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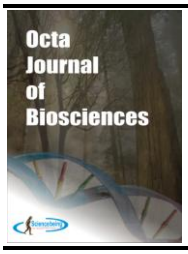

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Research Article

Studies on ready- to- eat Soybean Fortified Snack Food-Sorghum Sattu

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Abstract: '*Sattu'* is a roasted flour mixture of cereal and pulse combination and used as 'ready -to-eat' snack food in most parts of India. Owing to its high nutritional balance, long shelf life and excellent taste, *sattu* is also a popular supplement food especially in rural India. Efforts were made in present study to fortify soybean and sorghum with Bengal gram (Chickpea) in various proportions to prepare nutritious and ready- to- eat snack. The selected grains were moisture conditioned to 30% level, roasted and powdered and then blended in different proportions so that an acceptable final product with maximum nutritional benefit and adequate shelf life was developed. Soybeans were blended in the range of 10 to 40% while sorghum was incorporated from 10 to 35% and the proportion of Bengal gram varied in the range of 40 to 70%. The products developed were analyzed for their proximate composition, shelf life and sensory evaluation. Results indicated that protein content of the developed products increased from 20 to 70% when compared to the conventional sorghum:Bengal gram *sattu*, while fat content increased by 21 to 121% depending upon the level of soybean fortification. Results of sensory evaluation showed that soy-sorghum-*sattu* fortified up to a level of 30% soybean well accepted. The Shelf life studies indicated that *soy-sattu* could safely be stored in metallic containers up to 60 days during summer and rainy seasons. The economic analysis revealed that production of soy-sorghum fortified *sattu* could be a profitable proposition at small scale (50kg/d) pilot plant level.

Key words: *Soy- sattu*, Soy fortification, Sorghum *Sattu*, Roasting, Nutritious snack food, Development, Acceptability, Shelf – life

INTRODUCTION

India is one of the largest producers of coarse cereals with as many as ten crops under cultivation. The basket of coarse cereals includes maize, sorghum, pearl millet, finger millet (ragi), kodo millet, little millet, foxtail millet, barnyard millet, proso millet and barley. The features associated with these crops are low value status, adaptation to poor habitats, poor resource base, production and consumption by the poorer sections of society and stagnant demand and price structure (Seetharam 2001). In many semi-arid parts of Africa and Asia, millions of people rely on sorghum grain as their main protein source (Young *et al*, 1989). Sorghum is a staple food for a large section of population living in dry land regions of India

(Vimla *et al*, 1996). Supplementation of legume flours with cereal flours has great potential in developing countries for improving the nutritional value of different food products. A good number of studies on the supplementary value of legumes, particularly with respect to soybean are available

'*Sattu'* is a roasted flour mixture of cereal and pulse combination and used as 'ready -to-eat' snack food in most parts of India. It is a convenient and inexpensive food product, containing digestive and dietary constituents or principles of vital importance. Owing to its high nutritional value, long shelf life and excellent taste, *sattu* is popular supplement food especially in rural India. The present study was therefore undertaken with the objective of developing nutritionally rich soy-fortified *sattu* using sorghum and to study its shelf life and consumer's acceptability.

MATERIALS AND METHOD

Cleaned whole grains of soybean (*Glycine max*.), sorghum (*Sorghum vulgare*) and Bengal gram (*Cicer arietinum*) were procured from farm section standard AOAC (1984) method. To analyze the water absorption capacity, standard analytical methods for soybean and soybean products were used (Anon 1946). Ash content was analyzed using AOAC (1995) method. Urease activity of the product was determined to measure the presence of anti nutritional factors in the final product (AOCS, 1970).

The samples of *soysattu* were filled and packed using heat-sealing machine in Low Density Poly Ethylene (LDPE) packages of 100µ thickness and metal containers. These packages were stored for a period of sixty day at ambient conditions during the warm months of summer season (May-June) and humid rainy season (August-September). The environmental conditions i.e. temperature and humidity were recorded using a thermo-hydrograph (Lambrecht, U. K.) and the values were averaged for two-hour intervals. Packaged samples were analyzed for total bacterial count, lipolytic count, yeast and mould counts, moisture content and free fatty acids employing the standard methods (Ranganna, 1986). The insect infestation and change in colour were observed visually. The observations were recorded in the beginning and at 15 days interval for the storage period of two months considering the fact that such a shelf life should be adequate for a snack product packaged in small quantities and is consumed on a daily basis. All estimations were carried out in triplicates and mean values are reported.

