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ORIGINAL ARTICLE

Effect of incorporation of plantain and chickpea flours on the quality characteristics of biscuits

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Abstract Blends of plantain and chickpea flours each with concentrations of 0, 10, 20, 30 and 40% along with of refined wheat flour were used for development of biscuits. The flours were evaluated for their chemical and functional properties. Plantain flour had highest crude fiber (3.6%) and carbohydrate content (80.8%), whereas chickpea flour had highest protein content (19.3%) and fat content (4.4%). Plantain flour showed highest water absorption (167.7%) whereas lowest oil absorption capacity (144.6). The chickpea flour showed highest foaming capacity and stability. The thickness and diameter of biscuits did not differ significantly ($p<0.05$). The spread ratio and percent spread decreased with the addition of plantain and chickpea flours each up to a concentration of 30%. The fracture strength of biscuits increased significantly ($p<0.05$) with addition of plantain and chickpea flours and was highest at 40% concentration (21.1 N). The protein and crude fiber content of biscuits increased significantly ($p<0.05$) from 7.1 to 9.2% and 1.1 to 3.6%, respectively with increasing extent of chickpea flour and plantain flours in the blends. The sensory properties of biscuits prepared by replacing refined wheat flour up to 20% each with plantain and chickpea flour were more or less similar to those of control biscuits.

Keywords Plantain flour · Chickpea flour · Functional properties · Supplemented biscuits · Physicochemical properties · Sensory quality

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The growth of bakery industry is about 10% per annum and the products are increasingly becoming popular among all sections of people (Indrani et al. 1997). Among ready-to-eat snacks, biscuits possess several attractive features including wider consumption base, relatively long shelf-life, more convenience and good eating quality (Tsen et al. 1973; Akubor 2003; Hooda and Jood 2005). Long shelf-life of biscuits makes large scale production and distribution possible. Good eating quality makes biscuits attractive for protein fortification and other nutritional improvements. Biscuits, which are categorized as miscellaneous food category products, consist of three major components; flour, sugar and fat. The biscuits are the soft wheat products. Cereal grains, including soft wheat flour are low in protein (7–14%) and are deficient in essential amino acids such as lysine and certain other amino acids (Claughton and Pearce 1989). Legumes on the other hand, are higher in proteins (18–24%) than cereal grains and could be used to support certain amino acids such as lysine, tryptophan, or methionine (Potter 1986).

Plantains (*Musa paradisiaca*) are one of the commercially important tropical fruits being produced in more than 120 countries in the world with an annual production of 88 million mt from an area of 10 million ha. India is the largest producer of banana in the world with an annual production of 16.81 million mt from an area of 0.49 million ha (Anon 2002). When processed into flour, it is used traditionally for preparation of gruel which is made by mixing the flour with appropriate quantities of boiling water to form a thick paste. Akubor (2003) has shown that plantain flour has a good potential for use as a functional agent in bakery products on account of its high water absorption capacity. Since plantains are rich in carbohydrates, but poor in protein, people who eat much of plantain products are prone to malnutrition. The proteins of plantains could be supplemented with legume or cereal proteins. The resulting products would be rich in both proteins and carbohydrates. Olaoye et al. (2006) developed bread from wheat flour supplemented with soybean and plantain flour and acceptable breads were prepared with up to 15% supplementation of wheat flour with plantain flour. Mepba et al. (2007) also prepared composite breads and biscuits from mixed flours of wheat and plantain. Organoleptically most acceptable breads and biscuits were formulated from wheat-plantain composite flours using up to 80:20 (w/w) % and 60:40 (w/w) ratios of wheat: plantain flours for breads and biscuits respectively.

