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RESEARCH ARTICLE

EFFECT OF MALTING IN PROXIMATE, TOTAL AND AVILABLE IRON CONTENT OF MILLETS AND SOYBEAN FLOURS AND READY MIXES

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ABSTRACT

Malting of soy bean showed significant increase (0.01%, r>=0.606) in protein, total (double) and available iron content. Malting of cereals brought an improvement only in the protein (25%) content. Ready mixes prepared with soy and cereal (1:3) showed significant improvement in all the nutrients. There was a slight increase of total iron content in wheat, maize and decrease in sorghum on malting. In ready mixes, total iron content of wheat was highest and the available iron content was highest in maize mix. The storage studies at room temperature showed that the ready mixes prepared with wheat and sorghum incorporated with soy flour at the ratio of 1:3 was acceptable up to 21 days while maize mix was acceptable only for 14 days of storage.

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INTRODUCTION

Cereal grains are not only important sources of major nutrients, but they also contribute to the intake of certain important vitamins and mineral elements such as calcium, phosphorus and iron. The iron in cereals and pulses is largely bound to phytates, compound that render iron unavailable for absorption. Malting breaks this bond and the iron is readily utilized in the body, in presence of vitamin C creating the right environment for absorption. Growing sprouts from seeds can be like having a vegetable garden right in the kitchen (Klaus 1980). Malting breaks the starch into simple sugars by the action of enzyme 'amylase' such as sucrose and glucose, proteins to amino acids and amides by proteolytic enzyme and fats and oils to more simple fatty acids by the action of the enzyme lipase. The soaking, germination and heat treatments during malting reduces the carbohydrate content and increase the protein content of foods. The apparent increase in protein may reflect a loss of carbohydrates during respiration or on alteration of the nitrogenous substances rather than an actual increase in protein. Pre action of enzymes on food during malting make the food easily digestible as well reduces the oligosaccharide content causing the objectionable gas production (flatulence). Germination in malting process increases the B complex vitamin and mineral content by lowering the phytate content. There were several studies supported the beneficial changes in nutrient profile of many foods on malting. (Khader (1983), Adullah and Baldwin (1984), Chavan and Kadam (1989), Daldy *et al*. (1976), Suhasini and Mallesh (1995), Anuradha and Sunder (1996), Archana and Sarita (1997), Dhaliwal and Aggarwal (1999), Akpapunans and Achineatiu (1985), Lemar and Swanson (1976), Ranhotra *et al.* (1977) and Dorga *et al* (2001)).

Majority of the studies on malting in literature were restrained to individual foods viz. soybean, wheat, barley, oats, rice and rye, sorghum etc... The studies showing the malting effect on nutrient profile of products prepared using combination of different cereals and with soybean were limited. In this view the present study was carried out with the following objectives:

- Preparation of malted flours from wheat, sorghum, maize and soybean
- Estimation of proximate composition of raw, malted flours and ready mixes incorporated with soybean flour
- Estimation of total and available iron content of raw, malted flours and ready mixes incorporated with soybean flour
- Formulation of ready mixes and testing their consumer acceptability
- Storage studies of selected ready mixes

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MATERIALS AND METHODS

Procurement of raw materials

The cereals which are inexpensive, easily available, frequently consumed by general population and rich in protein and iron content were elected for preparation of ready mixes. Wheat (Triticum aestivum), Sorghum (Sorghum Vulgare), Maize (Zea mays) and yellow variety of Soybean (Glycine max) were selected for preparation of malted flours and ready mixes.

Processing of malted flours

Wheat, sorghum and maize

The grains chosen were cleaned and washed with potable water. Then the grains were soaked in triple amount of water to the weight of the sample. The soaking time followed were 24 hours for maize and 12 hours for sorghum, maize and wheat. After soaking the water was drained off from the grains and tied in a moist cloth to allow germination of grains at room temperature (37^0C). The germination timings were 24 hours for sorghum and wheat and 72 hours for maize. The germinated grains were dried at 50^0C for 16-18 hours in a hot air oven and brushed to remove the rootlets. The dried seeds were dry roasted and ground to flours and passed through 60 meshes and stored in airtight container.

