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POTENTIAL OF GERMINATED SORGHUM (*Sorghum bicolor*) FOR UTILIZATION AS A HEALTH FOOD

Vishakha Singh*, Vandana Sati and Shruti Agarwal
Department of Foods and Nutrition, College of Home Science
MPUAT, Udaipur, Rajasthan-313001
E-mail: vishakha_singh@yahoo.com (**Corresponding Author*)

Abstract: In the present scenario of exploding population and limited resources of food, there is need to find food source which has potential to meet demands of 4 F (Food, Fuel, Feed and Fibre) in near future. Sorghum is one of the most important crops in the world but is under privileged despite of its nutritional and commercial advantages. It has been regarded as low nutritional quality grain but processing methods like germination is known to have positive effects on nutritional quality and digestibility of sorghum grains. Objective of the study was to develop food products with germinated sorghum grains and assess their sensory attributes and nutritional quality. Sorghum variety CSV-15 was chosen for the study. ***Chaat*** and ***ladoo*** were prepared from germinated sorghum. Sorghum grains were germinated for 48 hours and milled. Ladoo was prepared by incorporating germinated sorghum flour at 20, 40 and 60 percent level. The products were evaluated for sensory parameters on 9-point Hedonic Rating Scale and proximate composition along with anti-nutrients and in-vitro protein digestibility. Sensory evaluation of products revealed that ladoo containing 40% GSF was the most acceptable and chaat prepared by using germinated sorghum grains was liked very much by the panel members. *Ladoo had* 13.57±0.02 g/100 g and chaat had 14.31±0.04 g/100 g crude protein. *Both* were found to have crude fibre content of 2.40±0.13g and 2.07±0.09g per 100g on dry weight basis. Phytic acid content was found to be 726±0.32mg/100g in ladoo and 615±1.2 mg/100g in chaat. Tannin content was 2.98±0.09 mg/100g and 1.04±0.01 mg/100g, in ladoo and chaat respectively. *Chaat* and *ladoo* had 79.04±0.01per cent and 73.71±0.23per cent in-vitro protein digestibility. Thus it can be concluded that germination is beneficial processing technique for enhancing nutritive value of sorghum greatly influencing nutritional composition, bio-availability and utilization of nutrients. The products developed were well accepted and will create a pathway for increasing nutrition security among masses. They can serve as beneficial means to address the issue of food security towards ever-increasing population of India.

Keywords: Sorghum, Germination, Product Development, Sensory Evaluation.

Introduction

Sorghum (*Sorghum bicolor*) is one of the most important crops on the world and is one of the four major food grains of our country after wheat, rice and maize. It is a staple food for millions of poor people in Asian and African countries. Besides being a major source of staple food for human beings, it also serves as an important source of fodder, animal feed and industrial raw material. Sorghum (jowar) is often referred to as “coarse grain”.

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While sorghum and millets are vital food crops for millions of people in parts of Africa and Asia, they are an under utilized resource in most developed countries, with sorghum being primarily used as animal feed. Sorghum and millets have considerable further potential to be used as a human food and beverage source. In developing countries the commercial processing of these locally grown grains into value-added food and beverage products is an important driver for economic development (Taylor, 2004).

Sorghum has been reported to have poor starch and protein digestibility. Sorghum is categorized as of low nutritional value a food for the poor. Traditional methods of processing like germination and fermentation are known to have some positive effects on the digestibility of sorghum and can be used to improve its nutritional quality.

Germination or sprouting not only produces a gruel of low viscosity, but also partially digests the starchy and protein components, reduces anti-nutritional and flatus-producing factors, improves availability of minerals and vitamin content of food materials. Germination also imparts desirable flavor and taste to the product. It causes significant increase in protein, thiamin, *in vitro* iron, calcium bioavailability, *in vitro* starch and protein digestibility (Ghavidel, 2007).

