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ORIGINAL ARTICLE

Quality of products containing defatted groundnut cake flour

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Abstract Defatted groundnut cake obtained from commercial oil processing units and that prepared in laboratory oil expeller (LOE) were analyzed for quality parameters. Defatted groundnut cake flour (DGCF) was incorporated at 15–100% levels in *laddoo*, *chutney* powder, fryums (deep fried crisp and crunchy item), biscuits, noodles and extruded snacks. The products were studied for sensory, physico-chemical and shelf-life quality. DGCF was creamish white with bulk density of 0.55±0.03 g/ml, water absorption capacity 135.6±1.97 ml %, oil absorption capacity 100.3±1.16 ml % and foam capacity 33±1%. Protein, fat and ash contents were 51.6±0.06, 4.5±0.05 and 4.2±0.11%, respectively. Tannins and aflatoxin B_1 were not detected. The increase of protein due to incorporation of DGCF into the products ranged from 5.5 to 21.9%. Shelf-life studies indicated the maximum storability for 90 days for all the products except *laddoo*, which could be stored for 30 days at ambient temperature (28±2°C). All the products were acceptable and the order of preference for the products as indicated by adults (fryums, *chutney* powder, extruded snacks, noodles, biscuits and *laddoo*) and children (biscuits, *laddoo*, extruded snacks, fryums, noodles and *chutney* powder) varied.

Keywords Defatted groundnut cake flour · Physico-chemical quality · Product quality · Shelf-life

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Introduction

Groundnut cake is a by product obtained after extraction of oil. The cake contains 45–60% protein, 22–30% carbohydrate, 3.8–7.5% crude fibre and 4–6% minerals (Desai et al 1999a). The groundnut production in India was 9.4 mt and in Andhra Pradesh 0.74 mt (Anon 2009). Andhra Pradesh is one of the major producers of groundnut contributing about 15% of the total production and more than 80% of the produce is utilized for oil extraction. The cake which is a rich source of protein is indigenously used as cattle feed or manure.

Utilization of meal or defatted meal into food products could be an excellent vehicle for enhancing the utilization of groundnut protein in the diets of malnourished people in developing countries. Groundnut flour produced from cake blends easily and enhances or enriches the nutritive value of wheat and other flour. It has potential to be used as low fat groundnut concentrate, composite flour, in bakery products, breakfast cereal flakes, snack foods, multipurpose supplement, infant and weaning foods, extruded foods or fabricated food (Venkataraghavan 1998; Gopala Krishna 2007). Central Food Technological Research Institute, Mysore, India has developed some processed foods (*paustic atta*, composite grain, protein isolate, multipurpose supplement, infant and weaning foods, bal-ahar and miltone) from edible groundnut meal (Parpia 1988). Utilization of defatted groundnut meal with mild processing treatment is becoming increasingly popular in other countries. However, in India because of the unhygienic processing conditions that prevail in many small-scale oilseeds processing factories/units the residual cake/meal is generally not fit for human consumption, but is only suitable for animal feed or as an ingredient of nitrogenous fertilizer (Ali 1995). Hence an attempt was made to obtain hygienically extracted defatted groundnut cake and to develop value added traditional and convenience food products through laboratory oil expeller.

Materials and methods

Groundnut cake produced in expeller press was procured from commercial oil expeller unit in Hyderabad. The cake was then ground into powder using mixer cum grinder (Sumeet, India) and passed through 40 mesh sieve and mixed thoroughly. The solvent extracted cake was procured from solvent extraction unit (SEU) in Medak district (AP) and passed through 40-mesh sieve and mixed.

Preparation of defatted groundnut cake (DGC) in laboratory oil expeller (LOE) Sound and cleaned groundnut kernels were obtained from local supermarket and were heated in oven at 98°C for 8 min and deskinned manually by rubbing between hands. The kernels were subjected to electrically operated oil expeller (KOMET Model Nr 201205, Germany) having a capacity of 15 kg/day at 110°C to extract oil and obtain defatted groundnut cake (DGC) (520 g/kg of seeds).

Nutrient composition (moisture, crude protein, crude fibre, crude fat and total ash) of the DGC obtained from different process units was analyzed using AOAC (1990) procedures. The acid insoluble ash (ISI 1989), tannin (Price et al. 1978) and aflatoxin B_1 content (Trucksess et al. 1994) were analyzed. The physical properties of DGC studied were bulk density (Ige et al. 1984), water absorption capacity (Janicki and Walczak 1954), oil absorption capacity (Sosulki et al. 1976) and foaming capacity (Lawhon et al. 1972).

Products with DGC DGC obtained from laboratory oil expeller (LOE) was selected for value addition into the traditional and convenience food products namely *laddoo*, *chutney* powder, fryums, biscuits, noodles and extruded snacks at different levels of incorporation. For ease of incorporation it was further milled in a laboratory mixer cum grinder (Sumeet, India) to obtain defatted groundnut cake flour (DGCF).

Biscuits Standardized recipe of the biscuits had the ingredients, refined wheat flour 100 g, powdered sugar 60 g, hydrogenated fat 55 g, skimmed milk powder (SMP) 5 g, baking powder 0.5 g and vanilla essence 2 to 3 drops. Biscuits containing DGCF were prepared from refined wheat flour and DGCF blends in the proportion of 100:0, 80:20, 70:30 and 60:40.

Hydrogenated fat and powdered sugar were creamed till light and fluffy. DGCF and baking powder were sifted and added to the above mixture. Vanilla essence and SMP were added and mixed well. Pliable dough prepared by kneading with hand. The dough was then rolled out into sheets of 1/8 inch thickness and cut with biscuit-cutter into cartoon (desired) shapes. Biscuits were placed on greased baking trays and baked in preheated oven at 200±10°C for~6 min.

Chutney powder Standardized recipe of the *chutney* powder had the ingredients, roasted and powdered *chana* dhal (*Cicer arietinum*) 100 g, red chillies (*Capsicum annuum*) 10 g, coriander seeds (*Coriandrum sativum*) powder 12 g, cumin seeds (*Cuminum cyminum*) powder 8 g, curry leaf (*Murraya koenigii*) powder 10 g, *amchur (Mangifera indica* L.) powder 12 g, turmeric (*Curcuma domestica*) powder 1 g, garlic (*Allium sativum*) powder 2 g, salt 10 g. DGCF *chutney* powder was prepared by blending roasted *chana* dhal and DGCF in the proportions of 100:0, 50:50, 25:75 and 0:100.

Chana dhal, DGCF, coriander seeds, cumin seeds were roasted without oil. Whole red chillies, curry leaves were roasted in little oil. All the above ingredients were powdered, sieved and mixed uniformly with turmeric powder and salt.

Fryums Standardized recipe of the fryums had the ingredients, sago flour 100 g, salt 4 g, asafoetida (*Ferula foetida*) 0.4 g, roasted cumin seeds 2 g, color 1 pinch and water 200 ml. DGCF fryums were prepared by blending sago *(Metroxylon sagu)* flour and DGCF in the ratios of 100:0, 90:10, 85:15 and 80:20.

