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Research Article

Quality characteristics of shortcake biscuit produced from wheat flour using sprouted jack bean flour and jackbean protein concentrate as composites

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Abstract

This study evaluated the effect of adding sprouted jackbean flour (SJF) and jackbean protein concentrate (JPC) on the quality of shortcake wheat flour biscuits. Clean jackbean seeds (3kg) were soaked (6h) in cold water, washed and half of it sprouted (4 days). The sprouted grains were washed, de-hulled, sun-dried for 3days, at 26 ±2^{O}C; oven-dried at 55^{OC} for 48 hand milled into fine flour (SJF). Un-sprouted grains (1.5kg) were de-hulled, sun-dried for 3d, at 26 ±2^{O}C; oven-dried at 55^{O}C for 48 hand milled into coarse powder. This was defatted using n-hexane (1:3, w/v), oven-dried (60^{O}C, 6h) and milled into fine flour. Phosphate buffer solution (1:5, w/v; pH: 4.5) was used to extract the protein. The precipitate (protein concentrate (JPC) was washed, oven-dried (55^{O}C, 48 h) and milled into flour. Shortcake biscuits with added 0, 10 or 20% of SJF or JPC were baked using standard procedures. Proximate and mineral composition of SJF, JPC and biscuits were analysed. Physical and sensory attributes of biscuits were also analysed. Sprouting significantly (p>0.05) improved nutrient composition of jack bean seed flour. Protein content improved from 15.59 to 30.31%; calcium from 0.03 to 0.07mg/100g and magnesium from 0.37 to 0.4gmg/100g but carbohydrate content decreased from70.55% to 55.10%. The SJF and JPC improved quality of biscuits. The 20% SJF and JPC addition in the shortcake biscuits significantly (p>0.05) improved ash contents of the biscuits from 1.44% to 2.57% and 2.52% respectively. Carbohydrate and protein contents, however, were not significantly (p 0.05) improved. The biscuits had good physical attributes and were all acceptable to the sensory panellists. Biscuits containing 10% sprouted jack bean flour could be adjudged the best in terms of nutrient and sensory properties.

1. Introduction

Biscuits are snacks consumed globally among all age groups. They are crisp unleavened and often sweet pastry made light by addition of baking powder. Sometimes chocolate fruit pulp is added. The water content is about 3% while the caloric value of sweet biscuit is about twice that of bread.The major raw material for biscuit manufacturing is wheat flour. Wheat flour contains gluten protein which forms elastic dough during baking (Enwere, 1998; Edwards et al., 2003).The need to substitute wheat flour with locally available cereals (rice, maize, sorghum, and millet), legumes (soybeans, African yam beans, pigeon pea, bambara groundnut, and cowpea) and tuber (cassava, yams and potatoes) flours is appropriate because of the high cost and low protein content of wheat (Akubor, 2003).Enrichment of cereals with legumes improves the nutrient composition and quality of biscuits commonly used as snack foods (Okoye et al., 2016) Flours from indigenouslegumes with high protein content could be used to replace part of wheat flour in orderto produce cheaper protein-enriched biscuit (Almazan, 1987; WHO, 2006). Jackbean (Canavalia ensiformis) is one of many unconventional indigenous legumes in Nigeria with high crude protein content (20-32%) (Almazan, 1987). It is cheap, readily available but neglected for use as food.

Sprouted legumes and their protein concentrates are of higher nutrient quality and more easily metabolized than the whole legumes in the human body. Sprouted legumes have improved protein and vitamin contents. Their minerals are more readily available. Sprouting promotes improved contents of bioactive health-promoting ingredients. Sprouts and protein concentrates of grains when added to food will improve the nutrient contents of such products (WHO, 2006).

Shortcake is a sweet biscuit made from flour, sugar, baking powder, salt, butter, milk or cream and sometimes eggs. The dry ingredients are blended and the butter cut in and the whole thing mixed to meal. The liquid ingredients are then mixed in. The resulting

wet batter is dropped in spoonful onto a baking sheet or poured into a cake form, and baked until set. The main objective of the study is to produce high quality shortcake biscuits enriched with sprouted jackbean seed flour and jackbean protein concentrate.