Due to inadequate knowledge, ignorance on the nutritional and health benefits of sorghum, and limited product development expertise; sorghum is categorized as of low nutritional value and a food for the poor but the traditional methods of processing such as, germination and fermentation are known to have some positive effects on the nutritional quality of sorghum. In the present scenario of exploding population and limited resources of food, there is need to find food source which has potential to meet demands of 4 F (Food, Fuel, Feed and Fibre) in near future. Sorghum is under privileged despite of its nutritional and commercial advantages. It also has therapeutic role in various diseases like diabetes, heart disease and celiac disease. In addition to introducing better, healthier and safer food for consumers, sorghum and millet snacks will create new markets for these crops. This market opportunity will link poor farmers to the Indian Agro-food Industry and increase their incomes. So there is a need to explore the opportunities of sorghum consumption.

By expanding the utilization of sorghum and millets would go a long way towards providing an ever increasing population with food and of course they also have the built-in advantage of thriving in areas of limited rainfall where other cereals often fail.

Therefore, the present study was undertaken to develop products from germinated sorghum and analyze their sensory and nutritional quality.

Material & Methods

The present study was conducted in the Department of Foods and Nutrition, College of Home Science, Maharana Pratap University of Agriculture and Technology, Udaipur. Sorghum variety CSV-15 was procured and the cleaned grains were washed with water and soaked for 12 hours. After soaking the remaining water was drained off and grains were then tied in muslin cloth and kept in dark for germination. The time for germination of grains was 48hrs which was pre standardized by trials. The grains were dried in hot air oven at 50°C. Dried grains were milled in electric grinder and sieved through 120µm mesh sieve. Germinated flour was thus obtained and stored in air tight container.

The flow chart of the standardized process is presented below:

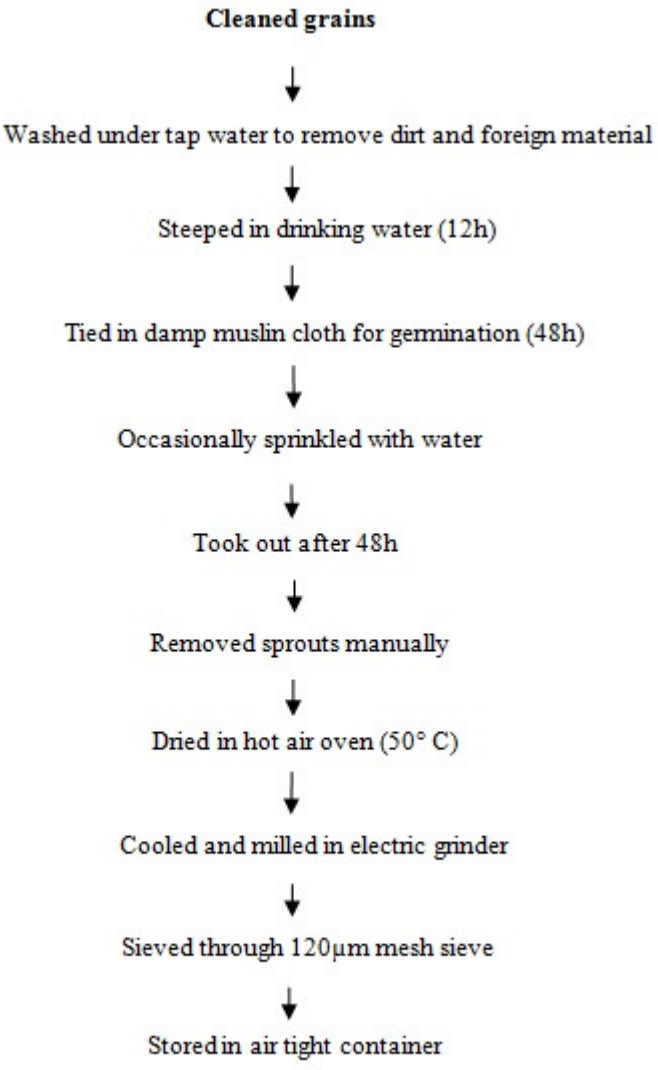

Figure 1: Process flow chart for germination of grains

In the present investigation, *ladoo* and *chaat* were developed. The developed products were standardized in terms of amount of ingredients, procedure and serving size. Recipe was prepared by incorporating 20, 40 and 60% germinated sorghum flour to it along with one control sample. The recipe of developed products, found most acceptable after analyzing the sensory score of ten panel members consisted of following ingredients:

Ladoo

Ladoo was prepared by incorporating GSF with whole wheat flour. *Ladoo* made with 100 per cent wheat flour served as control. The amount and ingredients used in preparation of *ladoo* is reported in table 1.