Soybean

The cleaned soybean was soaked for 24 hours and then water was drained off. The soaked soybean was spread in trays covering with moist cloth for germination (24, 48 and 72 hours). The seeds were washed in running water thrice a day to prevent mould growth. The sprouted seeds were pressure cooked using 1:2 ratios of seed to water at 15 ib/Kg and 110^0–120^0C for 10 minutes. Then the seedlings were dried at 50^o C for 16 – 18 hours in a hot air oven and brushed to remove rootlets. The dried seeds were roasted till flavor developed. The roasted seeds were ground to flour, passed through 60 meshes and stored in air tight container (Fig 1). The raw flours prepared with grains excluding the malting process were treated as control and malted cereal flours and ready mixes incorporated with soybean were treated as experimental samples.

Nutrient analysis of the raw, malted flours and ready mixes incorporated with soybean flour

Moisture, protein, energy, fat, fiber, total iron and available iron content of raw and malted cereals and soy bean were analyzed in triplicate using the standard methods. The proximate content and iron content were determined by using the methods of AOAC (1990). The total iron content was estimated using α,α– dipyridyl (AOAC (1990) and available iron content was predicted as per procedure of Prabhavathi and Narsing Rao (1979)

Product formulation with ready mixes and testing their consumer acceptability

Ready mixes were prepared by incorporating soy flour (commercial Gen / malted soy at 10, 15,20,25,30 and 35% percent levels with malted cereal flours. The standard recipes like laddoo and roti were prepared with ready mixes. The products were evaluated by selected panel judges in the laboratory using 5-point scale for testing the overall acceptability of the ready mixes.

Storage studies of selected ready mixes

Ready mixes were prepared hygienically and stored for 28 days at room temperature (28^oC) in 67 micro polyethylene covers (LDPE pack) of 25 X 15 cm diameter with zip lock sealing. Organoleptic characteristics were evaluated at the end of 7, 14, 21 and 28 days of storage.

Statistical analysis

The data was subjected to statistical analysis at the end of the study. Means and Standard Deviations were calculated for proximal composition, total and available iron content. Z test and T test was carried out to know the difference between two groups.

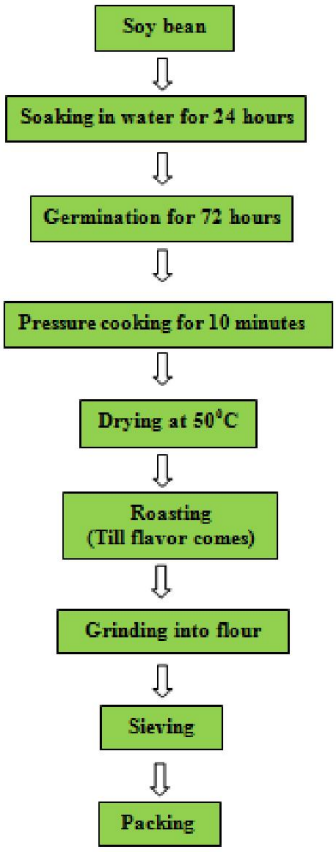


Fig. 1. Flow chart for preparation of soy malt

RESULTS AND DISCUSSION

Effect of germination time in total and available iron content of soybean

The process of germination was developed in some countries to overcome the disadvantages associated with ungerminated soybean such as undesirable flavor and odor. (Suberbie *et al*.,

1981). Among the treatments in preparation of soy malt, soaking and germination, (Bau *et al*., 1997), cooking under steam pressure and drying makes soy bean a very nutritious source of proteins and improves availability of iron (Ramamani *et al*., 1996). Roasting is done for enhancement of flavor and improved protein quality (Sing *et al*., 1994, Dhaliwal and Aggarwal 1999). Roasting of proteinaceous oilseed causes recemisation of essential amino acids as well reduction in availability of lysine (Ramamani *et al*., 1996). The treatment also make soybean free from objectionable flavor and render it to be palatable and acceptable for human consumption (Dogra *et al*., 2001).

Table 1 revealed that the malting of soybean was found to improve the iron content and it varied with different hours of germination. The total iron content was significantly improved and was almost doubled after 48 (89 %) and 72 hours (116.5 %) of germination.

double the values of the raw soy (Fig 2). These findings were in line with study of Anuradha and Sangheetha (2001) where they found 120 percent increase in total iron content on 72 hours germination. Increase in iron and available iron may be due to loss of phytates and other anti nutritional factors and release of bound iron due to malting conditions (Bau *et al* 1987, Hurrel *et al* 1992, Uma Chitra 1994). Germination for 24 hours showed significant decrease in total and available iron may be because of leaching out of iron during soaking.

