Kcal 100 g^{-1})	β-carotene (μg 100 g^{-1})	Cyanide content (mg 100 g^{-1})
Wheat flour	$8.50^{a}\pm0.01$	$10.25^{b}\pm0.11$	$1.90^{b}\pm0.06$	$1.25^{c}\pm0.05$	$1.10^{c}\pm0.13$	$77.00^{b}\pm0.03$	$366.10^{b}\pm0.17$	$136.50^{c}\pm0.08$	$5.03^{b}\pm0.05$
Mango flour	$7.30^{a}\pm0.05$	$6.40^{c}\pm0.02$	$1.70^{b}\pm0.01$	$4.10^{b}\pm0.02$	$3.70^{a}\pm0.09$	$76.80^{b}\pm0.01$	$348.10^{d}\pm0.33$	$385.40^{a}\pm0.14$	$2.25^{d}\pm0.15$
Soyabean flour	$7.45^{a}\pm0.01$	$34.50^{a}\pm0.18$	$20.46^{a}\pm0.07$	$5.30^{a}\pm0.01$	$2.95^{b}\pm0.21$	$29.34^{c}\pm0.07$	$439.50^{a}\pm0.03$	$172.60^{b}\pm0.05$	$4.01^{c}\pm0.06$
Cassava flour	$8.10^{a}\pm0.03$	$1.10^{d}\pm0.05$	$1.05^{b}\pm0.10$	$1.90^{c}\pm0.01$	$3.85^{a}\pm0.08$	$84.00^{a}\pm0.00$	$349.85^{c}\pm0.19$	$124.10^{d}\pm0.27$	$18.50^{a}\pm0.01$
LSD	-	1.53	0.97	0.80	0.67	1.41	1.28	1.87	0.94

Values with the same superscript in the same column are not significantly different ($p\geq 0.05$), values are means±standard deviations of triplicate determinations

Table 3: Chemical composition of cookies made from different composite flours

Cookies	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Energy value (Kcal 100 g^{-1})	β-carotene (μg 100 g^{-1})	Cyanide value (mg 100 g^{-1})
A	$10.32^{a}\pm1.01$	$10.90^{e}\pm0.08$	$3.12^{e}\pm0.02$	$1.06^{b}\pm0.23$	$1.30^{b}\pm0.10$	$73.30^{b}\pm1.45$	$364.88^{d}\pm0.87$	$95.80^{e}\pm0.05$	$2.30^{e}\pm0.01$
B	$9.05^{b}\pm0.92$	$6.83^{f}\pm0.01$	$2.25^{f}\pm0.17$	$1.96^{a}\pm0.14$	$2.50^{a}\pm0.05$	$74.41^{a}\pm1.03$	$357.21^{c}\pm1.13$	$63.10^{f}\pm0.90$	$8.15^{a}\pm0.08$
C	$9.11^{b}\pm0.07$	$12.30^{d}\pm0.01$	$5.76^{d}\pm0.05$	$2.01^{a}\pm0.04$	$2.36^{a}\pm0.01$	$68.10^{c}\pm1.22$	$373.44^{b}\pm0.80$	$128.45^{d}\pm0.14$	$6.08^{b}\pm0.13$
D	$9.17^{b}\pm0.41$	$14.55^{c}\pm0.71$	$6.50^{c}\pm0.01$	$2.10^{a}\pm0.02$	$2.20^{a}\pm0.07$	$65.48^{d}\pm1.07$	$378.62^{b}\pm1.35$	$145.70^{c}\pm0.03$	$5.00^{c}\pm0.05$
E	$9.22^{b}\pm0.03$	$15.80^{b}\pm0.04$	$7.30^{b}\pm0.15$	$2.25^{a}\pm0.17$	$2.05^{a}\pm1.09$	$63.38^{e}\pm0.95$	$382.42^{a}\pm0.11$	$170.25^{b}\pm0.47$	$4.45^{c}\pm0.15$
F	$9.26^{b}\pm0.22$	$16.60^{a}\pm1.01$	$8.40^{a}\pm0.08$	$2.40^{a}\pm0.03$	$1.94^{a}\pm0.94$	$61.40^{f}\pm0.28$	$387.60^{a}\pm0.63$	$193.20^{a}\pm1.06$	$3.10^{d}\pm0.09$
LSD	0.98	0.73	0.66	0.87	0.51	1.05	1.35	1.72	1.20