Sago flour and DGCF were first mixed with small quantity of lukewarm water to make into a paste. Specified quantity of boiling water was then added and mixed briskly. The paste was then cooked for 3–4 min till it gets partially gelatinized. Salt, roasted cumin seeds, asafoetida and colour were added during cooking. The paste was then poured with spoon in a greased tray and dried for 7–8 h at 65°C in a cabinet dryer. The dried fryums were packed and could be used as and when needed after deep frying in vegetable oil.

Extruded snacks Standardized recipe of the extruded snacks had the ingredients, rice (*Oryza sativa*) flour 100 g, salt 4 g, roasted cumin seeds 2 g, hydrogenated fat 2 g, baking powder 0.5 g, colour- sunset yellow FCF CI Nr 15985 1 pinch and water 400 ml. DGCF extruded snacks were prepared incorporating DGCF at different levels to rice flour (100:0, 70:30, 60:40 and 50:50).

Rice flour and DGCF were added to specified quantity of lukewarm water and mixed thoroughly to form a slurry. Slurry was cooked in a container for 10–15 min to obtain a thick paste. Salt, roasted cumin seeds, asafoetida and colour were added during cooking. The cooked material was then pressed in a house-hold *sev* machine (extruder) to get desired shape of snack. The snacks thus produced were dried in a cabinet dryer at 65°C for 7–8 h. The dried snacks were packed and could be used as and whenever needed after deep frying in vegetable oil

Noodles Standardized recipe of the noodles had the ingredients, refined wheat flour 100 g, hydrogenated fat 1 g, salt 1 g and water 30 ml. Noodles containing DGCF were prepared from refined wheat flour and DGCF blends in the proportion of 100:0, 80:20, 70:30 and 60:40.

Melted fat was mixed into the flour. All the dry ingredients were added and mixed well. The required amount of water (50°C) was added and kneaded for 10–15 min to obtain dough of optimum consistency. The dough was extruded into noodles by using a manual single screw hand press. The noodles were pre-dried for 30 min at 80°C and steamed at 100°C for 4–5 min. The steamed noodles were finally dried at 60–70°C for 3–4 h or till the noodles attained moisture <10%.

Two cups of water were boiled and one table spoon of edible oil and salt were added. The dried noodles were added to the boiling water and cooked for 8–10 min. The cooked noodles were strained on a sieve and held under cold running water to remove stickiness and get separate strands. The cooked noodles were served after garnishing with fresh chopped vegetable sauted in little oil.

Laddoo Standardized recipe of the *laddoo* had the ingredients, dessicated coconut powder 100 g, jaggery 100 g, SMP 20 g, cardamom powder 2 g and water 25 ml. DGCF *laddoo* was prepared by blending dessicated coconut powder and DGCF in the ratios of 100:0, 50:50, 25:75 and 0:100.

Jaggery was heated with water till it dissolved. Dessicated coconut powder and roasted DGCF were added and mixed well. SMP and cardamom powder were added when it started leaving sides of vessel, cooled for 2 min and pressed by hand to obtain round *laddoos* of 3–5 cm diameter while still hot and packed.

Sensory evaluation of the DGCF products The different DGCF products were evaluated sensorily to find the maximum acceptable level of incorporation by a panel of 10 semi-trained judges using 5- point Hedonic scale following the method of Peryam and Pilgrim (1957). The products were evaluated for their appearance, texture, taste, flavour and overall acceptability.

Physico-chemical analysis of the prepared DGCF products

Noodles Determination of minimum cooking time (min) was done by placing 10 g noodles in a beaker containing 200 ml of distilled water and heating in boiling water bath. After every 30 s a piece of noodle was taken out and squeezed in between 2 glass slides. When the white core just disappeared, the time taken for cooking was recorded as minimum cooking time. Percent water uptake or water absorption (ml/100 g) was determined as per BIS (1976) method. To estimate total solid loss/gruel solids (%), cooked water drained earlier in a flask was made to 250 ml volume using distilled water and 10 ml was poured to pre-weighed Petri dish and evaporated to dryness in an air oven at 100±1°C overnight. Weight was noted after keeping it in dessicator. Total solid loss/gruel solids (%) was calculated (Hundal et al. 2006).

$$\text{Gruel Solid Loss }(\%) = \frac{A}{10} \times B \times \frac{100}{10}$$

where A = weight of residue after drying and B = volume of cooking water made after boiling

Volume expansion was measured by first measuring volume of 25 g uncooked noodles by putting these into 250 ml water in measuring cylinder. Then similarly volume of noodles after cooking was measured and volume expansion was calculated (Hundal et al. 2006).

$$\text{Volume expansion }(\text{ml/g}) = \frac{\text{Increase in volume (ml)}}{\text{Weight of noodles (g)}}$$

Fryums For determination of percent oil uptake, weight of fryum was taken before and after frying. The fryums after frying were wiped with tissue paper to remove the adhering surface oil and weighed. The difference in weight was worked out and expressed as oil uptake in percentage. Product yield was calculated as total product obtained from the total flour/blend used and expressed as %. Percent water absorption of blends was measured by noting the volume of water absorbed by 100 g of flour/blend for fryum making. Percent expansion of fryums was calculated (Jagadeesh et al. 2007).

$$\text{Expansion }\% = \frac{\text{Diameter after frying} - \text{Diameter of raw fryums}}{\text{Diameter after frying}} \times 100$$

Extruded snack Percent oil absorption was calculated by taking weight of raw and fried snacks. The difference in weight was worked out and expressed as oil uptake in percentage. Product yield was calculated as total product obtained from the total flour/blend used and expressed as %. Percent water absorption of blends was measured by noting the volume of water absorbed by 100 g of flour/blend for snack making.

Biscuits Biscuits were made in cartoon shape. As it was difficult to assess the diameter for spread ratio, the thickness of the biscuits was calculated.

Chutney powder The bulk density of *chutney* powder was determined by the method of Ige et al. (1984).

For the control products the nutritive value (protein, fat, carbohydrate and calories) were calculated using the nutritive value of Indian foods (Gopalan et al. 2004). For DGCF incorporated products the actual analyzed values of DGCF were taken and the remaining ingredients were calculated based on nutritive value of Indian foods (Gopalan et al. 2004). Moisture and ash contents of all the products were estimated by standard AOAC (1990) procedure.

Consumer acceptability studies The accepted products were further evaluated for consumer acceptability with 100 members in Hyderabad comprising of 50 children (age 10–15 years) and 50 housewives using a 5-point Hedonic scale.