Proximate composition of raw, malted flour and ready mixes incorporated with soybean flour

The proximate composition of cereals was enhanced on malting and the results were depicted in Table 2. Malting increased the protein content and decreased energy, ash, fiber and fat significantly at (0.01%) (r>=0.606) except wheat in all cereals.

Table 1. Effect of germination time in total and available iron content of soybean
(Per 100g of edible portion)

S.No.	Sample	Total Iron (mg)	Available iron (mg)			
			pH 1.35	%TI	pH 7.5	% TI
1	Raw soy	10.29±0.10	5.48±0.07	53.44±0.21	2.21±0.01	21.53 0.11
2	Germinated	9.58±0.13**	6.67±2.82	52.3±0 0.1**	1.94±0.01	
a	24 Hrs	(6.9%↓)	(21.7%↑)		(12.2%↓)	20.37±0.23**
b	48 Hrs	19.45±0.3**	11.68±0.07	59.44±0.1**	4.23±0.10	
		(89%↑)	(113%↑)		(91.4%↑)	21.06±0.74**
c	72 Hrs	22.28±0.1**	13.9±0.05	62.48±0.1**	5.09±0.03	
		(116.5%↑)	(153.8%↑)		(130.3%v)	22.86±0.24**

M: Malted RM: Ready mix TI: Total iron
Values are mean ± SD
** Significant at (0.01%) (r>=0.606)
Not significant

Table 2. Proximate composition of raw and malted flours
(Per 100g of edible portion)

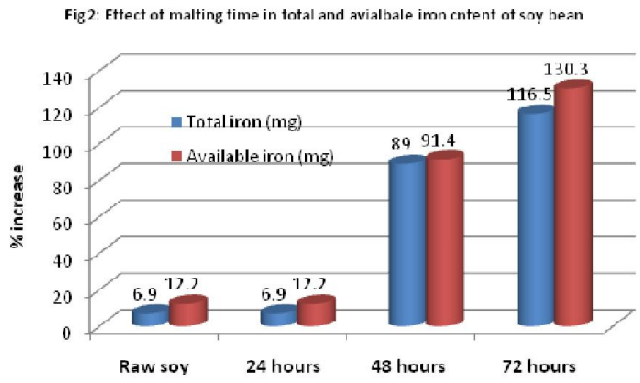
	Soy bean			Wheat			Sorghum			Maize		
Variable	Raw	Malted	T-Value	Raw	Malted	T-Value	Raw	Malted	T-Value	Raw	Malted	T-Value
Moisture (%)	9.55± 5.21	7.15±0.02 (25.1%↓)	18.9320**	9.60±0. 06	8.28±0.27 (13.8%↓)	8.1078**	12.49±0 .16	11.42±0.20 (8.6% ↓)	7.0336**	17.53±0 .30	15.36±0.20 (12.4%↓)	10.1496**
Protein (g)	37.93± 0.64	45.30± 1.17 (19.4% ↑)	19.1573**	12.33± 0.35	14.40±0.34 (16.8%↑)	7.2568**	9.53± 0.30	12.50±0.10 (31.2%↑)	15.9857**	11.23±0 .25	12.43±0.15 (10.7%↑)	7.0601**
Energy (Kcal)	429.30 ±3.54	427.00± 0.70 (0.47% ↓)	1.4039I	361.53 ±1.27	356± 1.60 (1.41%↑)	4.3125**	348.26± 1.43	345.26± 0.82 (0.86%↓)	3.2358**	342.63± 0.63	333.86± 1.06 (2.5%↓)	12.2103**
Fat (g)	18.66± 0.04	17.57± 0.08 5.9% ↓)	16.2214*	1.87± 0.01	165± 0.02 (11.7%↑)	11.9260**	1.67± 0.07	1.57± 0.06 (5.9%↓)	1.40I	4.06± 0.04	4.02± 0.02 (0.98%↓)	1.051I
Ash (g)	4.83± 0.05	2.70± 0.01 (44%↓)	64.0235*	2.26± 0.05	1.96± 0.05 (13.2%↑)	6.3643**	1.80± 0.05	1.26± 0.05 (30%↓)	15.9997**	1.40± 0.02	0.90± 0.01 (35.7%↓)	1543.7378**
Fiber (g)	3.62± 0.30	2.80± 0.05 (22.6% ↓)	4.2338*	1.28± 0.02	1.13± 0.02 (11.7%↑)	7.9546**	1.79± 0.14	1.92± 0.09 (7.2%↑)	1.2569I	2.63± 0.07	3.13± 0.11 (19%↑)	6.460**