of Central Institute of Agricultural engineering, Bhopal and separately moisture conditioned to obtain 30% moisture level in each of these samples. For this, samples were sprinkled with a predetermined quantity of distilled water calculated based on their respective initial moisture contents. The samples were then thoroughly mixed, sealed in a double-layered low-density polyethylene bags (400gauge), and stored under refrigerated conditioned (10^{o}C) for 48 h to facilitate the moisture equilibration. Each of these samples was then roasted in a hot sand bath at 180°C, with continuous stirring, for about 10-12 minutes followed by their dehulling. The dehulled samples were then mixed in following four selected proportions of soybean, sorghum and Bengalgram: 10: 20: 70; 25: 35: 40, 30: 10: 60 and 40: 20: 40 respectively. Samples thus prepared were ground and powdered so as to pass through ISS No. 30 (opening size 0.296 mm) sieve. Conventional *sattu* using sorghum and Bengal gram was also prepared following similar procedure to use as control.

Moisture, crude fat and crude protein (using the factor 6.25 x N) were determined according to

The samples of *soysattu* were used for evaluating sensory properties by a panel of nine trained judges. Various characteristics like taste, flavour, texture, appearance and general acceptability for all products were assessed using a nine-point Hedonic scale. All panelists were considered average consumers of these products. Analysis of variance was used to test the difference between the products (BIS: 1975).

RESULTS AND DISCUSSION

Physico-Chemical Properties: Effect of level of soy-fortification on various physico-chemical properties of soysattu is presented in Table 1 and their correlation was studied. Protein

content, oil content (fat), carbohydrate and ash content of *soysattu* appears to follow polynomial relationship with different soy fortification levels. The following regression models of the 2^{nd} order polynomial (non-linear) were developed:-

$$P.\ C. = -2.0857\ S_b^{\ 2} + 12.274\ S_b + 7.284\ (r^2 = 0.85) \quad \ldots (1)$$

$F. = -0.9786\ S_b^2 + 5.9814\ S_b - 0.64$ ($r^2 = 0.88$) . . . (2)

$C = 3.1429\ S_b^2 - 19.057\ S_b + 82.2$ ($r^2 = 0.80$) . . . (3)

$T. A. = -0.13\ S_b^2 + 0.796\ S_b + 2.098$ ($r^2 = 0.86$) . . . (4)

Where,

P. C. = Protein content, %

S_b = Soy fortification

F = Fat, %

C = Carbohydrate content, %

T. A. = Total ash, %.

High correlation (R^2>80%) was observed between various quality parameters of *soysattu* and level of soy fortification indicating that the quality parameters had a non-linear increase with the increasing level of soy fortification. Similar variation in the quality parameters had been reported by Kulkarni (1997) for roasted soy fortified biscuits.

Depending upon the level of soy-fortification the percent increase in protein and fat was observed to be in the range of 20 to 70 and 21 to 121 respectively. Further, as the soy fortification increased, reduction in carbohydrate was observed. This might have happened since the soybean contains low carbohydrates. Increase in total minerals may be attributed to higher amount of minerals present in the soybean. Valyasevi and Dhanamitra (1987) and Deshpande *et al.* (2004) have reported similar results for fortified foods developed for adoption at home and community level. Increase of soy proportion in the *sattu*, not only increased protein levels but also increased the hydrophilic nature perhaps on account of presence of considerable polar side chain in protein. The water holding capacity of soy-fortified *sattu* seems to have increased with increasing amount of soybean.

Table 1 Proximate composition of *sattu* prepared from different ingredients with varying soy fortification.

Proportions (Soybean: sorghum: Bengal gram)	Protein %	Oil %	Carbohydrate %	Ash content %	Water Holding Capacity %
10:20:70	18.7 (±1.30)	5.0 (±0.97)	61.0 (±3.27)	2.84 (±0.65)	185 (±4.15)
25:35:40	21.32 (±2.50)	6.2 (±1.36)	57.0 (±3.63)	3.04 (±0.86)	200 (±4.11)
30:10:60	24.48 (±2.29)	8.3 (±0.82)	50.8 (±3.65)	3.29 (±0.58)	235 (±5.11)
40:20:40	26.32 (±3.27)	9.1 (±2.31)	47.3 (±3.59)	3.42 (±0.63)	250 (±5.31)
0:30:70 (Control)	15.0 (±2.84)	4.1(±1.66)	68 (±5.53)	2.46 (±72)	154 (±4.13)

Mean±Standard deviation

Anti-Nutritional Factors: Different levels of soy-fortified *sattu* samples did not show any urease activity, which was taken as an index of presence of anti tryptic activity. Hence *sattu* prepared from different levels of soy fortification were considered safe for human consumption. Ramanani et al. (1996) and Kulkarni (1997) had also reported similar results on effectiveness of roasting for inactivation *of* trypsin inhibitor and hemagglutinins.

