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Effect of supplementation of malted sorghum flour on sensorial quality attributes of muffins and *murukkus*

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Abstract
Sorghum (Jowar) (Sorghum bicolor Moench) grains were malted to reduce the antinutritional factors (ANFS) which exert effects contrary to optimum nutrition. Sorghum has a significant advantage over wheat or maize that it is gluten free therefore; it is a best suitable option for the celiac patients to substitute the millet as their regular cereal. Out of all the processing treatments malting was the most effective processing treatments to reduce the phytic acid and tannic acid content. Malting resulted in 58.6 % reduction in phytic acid and 66 % reduction in tannic acid respectively. Although the consumption pattern of foods varies from person to person, the demand for instant foods are always on rise. The processed i.e. malted sorghum flour is used in the development of instant products like muffins and fried/baked murukkus and were evaluated by the panel of members. Muffins were tried with 50 % and 90 % replacement in refined flour, whereas fried/ baked murukkus were tried with 40 % and 60 % replacement in rice flour. Muffins with 50 % replacement were more accepted, whereas fried/ baked murukkus with 40 % / 40 % were more accepted.

Keywords: sorghum, malting, muffins, Fried/Baked *Murukkus*

1. Introduction

Sorghum is known under variety of names; great millet and guinea corn in West Africa, kafir corn in South Africa, Dura in Sudan, and *jowar* in India. Sorghum belongs to the tribe Andropogonae of the grass family Poaceae. Sorghum is treated as an annual, although it is perennial grass and in the tropics it can be harvested many times. Sorghum is number five after wheat, rice, maize and barley in terms of production (FAO, 2005) [11]. It feeds approximately 300 million people mainly in Africa and Asia (Leder, 2004) [22]. United states (US) is the number one producer, followed by Nigeria, Sudan, Mexico, China, India, Ethiopia, Argentina, Burkina Faso, Brazil and Australia (Dicko *et al*. 2005) [8]. It is widely used as animal feed and for ethanol production in US and other developed countries (Godwin and Gray, 2000) [15]. Whereas in Africa and Asia it is consumed as human food and animal feed (Anglan, 1998; Mahgoub *et al*. 1999; Yetneberk *et al*. 2004) [1, 25, 45].

Sorghum also find important use as a cereal base for low dietary bulk and calories dense weaning foods, supplementary food, health foods and also amylase rich food (Malleshi and Desikachar 1982; Gopaldas *et al*. 1986) [27, 16], with values ranging from 56 to 73 %, the average starch content of sorghum is 69.5 % (Jambunathan and Subramanian, 1988) [19]. About 70 to 80 % of the sorghum starch is amylopectin and the remaining 20 to 30 % is amylase. In Milled sorghum flours minerals such as phosphorus, iron, zinc and copper decreased with lower extraction rates. Sorghum and millets in general are rich sources of B- complex vitamins. Detectable amounts of other fat soluble vitamins, namely D, E and K have also been found in sorghum grain. On germination, some amount of vitamin C is synthesized in the grain (Taur *et al*. 1984) [37]. Among B - group vitamins, concentration of thiamine, riboflavin and niacin in sorghum were comparable to those of maize (Hulse *et al*. 1980) [18]. It is a rich source of vitamin B-complex and tocopherols (Dykes and Rooney, 2006) [9]. It was observed that 80- 90 % of the niacin in sorghum grains was in bound form and was available for the growth of the microorganisms used for the niacin assay only after alkali treatment (Ghosh *et al*. 1963) [14]. Other B-complex vitamins present in significant amounts are vitamin B_6 0.5 mg/100g, folacin 0.02 mg, pantothenic acid 1.25 ma and biotin 0.042 ma (United States National Research Council (USNRC)/ National Academy Of Sciences (NAS), 1982).

Sorghum is often recommended as a safe food for celiac patients because it is more closely related to maize than to wheat, rye, and barley (Kasarda, 2001) [21]. Sorghum might therefore provide a good basis for gluten-free products. Celiac disease is a syndrome characterized by damage to the mucosa of the small intestine caused by ingestion of certain wheat proteins and related proteins in rye and barley (Fasano and Catassi 2001) [12]. The gliadins of wheat gluten contain protein sequences toxic to persons with celiac disease (Kagnoff *et al*. 1982) [20]. Recent work has also shown that glutenins of wheat contain toxic sequences (van de Wal *et al*. 1999; Wieser *et al*. 2004). Modern screening studies show that celiac disease is much more prevalent than previously thought; the average worldwide prevalence is estimated as high as 1:266 (Fasano and Catassi, 2001) [12].