Values in parenthesis indicate percentage of increase (↑) or decrease (↓) compared with raw
Values are mean ± SD
**Significant at (0.01%) (r>=0.606)
I not significant

The available iron significantly increased with different hours of germination at pH 1.35.and pH 7.5. Germination for 72 hours showed the highest increase in total and available iron content. After 48 hours and 72 hours the increase in available iron content was 91.0 and 130.0 percent respectively, which is

Significant difference was not observed in energy content of malted soy bean and fat content in malted sorghum and maize compared to raw flours. There was a significant increase in protein content (19.4%) of malted soy bean compared to raw soy. Earlier studies by Khader 1983, Mostafa 1987, Dhaiwal

and Aggarwal 1999, Dogra *et al*., 2001 also indicated the similar findings. The improvement in protein quality to changes in amino acids in malted soybean could be due to decrease in tannin content on sprouting (Dogra *et al*., 2001).



On germination increase in protein content of cereals was 10.7 (maize) to 31.6 percent (sorghum) and decrease in other nutrient content was observed (Table 2).

Grain sorghum is a crop with poor nutritional quality. Sprouting has been suggested as a means to improve nutritional quality of these grains (Wu and Wall 1980, Chaven and Kadam 1989, Bhise *et al*., 1988). Archana and Saritha (1997) reported that steeping of sorghum grains for 20 hours caused significant decrease in crude protein and then subsequent sprouting for 24 hours caused significant increase, followed by decrease up to 72 hours. Loss in dry weight (carbohydrates) during sprouting may show apparent increase in protein, weight loss of low molecular nitrogenous compounds during soaking and rinsing of grains causes decrease in crude protein on sprouting (Chavan and Kadam 1989). Increase in protein content of sorghum on 24 hours germination (Table 2) was 20 percent more than the reported value by Chavan and Kadam 1989 which may be due to differences in processing conditions and varieties of grains. The nutritional qualities of maize protein is poor, but during germination of maize nutritionally superior and metabolically active proteins are synthesized. Increase in protein content (Table 2) was in line with findings of Mendoza *et al* (1998). Malting of cereals brought an improvement only in the protein content.

Table 3. Proximate composition of raw and ready mixes
(Per 100g of edible portion)

	Wheat			Sorghum			Maize		
Variable	Raw	Ready mix	T- Value	Raw	Ready mix	T- Value	Malted	Ready mix	T- Value
Moisture (%)	9.60±0.06	9.61±0.08 (0.01%↓)	0.2274I	12.49±0.16	11.37±0.21 (8.65↓)	7.1997**	17.53±0.30	15.61±0.31 (10.9%↓)	7.5642**
Protein (g)	12.33±0.35	23.26±0.40 (88.6%↑)	35.3750**	9.53±0.30	22.46±0.11 (135.6%↑)	68.5974**	11.23±0.25	22.00±0.34 (9.7%↑)	43.5548**
Energy (Kcal)	361.53±1.27	378.00±0.51 (4.6%↑)	20.7548**	348.26±1.43	372.80±1.80 (7%↑)	18.3551**	342.63±0.63	365.16±8.18 (6.5%↑)	4.7526**
Fat (g)	1.87±0.01	5.29±0.04 (94.7%↑)	108.0972*	1.67±0.07	5.78±0.21 (246%↑)	25.6920**	4.06±0.04	7.04±0.02 (73.3%↑)	73.7984**
Ash (g)	2.26±0.05	1.20±0.01 (46.9%↓)	32.0023**	1.80±0.05	1.16±0.05 (35.5%↓)	18.9999**	1.40±0.02	1.26±0.05 (10%↓)	3.9997**
Fiber (g)	1.28±0.02	1.28±0.03 (Nil)	0.2697I	1.79±0.14	1.36±0.04 (2.4%↓)	5.0052**	2.63±0.07	1.62± 0.01 (38.4%↓)	22.9612**