Organoleptic Evaluation: The mean score values of the *sattu* with different soy fortification for different characters such as taste, flavour etc. are given in Table 2.The mean scores for all the quality characters and general acceptability were more than the minimum acceptable score of 5. The results thus indicated that the samples of *sattu* fortified up to 30% soybean were well accepted by the panelists. These products were devoid of off flavour and possessed acceptable characteristics. The results are in accordance with Sahay and Kachru (1988), Deshpande (1990) and Deshpande *et al.* (2001) who obtained similar results while evaluating different products prepared as soy-blended snacks at domestic level.

Table 2 Mean score of sensory panel judges for the characteristics of *sattu* prepared from soybean, sorghum and bengal gram mix.

Characters	Control	Combination of ingredients				
		Soybean: Sorghum: Bengal gram				
		10 : 20 : 70	25 : 35 : 40	30 : 10 : 60	40 : 20 : 40	F-ratio
Taste	8.20±0.34	7.9±0.11	7.0±0.41	5.3±0.18	3.1±0.33	46.34*
Texture	8.00±0.70	7.7±0.34	6.6±0.16	5.5±0.47	3.3±0.88	37.81*
Flavour	8.5±0.41	7.7±0.77	6.8±0.51	5.8±0.26	4.7±0.21	23.96*
Colour	7.8±0.87	7.7±0.24	7.0±0.33	6.0±0.19	3.5±0.64	39.42*
Overall acceptability	8.20±0.54	7.8±0.61	7.0±025	6.1±0.68	3.5±0.89	62.40*

*significant at 5% level, Mean±Standard deviation

Table 3: Effect of storage on FFA and moisture content of soy-fortified-*sattu* packaged in LDPE bags for summer conditions (40°C/38% RH)

Proportions (Soybean: Sorghum: Bengal gram)	Storage parameters							
	Free Fatty Acid (FFA), (%) (Mean ±Std. Dev.)				Moisture content (m.c.) (% wb) (Mean ±Std. Dev.)			
	Storage period, days				Storage period, days			
	0	15	30	45	0	15	30	45
10:20:70	0.30±0.03	0.55±0.04	0.85±0.056	0.96±0.03	6.00±0.31	6.10±0.44	6.15±0.59	6.19±0.49
25:35:40	0.30±0.04	0.60±0.02	0.89±0.04	1.41*±0.07	6.00±0.48	6.15±0.28	6.19±0.61	6.24±0.39
30:10:60	0.38±0.03	0.65±0.03	0.9±0.06	2.22*±0.08	6.00±0.22	6.19±0.53	6.23±0.47	6.29±0.40
40:20:40	0.38±0.05	0.77±0.05	0.96±0.0.7	2.36*±0.05	6.00±0.37	6.22±0.43	6.25±0.55	6.40±0.48
0:30:70 (Control)	0.30±0.04	0.40±0.04	0.55±0.08	0.61±0.05	6.03±0.45	6.05±0.27	6.11 ±0.66	6.15±0.11

* Product in rancid/unacceptable range, hence, further analysis abandoned

Table 4: Effect of storage on FFA and moisture content of soy-fortified-*sattu* packaged in Metallic containers for summer conditions (40°C/38% RH)

Proportions (Soybean: Sorghum: Bengal gram)	Storage parameters									
	Free Fatty Acid (FFA), (%) (Mean ±Std. Dev.)					Moisture content (m.c.) (% wb) (Mean ±Std. Dev.)				
	Storage period, days					Storage period, days				
	0	15	30	45	60	0	15	30	45	60
10:20:70	0.30±0.03	0.51±0.04	0.66±0.04	0.85±0.05	0.87±0.06	6.00±0.42	6.01±0.58	6.05±0.31	6.12±0.32	6.16±0.56
25:35:40	0.30±0.04	0.54±0.02	0.69±0.05	0.89±0.06	0.91±0.04	6.00±0.51	6.03±0.44	6.07±0.57	6.13±0.58	6.18±0.58
30:10:60	0.38±0.05	0.57±0.04	0.81±0.06	0.90±0.02	0.93±0.05	6.00±0.48	6.05±0.60	6.10±0.60	6.15±0.49	6.20±0.47
40:20:40	0.38±0.03	0.62±0.05	0.82±0.04	0.93±0.07	0.95±0.04	6.00±0.45	6.07±0.42	6.10±0.33	6.15±0.52	6.22±0.43
0:30:70 (Control)	0.30±0.04	0.38±0.05	0.47±0.07	0.58±0.02	0.65±0.06	6.03±0.45	6.02±0.44	6.04±0.38	6.00±0.61	6.00±0.41

