Effect of Malting on the Nutritional Composition, Anti-nutrition Factors and Mineral Composition on Sorghum (*Sorghum bicolor*)

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ABSTRACT

Background: Sorghum (*Sorghum bicolor*) is commonly named as Jowar, belongs to family Framineae. The presence of anti-nutrients affect the nutritional values by limiting protein and starch digestibility, hinder mineral bioavailability. This can be reduced by malting procedures. Hence, the study was undertaken to study the effect of malting on nutritional composition, anti nutritional factors and mineral composition.

Methods: Processing methods include soaking for 24 hr and germination for different time periods and drying in hot air oven for 2-3 hr. at 50°C. The yield of malted sorghum flour is 95 g/100 g.

Result: Nutrient composition include moisture, protein, fat, ash, crude fibre, carbohydrate and energy showed that the sorghum germinated for 3 days has the higher value of 6.7%, 11.37 g, 3.27 g, 1g 2.4 g 73.57g 375/100 g respectively. The micronutrients *i.e.* calcium and iron content of malted flour was significantly increased ($p<0.05$) to 28 mg/100 g, 5.83 mg/100 g. Anti-nutrients like Tannin and Phytate decreased subsequently in three day germinated sorghum to 61.2 mg/100 g, 50.625 mg/100 g respectively. The result showed that processing increases the nutritional, mineral composition and decreases theanti-nutritional factors in sorghum. Hence, Sorghum has potential in fortification of food productsand its suitability of utilization in formulation of value added food products.

Key words: Anti-nutritional factors, Mineral composition, Nutritional analysis, Sorghum malting.

INTRODUCTION

Sorghum (*Sorghum bicolor*) is commonly named as Jowar, the “King of millets”. Sorghum is member of the family Gramineae and is one of the staple cereals for millions of people, particularly in Africa, India and central Asia, as a major source of starch and protein. Sorghum rank fifth important cereal crop among the world, after rice, wheat, maize and barley, often considered as subsistence crops because of unique and notable tolerance to drought, grown in arid and semi-arid tropical regions. The major sorghum plantation areas in India are Maharashtra, Karnataka, Uttar Pradesh and Tamil Nadu. Across world include Australia, Mexico and United States (FAO 2005).

India has the largest share (32.3%) of the world’s area under sorghum and ranks second in production after the US. The sorghum crop is grown in the world in over 45 million hectares and accounts for production of 65.53 million tons of grains with an average yield of 1459.2 kg/ha (FAO, 2009). Nearly 80% of the cultivated area lies in Asia and Africa. In India and Karnataka, sorghum cultivation production average is 9.0 million tones and 1.85 million tons from an area of 10.3 million hectares and 2.3 million hectares with productivity of 874 kg per hectare and 1122 kg per hectare, respectively (Tuinstra, 2008).

Sorghum is locally used in wide range of food preparations (thick and thin porridges, steam-cooked and boiled rice-like products, fermented and unfermented breads and snack foods. But Sorghum is found to contain many antinutritional factors such as, tannins, phytic acid, proteinase inhibitors and cyanogenic glycosides. Tannins are reported to interact with proteins (both enzymes and non-enzyme proteins) to form tannin-protein complexes resulting in inhibition of digestive enzymesPhytic acid is found to form complex with minerals, leading to lower mineral bioavailability, So it is necessary to identify ways of removing these undesirable compounds (Rahman *et al.,* 2011).

Malting, which involves soaking, germination and drying, aims to change grains into malt with high enzymes and vitamins content. Malting induces important beneficial

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biochemical changes in sorghum grains. Indeed, soaking generates grain softening and increase water availability. The enzymes will be produced during germination lead to the hydrolysis of starch and proteins with release of sugar and amino acids directly available. Proteolytic enzymes improve amino acid availability, particularly lysine, methionine and tryptophan that are lacking in cereals and contribute to the reduction of phytate level of grain and improve iron and zinc availability (Omary *et al.,* 2012).

Therefore, the study was conducted to investigate effects of malting on Nutritional composition, tannins, phytic acid content and mineral composition of sorghum cultivars for formulation of weaing foods that provides products of low viscosity and high energy density, because of the relatively higher amylolytic capacity of sorghum.

MATERIALS AND METHODS

Procurement of sample

Sorghum (*Sorghum bicolor*) was procured from Department of Agronomy, University of Agricultural Science, GKVK (Gandhi Krishi Vignan Kendra), Bangalore.

Malting of sorghum

Soaking

Sorghum grains were soaked in water for 24 hr and the soaked water was changed twice. At the end of soaking period, the soaked water was discarded.

Germination

The soaked grains were germinated for three different periods of 24, 48 and 72 hr. they were placed in room temperature, covered with cotton cloth and then the germinated grains were dried.