Table 1: Amount and ingredients used for preparation of *ladoo*

S.No	Ingredients	Amount
1	Wheat flour	90g
2	Germinated sorghum flour	60g (40%)
3	Desi ghee	80g
4	Powdered sugar	150g
5	Cardamom	2

Chaat

Sprouted grains, unlike processed grains, are extremely nutritious and provide a valuable part of any healthy diet. Hence, *chaat* was prepared from germinated sorghum grain. The amount and ingredients used in preparation of *chaat* are presented in table 2.

Table 2: Amount and ingredients used for preparation of *chaat*

S.No	Ingredients	Amount
1	Germinated grain	150g
2	Onion	50g
3	Tomato	80g
4	Green chilli	10g
5	Coriander leaves	25g
6	Salt	½ tsp
7	Refined oil	5ml
8	Water	150 ml

The prepared products were subjected to sensory evaluation with respect to colour, flavour, texture, taste, appearance and over all acceptability by a semi-trained panel of ten judges using 9-point hedonic rating scale.

Nutritional evaluation of the selected products was done for their proximate composition, and *in vitro* protein digestibility (**Mertz *et.al.* 1983**). The presence of anti nutrient factors viz, tannin and phytic acid was also analyzed. All estimations were done by standardized methods **NIN (2003)** and methods which are compiled by **Jain and Mogra (2006)**. The data were statistically analyzed as per the objectives of the study.

Results and Discussion

Ladoo was selected for incorporating germinated sorghum flour (GSF) in proportion of 20, 40 and 60 per cent whereas germinated product, *chaat* was prepared with germinated sorghum grains only. For development of *ladoo*, standardized procedure was adopted in which the basic ingredient (whole wheat flour for *ladoo*) was replaced by GSF.

Developed products along with one control were subjected to sensory evaluation (colour, appearance, flavour, texture, taste, and overall acceptability) on 9- point hedonic rating scale by panel of ten members. The acceptability of product was assessed on the basis of judgment given by panel members.

Ladoo is a traditional recipe of India prepared since ages. It is very popular among members of all age groups. Thus *ladoo* was selected and prepared by incorporating 20, 40, and 60 per cent GSF with one control prepared from whole wheat flour. *Ladoo* containing 40per cent GSF secured maximum value for colour (7.9±0.56), appearance (7.8±0.78), flavour (7.9±0.73), texture (7.6±0.51), taste (8.2±0.91) and overall acceptabilty (7.8±0.44) as compared to 20 and 60per cent GSF containing *ladoo* (Table 3). Mean scores of all developed *ladoos* reveals that 40 percent GSF incorporated *ladoo* was most acceptable by the panel members and it was chosen for analyzing nutritional composition. Significant difference ($p \leq 0.01$) was observed in sensory attributes namely colour, appearance, flavour, taste, and overall acceptability except texture among the products.

Table 3: Mean ± SD (SE) scores of sensory evaluation of *ladoo*
(N=10)

Variations	Sensory attributes					
	Colour	**Appearance**	**Texture**	**Taste**	**Flavour**	**Overall acceptability**
Control	8.4±0.51 (0.16)	8.5±0.52 (0.16)	7.9±0.73 (0.23)	8.2±0.63 (0.20)	8.2±0.63 (0.20)	8.2±0.38 (0.12)
20%GSF	7.8±0.63 (0.20)	7.5±0.70 (0.22)	7.6±0.51 (0.16)	7.5±0.52 (0.16)	7.5±0.52 (0.16)	7.6±0.30 (0.09)
40%GSF	7.9±0.56 (0.17)	7.8±0.78 (0.24)	7.6±0.51 (0.16)	8.2±0.91 (0.29)	7.9±0.73 (0.23)	7.8±0.44 (0.14)
60%GSF	7.1±0.73 (0.23)	6.9±0.73 (0.23)	7.3±0.67 (0.21)	7.1±0.73 (0.23)	7.1±0.73 (0.23)	6.9±0.43 (0.13)
GM	7.80	7.67	7.60	7.75	7.67	7.67
SE	0.19	0.22	0.19	0.22	0.21	0.12
CD5%	0.56	0.63	0.12	0.65	0.60	0.35
CD1%	0.75**	0.84**	0.34	0.87**	0.80**	0.48**