Chickpea (*Cicer arietinum*) is widely consumed throughout the world. Chickpea seeds are rich source of protein ranging from 12.6% to 30.5% (Singh et al. 1997). The protein efficiency ratio (PER) of chickpea protein has been reported higher than that of pigeonpea, blackgram and mungbean (Chandrasekharappa 1979). The biological value (BV) of chickpea proteins generally ranges from 75% to 85%, which is considerably higher than other legume proteins. Functional properties, which are assuming greater significance in terms of diversified and novel food uses of crops, play an important role in the utilization of chickpea in the cereal based composite flours (Iyer and Singh 1997). The functional properties of chickpea such as water absorption, oil absorption, gelation capacity, gel consistency and nitrogen solubility index (NSI) are considered important from utilization point of view of grain legumes (Singh et al. 1997).

The replacement of refined wheat flour with chickpea and plantain flour will upgrade the nutritional quality of such products with changed sensory attributes. Thus a chickpea-plantain blend would provide a nutritionally balanced food for both infants and adults because of the expected improved protein quality as well as abundant energy content. Therefore, in the current study the feasibility of partially replacing wheat flour with plantain and chickpea flours for biscuit making was investigated.

Materials and methods

Plantains (unripe bananas) were purchased from local market of Sirsa. The refined wheat flour and chickpea flour were prepared in the laboratory flour mill with particle size of 0.150 μm. Other raw materials such as sugar, ghee (Madhu brand) and milk (Vita brand) were purchased from local market of Sirsa.

Preparation of plantain flour

Fruits were hand-peeled and sliced into pieces of about 5–10 mm thickness. The slices were treated with 1–2% potassium metabisulphite and dried in hot air oven at 45 °C for 7 h. The dried slices were milled and sieved with a 0.150 μm mesh sieve. The flour was stored in an air and moisture tight container at room temperature for further use and analysis.

Product development

Biscuit were prepared from refined wheat flour, plantain flour and chickpea flour blends in the ratios of 100:0:0, 80:10:10, 60:20:20, 40:30:30 and 20:40:40 respectively. White flour biscuits were considered as control. The standardized formulation for the biscuits had the ingredients as 100 g flour, 60 g sugar, 40 g ghee, 1.5 g ammonium bicarbonate and required amount of milk. Ghee and ground sugar were taken and creamed to a uniform consistency. The flour, required amount of milk and ammonium bicarbonate were added to the creamed mixture and mixed for 8 min at medium speed in dough mixer to obtain a homogenous mixture. The dough was rolled out into thin sheet of uniform thickness and was cut into desired shape using mould. The cut pieces were placed over a perforated tray and transferred into a baking oven at 190 °C for 10–15 min till baked. The well baked biscuits were removed from the oven, cooled to room temperature, packaged and stored in air tight container till further use.

Analytical methods

Protein (micro-Kjeldahl, Nx6.25), fat (solvent extraction), moisture, ash and crude fiber were determined by the AOAC (1990) methods. The carbohydrate content was calculated by subtraction method.

Water and oil absorption capacity

The water and oil absorption capacities were determined by the method of Sosulski et al. (1976). The sample (1.0 g) was mixed with 10 ml distilled water or refined soybean oil, kept at ambient temperature for 30 min and centrifuged for 10 min at 2,000×g. Water or oil absorption capacity was expressed as percent water or oil bound per gram of the sample.

Bulk density

The bulk density was determined according to the method described by Okaka and Potter (1977). The sample (50 g) was put into a 100 ml graduated cylinder and tapped 20–30 times. The bulk density was calculated as weight per unit volume of sample.

Least gelation concentration

The least gelation concentration was determined using method of Coffman and Garcia (1977) with some modifications. The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 30% (w/v) prepared in 5 ml distilled water were heated at 90 °C for 1 h in a water bath. The contents were cooled under tap water and kept for 2 h at 10±2 °C. The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip.

Swelling capacity

The method of Okaka and Potter (1977) with some modifications was used for determining the swelling capacity. The sample filled up to 10 ml mark in a 100 ml graduated cylinder was added with water to adjust total volume to 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and allowed to stand for further 30 min. The volume occupied by the sample was taken after 30 min.