Values in parenthesis indicate percentage of increase (↑) or decrease (↓) compared with raw
Values are mean ± SD
**Significant at (0.01%) (r>=0.606)
I Not significant

Table 4. Total and available iron content of malted cereals
(Per 100g of edible portion)

			Available iron (mg)							
	Total Iron (mg0		pH 1.35		%TI		pH 7.5		% TI	
Cereals	R	M	R	M	R	M	R	M	R	M
Wheat	5.64± 0.05	5.86± 0.03**	3.02± 0.03	3.52± 0.03**	53.79± 0.16	60.16± 0.90**	0.92± 0.01	1.17± 0.01**	16.38± 0.20	20.11± 0.20**
Sorghum	4.34± 0.06	3.45± 0.14**	1.57± 0.01	1.84± 0.06**	36.42± 0.21	0.35± 0.01**	0.76± 0.03	8.33± 0.14**	22.20± 0.14	22.27± 0.14**
Maize	2.62± 0.01	2.82± 0.01**	1.38± 0.01	1.77± 0.02**	52.73± 0.50	62.73± 0.03**	0.56± 0.02	0.96± 0.01**	21.94± 0.01	34.20± 0.01**

R: Raw M: Malted TI: Total Iron
Values are mean ± SD
** Significant at (0.01%) (r>=0.606)

Table 5. Total and available iron content of ready mixes incorporated with soybean flour
(Per 100g of edible portion)

Cereals	Total Iron (mg)		Available iron (mg)							
			PH 1.35		%TI		PH 7.5		% TI	
	M	RM	M	RM	M	RM	M	RM	M	RM
Wheat	5.86±0.03	10.34±0.06	3.52±0.03	5.75±0.07	60.16±0.90	54.86±1.44	1.17±0.01	2.10±0.03	20.11±0.20	20.36±0.22
Sorghum	3.45±0.14	5.03±0.06	1.84±0.06	5.03±0.06	0.35±0.01	57.51±0.45	8.33±0.14	1.68±0.02	22.27±0.14	19.32±0.11
Maize	2.82±0.0	7.59±0.07	1.77±0.02	4.29±0.03	62.73±0.03	56.66±0.26	0.96±0.01	2.15±0.02	34.20±0.01	28.46±0.13

M: Malted RM: Ready mix TI: Total iron
Values are mean ± SD
** Significant at (0.01%) (r>=0.606)
Not significant

Increase in protein content of flour milled from sprouted wheat was also reported in earlier studies by Lemar Swanson 1976, Ranhotra *et al*., 1977, Leelavathi and Haridas 1988, Uma Chithra 1994). Percent increase in protein content in the present study was similar with study of Uma Chithra (1994) and slightly more than other studies which may be due difference in environmental conditions, processing conditions and varietal differences.

The protein and fat content was almost doubled in ready mixes incorporated with 25% soy bean flour (Table 3). There was significant increase in all the components except fiber, moisture and ash contents in ready mixes compared to raw. In ready mixes, protein (62-79%) and energy (6-9%) content increased significantly due to incorporation of 25% percent soy malt, which is rich in protein and energy (Table 3). Ready mixes prepared with cereals and soy malts showed significant enhancement of all the nutrients. Protein and fat content in all the ready mixes was doubled (Table 3).Fat content was doubled (75-268%) in ready mixes due to high fat content (18%) of soy malt.

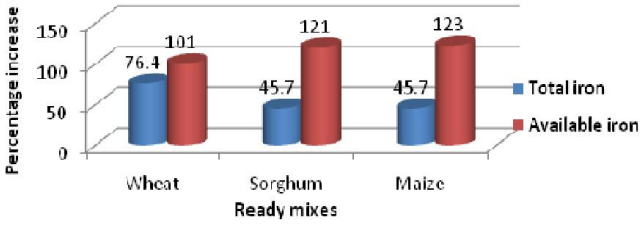
Total and available iron content of raw and malted flours

Sprouts are an extremely inexpensive method of obtaining a concentration of vitamins, minerals and enzymes. The changes in total and available iron content of the cereals varied with malting.