Storage studies Biscuits, fryums, extruded snacks, *chutney* powder and *laddoo* were packed in metalized polypropylene pouches and poly-ethylene pouches (noodles) having a thickness of 40 μm and stored at room temperature (28±2°C). Storage stability of the products was assessed by determining moisture and free fatty acid contents (AOAC 1990), total viable bacterial count, coliform count, and yeast and mold count (Cruickshank et al. 1975) and sensory quality parameters based on 5-point Hedonic scale (Peryam and Pilgrim 1957) at monthly intervals for 3 months for biscuits, fryums, noodles, *chutney* powder and extruded snacks whereas for *laddoo* at an interval of 10 days for one month.

Statistical analysis The data pertaining to sensory evaluation and effect of storage on shelf life of the products was analyzed using the analysis of variance (ANOVA) technique while paired *t*-test was used to compare physico-chemical parameters between the control and DGCF incorporated products (Snedecor and Cochran 1989).

Results and discussion

DGC obtained from LOE had highest protein (51.6%) and ash content (4.2%) (Table 1). Similar results for defatted flour were reported to range from 3.0 to 4.8% (Desai et al. 1999a). In the present study, crude fibre content in the DGC obtained from COE and SEU was significantly high as compared to that of LOE (Table 1). In the traditional method of oil extraction the groundnut seeds are crushed without cleaning along with seed coats and some proportion of hulls to improve extraction efficiency. This results in a cake that is rich in fibre (Tate et al. 1990). The DGC obtained from SEU had low crude fat (0.68%) as compared

Table 1 Physico-chemical characteristics of defatted groundnut cakes

	COE	SEU	LOE	CD at 5%
Physical				
Colour	Dark brown	Brown	Creamish white	–
Bulk density, g/ml	0.59±0.02[a]	0.47±0.04[c]	0.55±0.03[b]	0.04
Water absorption capacity, ml%	96.4±0.63[c]	119.5±1.51[b]	135.6±1.97[a]	1.93
Oil absorption capacity, ml%	89.6±1.02[c]	98.7±0.73[b]	100.3±1.16[a]	1.28
Foam capacity, % volume increase	12±1[c]	19±2[b]	33±1[a]	1.85
Nutritional				
Moisture, %	7.4±0.46[a]	5.9±0.16[c]	6.4±0.48[b]	0.51
Crude protein, %	43.4±0.73[c]	49.2±1.08[b]	51.6±0.06[a]	0.98
Crude fat, %	11.3±0.56[a]	0.68±0.03[c]	4.5±0.05[b]	0.42
Ash, %	5.5±0.71[a]	5.9±0.16[a]	4.3±0.11[b]	0.55
Acid insoluble ash, %	2.2±0.08[a]	2.1±0.02[a]	0.09±0.02[b]	0.06
Crude fibre, %	2.7±0.14[a]	1.8±0.04[b]	1.2±0.03[c]	0.11
Carbohydrate, %	29.8±0.73[c]	36.2±0.44[a]	32.1±0.63[b]	0.79
Energy, kcal/100 g	394.2±2.38[a]	347.9±0.24[c]	375.6±1.96[b]	2.32
Anti-nutritional				
Tannins, mg/100 g	112±3[a]	110.3±4.73[a]	ND	4.22
*Aflatoxin B1, ppb	1.18±0.03[a]	1.2±0.03[a] ND	ND	0.04

Values with different superscripts in a row differ significantly ($p<0.05$) ($n=3$)

ND Not detected, *COE* Commercial oil expeller, *SEU* Solvent extraction unit, *LOE* Laboratory oil expeller, *CD* Critical difference

*Permissible value=120 ppb (Desai et al 1999b) to that obtained through COE (11.2%) and LOE (4.5%) (Table 1). The variation in crude fat might be attributed to either inadequate oil expeller pressing and/or use of solvent during the extraction (Gopala Krishna 2007). The DGC obtained from COE and SEU had tannin 112 and 110 mg/100 g, aflatoxin content 1.18 and 1.2 ppb respectively (within permissible limits of 120 ppb) (Desai et al. 1999b) and had darker colour as compared to DGC obtained from LOE.

The DGC obtained from COE and SEU exhibited inferior water and oil absorption as well as foaming capacity when compared to that of DGC obtained from LOE (Table 1). This might be due to higher protein content of DGC obtained from LOE. Considering the poor quality parameters of the DGC obtained from COE and SEU the DGC obtained from LOE was used for product development.

Sensory quality of DGCF products All the DGCF products were rated acceptable to highly acceptable as compared to control (Table 2). The colour of fryums, extruded snacks, noodles and biscuits changed from creamish yellow to dark brown due to roasting as the proportion of DGCF increased (Table 2). This could be due to the increase in protein content with higher level of incorporation of DGCF which might have resulted in increased Maillard reaction. Similar observations were reported for biscuits made with defatted groundnut flour (Chetana and Reddy 2004).

Table 2 Sensory scores for products with different levels of defatted groundnut cake flour (DGCF)