Foaming capacity and foaming stability

Foaming capacity and foaming stability were determined as described by Narayana and Narasinga Rao (1982) with slight modifications. Sample (1.0 g) was added to 50 ml distilled water at 30±2 °C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of foam after whipping for 30 s was expressed as foaming capacity.

$$FC = \frac{\text{Volume of foam (AW)} - \text{Volume of foam (BW)}}{\text{Volume of foam (BW)}} \times 100$$

Where, AW: After whipping, BW: Before whipping

The volume of foam was recorded 1 h after whipping to determine foaming stability as percent of the initial foam volume.

Physical analysis of biscuits

Diameter of biscuits was measured by laying six biscuits edge to edge with the help of a scale rotating them 90° and again measuring the diameter of six biscuits (cm) and then taking average value. Thickness was measured by stacking six biscuits on top of each other and taking average thickness (cm). Weight of biscuits was measured as average of values of four individual biscuits with the help of digital weighing balance. Spread ratio was calculated by dividing the average value of diameter by average value of thickness of biscuits. Percent spread was calculated by dividing the spread ratio of supplemented biscuits with spread ratio of control biscuits and multiplying by 100.

Fracture strength of biscuits

Fracture strength of biscuits was measured with the help of Texture Analyzer (model TA-XT2i, Stable Micro systems, Haslemere, U.K) using a 3-point Bending Rig and 5 kg load cell. The distance between the two beams was 40 mm. Another identical beam was brought down from above at a pre-test speed of 1.0 mm/s, test speed of 3.0 mm/s, post-test speed of 10.0 mm/s. The downward movement was continued till the biscuit broke. The peak force was reported as fracture strength.

Sensory analysis of biscuits

Biscuit samples were analyzed for sensory characteristics. Sensory quality characteristics were evaluated by a panel of 10 semi-trained members using a 9-point Hedonic scale (Ranganna 1979). The biscuits were evaluated for their color, appearance, flavor, texture, taste and overall acceptability.

Statistical analysis

The data were reported as average of triplicate observations. The data were analyzed statistically in a completely randomized design (CRD) using one factor analysis of variance (ANOVA) with the help of OPSTAT version OPSTAT 1. exe (Hisar, India) (Yadav et al. 2009)

Results and discussion

Proximate composition

The chemical composition of refined wheat flour, plantain flour and chickpea flour is given in Table 1. The ash content of flour samples ranged from 0.7% to 2.6% with chickpea flour showing the highest value. The fat content ranged from 1.4% to 4.4% and was observed highest in chickpea flour. A large variation in fat content (3.8% to 10.2%) has been reported among chickpea genotypes (William and Singh 1987). The crude fiber and protein content values differed significantly among three types of flours ($p<0.05$). Plantain flour had the highest crude fiber content (3.6%). Similar value of crude fiber content has been reported by Mepba et al. (2007). The protein content as expected was the lowest for plantain (3.0%) and the highest for chickpea (19.3%). The protein content value of chickpea flour was in agreement with those reported by Rababah et al. (2006) and Singh et al. (1997). Since the carbohydrate content of flour samples was calculated by difference, the variation in carbohydrate content may be attributed to the differences in other constituents. It varied from 63.8% to 80.8%, the lowest for chickpea and highest for plantain flour.

Functional properties

The functional properties of refined wheat flour, plantain flour and chickpea flour are also presented in Table 1. The water absorption capacity (WAC) of different flours differed significantly ($p<0.05$) and it ranged from 90.0% to 167.7%. WAC represents the ability of a product to associate with water under conditions where water is limiting (Singh 2001). The highest WAC of plantain flour could be attributed to the presence of greater amount of hydrophilic constituents like soluble fiber and lower amount of fat content (Akubor and Badifu 2004). Mepba et al. (2007) also reported high water absorption capacity (284%) of plantain flour than wheat flour (65%).