2. Materials and methods.

2.1. Raw Materials

Wheat flour (*Triticumaesticum*), sugar, baking powder, vanilla flavour, common salt, whipping cream were obtainedcommercially in Lafia market while white variety of jackbean (*Canavalia ensiformis*) seeds were purchased from retailers at Alamis market, all in Nasarawa State, Nigeria. All laboratory reagents used were of the best analytical grade.

2.2. Processing ofsprouted jackbean seed flour and jackbean seed protein concentrate

Two batches (1.5 kg each) of clean jackbean seeds were soaked (6h) in excess cold water, washed with fresh clean water and drained using a sieve. One batch was spread on a raised wire mesh lined with muslin cloth and then covered with another muslin cloth on a laboratory bench. This was sprouted by sprinklingwith clean water in the mornings and evenings for 4 days. The sprouted seeds were de-hulled by rubbing between the palms, washed, sun-dried (3 days) and then oven-dried (55^{O}C) for 48 h. This was winnowed to remove radicals, leaving behind the dry nibs. The dried nibs were milled into fine flour and stored for use.

The remaining soaked 1.5 kgof jack bean seeds was dehulled manually,sun-dried (3days, at 26 ±2^{O}C), oven-dried (55^{O}C, for 48 h) using hot-air oven (Model D25, Genlab, Widnes Inc) and then ground into coarse powder. This was batched into 200g, and each batch fat-extractedtwice with n-hexane (1:3, w/v) using the method of Boadright and Hetiarachy (1995). The defatted coarse powder was oven-dried (60^{O}C) for 24h and then milled into fine flour using a laboratory grinder (National Model 308, Japan).This was dispersed in phosphate buffer solution (1:5, w/v) adjusted with sufficient 0.2M HCl to the isoelectric point (pH. 4.5) (Lawal and Adebowale, 2005) of the protein mixture. The suspension was stirred for about 30min. and then centrifuged at 1500rpm for 20min. The supernatant was discarded while the precipitate was re-suspended in fresh phosphate buffer (pH. 4.5) solution, after which it was extracted and oven-dried at 50^{O}C for 48 h. This was milled into fine powder. Both the germinated jack bean flour and jack bean protein concentrate were used to fortify biscuit.

2.3. Preparation of shortcake biscuits

Shortcake biscuitswere prepared from wheat flour, substituted with 100 1nd 20% sprouted jackbean flour and jackbean protein concentrate.One hundred (100%) percent wheat flour was used as control. All biscuits were made using the same procedure. Dry ingredients including flour (450g), castor sugar (170g), baking powder (25g), common salt (5g), vanilla essence and ground nutmeg (1 whole) were sieved, mixed together in a bowl and whipping cream (500 ml) was added gradually, tossing lightly with fork until the mixture formed chunks. The chunks were gathered together without kneading, rolled out into a 15cm length and cut into slices. They were then placed on thinly *greased* baking tray, sprinkled with castor sugar and then baked for about 20 minutes at oven temperature of about 200^{0}C. The biscuits were cooled and subjected to analysis.

2.4. Chemical analyses of flours and biscuit samples

Moisture, crude protein, crude fat, crude fibre and ash contents were determined in duplicate using standard method (AOAC, 1997). Moisture was recorded as loss in weight after heating (105^{O}C, 24 h) in a vacuum oven. Total nitrogen was determined by the micro-kjeldahl method, and crude protein calculated by multiplying the total nitrogen (TN) by 6.25 conversion factor. Crude fibre was estimated as the loss in weight after acid and alkaline digestions of defatted samples. Crude lipid determination was by ether extraction (40 – 60^{O}C) using Tecator Soxhlet apparatus. Ash content was estimated as the residual weight after ashing for 12 h at 550^{O}C. The resulting ash was dissolved in 5 ml of 0.1M. HCl solution and then diluted with distilled water to 100 ml in volumetric flask. The extract was used to determine the minerals Ca, Mg, Fe and Znusing atomic absorption spectrophotometer (AAS) model 703, 23.Carbohydrate was determined by difference. Phosphorus content was determined spectrophotometrically using phosphovanadomolybdate method (Coffman and Garcia, 2005).