Certain other health benefits associated with sorghum are they content some phenolic compounds which can decrease the risk of cardiovascular (Carr *et al*. 2005) [4]. Sorghum is excellent in antioxidant activity (Dykes *et al*. 2005) [9]. Moreover sorghum is efficient enough in cholesterol lowering (Klopfenstein *et al*. 1981), anti- inflammatory (Ziyan *et al*. 2007) [46], anti- cancer and anti- allergic properties (Yang *et al*. 2009) [43].

Snacks contribute an important part of many consumers in daily nutrients and calories intake (Detweiler, 1991) [7]. The nutritional awareness amongst the consumers has warranted the production of low calorie food products with an increased fibre content that can be readily included in the balanced diet. Muffins and *murukkus* are predominately based on refined wheat flour (RWF) and the blending of RWF with millet can upgrade the nutritional quality of such products. The use of composite flours in the production of baked products especially baked products especially in bread, cookies, crackers that are targeted at consumers who are gluten sensitive or diabetic (Lovis 2003) [24]. Millets are rich source of dietary fibre, phytochemicals, micronutrients, nutraceuticals, and hence now a days they are rightly termed as nutricereals.

Muffins and *murukkus* may be regarded as relatively simple cereal based food products commonly consumed as snack food to answer the occasional pangs of hunger. Muffins are quick-baking bread and have become a tea-table staple. They are usually split, toasted, buttered and then eaten with a savory or sweet topping such as honey. There are many varieties and flavors of muffins made with a specific ingredient such as blueberries, chocolate chips, cucumbers, raspberry, cinnamon, pumpkin, date, nut, lemon, banana, orange, peach, strawberry, boysenberry, almond, and carrot, baked into the muffin. Muffins are often eaten for breakfast; alternatively, they may be served for tea or at other meals. *Murukkus* is a savory snack popular in India and Sri Lanka, originating in the cuisine of the Indian state of Tamil Nadu. It is also popular in places with large Tamil populations, such as Fiji and Malaysia. *Murukkus* is typically made from a mixture of split black gram dal and rice flour, salt, and flavorings such as chili, asafoetida, ajawain, cumin seeds and other spices (The Hindu, 2010).

2. Materials and methods

2.1 Raw material

Dehusked Sorghum (*Jowar*) was procured from local market, Delhi. The millet was cleaned of all the foreign materials. Standards of Tannic acid and phytic acid and other reagents were procured from MERCK. Other ingredients like refined wheat flour, rice flour, castor sugar, butter, milk, eggs etc. for the preparation of muffins and *murukkus* are also procured from local market of Delhi.

2.2 Preparation of processed sorghum flour

Malting Finger millet malt (FMM) was prepared according to the method given by Pathirana *et al*. (1983) [29] with slight modifications. Finger millet grains were steeped for 18 h at room temperature and allowed to sprout for 120 h. Grains were dehydrated for 60 mins at 60°C. Further rootlets of grains were removed and powdered to obtain flour for later usage.

Germination Germinated finger millet was prepared by the method given by Srilakshmi (2003) [36]. Grains were steeped for 24 h at room temperature allow it to sprout for 48 h. Grains were dehydrated for 60 min at 60°C. Grains were powdered to obtain flour for later usage

Blanching Finger millet was prepared according to the method given by Sharma (2006) [35].Grains were steeped in boiling water for 2-5 min, and then immediately transferred in cold water for 2-5 min. Grains were removed and dehydrated for 60 min at 60°C. Grains were powdered to obtain flour for later usage.

Pressure cooking Finger millet was pressure cooked according to the method given by Sharma (2006) [35]. Grains were steeped for 24 h at room temperature, pressure cooked for 5 min. Grains were removed and dehydrated for 60 min at 60°C. Grains were powdered to obtain flour for later usage.

Roasting Finger millet was prepared according to the method given by Sharma (2006) [35]. Grains were dehydrated for 60 min at 60°C. Grains were powdered to obtain flour for later usage.

2.3 Biochemical analysis of processed sorghum flour

Tannic acid estimation in processed sorghum flour Processed sorghum flour (0.5g) obtained after different processing treatments were extracted in 70 mL distilled water for 30 min at 70-75 °C. Tannic acid was determined calorimetrically given by Folins –Deniswithslightmodifications(AOAC 1970). During the reaction, tannins like compounds reduce phosphotungstomolybdic acid in alkaline solution to produce a highlycoloredbluesolution,theintensityofwhich is proportional to the amount of tannins.The intensity of which was measured in a spectrophotometeratnm (Sadasivam and Manickam 1996).