GM stands for general mean
** Significant at 1%

Chaat

Sprouted grains are thought of as having exceptional nutritive value. They have good nutritional composition and better digestibility. Therefore, *chaat* was prepared with germinated sorghum grains. Data shown in table 4 depicts the mean score for all sensory attributes colour (8.3±0.21), appearance (8.0±0.29), flavour (7.4±0.22), texture (7.5±0.16), taste (7.9±0.23) and overall acceptability (7.8±0.13) of *chaat*. After evaluating the overall acceptability score it can be concluded that *chaat* was liked very much by majority of panel members.

Table 4: of Mean ± SD (SE) scores of sensory evaluation of *chaat*
(N= 10)

Product	Sensory attributes						
	Colour	**Appearance**	**Texture**	**Taste**	**Flavour**	**Overall acceptability**	**General mean**
Chaat	8.3±0.67 (0.21)	8.0±0.94 (0.29)	7.5±0.52 (0.16)	7.9±0.73 (0.23)	7.4±0.69 (0.22)	7.8±0.42 (0.13)	7.82±0.33 (0.10)

Most acceptable products viz, *ladoo* (40% GSF) and *chaat* (germinated sorghum grain) were subjected to nutritional analysis. All observations were calculated on dry weight basis.

Proximate composition

Table 5 illustrates the findings about the proximate composition of developed products viz, *ladoo* and *chaat.*

Moisture: The moisture contents of *ladoo* and *chaat* were recorded as, 3.72±0.27 and 8.51±0.09g per 100g on dry weight basis. The variation in moisture content observed among the prepared products may be attributed to differences in the cooking methods.

Crude protein: Protein content ranged from 13.57±0.02 (*Ladoo*) to 14.31±0.04g (*chaat*) per 100g.

Crude fat: Table 5 portrays the crude fat content of prepared products. Results reveal that 21.24±0.07gand 9.04±0.01g per 100g of fat content was recorded in *ladoo* and *chaat,* respectively. Use of good amount of fat in frying, cooking might have contributed to higher values of fat.

Ash: High ash content was recorded in *ladoo* (2.25±0.13g) and in *chaat* it was 1.86±0.02g per 100g on dry weight basis.

Crude fibre: *Ladoo* and *chaat* were found to have more crude fibre content i.e. 2.40±0.13 and 2.07±0.09g per 100g, respectively.

Carbohydrate: The highest carbohydrate content was observed in *ladoo* (65.72±0.26g) and *chaat* had carbohydrate content 64.39±0.32g per 100g.

Energy: Table 5 further depicts the energy value of developed products. Energy value recorded in *ladoo was* (427.32±1.32kcal), and in *chaat was* (395.44±0.14kcal) per 100g on dry weight basis.

Sikandra and Boora (2009) reported the proximate composition of biscuits containing 40per cent sorghum flour, 30per cent chickpea flour and 30per cent wheat flour. They reported that biscuit contained 1.87g, 13.89g, 24.07g, 1.32g and 1.93g per 100g of moisture, protein, fat, ash and crude fibre, respectively. They also evaluated the proximate composition of *ladoo* containing ingredients in the same proportion 40:30:30. The moisture content was 0.94g, protein 15.35g, fat 21.05g, ash 0.83g and crude fibre1.83g per 100g on dry weight basis.

Asha*et al*. (2005) reported that *ladoo* prepared from whole wheat flour and sorghum (75:25) had3.61g moisture, 6.36g protein, 24.00g fat, 0.95g ash, 0.35gfibre, and 64.60g carbohydrate and 516kcal energy/100g on dry weight basis.

