Journal of Agricultural Engineering Vol. 46(2): April-June, 2009

Quality, Acceptability and Shelf Life Study of Micronutrient Fortified Indian Traditional *Sattu*

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ABSTRACT

Three different fortified bengal gram and barley based *sattu* samples were prepared following standardized *sattu* making process and fortified as per FDA guidelines of flour for vitamins (thiamin, riboflavin, and niacin) and minerals (calcium and iron), packaged in low density polyethylene and laminated aluminium foil pouches and stored at 25°, 35°C and room temperature. Proportion of bengal gram and barley in different *sattu* samples was 100:0, 50:50 and 75:25. Although some changes in alcoholic acidity and moisture content were observed during 180 days storage period in different *sattu* samples at all the storage conditions, but these were within the permissible limit as per BIS standard. Free fatty acids also increased at all storage conditions; however it did not affect the degree of sensory acceptability of *sattu* samples. Protein digestibility in fortified *sattu* samples with 100:0, 50:50 and 75:25 parts of bengal gram and barley was 80.58%, 76.77% and 78.62%, respectively. Fortified bengal gram *sattu* provided 27.68% digestible protein, 5.23% fat, 3.21% ash, 1.03% dietary fibre, 396 Kcal, 170 mg calcium, and 12.5 mg iron per 100 g. Fortified *sattu* samples with 50:50 and 75:25 parts of bengal gram and barley provided 19.49 and 23.58% digestible protein; 3.31 and 4.21% fat; 2.57 and 2.93% ash; 1.45 and 1.11% dietary fibre; 387 and 391 Kcal; 130.78 and 144.58 mg calcium; and 8.39 and 10.4 mg iron per 100 g, respectively. Although the overall quality of the *sattu* samples stored at different storage condition was within the safe and acceptable limit, but the deterioration was low in *sattu* samples stored at 25°C (65%RH) in laminated aluminium foil pouches and hence may be considered for safe storage of *sattu*. Due to safer limit of alcoholic acidity 0.13%, overall nutritional quality, higher mean sensory score for roasted odour (7.61) and flavour and taste (8.14) of stored fortified bengal gram *sattu,* there is a scope for commercial production of nutritionally balanced bengal gram *sattu* with vitamins and minerals.

Traditional foods are still important items in most of the Indian's diet. The important traditional products, which are the part of not only the rural but also the urban people's diet, are *sattu*, *papad, wadian*, puffed rice, flaked rice, etc. *Sattu* is roasted flour made from only cereals, only legumes, or combination of cereal and legumes with added flavouring agents (Mridula *et al*., 2004). *Sattu*, in drink form, is believed by the consumers as one of the best food in breakfast during the summer season due to its good digestibility and cooling effect. It is preferred by all age group and generally consumed as breakfast in some of the states of India, particularly Bihar and Uttar Pradesh. Nowadays, the popularity of *sattu* made from bengal gram is also increasing amongst the diabetics due to its low glycemic index. Previously *sattu* was mainly prepared at village households, but now bengal gram *sattu* is manufactured at commercial scale (0.1 to 0.5 t/ h.) too in Bihar and Uttar Pradesh (Mridula *et al.*, 2004). Only bengal gram *sattu* is commercially produced, but in Uttar Pradesh barley and bengal gram based *sattu* is liked by a large section of population. The combination of cereal and legume in any formulation also improves the biological value of food, particularly for proteins due to their supplementary effects.

According to the National Nutrition Monitoring Bureau of India, over 50% children have subclinical deficiencies of micronutrients (Vijayraghavan *et al.,* 2000). There is increasing clinical and laboratory evidences that individuals with sub-clinical deficiencies of various micronutrients are more vulnerable to develop a variety of common day-to-day infections (Singh, 2004). According to the recommendations of United Nations Sub-committee on Nutrition, it is not possible to meet the requirements of 100% recommended dietary allowances (RDA) of micronutrients from dietary sources alone (Allen, 2001). Therefore, nutritional supplements are important to improve physical growth and mental development and prevent occurrence of common day-to-day infections. Owing to rich in protein, long shelf life, excellent taste, *sattu* is a popular food supplement, especially in rural India. Fortification of *sattu* with

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micronutrients can serve as an important source for enhancing the intake of micronutrients amongst the population at lower cost. Therefore, the present study was undertaken with the objective to evaluate the effect of storage conditions on physico-chemical qualities and acceptability of fortified (with vitamins and minerals) bengal gram and barley based *sattu* in different combinations for a period of six months.