Phytic acid estimation in different processed sorghum flour Processed sorghum flour (0.5 g) obtained after different processing treatments were extracted with 30 mL of 0.2 N Hydrochloric acid on magnetic stirrer. The extracts are then centrifuged at 2000 rpm for 20 min. Supernatants were collected and utilized for the analysis. Phytic acid was determined calorimetrically given by Haug and Lantzsch with slight modification. It is an indirect method hereby the sample extracts were reacted with an acidic iron-3- solution along with known iron content. The decrease in iron content was determined calorimetrically with 2, 2'- bipyridine in the supernatant which was a measure for the phytic acid content (Sadasivam and Manickam 1996; Haug and Lantzsch 1983) [17].

2.4 Development of muffins and *murukkus*

The refined wheat flour and the malted sorghum flour were mixed in the required proportions for muffins preparation; similar blend will be used for *murukkus* preparation with rice flour and malted finger millet flour. The various blends were sieved thrice to ascertain through mixing. The process adopted for muffins and *murukkus* was as per the method elaborated in 'The art and science of cooking' by Khaana and Gupta (2001) and *murukkus* as per Sanjeev Kapoor's recipe. The muffins and *murukkus* were cooled for 30 min and stored in air-tight containers. The muffins were developed using the basic recipe given in Table 1 and two different varieties of *murukkus* baked/ fried were developed using recipe given in Table 2.

Table 1: Basic recipe for preparing muffins

Ingredients	Amounts (g)
Refined flour	55
Butter	35
Castor sugar	55
Egg	1
Milk	15 ml
Baking powder	½ t
Cocoa powder	10
Choco chips	10
Chocolate essence	2 drops

Table 2: Basic recipe for making murukkus (fried/baked)

Ingredients	Amounts (g)
Rice flour	80
Washed black gram dal	20
Cumin seeds	¼ t
Asafoetida	¼ t
Salt	½ t
Refined oil (for dough)	35

2.5 Sensory evaluation
Sensory evaluation was done on freshly made muffins and *murukkus*. Fifty panel members of Institute of Home Economics including faculty and Masters Students were randomly chosen for evaluating sensory attributes of freshly prepared muffins and *murukkus*. The attributes evaluated were appearance, colour, texture, after taste, overall acceptability. For each sample of both muffins and baked/ fried *murukkus*, panelists scored their liking of these characteristics using the five point hedonic scale (1= unsatisfactory, 2= satisfactory, 3= good, 4= very good, 5= excellent)**.**

2.6 Data analysis
The data was analyzed by ANOVA followed by Tukey's HSD test for significant differences ($p< 0.05$).

3. Results and Discussions
3.1 Biochemical analysis
Chemical analysis of sorghum for antinutritional factors was done. Results in figure 1, indicate that malting showed the maximum reduction in both Tannic acid as well as Phytic acid contents, followed by blanching. Both malting and blanching reduces Tannic acid content similarly by 66 %. Phytic acid content of blanched sorghum was reduced by 58.6 % and 35.7 % respectively. Similarly, in another study, it has been reported by Wadikar *et al* (2006) that there was 3.4 % and 18.3 % reduction in tannic acid content after puffing in case of hilly and base region varieties respectively. Results of another study by Pawar *et al* (1997) reported that blanching reduces phytic acid by 38 % in foxtail millets.

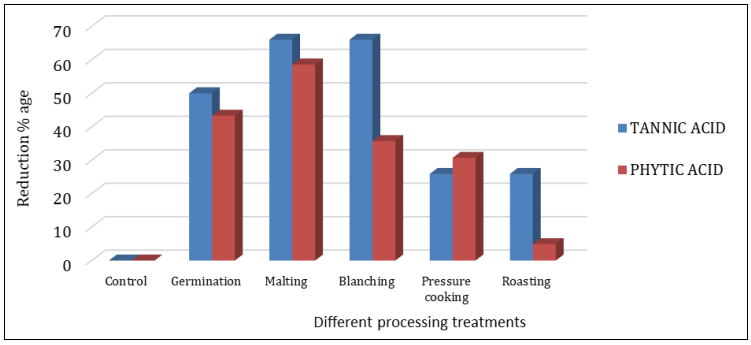

Fig 1: Reduction % age of Tannic acid and Phytic acid content in sorghum subjected to different processing treatments

The destruction of tannic acid content was by almost all the processing treatments. Malting & blanching was most effective treatment to reduce the tannic acid content. Germination also reduced the tannic acid content by half that of the control. In blanching reduction is due to leaching of tannic acid during steeping which may account for some of this loss. In malting reduction may be attributed to the activation of polyphenol oxidase and to the hydrolysis of tannic- protein and tannic- enzyme complexes which results in reduction of tannic acid. Similar reduction pattern for tannic acid content in pearl millet was reported by Archana *et al* (1998).