Products	DGCF incorporation, %	Appearance	Texture	Taste	Flavour	Overall acceptability
Biscuits	0	4.8 ± 0.43^{a}	4.8 ± 0.43^{a}	4.6 ± 0.52^{a}	4.8 ± 0.43^{a}	4.8 ± 0.43^{a}
	20	4.4 ± 0.52^{bc}	4.6 ± 0.52^{a}	4.4 ± 0.52^{ab}	4.5 ± 0.53^{ab}	4.5 ± 0.53^{a}
	30	4.3 ± 0.49^{cd}	4.6 ± 0.52^{a}	4.6 ± 0.52^{a}	4.5 ± 0.53^{ab}	4.5 ± 0.53^{a}
	40	4.0 ± 0.0^{d}	3.9 ± 0.32^{b}	4.1 ± 0.32^{b}	4.2 ± 0.43^{b}	4.0 ± 0.0^{b}
CD at 5%		0.31	0.34	0.36	0.36	0.32
Laddoo	0	4.6 ± 0.43^{a}	4.8 ± 0.43^{a}	4.7 ± 0.49^{a}	4.8 ± 0.43^{a}	4.8 ± 0.43^{a}
	50	4.2 ± 0.52^{bc}	4.5 ± 0.53^{a}	4.7 ± 0.49^{a}	4.5 ± 0.53^{ab}	4.5 ± 0.53^{ab}
	75	4.0 ± 0.43^{cd}	4.0 ± 0.0^{b}	4.5 ± 0.53^{a}	4.3 ± 0.49^{b}	4.3 ± 0.49^{b}
	100	3.8 ± 0.43^{d}	3.6 ± 0.52^{c}	4.1 ± 0.32^{b}	3.8 ± 0.43^{c}	3.8 ± 0.43^{c}
CD at 5%		0.30	0.32	0.35	0.35	0.35
Fryums	0	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.9 ± 0.32^{a}	4.9 ± 0.32^{a}	4.9 ± 0.32^{a}
	10	4.8 ± 0.43^{a}	4.7 ± 0.49^{a}	4.7 ± 0.49^{a}	4.6 ± 0.52^{ab}	4.7 ± 0.49^{ab}
	15	4.7 ± 0.49^{a}	4.7 ± 0.49^{a}	4.8 ± 0.43^{a}	4.6 ± 0.52^{ab}	4.7 ± 0.49^{ab}
	20	4.6 ± 0.52^{a}	4.5 ± 0.53^{a}	4.8 ± 0.43^{a}	4.4 ± 0.52^{b}	4.5 ± 0.53^{b}
CD at 5%		0.33	0.36	0.31	0.36	0.35
Chutney powder	0	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.9 ± 0.32^{a}
	50	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.7 ± 0.49^{a}	4.6 ± 0.52^{a}	4.7 ± 0.49^{a}
	75	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.8 ± 0.43^{a}	4.7 ± 0.49^{a}	4.8 ± 0.43^{a}
	100	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.9 ± 0.32^{a}	4.9 ± 0.32^{a}	4.9 ± 0.32^{a}
CD at 5%		0.24	0.32	0.30	0.33	0.30
Extruded snacks	0	4.8 ± 0.43^{a}	4.8 ± 0.43^{a}	4.9 ± 0.32^{a}	4.8 ± 0.43^{a}	4.8 ± 0.43^{a}
	30	4.7 ± 0.49^{a}	4.7 ± 0.49^{a}	4.6 ± 0.52^{ab}	4.5 ± 0.53^{ab}	4.6 ± 0.52^{ab}
	40	4.6 ± 0.52^{a}	4.7 ± 0.49^{a}	4.8 ± 0.43^{a}	4.6 ± 0.52^{ab}	4.7 ± 0.49^{a}
	50	4.2 ± 0.43^{b}	4.5 ± 0.53^{a}	4.3 ± 0.49^{b}	4.3 ± 0.49^{b}	4.3 ± 0.49^{b}
CD at 5%		0.35	0.36	0.33	0.37	0.36
Noodles	0	4.8 ± 0.43^{a}	4.4 ± 0.52^{a}	4.7 ± 0.49^{a}	4.7 ± 0.49^{a}	4.6 ± 0.52^{a}
	20	4.4 ± 0.52^{bcd}	4.2 ± 0.43^{ab}	4.5 ± 0.53^{a}	4.5 ± 0.53^{a}	4.3 ± 0.49^{a}
	30	4.4 ± 0.52^{cd}	4.2 ± 0.43^{ab}	4.6 ± 0.52^{a}	4.5 ± 0.53^{a}	4.4 ± 0.52^{a}
	40	4.1 ± 0.32^{d}	3.9 ± 0.32^{b}	4.4 ± 0.52^{a}	3.9 ± 0.32^{b}	3.9 ± 0.32^{b}
CD at 5%		0.34	0.32	0.39	0.36	0.35

Values with different superscripts in a column differ significantly ($p<0.05$), ($n=10$ panelists)

Max. sensory scores: 5-excellent, 4-very good, 3-good, 2-fair, 1-poor

Maximum incorporation at 15% level was acceptable in fryums as compared to control. Higher levels of DGCF incorporation increased the hardness (Table 2). Similar observation was reported for defatted soy flour *wadians* (Chetana and Reddy 2004) and soy biscuits (Gandhi et al. 2001) which may be attributed to increase in protein and decrease in fat and carbohydrate contents. Thus it was found that most acceptable level of incorporation of DGCF was: fryums 15%, biscuits and noodles 30%, extruded snacks 40%, *laddoo* 50% and *chutney* powder 100%.

Physico-chemical properties of products DGCF incorporation improved nutritive value of the products (Table 3). Protein content of DGCF (51.6%) was more than the minimum specified for edible groundnut flour (47%) (Desai et al. 1999b). The bulk density of DGCF obtained from LOE (0.55 g/ml) was close to the finding (0.57 g/ml) of Puyed and Prakash (2006). Water and oil absorption of DGC obtained from LOE was 135.6 ml% and 100.3 ml%, respectively. The results agreed with the observation for defatted groundnut flour by Puyed and Prakash (2006). The foaming capacity of DGC obtained from LOE (33%) was comparable with defatted groundnut meal (36%) (Tate et al. 1990).

The increase in protein content due to incorporation of DGCF was 5.5% to 21.9% (Table 1). The biscuits made with 30% level of incorporation had protein content more than the prescribed for high protein biscuits i.e. 12% (ISI 1986). Similar observations were reported in defatted soy fortified biscuits (Gandhi et al. 2001). High ash content of DGCF products as compared to their respective control might be due to high mineral content of DGCF (Tate et al. 1990) and of *laddoo* (control) might be due to inclusion of dessicated coconut powder. The carbohydrate content of DGCF products was lower than control counterparts and the addition of groundnut flour to wheat flour might have decreased the total carbohydrate levels while increasing protein content. Similar observations were reported in defatted groundnut grits incorporated *dambu* (a steamed, granulated dumpling product) (Agu et al. 2009) and linseed meal fortified *chapatis* (Sahu et al. 2009).

The physical properties of all the products were on par with the control except cooking time (noodles), expansion upon frying (fryums), oil absorption (fryums and extruded snacks), thickness (biscuits) and bulk density (*chutney* powder). Cooking time for noodles increased significantly ($p \leq 0.05$) in DGCF incorporated noodles (7 min) as compared to control (5 min). Similar result on substitution of wheat semolina with soy flour in spaghetti preparation was observed by Hundal et al. (2006). Water uptake (305.3 ml/100 g) and volume expansion (1.49 ml/g) of noodles on DGCF incorporation was slightly higher (not significant) as compared to control which was 279.7 ml/100 g and 1.09 ml/g, respectively. Similar observations were reported with spaghetti made with soy flour and pulse flour blends (Lakshmi Devi and Vijay Khader 1997; Hundal et al. 2006). Although total solid loss for DGCF noodles (7.4%) was slightly higher as compared to control noodles (6.4%), it was within the specified limits i.e. <9% (AACC 1983). Increase in cooking loss upon DGCF incorporation could be attributed to dilution of gluten protein (Hundal et al. 2006).