MATERIALS AND METHODS

Preparation of Fortified *Sattu* Samples

The flow diagram of unit operations involved in preparation of fortified bengal gram and barley based *sattu* is indicated in Fig 1. Cleaned and graded bengal gram (variety PBG-5) and barley (variety VJM 201) obtained from Punjab Agricultural University, Ludhiana were used for the study. The geometric mean diameter of raw bengal gram used for the study was 6.22±0.04 mm. Raw bengal gram grains were conditioned with water to 15% moisture content, and tempered at room temperature for 4hour. Roasting of bengal gram was done as per the standardized process at 220 °C for 60s, while single roasting of barley was done at 220 °C for 75s using 10:1 sand and tempered grain ratio. Roasted grains were subsequently cooled at room temperature for 6h before dehulling. Dehulling of roasted bengal gram was done using mini dhal mill (Make: Nalanda Agro Works, Patna; capacity 100 kg/h) at 7.5 mm dehuller clearance. Pearling of roasted barley was done using a grain pearler (Make: CIAE Bhopal, 100-300 kg/h) for 2 minutes. To remove any sand particle, dehulled bengal gram and pearled barley samples were passed through air screen grain cleaner (Make: CIAE, Bhopal, capacity 300-600 kg/h) before grinding for making flour (Sahay and Singh, 2001). Grinding of dehulled bengal gram and barley samples was done in Cyclotec sample mill (Make: Tecator, Sweden), followed by sieving (65 mesh size). The ground samples were then analyzed for acid insoluble ash content as per the standard method (Ranganna, 1986) before preparing the *sattu* samples. Proportion of bengal gram and barley in different *sattu* samples was 100:0, 50:50, and 75:25. Fortification of *sattu* samples was done as per Food and Drug Administration (FDA) guidelines (Ensminger *et al.,* 1995) for flour with 0.64 mg of thiamin (thiamin chloride), 0.40 mg of riboflavin, 5.3 mg of niacin (nicotinic acid), 212 mg of calcium (calcium carbonate) and 2.87 mg of iron (ferrous sulphate) per

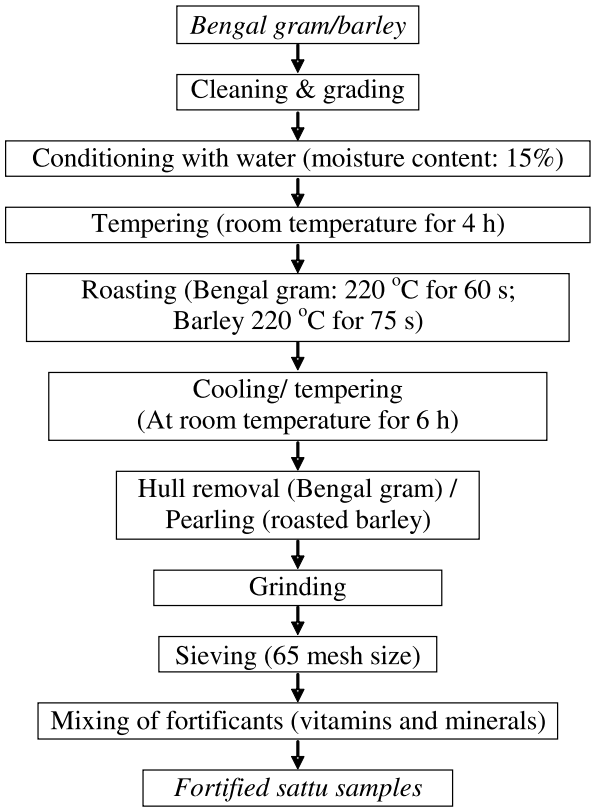

Fig. 1: Method for preparation of fortified bengal gram and barley based *sattu*

100 g of flour. The vitamins and minerals were purchased from the local market (Brand: S D Fine-Chem Limited, Chennai). The pre-mix required for fortifying the study samples was prepared at CIPHET following the requirement for 100 kg of flour by dry mixing of the weighed amount of vitamin and minerals. The prepared samples were then packaged and stored for further quality analysis.