Similar trends are also seen in phytic acid content by almost all the processing treatments. A destruction of phytic acid was produced by almost all the processing treatments. Among all the processing treatments, malting was most effective in decreasing the phytic acid content. Loss of phytic acid content during malting may be attributed due to leaching of phytate ions into the soaking medium under the influence of concentration gradient. Such losses may be a function of the changed permeability of the seed coat. Reduction may also be attributed to the increased activity of phytase enzyme during sprouting. A marked decrease in phytic acid content in pearl millet by malting has been reported by Opoku *et al* (1981).

A study by Ramakrishna *et al* (2006) reported that in Indian beans after germination of 96 h and 48 h, the reduction in tannic acid was 85 % and 78 % respectively. Another study by Bau *et al* (1997) reported that there was 17 % reduction in phytic acid content in soya bean seeds after 5-day germination. Study reported by Yasmin *et al* (2008) also reported that there is reduction in phytic acid content of kidney beans after long h of sprouting due to an increase in the phytase activity, leading to solubilization of phytates.

3.2 Standardization and development of products using sorghum malt flour
3.2.1 Sorghum malt muffins
In Table 3, different levels of malted sorghum were tried to

replace the maximum amount of refined wheat flour in standardized recipe. It is important to incorporate maximum amount of malt powder to make muffins more nutritious containing nutrients with high bioavailability, easy digestibility and quick & easy utilization by the body. Therefore, an attempt was made to incorporate malted sorghum at two different levels.

Table 3: Muffins prepared with malted sorghum flour incorporation at different levels

Variations	Ingredients							Remarks
	Refined wheat flour (g)	sorghum flour (g)	Butter (g)	Castor sugar (g)	Egg	Baking powder (g)	Cocoa powder (g)	
(20 %)	44	11	35	55	1	¼ t	¼ t	Taste – Good; Texture-Good
(30 %)	38.5	16.5	35	55	1	¼ t	¼ t	Taste – Good; Texture–Good
(50 %)	27.5	27.5	35	55	1	¼ t	¼ t	Taste – Good; Texture–Good
(90 %)	10	45	35	55	1	¼ t	¼ t	Taste- Acceptable aftertaste; Texture Good, soft
(100 %)	0	55	35	55	1	¼ t	¼ t	Taste – Bitter

Results in Table 3, indicates that variation I and II had good taste and texture with no after taste whereas variations III apart from having good taste and texture, had significant amount of sorghum malt flour i.e. 50 %. On the other hand, variation IV also had a good taste and the slight after taste of sorghum was liked by all and acceptable. Variation V had bitter taste and sticky texture and was unacceptable. Therefore, out of all the variations the two variations were selected i.e. Variation III and variation IV were finalized for sensory evaluation by panelists (40) which included faculty members and students of Masters in Foods and Nutrition Department, Institute of Home Economics, Delhi University who analyzed the product. Hence, optimum incorporation level of sorghum malt in muffins for final recipe was 50 % and 90 %.

Table 4: Different levels of malted sorghum used for final sensory evaluation of muffins

Ingredients	Amounts (g)	
	50 %	90 %
Refined wheat flour	27.5	10
Sorghum malt flour	27.5	45
Butter	35	35
Castor sugar	55	55
Egg	1	1
Cocoa powder	3	3
Baking powder	¼ t	¼ t
Milk	50 ml	50 ml
Chocolate essence	Few drops	Few drops
Chocó chips	3	3

3.2.2 Sorghum malt flour *murukkus* fried/ baked

Murukku or *Chakli* is a savory snack popular in India and Sri Lanka, originating in the cuisine of the Indian state of Tamil Nadu. It is also popular in places with large Tamil populations, such as Fiji and Malaysia. So, murukkus were developed in which malted sorghum flour was incorporated by replacing rice flour which makes *murukkus* a healthy snack

Different levels of malted sorghum were tried to replace the maximum amount of rice flour in standardized recipe. It is important to incorporate maximum amount of malt powder to make *murukkus* more nutritious containing nutrients with high bioavailability, easy digestibility and quick & easy utilization by the body. Therefore, an attempt was made to incorporate malted sorghum at two different levels.

As normal *murukkus* which are available in market are fried this adds to empty calories and also results in restricted consumption of this snack by cardiovascular and diabetic patient. As sorghum is associated with many health benefits like it can decrease the risk of cardiovascular (Carr *et al*, 2005) [4], it has high Antioxidant activity (Dykes *et al*, 2005) [9] and it has Cholesterol lowering properties (Klopfenstein *et al*, 1981). So in order to make it healthier and nutritious for the cardiovascular and diabetic patients as these patients are generally overweight/obese therefore an attempt is made to modify the basic preparation of murukkus by baking it and hence lowering the aggregate calories. Therefore in the present study both the *murukkus* fried/baked were tested for its acceptability.