2.5. Analysis of physical properties ofbiscuit

The AACC method 10-50D (AACC, 2000)was used to evaluate width, thickness, spread factor and spread ratio of biscuits. Biscuit width (W) was measured by placing 3 biscuits edge-to-edge to get average width in

millimetres. Biscuit thickness(T) was measured by stacking 3 biscuits on top of each other; and restocking in different order and measuring thickness to get average in millimetre. The mean values for the two parameters were used for calculating spread factors (S.F.) calculated as (width/ thickness) and spread ratios (S.R.) calculated as diameter /thickness.

Bulk density of biscuits was determined using a 100-ml beaker, electronic weighing scale and clean jack bean seeds (150g) in place of rapeseeds (Giami, et al., 2004). For each sample, the experiment was repeated four times and the average weight, W and volume, V calculated.Bulk density for each sample was calculated as W / V.

2.6. Sensory analysis

The biscuit samples were evaluated for sensory properties using a 15-member semi trained panellistsof ages between 20-46 years and comprising 10 females and 5 males drawn from 27 volunteers from the staff and students of the Faculty of Agriculture, Shabu-Lafia campus, Nassarawa State University, Keffi, Nasarawa state, Nigeria (Melligard, et al, 1999).Prior to the selection, volunteers were interviewed to ascertain their knowledge about shortcake biscuit and its quality characteristics; and the degree of preference of their consumption of market shortcake biscuits. The best 15 who showed high preference for consumption of market shortcake biscuits, based on the number of consumptions per week, were selected and trained according to the spectrum method (Melligard, et al, 1999).

The biscuits were presented as coded samples in similar saucers to panelliststo evaluate colour, texture, flavour and overall acceptability using a five-pointscale where 1 = disliked extremely, 2 = disliked moderately, 3 = neither liked nor disliked, 4 = liked moderately, and 5 = liked extremely. The panellistsscored each sample for the attributes immediately after tasting and rinsing mouthswith cold portable water in transparent glass cups between tests to avoid carry over effects of taste.

3. Results and Discussion

3.1. Nutrient composition of wheat flour, un-sprouted and sprouted jackbean seed flours and jackbean protein concentrate

Table 1 shows the nutrient compositions of wheat flour, un-sprouted and sprouted jackbean flours and jackbean protein concentrate. Wheat flour had 14.8% protein, 72.3% carbohydrate, 27.1% crude fibre, 2.8% fat and 1.82% ash. Calcium and iron content in wheat flour were 28.6 and 3.10mg/100g respectively. Jackbean protein concentrate had 6.71% moisture, 2.22% crude fibre and 1.36% ash. Un-sprouted and sprouted jackbean flour had 0.03 and 0.07mg/100g calcium content, 5.78 and 5.80mg/100g phosphorus and 0.37 and 0.42mg/100g magnesium respectively. Un-sprouted and sprouted jackbean flours had 15.59% and 30.31% crude protein content respectively indicating higher crude protein content in jackbean (Okonkwo and Udedibie, 1991).

Table 1: Nutrient composition of wheat flour, jack bean protein concentrate, defatted and un-defatted jackbean flour.

	WF	UJF	SJF	JPC
Moisture (%)	5.48^{b}	6.71^{a}	6.39^{a}	3.57^{c}
Crude protein (%)	14.80^{b}	15.59^{b}	29.24^{a}	30.31^{a}
Crude fiber (%)	2.71^{a}	2.22^{a}	2.21^{a}	2.21^{a}
Lipids (%)	2.89^{a}	1.36^{c}	1.84^{b}	1.88^{b}
Ash (%)	1.82^{c}	3.54^{b}	5.24^{a}	5.55^{a}
Carbohydrate (%)	72.30^{a}	70.59^{b}	55.10^{b}	56.47^{b}
Calcium (mg/100g)	0.60^{a}	0.03^{b}	0.03^{b}	0.07^{a}
Phosphorus (mg/100g)	ND	5.61^{a}	5.78^{a}	5.80^{a}
Iron (mg/100g)	3.10^{a}	2.74^{a}	2.88^{a}	0.07^{b}
Zinc (mg/100g)	ND	4.03^{b}	4.22^{b}	5.27^{a}
Magnesium (mg/100g)	ND	0.35^{a}	0.37^{a}	0.42^{a}