Storage Conditions

The prepared fortified bengal gram and barley based *sattu* samples were packaged in commercially available low density polyethylene (LDPE; thickness 65µ) and laminated aluminium foil (LAF; thickness 25µ) pouches. The pouches before loading were wrapped in brown paper and kept in hot air oven at 60^0C for 4 h to reduce any microbial loads. Samples (n=126) of 150g were filled in each of the pouches and stored in temperature-cum-humidity control cabinet (Make: Macro Scientific Works, Delhi) at (i) 25°C (65% RH), (ii) 35°C (90% RH) and (iii) room temperature (16-39 °C, 18-98% RH) for 6 months between February and August, 2007.

Physico-chemical Analysis

The moisture, fat, protein (6.5 x N), ash and dietary fibre contents of the samples were determined as per standard methods (AOAC, 1984). Total carbohydrates values were computed by adding the moisture, protein, fat, fibre and ash, and the total subtracted from 100 (Hira *et al*., 1996). Total calories were calculated by multiplying protein, carbohydrates and fat content by the factor 4, 4 and 9, respectively. Protein digestibility of samples was determined as per the method given by Akeson and Stachman (1964). Water absorption in the samples was determined according to the method reported by Anderson *et al.,* (1969). Alcoholic acidity and free fatty acids (flour basis) in the samples was determined as per the method suggested by Thapar *et al.,* (1988). Microbial load (viable bacterial count and yeast and mould) were determined by standard pour plating method (Cruickshank *et al*., (1975).

Colour Determination

The colour (L, a, b values) of the samples was determined by using Handy Colorimeter NR-3000 (Make: Nippon Denshoku Ind. Co. Ltd, Japan). C* (chroma) is the attribute of colour used to indicate the degree of departure of the colour from gray of the same lightness. C* are computed by using the following formula.

$$C^* = [a^2 + b^2]^{1/2} \quad \ldots (1)$$

Where, a = a values and b = b values, as indicated by the colorimeter.

Sensory Evaluation

Sattu samples were evaluated for different sensory attributes by a group of 7 semi-trained persons from *sattu* eating areas. *Sattu* drink was prepared with 16 g of sample, 100 ml potable water, 0.7 g salt, 0.04 g cumin seed powder, and 0.01 g white pepper powder for flavouring. The ingredients were mixed together by stirring with a spoon. An amount of 50 ml of freshly prepared drink was given to the test panel for sensory evaluation. Sensory attributes like appearance and colour, texture or body (sensory texture), roasted odour, flavour and taste as well as overall acceptability for all samples were assessed using nine point hedonic scale (BIS, 1971).

Statistical Analysis

All assays were carried out in triplicate. Mean, standard deviation and paired t-test were computed using Microsoft Excel 2003.

RESULTS AND DISCUSSION

Storage Effects on Physico-chemical Quality

Relative humidity and temperature during storage are two major factors that affect the overall quality of the product. High humidity gives rise to high moisture content, which is conducive for enzymatic hydrolysis of fat present in food products (Sowbhagya and Bhattacharya, 1976). Moisture content variation in different *sattu* samples due to different storage conditions is given in Table 1. The total increase in moisture contents in all three *sattu* samples with 100:0, 50:50 and 75: 25 parts of bengal gram and barley, respectively, during six months storage under different conditions (temperature and packaging materials) was 1.33, 1.24 and 1.61%, respectively. The increase in the moisture content up to 90 days was low at all the storage conditions, and thereafter the rate of increase at all temperatures was comparatively more. The increase in moisture content in samples packaged in LDPE pouches was more as compared to LAF pouches, which may be due to lesser moisture permeability of the LAF material as compared to LDPE pouches. The increase in moisture contents were within the maximum permissible limit of 7.0%, suggested by BIS (Bureau of Indian Standard) standard for *chana* (bengal gram) *sattu*. It may be due to the suitability of the packaging material for storage of the product even at the accelerated conditions. The water absorption capacity of bengal gram *sattu* samples was less than the *sattu* samples with barley.