The results of ANOVA for each characteristic from each individual score of sensory panel for different soyblends of s*oysattu* revealed that the difference among the various products was significant for all characters at 5% level of significance (Table 2). This may be due to inheritant characteristic qualities of soybean and being a new product it deviated from conventional foods. Further, variance due to judges did not exist, indicating that panelists group was homogenous.

Shelf Life Studies: Results of samples stored in LDPE packages under the high temp. low humidity conditions i.e. summer season indicated that total FFA (% oleic acid) increased from 0.30 to 0.96% as the storage period advanced from 0 to 45 days for the soy-sattu sample fortified at 10% level of soybean in comparison to the 0.61% FFA obtained after 45 days of storage for the control samples (i.e. sattu prepared without soybean, Table 3). These values, however, increased from 0.38 to 2.36%(SD±0.05) as the soy fortification level increased from 10 to 40%. This indicated that increased level of soy fortification increased the fat content of the samples and, therefore, the FFA level during storage of the product also increased. The increasing trend for FFA was much higher for product samples stored during rainy season, perhaps due to relatively higher increase in moisture content, the rancidity increased in these samples rather rapidly (Table 5).

Table 5: Effect of storage on FFA and moisture content of soy-fortified-*sattu* packaged in LDPE bags for rainy season conditions (30°C/92% RH)

Proportions (Soybean: Sorghum: Bengal gram)	Storage parameters					
	Free Fatty Acid (FFA), (%) (Mean ±Std. Dev.)			Moisture content (m.c.) (% wb) (Mean ±Std. Dev.)		
	Storage period, days			Storage period, days		
	0	15	30	0	15	30
10:20:70	0.30±0.03	0.89±0.05	1.86*±0.06	6.00±0.35	7.25±0.53	8.79±0.86
25:35:40	0.30±0.04	0.91±0.04	2.25*±0.04	6.00±0.46	7.52±0.71	9.21±0.41
30:10:60	0.38±0.02	0.93±0.06	2.71*±0.05	6.00±0.17	8.66±0.39	9.35*±0.63
40:20:40	0.38±0.06	0.97±0.05	2.95*±0.07	6.00±0.24	8.91±0.28	9.67*±0.44
0:30:70 (Control)	0.30±0.04	0.67±0.03	0.71±0.06	6.00±0.39	6.05±0.10	6.11±0.23

* Product in rancid/unacceptable range, hence, further analysis abandoned

Table 6. Effect of storage on FFA and moisture content of soy-fortified-*sattu* packaged in metallic containers for rainy season conditions (30°C/92% RH)

Proportions (Soybean: Sorghum: Bengalgram)	Storage parameters									
	Free Fatty Acid (FFA), (%) (Mean ±Std. Dev.)					Moisture content (m.c.) (% wb) (Mean ±Std. Dev.)				
	Storage period, days					Storage period, days				
	0	15	30	45	60	0	15	30	45	60
10:20:70	0.30±0.02	0.53±0.07	0.60±0.04	0.78±0.06	0.80±0.03	6.00±0.63	6.55±0.80	6.81±0.33	7.0±0.82	7.25±0.21
25:35:40	0.30±0.05	0.55±0.06	0.63±0.06	0.84±0.05	0.89±0.06	6.00±0.72	6.75±0.44	7.11±0.19	7.12±0.41	7.89±0.35
30:10:60	0.38±0.06	0.67±0.05	0.75±0.05	0.86±0.05	0.92±0.04	6.00±0.54	6.9±0.52	7.15±0.25	7.25±0.36	8.10±0.26
40:20:40	0.38±0.04	0.71±0.06	0.80±0.06	0.90±0.04	0.96±0.05	6.00±0.0.64	7.0±0.27	7.18±0.38	7.56±0.39	8.34±0.65
0:30:70 (Control)	0.30±0.04	0.67±0.03	0.71±0.06	0.77±0.03	0.80±0.03	6.00±0.39	6.13±0.32	6.25±0.29	6.42±0.52	6.48±0.43