The oil absorption capacity (OAC) of flour helps improve mouth feel and flavor retention (Kinsella 1976). The OAC ranged from 144.6% to 169.7%. The refined wheat flour showed the highest and plantain flour had lowest value. The fat absorption can also be influenced by the lipophilicity of protein (Kinsella 1976). The high OAC could suggest the presence of a large proportion of hydrophobic groups as compared with the hydrophilic groups on the surface of protein molecules (Subagio 2006). Swelling capacity determines the extent to which a flour sample increases in volume when soaked in water in relation to its initial volume. The swelling capacity (SC) ranged from 15.1 to 21.7 ml and was highest for plantain flour.

The foaming capacity of flour samples ranged from 8.8% to 35.9%. Proteins can help the foaming because of their surface active property. The foam stability which is measured by the rate at which foam volume decreases is generally determined by loss of liquid resulting from destabilization (leakage). The chickpea flour showed highest foaming capacity and stability. This may be due to high protein content in chickpea flour. Foams are used to improve texture, consistency and appearance of foods. Food ingredient with good foaming capacity and stability is required in bakery products (Akubor et al. 2000; Akubor and Ukwuru 2003; Alobo 2003).

The bulk density varied from 0.7 to 0.8 g/ml, highest for plantain flour. Akubor and Obiegbuna (1999) reported that bulk density of a sample could be used in determining its packaging requirements as this relates to the load the sample can carry if allowed to rest directly on one another. Least gelation concentration (LGC) indicates the index of gelation capacity. The LGC of plantain, chickpea and refined wheat flour were 14, 10 and 20%, respectively. The variation in the gelling properties of flours was attributed to the relative ratio of protein, carbohydrates and lipids that make up the flours and interaction between such components (Sathe et al. 1982).

Proximate composition of biscuits

The proximate composition of biscuits is given in Table 2. Moisture content in the supplemented biscuits ranged from 2.9% to 3.9%, significantly higher ($p<0.05$) than that of control biscuits (2.6%). Mustafa et al. (1986) reported an increase in moisture content of bakery products with increase in protein content. With the increase in the concentration of plantain and chickpea flour in the refined wheat flour, there was an increase in protein, ash and crude fiber contents. The ash content of biscuits increased as the substitution level increased and it was the highest at 40% substitution level (1.2%). The fat content of biscuits varied significantly ($p<0.05$) and it ranged from 31.0% to 38.1%. The decrease in fat content was observed with increasing extent of substitution as it might be due to low oil absorption capacity of plantain and chickpea flours in comparison with wheat flour. The protein content increased from 7.1% to 9.2% with increasing the concentration of

Table 1 Proximate composition (%) and functional properties of plantain, chickpea and refined wheat flour

	Plantain flour	Chickpea flour	Refined wheat flour
Moisture	$8.8^{a}\pm0.07$	$8.7^{a}\pm0.08$	$11.3^{b}\pm0.24$
Ash	$2.4^{b}\pm0.03$	$2.6^{c}\pm0.05$	$0.7^{a}\pm0.03$
Fat	$1.4^{a}\pm0.03$	$4.4^{b}\pm0.04$	$1.4^{a}\pm0.02$
Crude fiber	$3.6^{c}\pm0.05$	$1.2^{b}\pm0.04$	$0.8^{a}\pm0.04$
Protein	$3.0^{a}\pm0.11$	$19.3^{c}\pm0.36$	$11.7^{b}\pm0.31$
WAC (%)	$167.7^{c}\pm1.45$	$90.0^{a}\pm1.73$	$149.3^{b}\pm0.88$
OAC (%)	$144.6^{a}\pm0.98$	$149.5^{b}\pm0.61$	$169.7^{c}\pm3.18$
SC (ml)	$21.7^{c}\pm0.88$	$15.1^{a}\pm0.20$	$17.2^{b}\pm0.72$
FC (%)	$8.8^{a}\pm0.49$	$35.9^{c}\pm0.01$	$12.8^{b}\pm0.49$
FS (%)	$77.2^{a}\pm0.52$	$97.5^{c}\pm0.30$	$95.7^{b}\pm0.28$
BD (g/ml)	$0.8^{b}\pm0.01$	$0.7^{a}\pm0.01$	$0.7^{a}\pm0.01$
LGC (%)	14	10	20