Table 1. Moisture content in fresh and stored fortified bengal gram and barley based *sattu* sample

Proportion of bengal gram and barley in *sattu* sample	Packaging Material	25 ^{0}C		35 ^{0}C		RT	
		Initial*	Final**	Initial*	Final**	Initial*	Final**
100:0	LDPE	3.21 ± 0.03	4.28 ± 0.05	3.21 ± 0.03	4.54 ± 0.10	3.21 ± 0.03	4.33 ± 0.11
	LAF	3.21 ± 0.03	4.05 ± 0.06	3.21 ± 0.03	3.94 ± 0.08	3.21 ± 0.03	4.08 ± 0.12
50:50	LDPE	3.33 ± 0.17	4.22 ± 0.08	3.33 ± 0.17	4.57 ± 0.19	3.33 ± 0.17	4.43 ± 0.17
	LAF	3.33 ± 0.17	4.17 ± 0.09	3.33 ± 0.17	4.25 ± 0.17	3.33 ± 0.17	4.11 ± 0.07
75:25	LDPE	3.37 ± 0.19	4.91 ± 0.07	3.37 ± 0.19	4.74 ± 0.23	3.37 ± 0.19	4.98 ± 0.16
	LAF	3.37 ± 0.19	4.10 ± 0.04	3.37 ± 0.19	4.09 ± 0.08	3.37 ± 0.19	4.24 ± 0.13

* Freshly prepared; ** 180 days storage; values are mean ± S.D.; mean worked out for three replications.

This may be due to higher soluble fibre in barley that enhanced the water absorption capacity of *sattu* samples with barley. The acid insoluble ash content in roasted bengal gram and barley flour were 0.018 and 0.031% (dry basis), respectively as against 0.20% maximum permissible limit by BIS standard (BIS, 1998).

The effects of fortification on the colour of *sattu samples* were evaluated through the 'L, 'a', 'b' and chroma values. The L, a, b and chroma values of fortified *sattu* samples with 100:0, 50:50 and 75:25 parts of bengal gram and barley were 75.97, 2.88, 20.97 and 21.16; 77.56, 2.20, 15.97 and 16.12; and 76.75, 2.37, 18.77 and 18.92, respectively. The L, a, b and chroma values of unfortified *sattu* samples with 100:0, 50:50 and 75:25 parts of bengal gram and barley were 75.59, 2.86, 20.53 and 20.73; 77.58, 2.18, 16.01 and 16.17; and 76.77, 2.40, 18.91 and 19.06, respectively. No significant difference ($p>0.05$) was observed in the colours of the unfortified and fortified bengal gram and barley based *sattu* samples due to fortification with vitamins and minerals.

The proximate composition of different *sattu* samples is given in Table 2. The proximate composition in 100 g of raw bengal gram dhal and barley at moisture content of 9.46 and 10.39% were protein 25.68 and 11.59%; fat 4.93 and 1.36%; ash 3.26 and 1.24%; Ca 63.91 and 27.96 mg; and Fe 9.61 and 1.53 mg, respectively. In vitro protein digestibility of fortified *sattu* samples with 100:0, 50:50 and 75:25 parts of bengal gram and barley were 80.58%, 76.77% and 78.62%, respectively. Fortified bengal gram *sattu* provided 27.68% of digestible protein, 5.23% fat, 3.21% ash, 1.03% dietary fibre, 396 Kcal, 170 mg calcium, and 12.5 mg iron per 100 g. Fortified *sattu* samples with 50:50 and 75:25 parts of bengal gram and barley provided 19.49 and 23.58% of digestible protein; 3.31 and 4.21% fat; 2.57 and 2.93% ash; 1.45 and 1.11% dietary fibre; 387 and 391 Kcal;

Table 2. Proximate composition of fortified bengal gram and barley based *sattu* samples