Values with the same superscript in the same column are not significantly different ($p\geq 0.05$), values are means ± standard deviations of triplicate determinations. LSD = Least Significant Difference, Key: A (control) 100% wheat flour, B: 100% cassava flour, C: 80% cassava flour+10% soyabean flour+10% mango flour, D: 70% cassava flour+15% soyabean flour+15% mango flour, E: 60% cassava flour+20% soyabean flour+20% mango flour, F: 50% cassava flour+25% soyabean flour+25% mango flour

Table 4: Physical properties of cookies made from different composite flours

Cookies	Weight (g)	Thickness (mm)	Diameter (mm)	Spread ratio
A	7.05^{a}±0.02	40.00^{a}±0.00	30.80^{b}±0.12	7.70^{b}±0.03
B	6.80^{a}±0.04	36.10^{b}±0.01	34.13^{a}±0.08	9.45^{a}±0.27
C	6.73^{a}±0.01	36.21^{b}±0.07	34.30^{a}±0.02	9.47^{a}±0.14
D	6.51^{a}±0.03	36.42^{b}±0.01	34.36^{a}±0.05	9.43^{a}±0.08
E	6.38^{a}±0.02	36.50^{b}±0.03	34.48^{a}±0.01	9.45^{a}±0.11
F	6.26^{a}±0.01	36.64^{b}±0.02	34.53^{a}±0.10	9.42^{a}±0.07
LSD	-	1.54	1.83	1.38

Values with the same superscript in the same column are not significantly different ($p \geq 0.05$), Values are means±standard deviations of triplicate determinations, LSD = Least Significant Difference, Key: A (control): 100% wheat flour, B: 100% cassava flour, C: 80% cassava flour+10% soyabean flour+10% mango flour, D: 70% cassava flour+15% soyabean flour+15% mango flour, E: 60% cassava flour+20% soyabean flour+20% mango flour F: 50% cassava flour+25% soyabean flour+25% mango flour

Table 5: Sensory characteristics of cookies made from different composite flours

Cookies	Texture	Internal crumb colour	Surface colour	Flavour	Overall acceptability
A	4.5^{a}±0.01	3.4^{b}±0.01	3.2^{b}±0.01	3.6^{b}±0.01	3.9^{b}±0.00
B	3.6^{b}±0.00	3.5^{b}±0.01	3.1^{b}±0.00	3.2^{b}±0.01	3.1^{c}±0.01
C	3.8^{b}±0.01	4.3^{a}±0.02	4.5^{a}±0.01	4.4^{a}±0.00	4.2^{a}±0.01
D	3.8^{b}±0.00	4.5^{a}±0.00	4.6^{a}±0.01	4.6^{a}±0.01	4.5^{a}±0.00
E	3.9^{b}±0.02	4.5^{a}±0.01	4.7^{a}±0.01	4.7^{a}±0.03	4.6^{a}±0.00
F	3.9^{b}±0.01	4.2^{a}±0.00	4.1^{a}±0.00	4.5^{a}±0.01	4.4^{a}±0.02
LSD	0.47	0.90	0.93	0.85	0.74

Values with the same superscript in the same column are not significantly different ($p \geq 0.05$), Values are means±standard deviations of triplicate determinations, LSD = Least Significant Difference, Key: A (control) : 100% wheat flour, B: 100% cassava flour, C: 80% cassava flour+10% soyabean flour+10% mango flour, D: 70% cassava flour+15% soyabean flour+15% mango flour, E: 60% cassava flour+20% soyabean flour+20% mango flour, F: 50% cassava flour+25% soyabean flour+25% mango flour