Table 5: Proximate composition of developed products (mean ±SE) per 100g on dry weight basis

Products / Nutrients	*Ladoo*	*Chaat*
Moisture (g)	3.82±0.27	8.51±0.09
Fat (g)	21.24±0.07	9.04±0.01
Protein (g)	13.57±0.02	14.13±0.04
Ash (g)	2.25±0.13	1.86±0.02
Crude fibre (g)	2.40±0.13	2.07±0.09
Carbohydrates (g)	65.72±0.26	64.39±0.32
Energy (Kcal)	427.32±1.32	395.44±0.14

All values are (mean ±SE) of three observations

Anti-nutritional profile

Tannin: High value of tannin was observed in *ladoo* (2.98±0.09mg/100g). *Chaat* had tannin content of 1.04±0.01mg per 100g on dry weight basis.

Phytic acid: Table 6 reveals results about phytic acid content of *mathri, ladoo*, sweet biscuits and *chaat.* It is evident *that ladoo* had highest amount of phytic acid (726±0.32mg) followed by *chaat* (615±1.2mg) per 100g on dry weight basis. The anti-nutrient content of *ladoo* was higher as compared to other products. This may be due to the use of whole wheat flour used for preparing *ladoo* and refined wheat flour for other products.

Khetarpaul and Grewal (2008) reported the phytic acid content in two types of biscuits. Type-I prepared with 100% whole wheat flour and type-II prepared with 85% whole wheat flour+15% soy flour. Results showed that type-1 biscuits had 332.4mg and type-II contained 421.6mg per 100g on dry matter basis.

Table 6: Anti- nutrients content of developed products (mean ±SE) per 100g on dry weight basis

Products / Anti-nutrients	*Ladoo*	*Chaat*
Tannin (mg/100g)	2.98±0.09	1.04±0.01
Phytic acid (mg/100g)	726±0.32	615±1.2

All values are (mean ±SE) of three observations

In-vitro protein digestibility

Protein quality in essence refers to the ability of proteins to meet human nutritional requirements for essential amino-acids. Before proteins can be utilized by man, they must be digested by the gastric, pancreatic and intestinal proteolytic enzymes in the digestive tract to yield small peptides and amino acids. Domestic processing, including cooking, malting, germination etc are known to reduce the levels of phytate, tannin and amylase inhibitors which may, to some extent, be responsible for the increase in *in-vitro* digestibility.

Table 7 shows results about IVPD of all four prepared products. *Chaat* had highest (79.04±0.01per cent) IVPD followed by *ladoo* (73.71±0.23per cent), on dry weight basis.

Gahalawat and Sehgal (1998) undertook a study to formulate four nutritious products. Cake (40:40:30), biscuit (40:30:30), weaning food (50:30:20), *panjiri* (50:30:20) and *ladoo* (60:25:15) were developed using potato flour, defatted soy flour and corn flour in given ratios. The processed products were found to have 76.16 (cake), 75.78 (biscuit), 75.79 (weaning food), 75.15 (*panjiri*) and 76.66% (*ladoo*) IVPD.

The lower value of IVPD could be due to the non-enzymatic browning (Maillard) reactions, which could involve interaction between inherent proteins and the added sugar, resulting in nonreversible formation of compounds causing a decrease in the availability of protein for digestion.

The presence of phytic acid and polyphenols are also known to associate with proteins forming insoluble complexes that could also affect the IVPD.

Table 7: *In-vitro* protein digestibility of developed products (mean ±SE) per100g on dry weight basis

Products / **per cent**	***Ladoo***	***Chaat***
In-vitro protein digestibility	73.71±0.23	79.04±0.01

All values are (mean ±SE) of three observations

Conclusion

It can be concluded that germination is beneficial processing technique for enhancing nutritive value of sorghum greatly influencing nutritional composition, bio-availability and utilization of nutrients. The products developed were well accepted and will create a pathway

for increasing nutrition security among masses. They can serve as beneficial means to address the issue of food security towards ever-increasing population of India.

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