Similar increase in FFA was observed for samples stored in metallic containers under both low and high humidity conditions however, the rate of increase was lower compared to the samples kept in LDPE package (Table 4 and 6). The main reason for excessive increase in moisture content of LDPE packages may be the fact that the water vapour transmission rate of LDPE is much higher than that of metallic bins. Increased moisture accelerates the development of rancidity and therefore, the FFA values also increased. A value of 0.99% FFA (% Oleic acids), was used as the cut-off value for acceptability of the *soy-sattu* during storage in accordance with the recommendations of Mustaka and Griffin (1964) for soy-based products.

Table 7: Regression constants for the models on FFA of *soysattu* kept in different packages under varying ambient conditions

Type of packag	Ambient condition	Soy-fortification %	Regression constants		Regression coefficient
			A_1	B_1	r^2
Metallic container	Summer season	10	0.0114	0.294	0.99
		25	0.0157	0.250	0.98
		30	0.0170	0.304	0.95
		40	0.0185	0.310	0.93
	Rainy Season	10	0.0145	0.287	0.97
		25	0.0217	0.251	0.90
		30	0.0220	0.355	0.92
		40	0.3530	0.244	0.88
Low Density Polyethylene (LDPE)	Summer Season	10	0.0155	0.302	0.98
		25	0.0233	0.249	0.97
		30	0.0321	0.226	0.92
		40	0.0381	0.216	0.90
	Rainy Season	10	0.0513	0.2333	0.98
		25	0.0613	0.190	0.96
		30	0.0707	0.2067	0.93
		40	0.0807	0.170	0.92

Change in the moisture content was negligible being in the range of 6.0 to 6.22% w.b. as the storage period increased from 0 to 60 days for the samples stored in metallic containers even at ambient conditions in summer season (Table 4). Similarly, the results of the study in LDPE packages under high humid ambient conditions, exhibited the similar trend for moisture content except that percent increase was on higher side (Table 3). The regression constants A_2 and B_2 obtained for various treatments are given in Table 7 and 8.

The values of moisture content and FFA were found to be 6.22% (wb) and 0.95% for *soysattu* stored for 60 days under summer ambient conditions in metallic containers. These values are well within the range specified by the Bureau of Indian Standards of 9% moisture content (BIS: 1975).

The stored *soysattu* sample which attained a value of over 9% moisture content or 0.99% FFA was considered to be unacceptable.

This is to further mentioned that the respective initial values of total bacterial count, lipolytic count and fungal count were $5.13x10^3$, $1.09x10^3$ and

$1.047x10^2$per g. while there were no coliform and salmonella. The value for these parameters during and at the end of storage was well within the acceptable limits of total bacterial counts of $5.0x10^4$ per g.

Table 8: Regression constants for the models on moisture content of *soysattu* kept in different packages under varying ambient conditions

Type of package	Ambient conditi	Soy-fortification %	Regression constants		Regression coefficient
			A_1	B_1	r^2
Metallic container	Summer Season	10	0.0030	5.9860	0.93
		25	0.0032	5.9940	0.99
		30	0.0030	6.0060	0.97
		40	0.0036	6.0060	0.97
	Rainy Season	10	0.0713	5.8790	0.99
		25	0.0881	5.9120	0.99
		30	0.0940	5.9700	0.99
		40	0.0946	6.0390	0.99
Low Density Polyethylene (LDPE)	Summer Season	10	0.0039	6.0090	0.98
		25	0.0042	6.0180	0.94
		30	0.0041	6.0270	0.89
		40	0.0006	6.1840	0.88
	Rainy Season	10	0.0920	5.9433	0.99
		25	0.1000	5.9933	0.99
		30	0.1070	6.3150	0.91
		40	0.1240	6.2533	0.95

In conclusion, soybean was successfully fortified in traditional popular and nutritious snack of rural India called *sattu*. Soy fortification up to 25% was found acceptable providing an increase of almost 37% and 51% in protein and fat content respectively when compared traditional *sattu*. Prepared *sattu* could be stored safely for 60 days in humid and warm conditions of storage in metal containers while the LDPE packages stored it for 30 days in warm conditions and 15 days in humid conditions of storage. The economic analysis revealed that a small scale pilot plant of 50 kg per day capacity would be a profit proposition.

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