Table 5: Murukkus (fried/baked) prepared with malted sorghum flour incorporated at different levels

Variations	Ingredients						Remarks marks
	Rice flour (g)	Sorghum malt (g)	Washed black gram dal (g)	Oil for dough (g)	Salt (g)	Cumin seeds (g)	
(40 %)	48	32	20	35	½ t	1 t	Taste- Good (B/F) Texture- Good (B/F)
(50 %)	40	40	20	35	½ t	1 t	Taste – Good (B/F) Texture- Good (B/F)
(60 %)	32	48	20	35	½ t	1 t	Taste- Acceptable after taste (F) Acceptable bitterness (B) Texture Good (B/F)
(75 %)	20	60	20	35	½ t	1 t	Taste- Bitter (B/F)

B = Baked F= Fried

Results in Table 5, indicates that variation I and II had good taste and texture with no after taste, whereas variations III had a slight after taste of sorghum malt fried/baked murukkus but was liked by all and acceptable. On the other hand, variation

IV had bitter taste and was unacceptable. Therefore, out of all the variations the two variations were selected i.e. variation I and variation III were finalized for sensory evaluation by panelists (40) which included faculty members and students of Masters in Foods and Nutrition Department, Institute of Home Economics, Delhi University who analyzed the product. Hence, optimum incorporation level of sorghum malt in *murukkus* fried/baked for final recipe was 40 % and 60 %.

Table 6: Different levels of malted sorghum used for final sensory evaluation of murukkus fried/ baked

Ingredients	Amounts (g)	
	40 %	60 %
Rice flour	48	32
Sorghum malt flour	32	48
Washed black gram dal	20	20
Cumin seeds	¼ t	¼ t
Asafoetida	¼ t	¼ t
Salt	½ t	½ t
Refined oil (for dough)	35	35

3.3 Sensory characteristics of sorghum malt products

3.3.1 Sensory characteristics of sorghum malt flour muffins

Muffins were prepared by replacing refined flour with malted sorghum flour with two variations i.e. at 50 % and 90 % incorporation level along with control as indicated in Table 6. A comparison of mean score of sensory attributes namely appearance, colour, texture, after taste and overall acceptability has been done.

Table 7: Effect of malted sorghum flour on sensory characteristics of muffins

Characteristics	Mean ± SD			F- Test
	Malted Sorghum flour Muffins			
	Control	50% sorghum malt	90% sorghum malt	
Appearance	4.17±0.83^{b}	3.38±0.77^{a}	3.50±1.02^{a}	7.980*
Colour	4.11±0.80^{b}	3.64±0.73^{ab}	3.61±0.98^{a}	3.710*
Texture	3.88±0.91^{a}	3.41±0.089^{a}	3.61±0.95^{a}	2.234
Taste	4.02±0.83^{a}	3.58±0.82^{a}	3.64±1.06^{a}	2.323
After taste	4.08±0.86^{a}	3.55±0.85^{a}	3.61±1.10^{a}	3.172
Overall acceptability	4.08±0.86^{a}	3.67±0.80^{a}	3.61±1.07^{a}	2.624

Rating on 5-point rating scale. Means scores with different superscripts are significantly different as tested by Tukey's HSD.

Table 7 reveals that mean scores for texture, taste, after taste and overall acceptability were comparable for all the three products and there was no significant difference between the three whereas for appearance the mean score of muffins were comparable between 50 % and 90 % but significantly different for control muffins. Similarly for colour mean score of 50 % and 90 % are comparable but mean score of muffins with 90 % is significantly different at 5 % level of significance as control muffins. Mean score of muffins made with 50 % malted sorghum flour was compared to control muffins and the difference of 10.04 % was insignificant at 5 % level. Therefore, muffins made with 50 % malted sorghum flour were similar to the control muffins and the rating lies above good.

