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ORIGINAL ARTICLE

Effect of storage on quality of fortified Bengal gram *sattu*

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Abstract Fortified Bengal gram *sattu* was prepared following standardized *sattu* making procedure and fortified as per FDA using wheat flour with thiamin, riboflavin, niacin, Ca and Fe and stored at 25°C, 65% RH and 35°C, 65% RH and at ambient condition (16–39°C, 18–98% RH) in low density polyethylene and laminated aluminum foil pouches. Alcoholic acidity increased by 0.04% in different *sattu* samples during 180 days storage but was within the acceptable limit as per BIS standard. Free fatty acids content (as oleic acid) also increased from 0.06% (in fresh) to 0.14%; however it did not affect sensory acceptability of *sattu* stored under different conditions. Protein digestibility, Ca and Fe contents in fortified samples were 80.6%, 170.1 and 12.5 mg/100 g, as against 80.6%, 69.5 and 10.2 mg/100 g, in control sample respectively. Storage temperatures and packaging materials did not affect the overall quality of fortified *sattu* except moisture content and total microbial load during 6 months storage. Fortified Bengal gram *sattu*, both fresh and stored, were within the acceptable sensory quality when used in the drink form.

Keywords Bengal gram *sattu* · Fortification · Product quality

Introduction

The important traditional products, which are still popular among Indian population are *sattu*, *papad, wadian*, puffed rice and flaked rice. *Sattu* is roasted flour made either from cereals or legumes alone or combination of both with added flavourings (Mridula et al. 2004). Roasting pre-cooks the ingredients used in food grains and oilseed based mixes and increases shelf-life and acceptability of the products (Gopaldas et al. 1975). Roasting improves the flavour, texture and nutritive value of grains (Siegel and Fawcett 1976) and eliminates most of the anti-nutritional or toxic factors in legumes either partially or wholly (Liener 1973).

Owing to its high protein, long shelf-life, excellent taste, *sattu* is a popular food supplement especially in rural India. As it is being consumed by the people of all age groups in Bihar and Uttar Pradesh where the problems of under nutrition is one of the major cause of poor health, specially amongst children and mothers, fortification of *sattu* with micronutrients can serve an important source for enhancing the intake of micronutrients amongst the population at lower cost. Therefore, the present study was undertaken to find the effect of storage on physico-chemical quality and sensory acceptability of fortified Bengal gram *sattu*.

Materials and methods

Preparation of fortified bengal gram sattu: Cleaned and graded Bengal gram (*Cicer arietinum*) (variety 'PBG-5') purchased from Punjab Agricultural University, Ludhiana was used for the study. The geometric mean diameter of raw Bengal gram (BG) used for the study was 6.2 ± 0.04 mm. Raw BG grains were conditioned with water and allowed for tempering at room temperature for 4 h. Roasting of tempered BG was performed as per the process standardized by Mridula et al. (2004). De-hulling of roasted BG was done using mini *dhal* mill (capacity 100 kg/h) at 7.5 mm dehuller clearance. The dehulled BG was subjected to CIAE (Central Institute of Agricultural Engineering, Bhopal, India) developed cleaner-cum-grader to remove sand particles, if any, before grinding for making flour. Grinding of dehulled BG was done in the cleaned and sterilized sample mill followed by sieving (65 mesh size). The ground sample was analyzed for acid insoluble ash in the BG flour, which