ND= Not determined, WF= Wheat flour, UJF= Un-sprouted jack bean flour, SJF= Sprouted jack bean flour, JPC= Jack bean Protein concentrate

3.2. Proximate composition of shortcake biscuits

Table 2 shows the proximate composition of shortcake biscuit samples C_1, C_2, C_3, C_4 and C_5 prepared with different substituted levels (0, 10, 20, 10, and 20%) of sprouted jackbean flour and jackbean protein concentrate. Substituting sprouted jackbean flour and jackbean protein concentrate for wheat flour increased protein, lipids and ash content but decreased carbohydrate, fibre and moisture content of the shortcake biscuit samples. Substituting 20% of sprouted jackbean flour for wheat flour increased the protein content from12.35% to 12.73%, ash from

1.44% to 1.54% but carbohydrate content decreased from 66.32% to 66.29%. Also substituting 20% jackbean protein concentrate flour for wheat flour increased protein from 12.35% to 13.14%, ash from 1.44% to 2.52% and lipids from 1.14% to 4.11% but resulted in a decrease in carbohydrate from 66.32% to 64.76% and crude fibre from 3.24% to 1.13%. Carbohydrate which is abundant in wheat flour was reduced with the low carbohydrate of sprouted jackbean flour and jackbean protein concentrate. This is a good approach to increase the nutritional quality of shortcake biscuit from such blends over those of 100% wheat flour (Hossain, et al., 2005).

Carbohydrate provides energy to cells in the body, particularly the brain, the only carbohydrate dependent organ in the body (Effiong, et al, 2005). High ash content implies high mineral contents and nutritionally, ash aids in the metabolism of protein, carbohydrate and fat (Okaka, 2005). Fibre in the diet modulates faecal water content, faecal bulk, transit time and elimination of bile acids and neutral sterols in the body; which lowers the body's cholesterol pool. Fibres reduce the incidence of coronary and breast cancer (Lintas, 1992; Effiong, et al., 2005).

Table 2. Proximate composition of shortcake biscuit samples fortified with protein concentrate of jackbean and germinated jackbean flour

Nutrients (%)	Control C_1	SJF C_2	SJF C_3	JPC C_4	JPC C_5
Moisture	10.52^a	9.54^b	9.46^b	9.39^b	9.34^b
Crude Protein	12.35^a	12.49^a	12.73^a	12.86^a	13.14^a
Crude fiber	3.24^a	2.23^b	2.21^b	1.66^c	1.13^c
Lipids	1.14^c	1.28^c	2.74^b	2.41^b	4.11^a
Ash	1.44^b	1.54^b	1.57^b	1.59^b	2.52^a
Carbohydrate	71.32^a	72.91^a	71.29^a	72.10^a	69.76^a

Values are mean of 3 determinations ± standard deviation. Values on the same row with the same superscripts are not ($p>0.05$) significantly different. C_1 is control biscuit with 100% wheat flour, C_2 and C_3 are biscuit samples with 10% and 20% germinated jackbean seed flour, respectively, while C_4 and C_5 are biscuit samples with 10% and 20% jackbean protein concentrate, respectively.