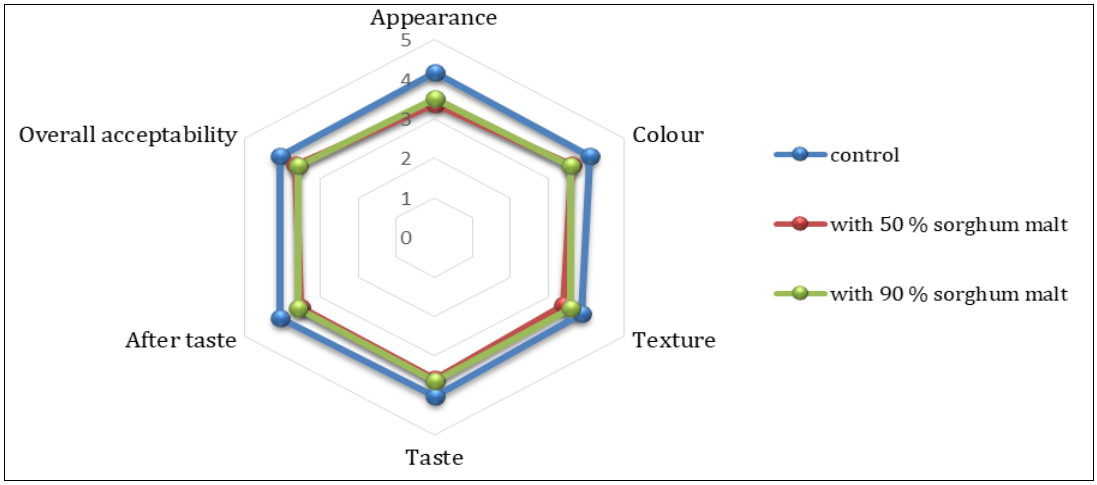

Fig 2: Graphical representations of mean scores of malted sorghum flour muffins

Figure 2 shows mean scores of all the attributes. Mean scores of muffins made with 50 % malted sorghum flour were found to have no significant statistical difference from mean score of control muffins at 5 % level of significance. Though the muffins made with 90 % malted sorghum flour have a significant difference from control but there was only a difference of 11.51 % between them. A study by Mahgoub (1999) [25] concludes that weaning foods prepared from sorghum malt flour are comparable to the commercial formulas, Cerelac. Moreover these formulations are inexpensive, easily available and nutritious and could be make them effective in solving some of the nutrition problems facing infantsand children.

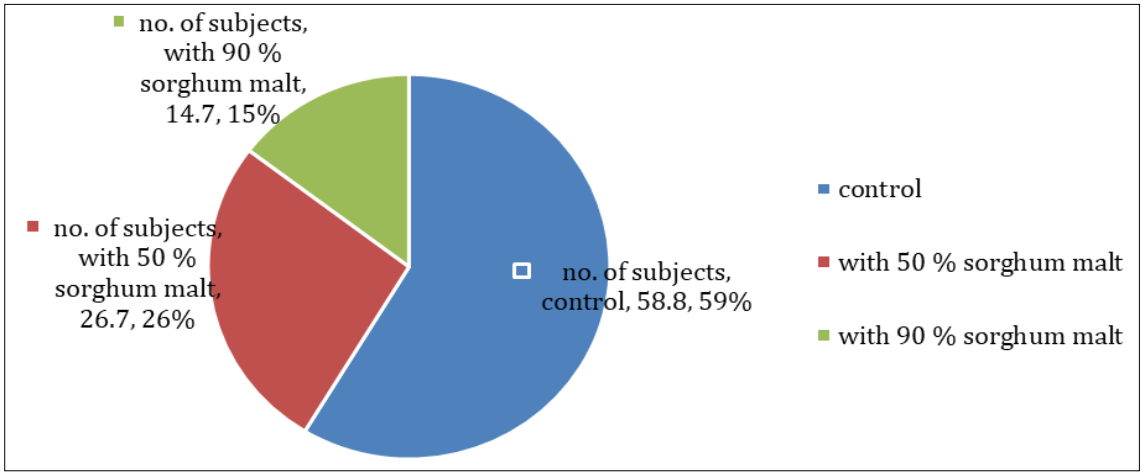

Fig 2: Consumer preference for sorghum malt muffin

Figure 2 depicts that the preference of consumers for muffins made with 50 % were liked more by consumers in comparison with muffins made with 90 % sorghum malt. Data revealed that 26 % of consumers preferred muffins made with 50 % of sorghum malt compared to 15 % of consumers preferred muffins made with 90 % of sorghum malt.

When consumers were asked how often would they like to have the product, 79.4 % responded occasionally and 8.82 % responded daily. When asked if consumers would buy if product is available in the market, 85.6 % responded positively whereas 5.8 % were not sure about it.