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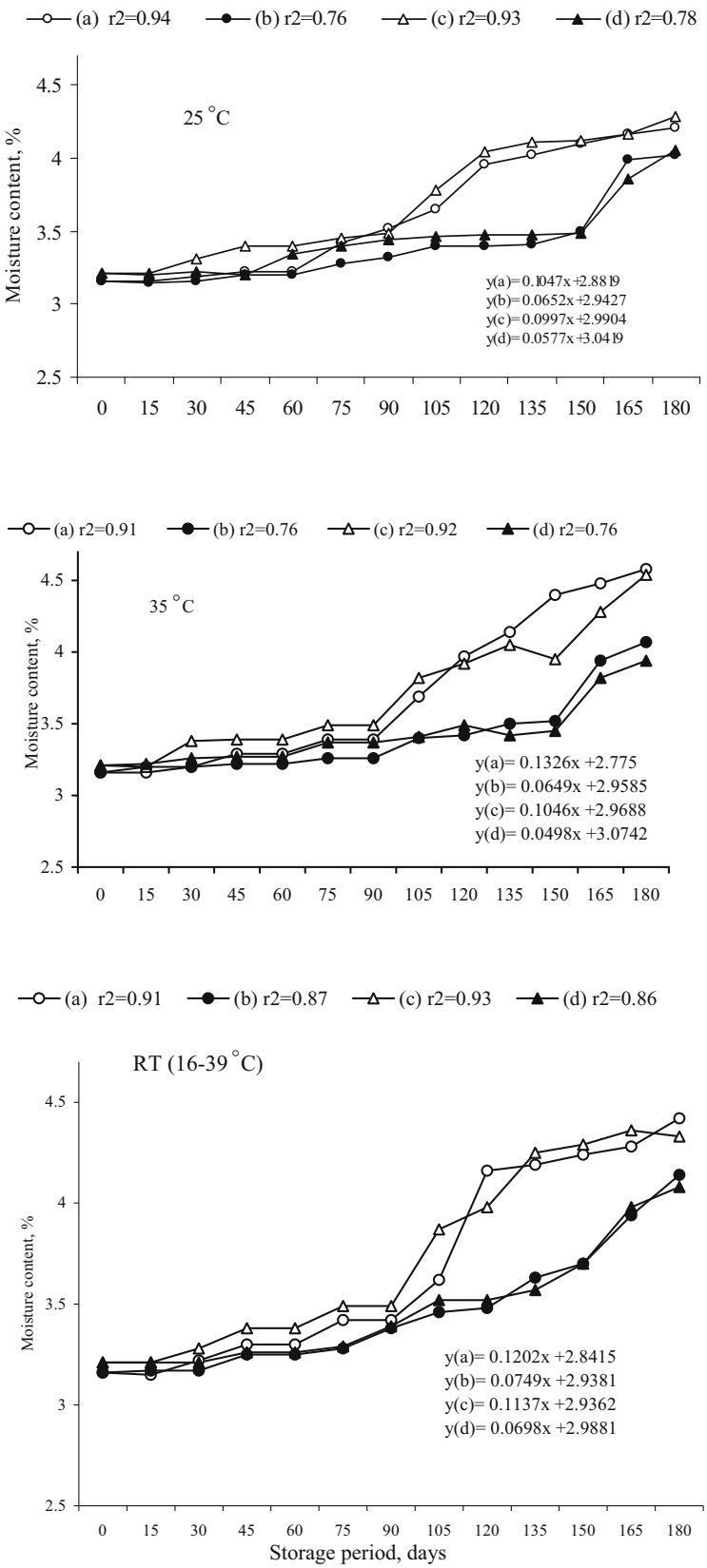

Fig. 1 Effect of storage conditions on moisture content of Bengal gram *sattu* samples (a) Control (LDPE), (b) Control (LAF), (c) Fortified (LDPE), (d) Fortified (LAF)

was 0.055%. Premix containing vitamin and minerals were mixed with the BG flour using Flour Mixer, developed at CIPHET. Fortification of BG *sattu* was done as per FDA guidelines for wheat flour (Ensminger et al. 1995) with 0.64 mg of thiamin (thiamin chloride), 0.40 mg of riboflavin, 5.3 mg of niacin (nicotinic acid), 212 mg of Ca (as calcium carbonate) and 2.87 mg of Fe (as ferrous sulphate) per 100 g of flour.

The prepared fortified and control BG *sattu* samples were packed in low density polyethylene (LDPE) pouches (thickness 0.065 mm) and laminated aluminium foil (LAF) (thickness 0.025 mm) pouches of 200 g capacity. In order to reduce the microbial load, if any in the pouches before filling the samples, the pouches were wrapped in brown paper and kept in hot air oven at 60°C for 4 h and under UV light for 30 min. Samples (150 g) were filled in the pouches and stored in temperature-cum-humidity control cabinet at 25°C, 65% RH and 35°C, 90% RH and at ambient condition (16–39°C, 18–98% RH) for 6 months.