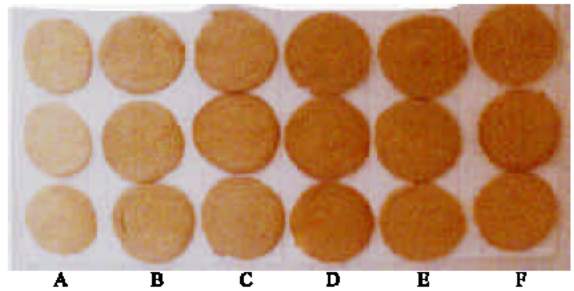

Fig. 1: Cookies samples

The chemical composition of flour samples used in this study compared favourably well with that reported by (Yaseen *et al*., 1991; Badifu and Ilochi, 2004; Akubor, 2004b). The increase in protein, fat, ash, moisture, energy and β-carotene content of cookies with increasing supplementation of soyabean and mango flours could be attributed to addition effect. In a similar study (Akubor, 2004b) observed a steady increase in protein, fat, ash, energy content when soyabean flour was supplemented to maize flour for biscuit production. However, the concentration of β-carotene in mango flour sample was higher than those found in cookies. This may be due to the effect of heat treatment. During processing, carotenoids are very prone to degradation with a consequent alteration in bioavailability and biological activity (Badifu and Ilochi, 2004). The slight increase in moisture content of cookies as the proportion of mango flour increased in the blends could be attributed to high sugar content present in the samples which made the cookies to be hygroscopic. The decline in crude fibre, carbohydrate and cyanide content of cookies with increasing concentration of soyabean and mango flour could be attributed to subtraction effect since cassava flour is high in crude fibre, carbohydrate and cyanide content. The cyanide values obtained in this study were below the maximum recommended safe level of 10 mg HCN kg^{-1} dry weight basis (FAO/WHO, 1992). The slight decrease in weight of cookies made from composite flour blends as the proportion of soyabean and mango flour increased may be due to large bulk density of cassava flour which when mixed with lower bulk density of soyabean and mango flours causes a decrease in the weight of the products. Also higher bulk density of wheat flour than cassava, soyabean and mango flours could have accounted for higher weight of cookies made from 100% wheat flour than those of composite blends. The slight increase in the thickness of cookies as the proportion of soyabean and mango flour increased in the blends could be attributed to hydrophilic nature of soyabean flour (FAO/WHO, 1992) which causes reduction in spread thus leading to a slight increase in thickness of cookies as the proportion of soyabean flour increased. The low diameter value of cookies made from 100% wheat flour compared to composite blends may be due to high gluten content present in wheat flour (Fuhr, 1962) than composite flour blends which formed an elastic network (Chris, 1987) capable of holding the gluten strands such that during baking, three is contraction in the product structure. The blends had little quantity of gluten to effect a similarcontraction, hence the large diameter values. The reduction in spread ratio as the proportion of soyabean and mango flour in the blends increased could be attributed to the hygroscopic nature of mango flour which absorbs moisture resulting in a reduction in the spread ratio.

Cookies from composite flours were significantly more ($p \leq 0.05$) acceptable than 100% wheat flour cookies (Fig. 1). This was primarily due to the enhanced attractive colour, flavour and taste imparted by mango flour. The decline in sensory characteristics such as flavour, taste and colour (internal crumb/surface) at higher level of supplementation (50:25:25) may be due to high sugar content in the product which became pronounced at such levels and caused browning reactions leading to intense colour during baking.

CONCLUSION

This study has indicated that acceptable and nutritious cookies could be obtained from a composite flour made of cassava, soyabean and mango flours since these cookies competed favourably with 100% wheat flour cookies.

Also the use of such composite flour will reduce over dependence on imported wheat flour since Nigeria is a non-traditionally wheat producing country so as to save foreign exchange. It will also lead to diversification of food use of such crops in the confectionary industry.

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