The values are mean ± SD ($n=3$)

Values with similar superscripts in row do not differ significantly ($p<0.05$)

WAC Water absorption capacity; *OAC* Oil absorption capacity; *SC* Swelling capacity; *FC* Foaming capacity; *FS* Foaming stability; *BD* Bulk density; *LGC* Least gelation concentration

Table 2 Proximate composition (%) and physical properties of biscuits

	A	B	C	D	E
Ash	0.9^{a}±0.03	1.0^{ab}±0.01	1.1^{b}±0.16	1.2^{b}±0.02	1.2^{b}±0.03
Moisture	2.6^{a}±0.03	2.9^{b}±0.03	3.3^{c}±0.03	3.7^{d}±0.04	3.9^{e}±0.02
Fat	38.1^{d}±0.78	37.6^{cd}±1.09	36.5^{c}±0.32	33.1^{b}±0.23	31.0^{a}±0.52
Crude fiber	1.1^{a}±0.07	2.7^{b}±0.05	2.9^{c}±0.03	3.2^{d}±0.03	3.6^{e}±0.07
Protein	7.1^{a}±0.04	8.1^{b}±0.05	8.5^{c}±0.06	8.8^{d}±0.05	9.2^{e}±0.05
Carbohydrate	50.2	47.7	47.7	50.0	51.1
Diameter* (cm)	5.9±0.13	6.2±0.06	6.1±0.28	6.1±0.05	6.0±0.28
Thickness*(cm)	0.7±0.03	0.8±0.03	0.8±0.05	0.8±0.06	0.7±0.08
Spread ratio	8.4^{b}±0.03	7.7^{a}±0.05	7.6^{a}±0.08	7.6^{a}±0.13	8.6^{b}±0.05
Weight (g)	11.4^{d}±0.43	10.1^{c}±0.70	9.3^{b}±0.41	9.4^{b}±0.23	8.7^{a}±0.20
% spread	100.0	91.7	90.5	90.5	102.4
Fracture strength (N)	7.2^{a}±0.12	10.3^{b}±0.22	18.0^{c}±0.17	18.6^{c}±0.23	21.1^{d}±0.28

The values are mean ± SD (n=3); the carbohydrate content was determined by subtraction method

Values with similar superscripts in a row do not differ significantly ($p<0.05$)

*Non significant difference

A=Control; B=80 RWF: 10 PF: 10 CF; C=60 RWF:20 PF:20 CF; D=40 RWF:30 PF:30 CF; E=20 RWF:40 PF:40 CF

RWF Refined wheat flour; *PF* Plantain flour; *CF* Chickpea flour

chickpea flour in the blends from 0% to 40%. The increase in protein content of supplemented biscuits might be the result of the higher protein content of chickpea flour. The protein content in supplemented biscuits was significantly higher than that of control ($p<0.05$). Anu et al. (2007) reported higher protein content in pearl millet and green gram supplemented biscuits as compared to control. In the case of supplemented biscuits, the crude fiber content increased significantly ($p<0.05$) and it ranged from 2.7% to 3.6%. The increase in crude fiber content may be due to higher content of crude fiber in plantain and chickpea flour than refined wheat flour.

Physical characteristics of biscuits

The physical properties of biscuits prepared from different blends of flours are also shown in Table 2. The diameter of biscuits varied from 5.9 to 6.2 cm. The biscuits of type B showed the highest diameter of 6.2 cm. The average thickness of control biscuit was 0.7 cm and for other supplemented biscuits, it varied from 0.7 to 0.8 cm. The weight of biscuits decreased as the concentration of plantain and chickpea flour increased in the blends. This was probably due to low OAC of the plantain and chickpea flour. The changes in diameter and thickness were reflected in spread ratio and percent spread of biscuit. The spread ratio and percent spread of control biscuits were 8.4 and 100, respectively. Spread ratio and percent spread decreased with the addition of plantain and chickpea flour except at 40% supplementation level, which had spread ratio and percent spread value comparable to control biscuits. Rababah et al. (2006) reported reduction in spread ratio when the chickpea, broad bean and isolated soy protein were substituted for wheat flour in biscuits. The fracture