Constituent	Proportion of bengal gram and barley in *sattu* samples				Require-ment for *chana sattu**
	100:0 (Unfortified)	100:0 (F)	50:50 (F)	75:25 (F)	
Moisture (%, w.b.)	3.16 ± 0.06	3.21 ± 0.01	3.33 ± 0.03	3.37 ± 0.01	7.0 (max)
Protein (%)	27.68 ± 0.11	27.68 ± 0.03	19.49 ± 0.10	23.58 ± 0.09	21.0 (min)
In vitro protein digestibility (%)	80.60 ± 0.54	80.58 ± 0.07	76.77 ± 0.12	78.62 ± 0.09	--
Fat (%)	5.23 ± 0.12	5.23 ± 0.05	3.31 ± 0.08	4.21 ± 0.10	--
Ash (%)	3.09 ± 0.03	3.21 ± 0.10	2.57 ± 0.08	2.93 ± 0.13	2.0 (max)
Fibre (%)	1.06 ± 0.05	1.03 ± 0.02	1.45 ± 0.10	1.11 ± 0.02	--
Total carbohydrate (%)	59.73 ± 0.03	59.64 ± 0.44	69.85 ± 0.86	64.88 ± 1.00	--
Total calory (Kcal/ 100 g)	396 ± 2.64	396 ± 2.00	387 ± 3.60	391 ± 2.64	--
Ca (mg/ 100 g)	69.49 ± 0.27	170.1 ± 0.3	130.78 ± 0.89	144.58 ± 0.49	--
Iron (mg/ 100 g)	10.19 ± 0.06	12.55 ± 0.07	8.39 ± 0.06	10.40 ± 0.09	--
Alcoholic acidity (%)	0.12 ± 0.003	0.12 ± 0.003	0.14 ± 0.01	0.14 ± 0.01	0.15 (max)
FFA (%)	0.06 ± 0.005	0.06 ± 0.005	0.06 ± 0.005	0.06 ± 0.005	--
Water absorption (%)	289.9 ± 1.88	293.25 ± 0.95	354.71 ± 1.90	334.81 ± 1.11	--

F-Fortified; * as per BIS standard (IS 14617:1998); max – maximum; min-minimum; values are mean ± S.D.; mean worked out for three replications.

130.78 and 144.58 mg calcium; and 8.39 and 10.4 mg iron per 100 g, respectively. The protein, fat, calcium and iron content of roasted bengal gram flour was almost double than that of barley flour while fibre and carbohydrates content was more in barley. Due to this reason, barley levels in *sattu* formulations decreased the protein, fat, ash, calcium and iron content of *sattu* samples.

Alcoholic acidity is basically determined to assess the changes caused, in the grain and grain-based product, due to deterioration in the fats and proteins present in them. Alcoholic acidity of freshly prepared sample of bengal gram *sattu* was 0.12%, while in bengal gram and barley based *sattu* samples it was 0.14%. After six months storage, alcoholic acidity of bengal gram *sattu* was 0.15%, while in bengal gram and barley based *sattu* samples it was 0.16%. The marginal increases in alcoholic acidity, observed in all the three types of *sattu* samples stored at different storage conditions were within the limits of the standard (0.15%) set by BIS (1998) for bengal gram *sattu*. FFA content in freshly prepared bengal gram and barley based *sattu* samples was 0.06 per cent. The total increase in FFA content of different *sattu* samples at 25°C and 35°C during 180 days storage period was lower (0.08-0.11%) as compared to more than double FFA content (0.13-0.14%) at room temperature. The maximum increase at room temperature was observed during the rainy days of summer season that may be due to high humid atmosphere. The increase in FFA content may be mainly from degradation products of hydroperoxide, which is directly related with the relative humidity and moisture content of the products (Thakur and Arya, 1990). Although the FFA content increased in all the samples during 180 days storage period, but no samples showed off-flavour and aroma or any rancid smell during sensory evaluation. All the samples were well accepted during sensory evaluation by the panelists. As the alcoholic acidity includes the degradation due to fat and was within the permissible limit as per BIS standard, this increase in FFA (on flour basis) may be considered within the safe limit.

Storage Effects on Total Microbial Load

The effect of storage temperature and packaging material on total bacterial and yeasts and moulds count in different samples is presented in Table 3. No *coliform* and *salmonella* bacteria were found in the fresh and stored samples. Although some increase in the total count was observed in different samples at different storage temperatures and packaging materials, but the counts during and at the end of storage period were well within the acceptable limits of total bacterial counts of 5.0×10^4 cfu/ g (Deshpande *et al.,* 2004).

Storage Effects on Sensory Quality

The mean sensory scores for different *sattu* samples, evaluated in drink form, are given in Table 4. Although mean sensory scores for overall acceptability after storage was slightly lower for samples with barley as compared to bengal gram *sattu* samples, but the sensory scores were in the same category of hedonic scale. As physico-chemical quality of different *sattu* samples, packaged in LDPE and LAF pouches and kept at different storage conditions was within the acceptable quality, *sattu* samples packaged in LDPE bags and stored at room temperature were considered for sensory evaluation purpose. The mean sensory scores for roasted odour, flavour and taste and overall acceptability for different stored *sattu* samples were slightly lower than the fresh samples, but they were in the same hedonic scale category i.e. like very much to like moderately. This indicated that storage did not affect the degree of acceptability of the *sattu* samples, in general.