3.3.2 Sensory characteristics of sorghum malt four fried *murukkus*

Murukkus were prepared by replacing rice flour with sorghum malt flour with two variations i.e. at 40 % and 60 % incorporation level along with control as indicated in Table 8. A comparison of means of sensory attributes namely appearance, colour, texture, after taste and overall acceptability has been done

Table 8: Effect of sorghum malt flour on sensory characteristics of fried *murukkus*

Characteristics	Mean ± SD			F- Test
	Fried sorghum *Murukkus*			
	Control	With 40% sorghum malt	With 60% sorghum malt	
Appearance	3.81±0.81^{a}	3.94±0.74^{a}	3.64±0.75^{a}	1.380
Colour	3.91±0.72^{b}	3.91±0.72^{b}	3.43±0.83^{a}	5.034*
Texture	3.78±0.97^{a}	3.78±1.03^{a}	3.75±0.9^{a}	0.009
Taste	3.78±0.91^{a}	3.81±0.81^{a}	3.56±0.98^{a}	0.798
After taste	3.48±0.98^{a}	3.72±0.76^{a}	3.37±1.00^{a}	1.387
Overall acceptability	3.83±0.83^{a}	3.81±0.73^{a}	3.67±0.85^{a}	0.426

Rating on 5-point rating scale. Mean scores with different superscripts are significantly different as tested by Tukey's HSD. ***Significant at p<0.05**

Data shown in Table 8 indicates that mean scores for appearance, texture, taste, after taste, overall acceptability were same for all the three products and there was no significant difference between the three whereas for colour the mean score of fried sorghum murukkus with 60 % sorghum malt was significantly different from control murukkus and was less acceptable of all. Mean score of 40 % sorghum malt murukkus was comparable as control murukkus and the difference of 0.52 % was insignificant at 5 % level. Therefore, murukkus made with 40 % sorghum malt were similar to control murukkus and the rating lies above good. A study by Anglani (1998) [1] reported that tortillas made with sorghum by replacing maize by 50 % was found more acceptability then 100 % or 25 % The graphical representations of mean scores of malted sorghum fried murukkus have been shown in figure 3.

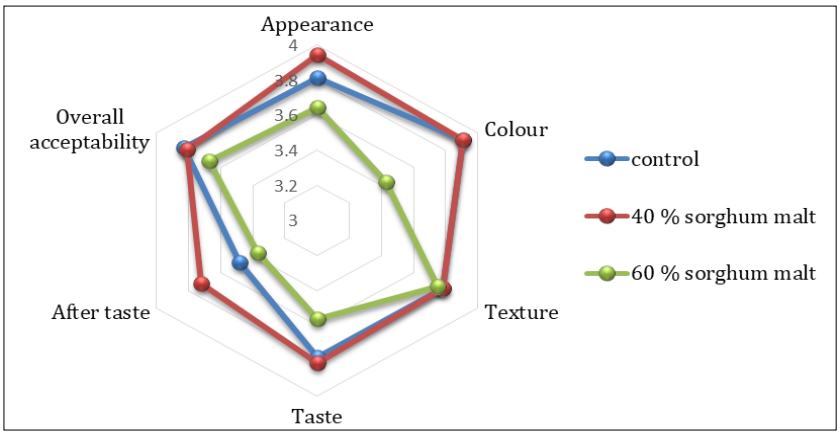

Fig 3: Graphical representations of mean scores of malted sorghum fried murukkus

Figure 3 shows mean scores of all the attributes. Mean scores of murukkus made with 40 % sorghum malt were found to have no significant statistical difference from mean score of control murukkus at 5 % level of significance. Though the murukkus made with 60 % sorghum malt have a significant difference from control but there was only a difference of 4.17 % between them

Figure 4 depicts that the preference for consumers for murukkus made with 40 % malted sorghum. Murukkus made with 60 % malted sorghum were almost equally liked by consumers as of control fried murukkus. Results revealed that consumer preference was high for murukkus with 40 % malted sorghum as compared to control and murukkus fried with 60 % malted sorghum.

When consumers were asked how often would they like to have the product, 59.4 % responded occasionally and 13.9 % responded daily. When asked if consumers would buy if product is available in the market, 83 % responded positively whereas 14.3 % were not sure about it.

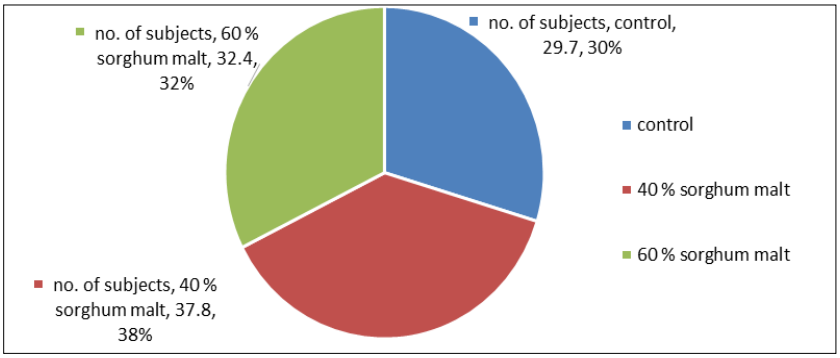

Fig 4: Consumer preference for malted sorghum fried murukkus

3.3.3 Sensory characteristics of malted sorghum baked murukkus

Baked murukkus were prepared by replacing rice flour with malted sorghum flour with two variations i.e. at 40 % and 60 % incorporation level along with control. As indicated in table 3. A comparison of mean of sensory attributes namely appearance, colour, texture, after taste and overall acceptability has been done.