It was that the total iron content increased significantly in malted wheat (3.9%) followed by maize (Table 4). The increase in iron content may be due to dry matter losses as a result of respiration during germination whereas significant decrease in iron content was found in sorghum and maize malts. This could be due to leaching out of the nutrients while washing and soaking of the grains. Reduction of total iron after malting was also reported by others in malted sorghum (Bhise *et al* 1988, Pranathi das (1994). The reduction in iron content of sorghum was 6 percent less than the values reported in the earlier studies. The available iron content in terms of absolute amount (mg/100g) was highest (1.17mg) in malted wheat and least (0.90mg) in sorghum. The relative amount of available iron, expressed as percentage of total iron was found to be highest (34.2%) in malted maize and least (20.11%) in malted wheat. Similar observations were reported by Pranith das (1994). Increase in available iron could be due to structural change of protein-iron-phytate complex or due to the degradation of phytate in the malted samples (Radha and Shiva 1980).

Total and available iron content of cereal mixes fortified with 25% soy malt is presented in Table 5. Among the cereal ready mixes total iron content of wheat was highest (10.34 ±0.06) followed by maize and sorghum. The available iron content in terms of absolute amount was lowest in sorghum (1.68mg). The relative amount of available iron, expressed as percentage of total iron was found to be highest in maize mix (28.46%) followed by wheat and sorghum. The percent increase of total and available iron content of maize mix was higher than other cereals. Higher availability of iron in malted maize may be the reason for the higher availability of iron in maize mix. (Fig 3)

Fig 3: Per cent increase in total and avilable iron in ready mixes



Product formulations and testing the consumer acceptability of ready mixes

The products like laddoo and roti prepared with 25% incorporation of malted soy and 10% commercial soy flour was acceptable. Hence, the proportion of 25: 75 was found to be accepted among the all proportions studied from all millets. This was higher than the study results reported by Anuradha and Sangeetha (2001), who incorporated with soy malt at 20% level in biscuits. Difference in acceptability may be due to variations in products and processing methods

Effect of storage on overall acceptability scores of soy incorporated cereal based ready mixes

It is evident from the table 6 that sensory evaluation of ready mixes by wheat and sorghum fortifying with soy bean were acceptable for 21 days and 14 days respectively. The variations in the mean scores for maize ready mix were observed from 7th day onwards.

Table 6. Effect of storage on overall acceptability scores of soy incorporated cereals ready mixes
(Per 100g of edible portion)

Cereal ready mix	Overall acceptability scores				
	Initial	7th day	14th day	21st day	28th day
	OA	OA	OA	OA	OA
Wheat	4.70±0.78	4.40±0.52	4.10±0.74	3.49±0.67	2.20±0.70
Sorghum	4.60±0.51	4.50±0.53	3.80±1.03	3.20± .52	2.10±0.74
Maize	4.30±0.82	3.80±0.63	3.50±0.53	1.50±0.53	-

Values are mean ± SD
OA – overall acceptability

Ready mixes prepared using wheat/ maize/sorghum malt and soy malt in the proportion of 3:1 was stored at room temperature for 28 days. Products prepared with wheat, sorghum ready mixes stored for 21 days and with maize for 14 days were acceptable. It was also observed there was a constant increase in moisture content with increase in storage period. This may be the reason for decreased acceptability of ready mixes prepared with cereal ready mixes after storage. Incorporation of 25% of full fat soy malt may be the reason for increase in moisture content and low storage stability, due to the presence of highly unsaturated fats and loss in functional properties of such high protein flour. Being hygroscopic, soy flour may absorb moisture from the atmosphere resulting in increased free fatty acidity (FFA). High moisture along with high temperature adversely affects the nitrogen solubility index. Moisture content of maize mix (15.6%) may be the reason for poor storage stability when compared to other two mixes.

Conclusion

The results of the study revealed that malting of soybean significantly increased protein content and doubled total and available iron content. Malting of cereals brought an improvement (25%) in the protein content only. Ready mixes prepared with cereal and soy malts (3:1) showed significant improvement in all nutrients. Malting resulted in slight increase of total iron in wheat and maize, and a decrease in sorghum. In ready mixes, total iron content was found to be highest in maize followed by wheat and sorghum mix. Acceptability of ready mixes was in agreement with 1:3 ratios. Sorghum, wheat ready mixes and maize mixes incorporated with 25 grams of malted soy flour was stored for 21 days and 14 days respectively at room temperature were acceptable.

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