Table 3. Effect of storage on microbial load (x 10^3 cfu/ g) in fortified bengal gram and barley based *sattu*

Storage period (day)	Proportion of bengal gram and barley in *sattu* samples																	
	100:00						50:50						75:25					
	LDPE, ^{0}C			LAF, ^{0}C			LDPE, ^{0}C			LAF, ^{0}C			LDPE, ^{0}C			LAF, ^{0}C		
	25	35	RT	25	35	RT	25	35	RT	25	35	RT	25	35	RT	25	35	RT
Bacterial counts																		
0	10	10	10	10	10	10	12	12	12	12	12	12	19	19	19	19	19	19
90	11	24	5	16	27	10	7	24	14	12	12	14	11	21	9	11	8	16
180	13	20	22	11	16	33	11	21	17	10	14	24	16	17	19	20	22	24
Yeast and mould counts																		
0	9	9	9	9	9	9	7	7	7	7	7	7	5	5	5	5	5	5
90	6	11	3	11	6	14	11	14	12	9	12	6	4	8	12	6	4	16
180	8	8	7	5	8	9	10	20	13	9	11	19	9	11	12	7	14	16

Table 4. Sensory characteristics of fortified bengal gram and barley based fortified *sattu*

Proportion of bengal gram: barley	Appearance and colour	Texture/ Body	Roasted odour	Flavour and taste	Overall acceptability
Fresh sample					
100:00	8.48	7.68	7.92	8.42	8.12
50:50	8.0	7.56	7.58	8.66	8.0
75:25	8.36	7.78	7.82	8.62	8.04
After 180 days storage*					
100:00	8.4	7.98	7.61	8.14	8.04
50:50	8.28	7.50	7.28	8.0	7.56
75:25	8.13	8.1	7.23	8.0	8.18

*in LDPE pouches at RT; values are mean of seven

Although the physico-chemical quality, microbial load and sensory characteristics of the *sattu* samples stored at three different storage conditions in two different packaging material were within the safe and acceptable limit, but the deterioration was low in the *sattu* samples stored at 25°C (65%RH) in laminated aluminium foil pouches than other storage conditions. Hence this storage condition may be considered for safe storage of *sattu*. Due to safer limit of alcoholic acidity 0.13%, overall nutritional quality, higher mean sensory score for roasted odour (7.61) and flavour and taste (8.14) of stored fortified bengal gram *sattu*, it may be considered the best *sattu* amongst all three formulations for commercial production.

CONCLUSIONS

1. Storage brought some changes in alcoholic acidity in different *sattu* samples, kept under different storage conditions for 180 days. These changes were within the permissible limit as per BIS standard. Moisture and free fatty acids were also found to increase at all storage conditions, but it did not affect the degree of sensory acceptability of *sattu* samples.

2. Physico-chemical quality, microbial load and sensory characteristics of the *sattu* samples stored at three different storage conditions in two different packaging materials were within the safe and acceptable limit, but the deterioration was lowest in the samples stored at 25°C (65%RH) in laminated aluminium foil pouches. This storage condition may be considered for safe storage of *sattu*.

3. In vitro protein digestibility of bengal gram *sattu* was more as compared to bengal gram and barley based *sattu*. The protein, fat, calcium and iron content of bengal gram based fortified *sattu* was more, while fibre and carbohydrates content was less than bengal gram and barley based *sattu*.

4. Bengal gram *sattu* was the best amongst all three studied *sattu* formulations in light of the alcoholic acidity (0.13%), overall nutritional quality and higher sensory score for roasted odour (7.61), and flavour and taste (8.14) of stored fortified bengal gram *sattu,* and has scope for commercial production.

5. Fortified *sattu* with vitamins (0.64 mg of thiamin, 0.40 mg of riboflavin, 5.3 mg of niacin) and minerals (212 mg of calcium and 2.87 mg of iron per 100 g) was well accepted during sensory evaluation; both fresh and stored for 180 days, and hence recommended to make the product more nutritive and balanced.

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