3.3. Mineral composition of shortcake biscuits

Table 3 shows the mineral composition of shortcake biscuit samples C_1, C_2, C_3, C_4 and C_5 containing different substituted levels (0, 10, and 20%) of sprouted jackbean flour and jackbean protein concentrate. Substituting sprouted jackbean flour and jackbean protein concentrate for wheat flour increased calcium, phosphorus, iron, zinc and magnesium content. Substituting 10% protein concentrate flour for wheat flour increased calcium content from 0.12 to 0.15mg/100g; iron from1.07 to 2.29mg/100g while substituting 10% sprouted jackbean flour also increased phosphorus content from 8.37 to 8.68mg/100g and magnesium form 0.11 to 0.17mg/100g. Substituting 20% of sprouted jackbean flour for wheat flour increased calcium from 0.12 to 0.13mg/100g, iron from 1.07 to 1.13mg/100g and phosphorus from 8.37 to 8.93mg/100g while substituting 20% jackbean protein concentrate flour for wheat flour increased phosphorus content from 8.37 to 9.63mg/100g, zinc from 5.57 to 5.87% and magnesium from 0.11 to 0.23mg/100g. This could be an advantage in improving the nutritional quality of the shortcake biscuit from such blends over those of conventional wheat flour as reported by Lorenz (1983) and Iwe (2002).

Iron is a major component of hemoglobin necessary to transport the respiratory gases, namely oxygen (0_2) and carbondioxide ($C0_2$) (Okoye et al. 2016). Deficiency of iron in the blood may lead to death. Zinc should be supplied in the diet and is involved in ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) synthesis needed for cell division, repair and growth (Iwe, 2002). Zinc helps to prevent the growth of abnormal cells associated with cancer**.** Zinc has been used as food supplement to enhance wound healing and improve impaired acuity of taste, smell and night vision. Lack of zinc in the bodycausesrapid egestion on the surface of wound and may delay quick healing (Schauss, 1995). Magnesium activates the enzymes necessary for carbohydrate metabolism (Merki and Merki, 1987: FNB, 2001).

Table 3. Mineral composition of shortcake biscuit samples fortified with jack bean protein concentrate and sprouted jack bean seed flour

Minerals (mg/100g)	C_1	C_2	C_3	C_4	C_5
Calcium	0.12^b	0.13^b	0.13^b	0.15^a	0.15^a
Phosphorus	8.37^c	8.68^b	8.93^b	9.31^a	9.63^a
Iron	1.07^b	1.10^b	1.13^b	2.29^a	2.52^a
Zinc	5.57^a	5.58^a	5.65^a	5.87^a	5.87^a
Magnesium	0.11^c	0.17^b	0.19^b	0.22^a	0.23^a

Values are mean of 3 determinations. Values on the same row with the same superscripts are not ($p>0.05$) significantly

different. C_1 is control biscuit with 100% wheat flour, C_2 and C_3 are biscuit samples containing 10% and 20% sprouted jackbean seed flour respectively while C_4 and C_5 are biscuit samples with 10% and 20% jackbean protein concentrate, respectively.

3.4. Physical properties of shortcake biscuits

Figures 1a and 1b show the physical properties of shortcake biscuit samples prepared with different substituted levels (0, 10, and 20%) of sprouted jackbean flour and jackbean protein concentrate. There was no significant ($p<0.05$) difference in the spread factor of shortcake biscuit made with the different substituted flour blends. The biscuit sample with 10% sprouted jackbean flour had the lowest spread factor (4.43) while biscuit sample with 20% jackbean protein concentrate had the highest spread factor (5.88). The biscuit sample with 10% sprouted jackbean flour had the lowest spread ratio (4.87) while biscuit sample with 20% jackbean protein concentrate had the highest spread ratio (6.47).

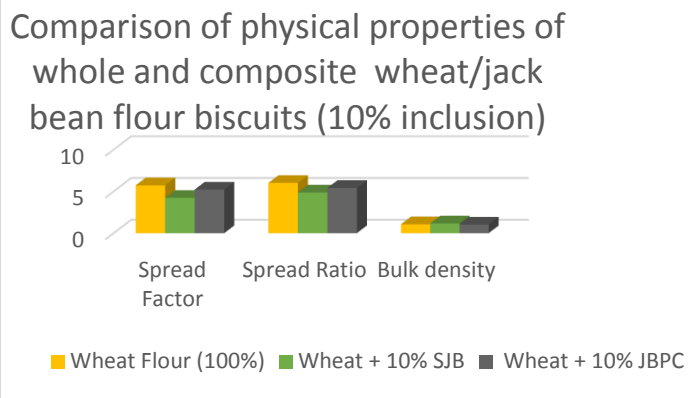

Figure 1a. Comparison of physical properties of whole composite wheat/jack flour biscuits (10% inclusion).

