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Physico-chemical properties and nutrient composition of sorghum grain and flour of two different varieties

Sarita Verma, Neelam Khetrapaul and Vandana Verma

Abstract
Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley. It is the main cereal food for over 750 million people living in semi-arid tropical regions of Africa, Asia and Latin America. The largest producers are the United States (almost 17% of world production), with yields obviously much higher, followed by India, Nigeria, China, Mexico, Sudan and Argentina. The physico-chemical properties of sorghum varieties viz., HC 308 and HJ 513 indicated that their swelling capacity was 0.29 and 0.26 ml/seed, respectively. Water absorption of HC-308 and HJ-513 was 1.16 and 1.03g per g, respectively. The water absorption capacity of sorghum flour could be attributed to high amount of carbohydrate and fibre in this flour. Oil absorption of HC-308 and HJ-513 was 2.90 and 2.86g per g, respectively. HJ-513 sorghum variety had higher crude protein content than HC 308 but almost similar to that of wheat control (11.55%). Crude fat contents of HC-308, HJ-513 and wheat (control) were found to be 2.89, 3.17 and 3.07 per cent, respectively which were almost similar. Crude fibre contents of HJ-513 (2.16%) and HC 308 (2.09 %) were significantly ($p \leq 0.05$) higher than that of the wheat control i.e.1.72 per cent. Ash contents of both the sorghum varieties i.e HC-308 (1.53%) and HJ-513 (1.75%) were almost similar. The total calcium content in wheat (control) was higher (53.57 mg/100g) in comparison to 31.96 and 32.43 mg/100g present in HC-308 and HJ-513 varieties of sorghum, respectively

Keywords: HJ-513, HC 308 physico-chemical properties, nutrient composition

Introduction

Sorghum (*Sorghum bicolor* (L). *Moench*) is the crop for human and animal consumption. Sorghum is produced in areas that are too hot, a minimum average temperature of 25°C is necessary to ensure maximum grain production. The morphological characteristics of the culture make it one of the currently cultivated cereals that have the best drought tolerance. During the drought, it rolls its leaves to reduce water loss due to perspiration. If the drought continues, it becomes dormant instead of dying. The leaves are protected by a waxy cuticle to reduce evapo-transpiration.

Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley. It is the main cereal food for over 750 million people living in semi-arid tropical regions of Africa, Asia and Latin America. The largest producers are the United States (almost 17% of world production), with yields obviously much higher, followed by India, Nigeria, China, Mexico, Sudan and Argentina. India is the third largest producer of sorghum in the world with its 2016-17 crop forecast at 5.5 million tonnes, up from 4.4 million tonnes. In Sorghum, the cultivation area is showing a decreasing trend and the reduction is to the extent of 41.81 per cent from the year 2008-09 to 2014-15 and a decline 74.71 per cent was recorded over the past four decades in the country. The crop is primarily produced in Maharashtra and southern states of Karnataka and Andhra Pradesh. These, three states together account for close to 80 per cent of the all-India production. Madhya Pradesh, Gujarat and Rajasthan are the other states producing sorghum. In many semi-arid countries of Africa and Asia, grains occupy an important place in the food and feed.

It is one of the major cereal crops produced and consumed after rice (*Oryza sativa*) and wheat (*Triticum aestivum*). Sorghum grains are used by these people (especially farmers), who often do not have the means to feed themselves with food sources of energy, rich in protein, vitamins, minerals. Sorghum grains are rich in energy and non-energy nutrients (Ramatoulaye *et al.* 2016). Sorghum commonly is eaten with the hull (the outer layer of the grain), which retains the majority of the nutrients. Sorghum has excellent chemical and physical properties, which make it a grain of good quality for processing different types of products. The nutrient composition of sorghum grain indicates that it is a good source of carbohydrates, fibre, protein, vitamins and minerals. Sorghum contains about 70 per cent starch, so is a good energy source. Its starch consists of 70 to 80 per cent amylopectin, a branched-chain polymer of glucose, and 20 to 30 per cent amylose, a straight-chain polymer.