Table 3 Sensory quality characteristics of biscuits

	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
A	7.7^{b}±0.13	7.1^{b}±0.07	7.6^{b}±0.11	7.0^{b}±0.13	7.4^{b}±0.12	7.3^{b}±0.10
B	7.3^{b}±0.15	6.7^{ba}±0.13	7.1^{b}±0.09	7.1^{b}±0.19	7.5^{b}±0.18	7.2^{b}±0.28
C	7.3^{b}±0.17	7.3^{b}±0.15	7.1^{b}±0.18	6.6^{b}±0.11	7.0^{b}±0.15	7.1^{b}±0.22
D	6.7^{a}±0.20	6.1^{a}±0.25	6.0^{a}±0.15	5.3^{a}±0.18	5.7^{a}±0.22	6.1^{a}±0.13
E	6.4^{a}±0.11	6.0^{a}±0.20	6.1^{a}±0.13	5.3^{a}±0.16	6.0^{a}±0.14	6.1^{a}±0.15

The values are mean ± SD (n=10)

Values with similar superscripts in column do not differ significantly ($p<0.05$)

A=Control; B=80RWF: 10PF: 10CF; C=60RWF:20PF:20CF; D=40RWF:30PF:30CF; E=20RWF:40PF:40CF

RWF Refined wheat flour; *PF* Plantain flour; *CF* Chickpea flour strength of biscuits increased significantly ($p<0.05$) with addition of plantain and chickpea flour and it was the highest at 40% concentration (21.1 N). The high values indicate that the supplemented biscuits were harder than the control.

Sensory characteristics of biscuits

The effects of plantain and chickpea flour incorporation on the sensory characteristics of biscuits are presented in Table 3. With the increase in the level of plantain and chickpea flour in the formulation, the sensory scores for color, texture, appearance and flavor of biscuits decreased. However, the biscuits prepared by replacing refined wheat flour up to 20% PF and 20% CF were more or less similar to control biscuits with respect to color, taste, flavor, texture and overall acceptability. Increasing the levels of incorporation of PF and CF above 20% resulted in significantly decreased ($p<0.05$) score for quality characteristics and this decreasing effect was more pronounced in the texture of the biscuits as the biscuits produced were much harder in texture. Replacement of refined wheat flour with up to 20% plantain and chickpea flour produced protein–enriched biscuits with moderately desirable overall acceptability.

Conclusion

The results of the study concludes that biscuits with acceptable sensory properties and enhanced protein and fiber content can be developed by incorporating plantain and chickpea flour each up to a level of 20% in refined wheat flour. Since, the use of composite flours is the latest trend in the bakery industry, the use of plantain and chickpea flours can be exploited successfully in bakery products other than biscuits also.

References

Akubor P (2003) Functional properties and performance of cowpea/ plantain/ wheat flour blends in biscuits. Plant Food Hum Nutr 58:1–8

Akubor PI, Badifu GIO (2004) Chemical composition, functional properties and baking potential of African bread fruit kernel and wheat flour blends. Int J Food Sci Technol 39:223–229

Akubor PI, Obiegbuna JE (1999) Certain chemical and functional properties of ungerminated and germinated millet flour. J Food Sci Technol 36:241–243

Akubor PI, Ukwuru (2003) Functional properties and biscuit making potential of soybean and cassava flour blends. Plant Food Hum Nutr 55:1–12

Akubor PI, Isolokwu PC, Ugbane O, Onimawo IA (2000) Proximate composition and functional properties of African breadfruit kernel and wheat flour blends. Food Res Int 33:707–712

Alobo AP (2003) Proximate composition and selected functional properties of defatted papaya (*Carica papaya*) kernel flour. Plant Food Hum Nutr 58:1–7