Fryums and extruded snacks Water required to make a paste was higher for DGCF fryums (225 ml/100 g) and extruded snacks (430 ml/100 g) than the control fryums (200 ml/100 g) and extruded snacks (400 ml/100 g). It may be due to higher water absorption capacity of DGCF. Earlier workers also observed higher water absorption by

Table 3 Nutrient profile of defatted groundnut cake flour (DGCF) value added products

		[a]Moisture, %	Protein, %	Fat, %	* Ash, %	Carbohydrate, %	Energy, kcal/100 g
Noodles	Control	6.8	7.8	1.4	0.52	82.9	483.9
	DGCF	7.0	16.4	2.1	1.2	73.2	549.9
Fryums	Control	5.8	0.42	0.36	1.3	92.0	483.9
	DGCF	5.7	5.9	0.82	1.7	85.6	549.9
Extruded Snacks	Control	6.0	5.1	2.0	1.4	85.1	210.1
	DGCF	5.8	17.8	2.8	1.5	28.4	375.0
Biscuits	Control	2.6	9.2	39.6	0.7	47.4	583.3
	DGCF	2.6	17.8	40.4	1.5*	37.0	583.2
Chutney Powder	Control	5.4	28.2	6.7	3.4	54.2	323.7
	DGCF	5.6	50.1	6.0	4.5	30.0	344.2
Laddoo	Control	14.8	14.8	2.9	1.6	92.0	338.6
	DGCF	14.5*	20.4	2.7	1.5	85.6	368.3

[a] Significant difference from control at $p \leq 0.05$ ($n=3$)

Table 4 Changes in chemical and microbiological quality of defatted groundnut cake flour (DGCF) products during storage at 28±2°C

Products	DGCF level, %	Storage period, days	Moisture, %	FFA, % as oleic	TVBC, log cfu/g	Y& M, log cfu/g	Coliform, log cfu/g
Biscuits	0	0	2.6±0.01[a]	0.69±0.11[a]	ND	ND	ND
		30	2.7±0.00[b]	0.78±0.13[b]	1.3±0.40[c]	1.2±0.50[b]	1.1±0.50[c]
		60	2.7±0.01[c]	0.89±0.19[c]	1.5±0.50[b]	1.3±0.60[ab]	1.3±0.60[b]
		90	2.9±0.00[d]	1.1±0.23[d]	1.6±0.50[a]	1.4±0.70[a]	1.4±0.70[a]
	30	0	2.6±0.00[a]	0.61±0.11[a]	ND	ND	ND
		30	2.7±0.00[b]	0.73±0.13[b]	1.3±0.20[c]	1.3±0.50[b]	1.1±0.30[b]
		60	2.8±0.01[c]	0.85±0.15[c]	1.5±0.40[b]	1.4±0.50[ab]	1.2±0.20[ab]
		90	3.0±0.01[d]	1.1±0.13[d]	1.6±0.50[a]	1.5±0.70[a]	1.2±0.60[a]
	CD (*n*=3)		0.0149	0.0141	4.313	5.8273	5.3118
Laddoo	0	0	14.8±0.01[a]	0.65±0.00[b]	1.0±0.20[ab]	0.7±0.30[d]	ND
		10	14.9±0.00[a]	0.91±0.01[a]	1.0±0.30[bc]	1.2±0.10[c]	0.5±0.00[bc]
		20	15.0±0.00[a]	0.95±0.00[a]	0.9±0.30[c]	1.7±0.00[b]	0.4±0.30[c]
		30	15.0±0.01[a]	0.99±0.09[a]	1.0±0.60[a]	1.9±0.00[a]	0.8±0.40[a]
	50	0	14.5±0.03[a]	0.63±0.02[b]	1.1±0.40[a]	0.7±0.30[d]	ND
		10	14.6±0.01[a]	0.84±0.03[a]	1.0±0.20[bc]	1.2±0.20[c]	0.6±0.00[ab]
		20	14.6±0.01[a]	0.91±0.02[a]	1.0±0.20[c]	1.7±0.30[b]	0.6±0.30[b]
		30	14.7±0.01[a]	0.94±0.02[a]	1.1±0.20[a]	2.0±0.30[a]	0.7±0.00[a]
	CD (*n*=3)		0.5089	0.1079	1.9414	2.029	1.0957
Fryums	0	0	5.8±0.02[a]	0.43±0.01[a]	3.7±0.40[a]	2.6±0.20[abc]	ND
		30	5.6±0.01[b]	0.48±0.01[b]	3.6±0.20[a]	2.4±0.20[bc]	0.6±0.40[c]
		60	5.6±0.02[c]	0.55±0.01[c]	3.5±0.20[a]	2.3±0.00[c]	0.7±0.00[b]
		90	5.5±0.02[d]	0.65±0.00[d]	3.7±0.30[a]	2.7±0.00[a]	0.8±0.10[a]
	15	0	5.7±0.02[a]	0.47±0.00[a]	3.8±0.00[a]	2.6±0.20[bcd]	ND
		30	5.6±0.01[b]	0.49±0.00[b]	3.5±0.30[ab]	2.6±0.30[cd]	0.6±0.60[c]
		60	5.5±0.04[c]	0.58±0.00[c]	3.4±0.20[b]	2.5±0.20[d]	0.7±0.10[b]
		90	5.5±0.01[d]	0.69±0.01[d]	3.7±0.20[ab]	2.8±0.00[a]	0.8±0.50[a]
	CD (*n*=3)		0.0185	0.015	3.1603	2.317	0.3145
Chutney Powder	0	0	5.4±0.17[d]	0.27±0.01[a]	0.9±0.10[a]	1.3±0.50[bcd]	ND
		30	5.6±0.25[cd]	0.33±0.01[b]	0.8±0.20[ab]	1.2±0.40[cd]	0.4±0.20[bc]
		60	5.9±0.18[bc]	0.41±0.00[c]	0.7±0.20[ab]	1.2±0.40[d]	0.2±0.20[c]
		90	6.5±0.22[a]	0.57±0.01[d]	0.7±0.20[b]	1.4±0.30[a]	0.6±0.00[a]
	100	0	5.6±0.13[d]	0.30±0.01[a]	1.0±0.20[a]	1.3±0.50[bcd]	ND
		30	5.7±0.28[cd]	0.35±0.00[b]	0.9±0.30[abc]	1.3±0.30[cd]	0.2±0.20[bc]
		60	6.0±0.21[bcd]	0.43±0.02[c]	0.9±0.30[bc]	1.3±0.40[d]	0.0±0.00[c]
		90	6.9±0.19[a]	0.61±0.01[d]	0.9±0.10[c]	1.4±0.30[a]	0.5±0.20[a]
	CD (*n*=3)		0.3609	0.0226	2.4367	4.4972	0.9348
Noodles	0	0	6.82±0.01[a]	0.35±0.01[a]	3.8±0.40[a]	2.7±0.20[abc]	ND
		30	7.0±0.00[b]	0.49±0.00[b]	3.7±0.20[a]	2.6±0.20[bc]	0.8±0.50[a]
		60	7.0±0.00[c]	0.64±0.00[c]	3.6±0.20[a]	2.5±0.00[c]	0.8±0.20[a]
		90	7.1±0.00[d]	0.85±0.00[d]	3.8±0.30[a]	2.8±0.00[a]	0.9±0.10[a]
	30	0	7.0±0.01[a]	0.37±0.00[a]	3.8±0.00[a]	2.7±0.20[bcd]	ND
		30	7.1±0.01[b]	0.49±0.01[b]	3.6±0.30[ab]	2.7±0.30[cd]	0.8±0.50[ab]
		60	7.1±0.00[c]	0.82±0.00[c]	3.6±0.20[b]	2.6±0.20[d]	0.8±0.40[b]
		90	7.3±0.01[d]	0.97±0.00[d]	3.8±0.20[ab]	2.9±0.00[a]	1.0±0.40[a]
	CD (*n*=3)		0.0161	0.0141	3.1603	2.317	3.0343
Extruded Snacks	0	0	6.0±0.17[a]	0.40±0.01[a]	3.8±0.40[a]	2.8±0.20[abc]	ND
		30	6.1±0.15[b]	0.42±0.00[b]	3.7±0.40[a]	2.6±0.30[bc]	0.4±0.20[bc]
		60	6.1±0.14[c]	0.46±0.00[c]	3.7±0.10[a]	2.6±0.20[c]	0.2±0.20[c]
		90	6.2±0.11[d]	0.63±0.00[d]	3.8±0.00[a]	2.8±0.00[a]	0.6±0.20[a]
	40	0	5.8±0.10[a]	0.45±0.01[a]	3.8±0.20[a]	2.8±0.20[abc]	ND
		30	5.9±0.17[b]	0.47±0.00[b]	3.8±0.00[a]	2.8±0.30[bc]	0.5±0.20[bc]
		60	6.0±0.15[c]	0.50±0.01[c]	3.8±0.20[a]	2.7±0.20[c]	0.4±0.20[c]
		90	6.1±0.17[d]	0.67±0.01[d]	3.9±0.00[a]	2.9±0.10[a]	0.7±0.20[a]
	CD (*n*=3)		0.0208	0.0162	2.3177	2.5965	0.8655