It is a gluten-free, high protein and cholesterol-free source of a variety of essential nutrients i.e. iron, zinc, manganese and copper. Sorghum has the potential for high levels of iron (more than 70 ppm) and zinc (more than 50 ppm) in the grain. It is rich in B-complex vitamins like thiamine, riboflavin, niacin, pantothenate, and vitamin B_6 which play key role in energy metabolism. Sorghum's high-energy content and ready supply of B-complex vitamins are a perfect combination for energy utilization. Eaten in a variety of forms depending on the region, sorghum may be consumed as whole grain, flat bread, (unleavened and prepared from fermented or unfermented dough), deep fried preparations, popped as a snack or boiled into porridge, processed into flour for baking, or fermented to produce beer or other baked goods. Sorghum can be puffed, popped, shredded and flaked to produce ready-to-eat breakfast cereals. As, sorghum is genetically more closely related to maize than it is to wheat, rye or barley, hence value added products prepared from it can be considered a safe food for patients with celiac disease (Ciacci *et al*., 2007) [3]. The present study was planned with the following specific objective

- To study the physico-chemical properties and nutrient composition of two varieties of sorghum.

Materials and Methods

Procurement of raw material

The locally available varieties of sorghum *i.e* HC 308 and HJ 513 were procured from the Department of Genetics and Plant Breeding, CCSHAU, Hisar.

Physico-chemical properties of sorghum grain and flour

Swelling capacity

Swelling capacity was determined by method of Subramanian *et al.* (1986) [7].

Water absorption capacity

Water absorption capacity was determined using the method of Sathe *et.al* (1981) with slight modifications.

Oil absorption

Oil absoption capacity was determined by method of Rosario and Flores (1981).

Flour solubility

Flour solubility was determined by the method of Subramanian *et al.* (1986) [7].

Gel consistency

Gel consistency was determined by the method of Iyer and Singh (1997).

Gelation capacity

The gelation capacity was determined according to the method of Singh and Singh (1991).

Gluten content

AACC method (2000) was used for wet gluten estimation.

Nutrient Composition

Proximate composition

Moisture

Moisture content was determined by employing the standard method of analysis (AOAC, 2000).

Crude protein

The total nitrogen was estimated by standard method of analysis (AOAC, 2000), using KEL PLUS Automatic Nitrogen Estimation System.

Crude fat

Crude fat was estimated by employing the standard method of analysis (AOAC, 2000) using the Automatic SOCS plus Solvent Extraction System.

Crude fibre

The crude fibre was estimated by employing the standard method of analysis (AOAC, 2000) using Automatic Fibra plus system.

Ash

Ash in the sample was estimated by employing the standard method of analysis (AOAC, 2000).

Carbohydrates

Carbohydrates content was calculated by difference method.

Total carbohydrate (%) = 100 – [moisture (%) +crude protein (%) + crude fat (%) + crude fiber (%) + total ash (%)]

Energy

Energy was calculated by factorial method by multiplying the protein, carbohydrates and fat contents present in the sample by 4, 4 and 9, repectively using following formula.

Energy (K cal/100gm) = 4.0 × protein (%) + 4.0 × carbohydrate (%) + 9.0 × fat (%)

Dietary fibre

Total dietary fibre

Total, soluble and insoluble dietary fibre constituents were determined by enzymatic method (Furda, 1981). The sum of insoluble dietary fibre and soluble dietary fibre contents were calculated for determining total dietary fibre content.

Total dietary fibre = Insoluble dietary fibre + Soluble dietary fibre

Soluble dietary fibre

Precipitation and isolation of soluble dietary fibre

The saved filtrate was acidified with a few drops of concentrated hydrochloric acid to pH 2-3; this pH tended to facilitate the rapid precipitation of polysaccharides. Slowly added four volumes of ethanol and left suspension to stand for about 1 h. Filtered the precipitate on a tarred, coarse Gooch crucible containing glass wool, then washed with 75 percent ethanol, absolute ethanol, and acetone before drying at 70°C in a vacuum oven overnight. The residue was weighed in the crucible to give the soluble dietary fibre content of the original material. The soluble dietary fibre fraction was corrected for ash and for co-precipitated protein.

Minerals
Total minerals
Mineral contents of the sample were determined by wet digestion method.

Available minerals
Available iron

Ionizable iron in the samples was extracted according to the procedure of Rao and Prabhavati (1978).

Available calcium
Available calcium was extracted by the method of Kim and Zemel (1986)

Results of the Study
Physico-chemical properties of sorghum
Sorghum varieties viz., HC 308 and HJ 513were evaluated for physico-chmeical characteristics. Table: 1 depicts the data related to swelling capacity, swelling power, water absorption, oil absorption, flour solubility, gel consistency, gelation capacity and gluten content of both the varieties.