Physico-chemical analysis: Moisture, crude fat, protein (6.5 × N), ash and dietary fibre contents were determined as per AOAC (1984). Total carbohydrate was determined by difference. Total calories were calculated by multiplying protein, carbohydrates and fat contents by 4, 4 and 9, respectively. Protein digestibility of samples was determined by Akeson and Stachman (1964) method. Water absorption in the samples was determined according to Anderson et al. (1969) method. Alcoholic acidity and free fatty acids (FFA) in samples were determined as per Thapar et al. (1988) method. Microbial load i.e. viable bacterial count and yeast and mould (fungi) were determined by standard pour plating method (Cruickshank et al. 1975).

Hunter colour determination: L, a, b values of samples were determined by using Handy Colorimeter (NR-3000; Nippon Denshoku Ind Co. Ltd., Japan). Chroma (C*) is the attribute of colour used to indicate the degree of departure of the colour from gray of the same lightness. Chroma was computed by using the following formula (Hernandez et al. 2008).

$$C^* = \sqrt{a^2 + b^2}$$

Sensory evaluation: *Sattu* drink was prepared with 16 g of fortified / control BG *sattu* samples, 100 ml potable water, 0.7 g salt, 0.04 g cumin seed powder, 0.01 g white pepper powder for flavouring purposes. These ingredients were mixed together by stirring with a spoon. Fifty ml of freshly prepared drink was given to the panel of scientists for sensory evaluation. Sensory appearance and colour, texture or body, roasted odour, flavour and taste and overall acceptability using 9-point Hedonic scale (BIS 1971).

Statistical analysis: All assays were carried out in triplicate. Mean, standard deviation, paired t test and linear regression were computed using Microsoft Excel 2003.

Results and discussion

The increase in the moisture content up to 90 days was at slower rate and thereafter it was faster (Fig. 1). The difference due to LDPE and LAF packaging material seems to be marginal. Total moisture content in different *sattu* samples after 180 days was within the maximum permissible limit of 7% as suggested by BIS (1998) for *Chhana* (BG) *sattu*. Hunter colour values (L, a, b and chroma) and water absorption capacity showed no significant difference due to

Table 1 Effect of fortification on quality of Bengal gram *sattu* samples

	Control	Fortified	't' value ($p \leq 0.05$)
Moisture, %	3.2 ± 0.06	3.2 ± 0.08	0.04^{NS}
Protein, %	27.7 ± 0.11	27.7 ± 0.64	0.01^{NS}
Protein digest., %	80.6 ± 0.54	80.6 ± 0.33	0.07^{NS}
Fat, %	5.2 ± 0.12	5.2 ± 0.19	0.08^{NS}
Ash, %	3.1 ± 0.03	3.2 ± 0.07	2.34^{NS}
Total dietary fibre, %	1.1 ± 0.05	1.1 ± 0.09	0.14^{NS}
Total carbohydrate, %	59.7 ± 0.03	59.6 ± 0.13	1.95^{NS}
Total calories, kcal/100 g	396 ± 2.64	396 ± 1.24	0.01^{NS}
Ca, mg/100 g	69.5 ± 0.27	170.1 ± 0.13	892.77*
Fe, mg/100 g	10.2 ± 0.06	12.6 ± 0.1	24.26*
WAC, %	289.9 ± 1.88	292.2 ± 1.33	1.17^{NS}
Hunter colour values (n = 4)			
L	75.6 ± 2.16	76.0 ± 1.71	0.77^{NS}
a	2.9 ± 0.12	2.9 ± 0.11	0.81^{NS}
b	20.5 ± 0.57	21.0 ± 0.65	0.40^{NS}
Chroma	20.7 ± 0.55	21.2 ± 0.65	0.39^{NS}

n = 3, NS = Non-significant, * = Significant, WAC: Water absorption capacity

Table 2 Effect of storage on alcoholic acidity and free fatty acids (FFA) content of Bengal gram *sattu* samples