ND Not detected, *FFA* Free fatty acids, *TVBC* Total viable bacterial count, *Y&M* Yeast and mould defatted soy flour in the preparation of soy-cereal *papads* (Baby Latha and Bhat 2004). The oil absorbed by DGCF fryums (14.7%) and extruded snacks (15%) on frying was significantly lower as compared to control (18.4%) and extruded snacks (17%). Similar decrease in oil absorption of black gram *wadians* on substitution with defatted soy flour was reported (Chetana and Reddy 2004). The uptake of oil by the fried product varied with the water content and biochemical make up of the product (Math et al. 2004). The lower oil uptake of DGCF fryums and extruded snacks may be attributed to lesser moisture content as compared to their respective controls. Earlier studies also reported that the *papads* with higher moisture content were found to absorb more oil on frying. DGCF fryums showed significantly lesser expansion upon frying (14.4%) than the control fryums (18%), which may be due to less oil uptake during the preparation as against control.

Biscuits The thickness of biscuits (0.91 cm) decreased ($p<0.05$) with incorporation of DGCF (0.79 cm).

Chutney powder DGCF *chutney* powder had lower ($p<0.05$) bulk density (0.680 g/ml) than the control (0.726 g/ml). This may be because the fat content of DGCF *chutney* powder was slightly less than the control *chutney* powder (Table 3).

Consumer acceptability of selected DGCF products Housewives and children liked all DGCF incorporated products. Overall acceptability scores of housewives showed that the fryums were highly acceptable followed by *chutney* powder, extruded snacks, noodles, biscuits and *laddoo*. All the DGCF products were liked extremely by 74 to 98% and 1 to 26% housewives said to like it moderately. In case of children the taste of DGCF biscuits was highly acceptable followed by *laddoo*, extruded snacks, fryums, noodles and *chutney* powder. The colour and taste of all the DGCF products were liked extremely by 61 to 92% and 52 to 90% children respectively, whereas 8 to 38% and 10 to 44% children liked it moderately.

Storage studies There was a gradual increase ($p<0.05$) in the moisture content of all the products except fryums during the storage period (Table 4). Both control and DGCF fryums recorded a gradual decrease ($p\leq0.05$) in moisture content during storage period. Similar behaviour of jackfruit *papads* during 180 days of storage was reported (Jagadeesh et al. 2007). The increase in moisture content of other products could be attributed to vapor transmission characteristics of the packaging material (Jagadeesh et al. 2007). In case of *laddoo* both control and DGCF showed non significant increase in moisture content during storage of 1 month. There was an increase ($p<0.05$) in FFA of all the products during storage (Table 4). The increase in FFA could be due to increased moisture content, which promoted fat oxidation during storage (Singh et al. 2000). Similar increases in FFA content in stored food products were reported for high protein pulse based noodles (Vani and Manimegalai 2004), soy fortified biscuits (Singh et al. 2000) as well as groundnut and sesame based *chutney* powder (Rao et al. 2004).

Microbiological quality In biscuits, fryums noodles and extruded snacks, the total viable bacterial count slightly decreased up to 60 days of storage and slightly increased up to 90 days. The increase after 60 days was significant ($p<0.05$) in biscuits and not significant in fryums, noodles and extruded snacks (Table 4). *Chutney* powder was an exception as in *chutney* powder there was a decrease in total bacterial count at each monthly interval from 0 to 90 days, however the decrease was not significant ($p<0.05$) during storage (Table 4). It could be attributed to the anti microbial quality of the added spices such as garlic, cumin, turmeric in the *chutney* powder (Raghavan 2007). There are no microbiological standards available for these types of products however, BIS has specified the standard plate count of 50,000 cfu/g for high protein mixes (ISI 1974), high protein biscuits (ISI 1986) and ready-to-eat protein rich extruded snacks (ISI 1980). Total bacterial count of all the products in the present study was less than this specified limit.

Initially in all the food products no coliforms were found but there was an increase in total coliform count in all the food products at the end of storage period (Table 4). Coliforms could not have survived the heat processing received during manufacture of these products and hygienic practices followed in the preparation. The only possible source would be secondary sources of contamination during post preparation handling or packaging.

A significant increase in total yeast and mold count was observed for fryums (DGCF), noodles (DGCF), *chutney* powder (control and DGCF) and biscuits (control and DGCF) during the storage period. In *laddoo* after 30 days of storage there was visible mold growth on the surface of *laddoo* which was not acceptable.

Sensory quality Significant ($p<0.05$) reduction in sensory scores were found for texture and taste (biscuit), taste (fryums), texture (noodles and extruded snacks). However, no significant decrease in the scores was observed for appearance, flavour and overall acceptability in all the products (Table 5).