Drying

The germinated grains were dried using hot air oven at 50°C for 3-4 hrs, until the moisture content reached 5.6% and the root and shoot portions were manually removed. The grains were milled into fine powder and packed in air tight container.

Procurement of sample
↓
Cleaning and sorting
↓
Soaking for 24 hours
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Germination for 1-3 days
↓
Dried in hot air oven at 50°C for 3-4 hr.
↓
Milling into fine flour
↓
Sieving and packing

Fig 1: Flow chart of Malting of sorghum.

Nutritional composition of Malted sorghum

Malted sorghum flour prepared with different germination periods was analyzed for proximates such as moisture, protein, fat, crude fiber, ash, carbohydrates, energy and mineral composition *i.e.* Calcium and Iron were analyzed by following standard protocol (Association of official agricultural chemist AOAC, 1980). Anti-nutritional factor such as Phytate and tannin was estimated by standardprotocol (Katoch, 2011 and Sadashivam and Manickam 1991).

Statistical analysis

The statistical analysis was done using Microsoft Ex-cel and SPSS software. One-way analysis of variance (ANOVA) was applied for sensory parameters to analyze difference between incorporation levels of malted sorghum. Nutritive value analysis was subjected for F test. Significant difference was defined as $p \leq 0.05$.

RESULTS AND DISCUSSION

Research findings pertaining to nutritional composition, anti-nutritional factors and mineral composition are presented with following subheadings.

Malting of sorghum grain

Sorghum grain was subjected to different processing technique like soaking for 24 hour and germination for 24 hour, 48 hour and 72 hour and dried at 50°C for 3-4 hours in hot air oven and milled to fine powder. Per cent recovery of the malted sorghum flour is 93 per cent. The main reason for decrease in malted sorghum powder weight is drying which results in loss of moisture. Removal of vegetative growth and milling loss contribute to significant reduction in recovery of flour.

Nutritional composition of malted sorghum

Moisture

Moisture content of any food ingredient greatly decides the shelf-life and possibility of increased hydrolytic rancidity. The low moisture content is an index of stability, quality and increased shelf- life of grains. Moisture content of the malted sorghum flour ranged from 6 to 6.7 per cent, the highest moisture content was in 72 hr germinated sorghum (6.7) followed by 48 hr (6.67) and 24 hr germinated sorghum (6). The difference observed in moisture content was not statistically significant.

Protein

The results obtained in this study showed that Protein content of processed sorghum flour indicated significant ($P<0.05$) difference. It ranged from 9.37 to 11.37 g. The highest protein content was found in 72 hr germinated sorghum (11.37 g) followed by 48 hr germinated sorghum and lowest protein content was observed in 24 hr germinated sorghum flour (9.37 g) respectively.

Suhaidi (2003) suggested that soaking lead changes in the biology of the breakdown of the various components into simpler compounds. However, during germination, protease enzyme increases and is involved in the degradation of peptide component to amino acids and the amount of protein will increase.

Laetitia *et al.* (2005) suggested that protease enzymes break down the peptide bonds into proteins and produces amino acids. An increasing number of proteins have occurred during germination due to the presence of synthesis processes in the process of soaking.

Fat

The range of fat content in the sorghum seeds analyzed was 3.27 g to 1.87 g (Table 1). As the soaking and germination time increases, the fat content decreased. The soaking process can decrease the fat content of sorghum grain due to absorption of water after the enzyme is activated and then into the endosperm and digest food reserve substance. Lipase enzymes break down fats into glycerin and fatty acids and since these compounds are water soluble, they can diffuse into the cells tissue. Similar results were observed by Inyang and Zakari (2008) who reported that during germination of the seed, the decreasing in the amount of fat is due to the increased activity of lipolytic enzymes during germination, which hydrolyzed the fats into fatty acid and glycerol. Whilst Kiranawati (2002) noted that fatty acids is reduced as a result of reforms in the cell. Glycerol dissolved in water and transported by the Krebs cycle to metabolism in cells whereas fatty acids also dissolved in water.

Ash

Ash refers to any inorganic material, the powdery residue left after the burning of a substance. Ash content of processed sorghum flour is from 1 to 1.12 g. The difference observed in ash content was not statistically significant

Table 1: Recovery of sorghum flour after processing.

Parameters	MSF1	MSF2	MSF3
Initial weight of sorghum (g)	100	100	100
Weight of sorghum after germination (g)	120	116	117
Weight of sorghum after drying	95	96	95
Milling loss (g)	7	6.5	7
Recovery of powder after sieving (g)	93	93	93
Per cent recovery (%)	93	93	93

MSF1- 24 hr malted Sorghum flour, MSF2- 48 hr malted Sorghum, MSF3- 48 hr malted Sorghum.