Storage period, days	Control (unfortified)						Fortified					
	LDPE			LAF			LDPE			LAF		
	25°C	35°C	RT	25°C	35°C	RT	25°C	35°C	RT	25°C	35°C	RT
Alcoholic acidity, %												
0	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
30	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
60	0.12	0.12	0.12	0.13	0.12	0.14	0.12	0.15	0.14	0.12	0.12	0.15
90	0.12	0.12	0.14	0.12	0.12	0.12	0.15	0.13	0.15	0.13	0.13	0.12
120	0.12	0.12	0.16	0.12	0.13	0.16	0.15	0.13	0.15	0.13	0.13	0.15
150	0.12	0.14	0.13	0.12	0.14	0.12	0.13	0.14	0.14	0.12	0.14	0.14
180	0.15	0.13	0.16	0.12	0.14	0.14	0.13	0.13	0.14	0.12	0.15	0.15
r^2	0.23	0.47	0.59	0.04	0.79	0.15	0.21	0.13	0.46	0.03	0.87	0.44
FFA (% oleic acid) content												
0	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
30	0.06	0.08	0.06	0.06	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06
60	0.08	0.08	0.08	0.06	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06
90	0.08	0.08	0.08	0.06	0.08	0.08	0.06	0.06	0.06	0.06	0.06	0.06
120	0.10	0.11	0.11	0.11	0.11	0.11	0.09	0.11	0.11	0.10	0.11	0.11
150	0.11	0.10	0.11	0.10	0.10	0.08	0.10	0.11	0.13	0.10	0.10	0.13
180	0.10	0.10	0.13	0.10	0.10	0.08	0.10	0.11	0.14	0.10	0.10	0.13
r^2	0.87	0.74	0.93	0.68	0.73	0.41	0.80	0.75	0.82	0.75	0.68	0.80

RT = Room temperature (16–39°C), r^2 regression (linear), LDPE = low density polyethylene, LAF = laminated aluminium foil

Table 3 Effect of storage on microbial load (log cfu/g) in Bengal gram *sattu* samples

Storage period, days	Control (unfortified)						Fortified samples					
	LDPE			LAF			LDPE			LAF		
	25°C	35°C	RT	25°C	35°C	RT	25°C	35°C	RT	25°C	35°C	RT
Standard plate count												
0	3.3	3.3	3.3	3.3	3.3	3.3	4	4	4	4	4	4
90	3.8	4.2	4.1	4.1	4.1	4.3	4.0	4.4	3.7	4.2	4.4	4
180	3.9	4.2	4.3	4.1	4.1	4.5	4.1	4.3	4.3	4.0	4.2	4.5
Yeasts and moulds												
0	3.8	3.8	3.8	3.8	3.8	3.8	3.9	3.9	3.9	3.9	3.9	3.9
90	3.8	4.1	4	3.8	3.8	3.6	3.8	4	3.5	4	3.8	4.1
180	3.9	4	3.8	3.7	3.7	3.9	3.9	3.9	3.8	3.7	3.9	3.9

RT, LDPE, LAF: See Table 2

fortification of products (Table 1). Proximate composition, calorie and protein digestibility of control and fortified BG were similar except for ash content due to addition of Ca and Fe to the fortified *sattu* samples (Table 1).

Alcoholic acidity of freshly prepared control and fortified *sattu* samples was 0.12%, which slightly increased during storage (Table 2) but was within the standard (0.15%) set by BIS (1998) for BG *sattu*. The increase in FFA content may be mainly from degradation products of hydroperoxide (Thakur and Arya 1990), which is directly related with RH and moisture content of the products (Sowbhagya and Bhattacharya 1976) (Table 2). Total bacterial counts and yeast and mould counts (log cfu/g) increased from 3.3 to 4.5 and 3.8 to 4.1, respectively during 6 months storage (Table 3) but were within the acceptable limits of total bacterial counts of 4.7 log cfu/ g (Deshpande et al. 2004).

Both fortified and control *sattu* samples were liked by taste panel and difference between them were marginal

Table 4 Sensory characteristics of Bengal gram *sattu* samples

	Appearance and colour	Texture/ Body	Roasted odour	Flavour and taste	Overall acceptability
Fresh samples					
Control	7.7	7.2	7.4	7.5	7.6
Fortified	7.4	7.2	7.3	7.3	7.4
After 6 months storage*					
Control	7.4	7.2	7.1	7.2	7.3
Fortified	7.4	7.2	7.2	7.1	7.2

*in LDPE pouch at room temperature

(Table 4). Sensory scores for both the stored *sattu* samples for roasted odour, flavour and taste and overall acceptability were slightly lower than those for fresh samples but were within like very much to like moderately. This may be due to suitability of packaging material and lower moisture content of product even after 6 months of storage which did not deteriorate the physico-chemical and sensory quality of products.

Conclusion

Changes in quality of control and fortified *sattu* samples during storage were marginal and were within the acceptable limit as per BIS standard. Fortification with vitamins and minerals should be followed in the commercial *sattu* processing units to make the product more nutritive.

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