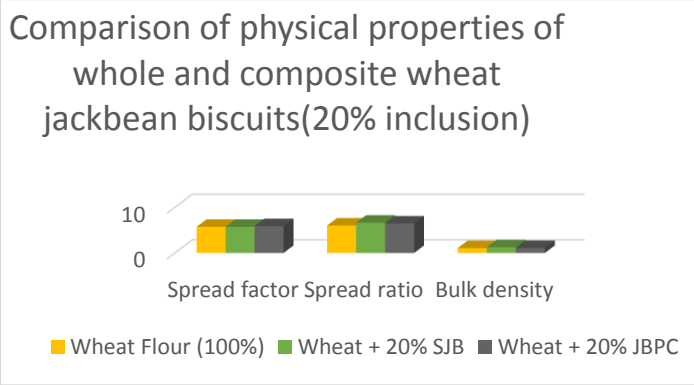

Figure 1b. Comparison of physical properties of whole composite wheat/jack flour biscuits (20% inclusion).

3.5. Sensory properties of shortcake biscuits

The sensory scores of the five shortcake biscuit samples(C_1, C_2, C_3, C_4 and C_5) prepared with different levels (0, 10, 20, 10, and 20%) of sprouted jackbean flour and protein concentrate are shown in Table 4. All the five biscuit samples were acceptable by the panellists. Sensory scores for the biscuit samples were above the mean mark of 2.5 of the 5-point scale used. This implies that none was out-rightly rejected. There was no significant difference ($p>0.05$) in colour, flavour, mouth feel and overall acceptability of the samples. The sensory scores for colour ranged 4.20 and 3.80 for samples with 10% and 20% levels of jackbean protein concentrate flour and 3.80 and 3.13 for samples with 10% and 20% levels of sprouted jackbean flour. The shortcake biscuit samples with sprouted jackbean flour compared favourably with the control in terms of colour, texture, flavour, mouth feel and overall acceptability. Substituting sprouted jackbean flour and jackbean protein concentrate for wheat flour resulted in biscuits of acceptable sensory properties while improving the nutritional quality at the same time. It is advantageous therefore to substitute sprouted jackbean flour and jackbean protein concentrate for wheat flour in shortcake biscuit production.

Table 4: Sensory properties of shortcake biscuit samples fortified with protein concentrate of jack bean and sprouted jackbean flour.

Sample Code	Levels (%) of flour blends	Colour	Texture	Flavour	Mouth feel	Overall acceptability
C_1	0	4.00^a	3.73^a	4.00^a	3.73^a	3.87^a
C_2	10	4.20^a	3.80^a	4.07^a	3.73^a	3.93^a
C_3	20	3.80^a	2.93^b	3.60^{ab}	3.40^{ab}	3.60^a
C_4	10	3.80^a	3.00^b	4.13^a	3.60^a	3.87^a
C_5	20	3.13^c	2.93^b	3.40^b	3.20^b	3.20^b

Values are mean of 3 determinations Values on the same column with the same superscripts are not ($p>0.05$) significantly different. C_1 is control biscuit with 100% wheat flour, C_2 and C_3 are biscuit samples with 10% and 20% sprouted jackbean seed flour, respectively while C_4 and C_5 are biscuit samples with 10% and 20% jackbean protein concentrate, respectively.

4. Conclusions

Sprouted jackbean flour and jackbean protein concentrate improved nutrient characteristics without reducing the sensory and physical

attributes of shortcake biscuit. Jackbean seed is locally available, cheap and is easily processed into germinated flour and protein concentrate. It could be used to enrich wheat flour for increased protein and mineral content.

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