Crude fiber

With regards to the fiber content of the sorghum seeds, Data from Table 2 showed variation in crude fiber content of processed malted sorghum from 2.0 to 2.4 g. The highest crude fiber content was in 72 hr germinated sorghum (2.4 g) followed by 48 hr and 24 hr germinated sorghum (2.0 and 2.2 g). The difference observed in crude fiber content was statistically significant at 5 per cent level.

Soaking process could decreased fiber content as sorghum contained soluble and insoluble fiber in water. Therefore, the longer soaking process may reduce water-soluble fiber content of sorghum seed namely β-glucan

Narsih *et al.* (2012) reported fiber content was lowest of 0.87% found at soaking time of 72 h and germination time of 36 h and the highest of fiber content in sorghum was 1.68% found at soaking time of 24 h and germination time of 12 h This indicates that germination process affect the level of crude fibre during the period of soaking before the actual phase of germination

(Muyanja *et al.*, 2001) reported that the crude fiber content increases during germination of millet grains. The amount of crude fiber was contributed by the presence of bran layer, an outer layer of grain that contained fiber.

Carbohydrate

Carbohydrates are naturally occurring sugars, starches and fiber in food. Carbohydrate content was reduced by processing such as germination. The reduction in carbohydrate content observed ranged from 79.5 to 73.5 g. The lowest carbohydrates content was in 72 hr germinated sorghum (73.5 g) followed by 24 and 48 hr germinated sorghum (78.2 and 79.5 g). The difference observed in carbohydrate content was statistically significant at 5 per cent level among variations.

The sorghum contains maltose, glucose and fructose but during germination the level of germination gets increased because of conversion of maltose and fructose to glucose, due to activities of α-amylase and β-amylase enzymes, which increase with soaking and subsequent germination.

The results of soaking, germination and heating related with decrease in total carbohydrate and increase in sugars (total, reducing and nonreducing) are in agreement with those of germination effect study by (Tatsadjieu *et al.*, 2004)

Table 2: Proximate composition of variation in malted sorghum flour (100g).

Sorghum Variations	Moisture (%)	Protein (g)	Fat (g)	Ash (g)	Crude fiber (g)	CHO (g)	Energy (Kcal)
MSF1	6	9.37	3.27	1.17	2.07	79.53	369
MSF2	6.67	10.58	1.87	1	2.2	78.23	368
MSF3	6.7	11.37	1.87	1	2.4	73.57	376
F-value	NS	*	*	NS	*	*	NS
S.Em±	1.72	0.11	0.74	0.09	0.03	0.73	7.86
CD at 5%	5.95	0.38	2.57	0.33	0.13	8.38	27.23

*Significant at 5% level. MSF1- 24 hr malted sorghum flour, MSF2- 48 hr malted sorghum flour, MSF3- 72 hr malted sorghum flour.

and germination effect study on sorghum by (Neelam and Chauhan, 1990).

Energy

Energy content of malted sorghum ranged from 369 to 376 Kcal. Germinated sorghum for 72 hrs recorded higher energy value (376 Kcal) followed by 48 hr and 24 hr germinated sorghum (368 and 369 Kcal). The difference observed in energy value was not statistically significant.

The study was done by El-Beltagi *et al.* (2012), reported germination increase the crude protein from 10.62-12.46 per cent, fat 2 per cent and ash 1 per cent. Significant reduction in carbohydrate levels upon germination is due to increased amylase activity and breakdown of glucose molecules.

Similarly, the findings of Narsih *et al.* (2012) reported that germination and soaking time improves the nutritional quality of sorghum and reported the values for protein (8.03%), fat (1.64%), fiber (1.45%) and ash (2.24%). These findings are in supportive to present research.

Anti- nutritional content of malted sorghum

Anti-nutrients are natural or synthetic compounds found in a variety of foods, especially in grains, beans, legumes and nuts that interfere with the absorption of vitamins, minerals and other nutrients. They can even get in the way of the digestive enzymes, which are key for proper absorption. This can be reduced by soaking, cooking and germination. Anti-nutrients such as tannin and phytic acid were analyzed and the results are depicted in Table 3 and Fig 1.

Tannin

Tannin content in processed sorghum was reduced and it ranged from 61.2 to 329 mg/100 g. The difference observed in tannin content was statistically significant (P≤0.05). Tannin content was reduced more in 72 hr malted sorghum (61 mg) compared to 48 and 24 hr malted sorghum (106 mg and 329 mg) respectively. Statistically significant difference at 5 per cent level was observed.