Conclusion

Considering the nutritional importance of defatted groundnut cake (DGC) and its suitability of incorporation into traditional

Table 5 Changes in sensory quality of defatted groundnut cake flour (DGCF) products during storage at 28±2°C

Products	DGCF level, %	Storage period, days	Appearance	Texture	Taste	Flavour	Overall acceptability
Biscuits	0	0	4.8±0.43[a]	4.8±0.43[a]	4.6±0.52[a]	4.8±0.43[a]	4.8±0.43[a]
		30	4.8±0.43[a]	4.7±0.49[a]	4.5±0.53[a]	4.7±0.49[a]	4.7±0.49[a]
		60	4.7±0.49[a]	4.6±0.52[a]	4.3±0.49[a]	4.7±0.48[a]	4.5±0.53[ab]
		90	4.6±0.52[a]	4.5±0.53[a]	4.2±0.43[a]	4.5±0.53[a]	4.2±0.43[b]
	30	0	4.3±0.49[a]	4.6±0.52[a]	4.6±0.52[a]	4.5±0.53[a]	4.5±0.53[a]
		30	4.3±0.48[a]	4.4±0.52[ab]	4.5±0.53[a]	4.4±0.52[a]	4.4±0.52[a]
		60	4.2±0.42[a]	4.2±0.42[ab]	4.2±0.42[ab]	4.3±0.49[a]	4.3±0.49[a]
		90	4.0±0[a]	4.1±0.32[b]	4.0±0[b]	4.1±0.32[a]	4.1±0.32[a]
	CD		0.3796	0.4203	0.4014	0.4158	0.4177
Laddoo	0	0	4.6±0.43[a]	4.8±0.43[a]	4.7±0.49[a]	4.8±0.43[a]	4.8±0.43[a]
		10	4.6±0.52[a]	4.7±0.49[a]	4.7±0.48[a]	4.8±0.42[a]	4.7±0.49[a]
		20	4.6±0.52[a]	4.6±0.52[a]	4.6±0.52[a]	4.8±0.42[a]	4.3±0.48[bc]
		30	4.6±0.52[a]	4.6±0.52[a]	4.5±0.53[a]	4.6±0.52[a]	4.2±0.00[c]
	50	0	4.2±0.52[a]	4.5±0.53[a]	4.7±0.49[a]	4.5±0.53[a]	4.5±0.53[a]
		10	4.2±0.42[a]	4.5±0.53[a]	4.7±0.48[a]	4.4±0.52[ab]	4.5±0.53[a]
		20	4.1±0.32[a]	4.4±0.52[a]	4.4±0.52[a]	4.2±0.42[ab]	4.2±0.42[ab]
		30	4.0±0[a]	4.2±0.42[a]	4.3±0.48[a]	4.1±0.32[b]	4.0±0.42[b]
	CD		0.3824	0.4321	0.4358	0.3947	0.3944
Fryums	0	0	4.9±0.32[a]	4.8±0.43[a]	4.9±0.32[a]	4.9±0.32[a]	4.9±0.32[a]
		30	4.9±0.32[a]	4.7±0.48[a]	4.9±0.32[a]	4.9±0.32[a]	4.8±0.43[a]
		60	4.8±0.43[a]	4.6±0.52[a]	4.9±0.32[a]	4.7±0.49[a]	4.7±0.49[a]
		90	4.7±0.49[a]	4.6±0.52[a]	4.7±0.48[a]	4.6±0.52[a]	4.6±0.52[a]
	15	0	4.7±0.49[a]	4.7±0.49[a]	4.8±0.43[a]	4.6±0.52[a]	4.7±0.49[a]
		30	4.7±0.48[a]	4.6±0.52[a]	4.7±0.49[ab]	4.5±0.53[a]	4.7±0.49[a]
		60	4.7±0.48[a]	4.5±0.53[a]	4.6±0.52[ab]	4.4±0.52[a]	4.6±0.52[a]
		90	4.6±0.52[a]	4.3±0.48[a]	4.4±0.52[b]	4.2±0.42[a]	4.5±0.53[a]
	CD		0.3893	0.4334	0.3767	0.4027	0.423
Chutney powder	0	0	4.9±0.32[a]	4.8±0.43[a]	4.9±0.32[a]	4.8±0.43[a]	4.9±0.32[a]
		30	4.8±0.43[a]	4.8±0.43[a]	4.8±0.43[ab]	4.8±0.42[a]	4.9±0.32[a]
		60	4.8±0.43[a]	4.7±0.49[a]	4.7±0.49[ab]	4.7±0.49[a]	4.8±0.43[a]
		90	4.7±0.49[a]	4.6±0.52[a]	4.5±0.53[b]	4.6±0.52[a]	4.6±0.52[a]
	100	0	4.9±0.32[a]	4.8±0.43[a]	4.9±0.32[a]	4.9±0.32[a]	4.9±0.32[a]
		30	4.8±0.43[a]	4.7±0.49[a]	4.8±0.43[a]	4.9±0.32[a]	4.8±0.43[a]
		60	4.8±0.43[a]	4.6±0.52[a]	4.7±0.49[a]	4.7±0.48[a]	4.8±0.43[a]
		90	4.7±0.49[a]	4.5±0.53[a]	4.7±0.48[a]	4.6±0.52[a]	4.6±0.52[a]
	CD		0.3638	0.4171	0.3837	0.3865	0.3697
Noodles	0	0	4.8±0.43[a]	4.4±0.52[a]	4.7±0.49[a]	4.7±0.49[a]	4.6±0.52[a]
		30	4.7±0.48[a]	4.3±0.49[a]	4.7±0.48[a]	4.6±0.52[a]	4.6±0.52[a]
		60	4.7±0.48[a]	4.2±0.43[a]	4.5±0.53[a]	4.5±0.53[a]	4.3±0.48[a]
		90	4.5±0.53[a]	4.1±0.32[a]	4.4±0.52[a]	4.5±0.53[a]	4.2±0.42[a]
	30	0	4.4±0.52[a]	4.2±0.00[a]	4.6±0.52[a]	4.5±0.53[a]	4.4±0.52[a]
		30	4.3±0.49[a]	4.0±0.00[ab]	4.6±0.52[a]	4.5±0.53[a]	4.4±0.52[a]
		60	4.2±0.43[a]	3.9±0.32[ab]	4.5±0.53[a]	4.3±0.49[a]	4.3±0.48[a]
		90	4.2±0.42[a]	3.8±0.42[b]	4.4±0.52[a]	4.2±0.43[a]	4.1±0.32[a]
	CD		0.4132	0.3512	0.4479	0.4407	0.4256
Extruded Snacks	0	0	4.8±0.43[a]	4.8±0.43[a]	4.9±0.32[a]	4.8±0.43[a]	4.8±0.43[a]
		30	4.8±0.43[a]	4.7±0.49[a]	4.9±0.32[a]	4.8±0.43[a]	4.8±0.43[a]
		60	4.8±0.43[a]	4.6±0.52[a]	4.8±0.43[a]	4.7±0.49[a]	4.6±0.52[a]
		90	4.7±0.49[a]	4.6±0.52[a]	4.6±0.52[a]	4.5±0.53[a]	4.5±0.53[a]
	40	0	4.6±0.52[a]	4.7±0.49[a]	4.8±0.43[a]	4.6±0.52[a]	4.7±0.49[a]
		30	4.6±0.52[a]	4.5±0.53[ab]	4.8±0.43[a]	4.5±0.53[a]	4.5±0.53[ab]
		60	4.6±0.52[a]	4.3±0.48[ab]	4.7±0.49[a]	4.4±0.52[a]	4.4±0.52[ab]
		90	4.5±0.53[a]	4.2±0.42[b]	4.6±0.52[a]	4.2±0.43[a]	4.2±0.43[b]
	CD		0.4209	0.432	0.3796	0.4119	0.4558

n=10 panelists

and convenience products, value addition and popularization of DGC goes a long way in tackling protein energy malnutrition in the country. The study thus signifies the need for adoption of safe processing methods and policies for availability of safe and hygienically prepared DGCF for household and commercial consumption.