Table 8: Effect of malted sorghum flour on sensory characteristics of baked murukkus

Characteristics		Mean ± SD		F- Test
	Malted sorghum Baked Murukkus			
	Control	With 40% sorghum malt	With 60% sorghum malt	
Appearance	3.19±0.85[a]	3.55±0.87[a]	3.30±1.06[a]	1.403
Colour	3.16±0.91[a]	3.3±0.97[a]	3.55±0.84[a]	1.606
Texture	3.22±0.92[a]	3.16±1.10[a]	3.00±1.19[a]	0.410
Taste	3.16±1.05[a]	3.25±1.05[a]	2.83±1.20[a]	1.427
After taste	3.00±1.06[a]	3.05±1.06[a]	2.58±1.15[a]	1.927
Overall acceptability	3.27±0.94[a]	3.33±0.95[a]	2.91±1.13[a]	1.792

Rating on 5-point rating scale

Mean scores with different superscripts are significantly different as tested by Tukey's HSD.

Data shown in the table 3.22 reveals that mean scores for appearance, colour, texture, taste, after taste, overall

acceptability were same for all the three products. Mean score of murukkus made with 40 % malted sorghum was same as compared to control murukkus and the difference of 1.83 % was insignificant at 5 % level. Therefore, murukkus made with 40 % finger millet malt were similar to control murukkus and the rating lies above good. A study by Badi & Hoseney (1976) reported that bread made with incorporation levels of 30 % sorghum flour and 70 % wheat flour has excellent acceptability. The graphical representations of mean scores of malted sorghum baked murukkus have been shown in Figure 3.13.

Figure 5 shows mean scores of all the attributes. Mean scores of murukkus made with 40 % malted sorghum were found to have no significant statistical difference from mean score of control murukkus at 5 % level. Though the murukkus made with 60 % malted sorghum malt have a significant difference from control but there was only a difference of 11 % between them.

Figure 6 depicts that the preference of consumers for murukkus made with 40 % malted sorghum. Results reveals that murukkus made with 40 % malted sorghum were highly acceptable as compared to control murukkus and murukkus with 60 % malted sorghum.

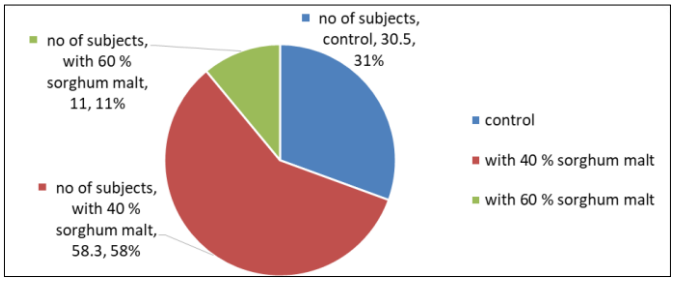

Fig 6: Consumer preference for malted sorghum baked murukkus

When consumers were asked how often would they like to have the product, 50 % said occasionally and 11.1 % said daily. When asked if consumers would buy if product is available in the market, 58.3 % said yes while 25 % were not sure about it.

4. Conclusion

The study indicated that phytic acid and tannic acid were reduced significantly after various processing treatments. Malting shows the maximum reduction in both phytic acid and tannic acid content, as malting awakens the enzymes and makes the nutrients available in its pre-digested form as well increases the activity of certain bound enzymes which ultimately leads to releasing of anti-nutritional factors which are bound to the nutrients hereby increasing the bioavailability of nutrients. From here nutrients will be absorbed directly in the blood and hence increasing nutrient store house of the body. Snacking is becoming a common practice especially in children and adults therefore an attempt is made to develop some healthy snacks from processed malted sorghum flour to get the maximum advantage of their nutrient content in terms of bioavailability. That's why in present study products like *muffins* and *murukkus* were developed from malted sorghum flour and were evaluated by the panel members. All the products with different variations were acceptable to the panel members. Finally 50 % malted sorghum flour replacement was acceptable in *muffins*, 40 % malted sorghum flour replacement was acceptable in fried *murukkus* and 40 % malted sorghum flour replacement was acceptable in baked *murukkus*. Therefore, malting holds a good potential for improving the nutritional value of sorghum by reduction in anti-nutrients and thereby enhancing its utilization.

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