Phytate

Phytic acid content in processed sorghum reduced from 191 to 50.6 mg/100 g. Result showed that 72hr germinated sorghum showed less phytic acid content (50.6 mg) followed by 48 hr germinated sorghum (80.6 mg) and highest phytate was found in 24 hr germinated sorghum (191 mg). ‘F’ tests revealed that germinated sorghum showed significant difference with respect to Phytate content at 5 per cent level. Milling processes in which cereal grains are dehulled and the outer bran layers are eliminated can decreases the phytic acid content of the milled cereal product by up to 90%. Soaking, germination and fermentation can reduce phytic acid by activating the enzyme phytase naturally found in cereals and legumes, these processes along with dehulling and milling of the grain product can reduce phytic acid by 40% to 100% (Sharma, 1994).

Ojha *et al.* (2018) reported that Phytic acid content of whole sorghum flour was 180 mg/100 g and after malting it reduced to 120 mg/100 g of sorghum. Similarly malting reduced the tannin content of sorghum flour to 260 mg/100 g respectively, while unprocessed whole sorghum flour contained 310 mg/100 g.

Also, Tizazu *et al.* (2011) reported that 36 hr germinated sorghum contain high Phytic acid of 255.66 mg/100 g and in 48 hr germinated sorghum significantly reduction in the Phytate to 190.11 mg/100 g was observed

Micro nutrient composition of malted sorghum

Mineral element constitute an important group of nutrients required by the human body for optimal functioning. Mineral content such as calcium and iron were analyzed and the results are depicted in Table 4, Fig 2.

Calcium (mg)

The calcium content of processed sorghum flour ranged from 25 to 28 mg. The difference observed in calcium content was statistically significant (P≤0.05). Calcium content was higher in 72 hr Germinated sorghum (28 mg) followed by 48 and 24 hr germinated sorghum (27.38 mg and 25 mg). Statistical analysis showed significant difference at 5 per cent level among variations

Table 3: Anti-nutritional content of malted sorghum (mg/100g).

Sorghum samples	Phytate (mg)	Tannin (mg)
MSF1	191.9	329mg
MSF2	80.6	106mg
MSF3	50.6	61mg
F-value	*	*
SEm±	0.152	0.043
CD (P≤0.05)	0.527	0.149

*Significant at 5% level. MSF1-24 hr malted sorghum flour, MSF2-48 hr malted sorghum flour, MSF3- 72 hr malted sorghum flour.

Table 4: Micro nutrient composition of malted sorghum (mg/100g).

Sorghum samples	Calcium (mg)	Iron (mg)
MSF1	25	4.50
MSF2	27.38	5.63
MSF3	28	5.83
F-value	*	*
SEm±	0.441	0.092
CD (P≤0.05)	1.527	0.319

*Significant, MS1-24 hr malted sorghum flour, MS2- 48 hr malted sorghum flour, MS3- 72 hr malted sorghum flour.

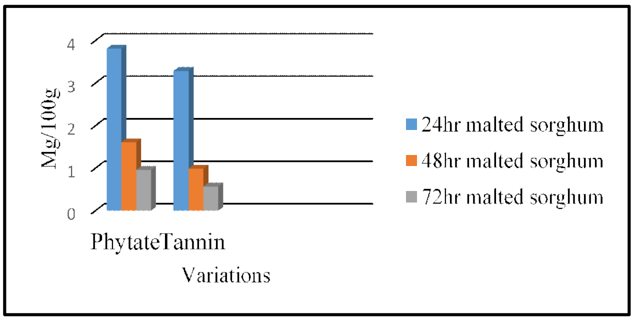

Fig 1: Anti- nutrients in malted sorghum flour.

Iron (mg)

The iron content of malted sorghum flour ranged from 4.5 to 5.83 mg. The highest iron content was in 72 hr germinated sorghum (5.83 mg) followed by 48 hr (5.63) and 24 hr germinated sorghum (4.5). The difference observed in iron content was statistically significant at 5 per cent level.

Gerrano *et al.* (2016) studied on mineral composition of sorghum variety. Results revealed that calcium content varied from 27.5 to 32.7 mg/100 g based on genetic factors and varieties. Iron content varies from 3.8 to 5.5 mg/100 g. The present findings are having the results in the same range.

Hassani (2014) reported on effect of processing on mineral content of sorghum. They found 100 grams of sorghum had 10.5 to 12.5 mg of calcium, 3.8 to 4.5 mg of iron respectively a nearby value is obtained which is in accordance with the present study.

CONCLUSION

Sorghum has good nutritional value but its utilization is limited due to its grittiness and high fiber coating interfering with protein and starch digestibility. Sorghum grain contains Anti nutritional factors thatbind minerals in the gastrointestinal tract making dietary minerals unavailable for absorption and utilization by the body. This can be reduce by malting which improves proteindigestibility and reduce Anti nutritional factors.Treatment with the combination of soaking for 24 h and germination for 72 h increases the nutritional value of sorghum. Better taste and superior nutritive value of sweet sorghum justifies its suitability of utilization in formulation of value added food products. Hence Sorghum has potential in fortification with pulses to replenish the nutrients that are lost during processing.

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