Anon (2002) Global Conference on banana and plantain, Organized by association for Improvement in Production and Utilization of Banana, New Delhi, International Network for Improvement of Banana, Montpellier (France) and FAO, 28–31 Oct, Bangalore, India

Anu, Sehgal S, Kawatra A (2007) Use of pearl millet and green gram flours in biscuits and their sensory and nutritional quality. J Food Sci Technol 44:536–538

AOAC (1990) Official methods of analysis, 15th edn. Association of Official Analytical Chemists, Washington DC

Chandrasekharappa G (1979) Nutritional quality of the blends of wheat and rice with bengal gram, red gram and black gram. Nutr Rep Int 18:401–410

Claughton SM, Pearce RJ (1989) Protein enrichment of sugar-snap cookies with sunflower protein isolates. J Food Sci 54:354–356

Coffman CW, Garcia VV (1977) Functional properties and amino acid content of a protein isolate from mung bean flour. J Food Technol 12:473–480

Hooda S, Jood S (2005) Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chem 90:427–435

Indrani S, Savithri GD, Venkateswara Rao G (1997) Effect of defatted soy flour on the quality of buns. J Food Sci Technol 34:440–442

Iyer L, Singh U (1997) Functional properties of wheat and chickpea composite flours. Food Australia 49:27–31

Kinsella JE (1976) Functional properties of proteins in foods: A survey. Crit Rev Food Sci Nutr 7:219–232

Mepba HD, Eboh L, Nwaojigwa SU (2007) Chemical composition, functional and baking properties of wheat-plantain composite flours. AJFAND 7:1–22

Mustafa AI, Alwessali MS, SI-Busha OM, Al-Amia RH (1986) Utilization of cowpea flour and protein isolate in bakery products. Cereals Food World 31:756–759

Narayana K, Narasinga Rao MS (1982) Functional properties of raw and heat processed winged bean flour. J Food Sci 42:534–538

Okaka JC, Potter NN (1977) Functional and storage properties of cowpea-wheat flour blends in breadmaking. J Food Sci 42:822–833

Olaoye OA, Onilude AA, Idowu OA (2006) Quality characteristic of bread produced from composite flour of wheat, plantain and soybeans. Afri J Biotechnol 5:1102–1106

Potter NN (1986) Food science, 4th edn. Van Nostrand Reinhold, Inc., New York

Rababah TM, Al-Mahasneh MA, Ereifej KI (2006) Effect of chickpea, broad Bean, or isolated soy protein (ISP) additions on the physicochemical and sensory properties of biscuits. J Food Sci 71:438–442

Ranganna S (1979) Hand book of analysis and quality control for fruits and vegetables products, 2nd edn. Tata Mcgraw Hill Publ Co, New Delhi

Sathe SK, Deshpande SS, Salunkhe DK (1982) Functional properties of winged bean proteins. J Food Sci 47:503–508

Singh U (2001) Functional properties of grain legume flours. J Food Sci Technol 38:191–199

Singh U, Williams PC, Petterson DS (1997) Processing and grain quality of cool season food legumes to meet the market demands. In Proceedings, International Food Legume Research Conference (26–30September 1997), Adelaide, Australia

Sosulski FW, Ganat MD, Slinkard AF (1976) Functional properties of ten legume flours. Can Inst Food Sci Technol J 9:66–74

Subagio A (2006) Characterization of hyacinth bean (*Lablab purpureus* L. sweet) seeds from Indonesia and their protein isolate. Food Chem 95:65–70

Tsen CC, Peters EM, Schaffer T, Hoover WJ (1973) High protein cookies. Effect of soy fortification and surfactants. Bakers Digest 47:34–37

William PC, Singh U (1987) Nutritional quality and the evaluation of quality in breeding programmes. In: Saxena MC, Singh KB (eds) The chickpea. CAB International/ICARDA, Wallingford, pp 329–356

Yadav BS, Sharma A, Yadav RB (2009) Studies on effect of multiple heating/cooling cycles on the resistant starch formation in cereals, legumes and tubers. Int J Food Sc Nutr 60(1):258–272