References

AACC (1983) Approved laboratory methods. American Association of Cereal Chemists, St. Paul

Agu Ho, Jideani IA, Humphrey JU (2009) Quality of Dambu prepared with different cereals and groundnut. J Food Sci Technol 46 (2):166–168

Ali N (1995) Post-harvest technologies for production of oilseed derivatives and value added products. Oilseed quality and value added products. Directorate of Oilseeds Research (ICAR), Progressive Press Pvt Ltd, New Delhi, pp 35–36

Anon (2009) Agricultural output, groundnuts: major states. In: Economic intelligence service agriculture. Centre for Monitoring Indian Economy Pvt. Ltd. Andheri, Mumbai, p 154

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

Baby Latha R, Bhat KK (2004) Preparation of soy cereal *papad*. J Rural Technol 1:188–193

BIS (1976) IS: 1485, Specification for macroni, spaghetti and vermicelli. Bureau of Indian Standards, New Delhi

Chetana R, Reddy SY (2004) Development of *wadian*—a traditional savory with defatted soya. J Rural Technol 1:172–181

Cruickshank R, Duguid JP, Marmion BP, Swain RHA (1975) Medical microbiology. In: Cruickshank R (ed) The practice of medicinal microbiology, vol 2, 12th edn. Churchill Livingstone, Edinburgh, p 306

Desai BB, Kotecha PM, Salunkhe DK (1999a) Composition and nutritional quality. In: Introduction science and technology of groundnut: biology, production, processing and utilization. Naya Prokash Publ, New Delhi, India, pp 185–199

Desai BB, Kotecha PM, Salunkhe DK (1999b) Groundnut protein product. In: Introduction science and technology of groundnut: biology, production, processing and utilization. Naya Prokash Publ, New Delhi, India, pp 546–582

Gandhi AP, Kotwaliwale N, Kawalkar J, Srivastav DC, Parihar VS, Raghu N (2001) Effect of incorporation of defatted soyflour on the quality of sweet biscuits. J Food Sci Technol 38:502–503

Gopalan C, Rama Sastri BV, Balasubramanian SC (2004) Food composition tables. In: Narsinga Rao BS, Deosthale YG, Pant KC (eds) Nutritive value of Indian foods. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, pp 45–95

Gopala Krishna AG (2007) Edible oilseed, oil and meal need for quality control. Beverage Food World 34(1):42–44

Hundal M, Bakshi AK, Sexena AK (2006) Effect of various kinds of flour (soy, rice and wheat) substitutions on the quality characteristics of spaghetti made from wheat semolina. Beverage Food World 33(8):74–76

Ige MM, Ogunsua AO, Oke OL (1984) Functional properties of the proteins of some Nigerian oilseed, conophor seeds and three varieties of melon seeds. J Agric Food Chem 32:822–825

ISI (1974) IS: 3137, Specification for high-protein mixes for use as food supplements. Bureau of Indian Standards, New Delhi

ISI (1980) IS: 9487, Specification for 'ready-to-eat' protein -rich extruded snacks. Bureau of Indian Standards, New Delhi

ISI (1986) IS: 7487, Specification for protein-enriched biscuits. Bureau of Indian Standards, New Delhi

ISI (1989) IS: 12711, Bulletin of Indian standard bakery products, Method of analysis. Bureau of Indian Standards, New Delhi

Jagadeesh SL, Hegde L, Kotimani S, Gorbal K, Reddy BS, Swamy GSK, Basavaraj N, Raghavan GSV (2007) Influence of packaging on storage behaviour of jackfruit *papads*. Beverage Food World 34(3):15–19

Janicki NA, Walczak J (1954) Wateriness in meat and methods for its determination. Przem Rol Spoz 8:197–201

Lakshmi Devi N, Khader V (1997) Preparation of vermicelli from wheat flour-pulse blends for geriatrics. J Food Sci Technol 34:513–515

Lawhon JT, Carter CM, Mattil KF (1972) A comparative study of the whipping potential of an extract from several oilseed flours. Cereal Sci Today 17:240–246

Math RG, Velu V, Nagender A, Rao DG (2004) Effect of frying conditions on moisture, fat and density of *papad*. J Food Eng 64:429–434

Parpia HAB (1988). Oilseed proteins for human consumption. In: Ranga Rao V, Prasad MVR (eds), Proc National seminar on strategies for making India self-reliant in vegetable oil, 5–9 Sep. India Society of Oilseeds Research, Directorate of Oilseeds Research, Indian Council of Agricultural Research, pp 550–558

Peryam DR, Pilgrim JF (1957) Hedonic scale method of measuring food preferences. Food Technol 11(9):9–14

Price ML, Scoyoc SV, Butler LG (1978) A critical evaluation of the Vanillin reaction as an assay for tannin in sorghum grain. J Agric Food Chem 26:1214–1218

Puyed SS, Prakash J (2006) Functional properties of thermally treated defatted soy and peanut flours. J Food Sci Technol 43:286–292

Raghavan S (2007) Functions of spices. In: Handbook of spices, seasonings and flavorings, 2nd edn. CRC Press, Boca Raton, London, New York, pp 35–46

Rao PGP, Rao NG, Satyanarayana A, Rao DG (2004) Studies on chutney powders based on tamarind (*Tamarindus indica* L.) leaves. Foodserv Res Int 15:13–24

Sahu A, Vajpeyi M, Mohan M (2009) Detoxification of linseed (*Linum usitatissimum* L.) meal for enrichment of wheat flour *chapati*. J Food Sci Technol 46:470–472

Singh R, Singh G, Chauhan GS (2000) Development of soy-fortified biscuits and shelf-life studies. J Food Sci Technol 37:300–303

Snedecor GW, Cochran WG (1989) Statistical methods. Iowa State University Press, Ames

Sosulki FW, Humbert ES, Bui K, Jones JD (1976) Functional properties of rapeseed flour, concentrates and isolates. J Food Sci 41:1349–1353

Tate PV, Chavan JK, Patil PB, Kadam SS (1990) Processing of commercial peanut cake into food-grade meal and its utilization in preparation of cookies. Plant Foods Human Nutr 40:115–120

Trucksess MW, Stack ME, Nesheim S, Albert RH, Romer TR (1994) J Assoc Off Anal Chem Int 77:1512–1521

Vani V, Manimegalai G (2004) Processing of high protein pulse based noodles. Indian Food Pack 58(2):63–67

Venkataraghavan U (1998) Newer dimensions in the processing of oilseeds for food uses. Indian Food Ind 17:272–275