Table 1: Physico -chemical properties of sorghum (on dry matter basis)

Physico –chemical parameters	Sorghum varieties		t-value
	HC 308	HJ 513	
Swelling Capacity (ml/seed)	0.29±0.03[a]	0.26±0.01[a]	0.812
Swelling Power (g/g)	110.68±1.10[a]	109.18±1.04[a]	0.985
Water absortpion (g/g)	1.16±0.08[a]	1.03±0.08[a]	1.069
Oil absorption (g/g)	2.90±0.15[a]	2.86±0.08[a]	0.189
Flour solubility (%)	17.69±0.49[a]	17.14±0.34[a]	0.198
Gel consistency (mm)	76.0±0.37[a]	79.3±0.42[a]	0.585
Gelation capacity (%)	0.95±0.02[a]	1.01±0.04[a]	1.265
Gluten content (%)	ND*	ND*	

Values are mean ±SE of three independent determinations
Similar superscripts in the column indicate that they do not differ significantly (p ≤0.05) * Non detectable

Swelling capacity of HC 308 and HJ 513was found to be 0.29 and 0.26 ml/seed, respectively and did not differ significantly. Swelling power, water absorption and oil absorption of HC 308 and HJ 513were noticed to be 110.68, 1.16 and 2.90 g per g; 109.18, 1.03 and 2.86 g per g, respectively. The differences were statistically non-significant. Flour solubility of HC 308 (17.69%) and HJ 513(17.14 %) follows the same trend and did not differ significantly. Gel consistency and gelation capacity of HC 308 and HJ 513were 76.0 mm and 0.95 per cent and 79.3 mm and 1.01 per cent respectively, which were almost similar. It was found that both of the varieties i.e HC 308 and HJ 513 had no gluten content.

Nutrient composition of sorghum flour
Proximate composition
Sorghum varieties viz HC 308 and HJ513 were analysed for proximate composition i.e moisture, fat, ash, crude fibre and carbohydrates. Data regarding proximate composition has been presented in Table.2. The moisture content of HC 308 (10.74%) and HJ 513(10.85%) did not differ significantly but both had significantly ($p \leq 0.05$) higher moisture content when compared with that of wheat control cereal bar.
Crude protein content of HC 308 and HJ 513was 10.26 and 12.14 per cent, respectively and differed significantly. HJ 513 sorghum variety had significantly higher ($p \leq 0.05$) crude protein content in comparison to HC 308 but it was almost similar to that of wheat (control) 11.55 percent.

Table 2: Proximate composition of sorghum flour (per cent, on dry matter basis)

Proximate nutrients	Sorghum varieties		Wheat (control)	CD (p≤0.05)
	HC 308	HJ 513		
Moisture	10.74±0.35[a]	10.85±0.32[a]	9.66±0.13[b]	1.06
Crude protein	10.26±0.38[a]	12.14±0.15[b]	11.55±0.37[b]	1.13
Crude fat	2.89±0.04[a]	3.17±0.05[a]	3.07±0.12[a]	NS*
Crude fibre	2.09±0.02[a]	2.16±0.03[a]	1.72±0.07[b]	0.15
Ash	1.53±0.14[a]	1.75±0.13[a]	1.63±0.03[a]	NS*
Carbohydrate	83.23±0.25[a]	80.78±0.28[a]	82.03±0.45[a]	2.617

Values are mean ±SE of three independent determinations
Similar superscripts in the column indicate that they do not differ significantly (p ≤0.05) *Not significant

Crude fat contents of HC 308, HJ 513 and wheat control cereal bar were found to be 2.89, 3.17 and 3.07 percent, respectively which were almost similar. Crude fibre contents of HJ 513 (2.16%) and HC 308 (2.09 %) were almost similar but these sorghum varieties had significantly ($p \leq 0.05$) higher crude fibre content than that of wheat control cereal bar (1.72%). Ash content of both the sorghum varieties i.e HC 308 (1.53%) and HJ 513 (1.75%) were almost similar to that of wheat control cereal bar (1.63%) too.
Carbohydrate content of HC 308, HJ 513and wheat control cereal bar were 83.23, 80.78 and 82.03 per cent, respectively which were not significantly different.

Dietary fibre
The data related to dietary fibre content of sorghum varieties HC 308 and HJ 513 is presented in Table 3. Total dietary fibre contents of HC 308 (11.26 g/100g) and HJ 513(11.29 g/100g) were almost similar to each other as well as to that of wheat control cereal bar (11.35 g/100gm). Similarly, the soluble and insoluble dietary fibre contents of HC 308 and HJ 513 respectively did not differ significantly ($p \leq 0.05$) when compared to each other as well as when compared to that of wheat control cereal bar.

Table 3: Dietary fibre contents of sorghum varieties (g/100g, on dry matter basis)

Dietary fibre constituents	Sorghum varieties		Wheat (control)	CD (p≤0.05)
	HC 308	HJ 513		
Total dietary fibre	11.26±0.38[a]	11.29±0.15[a]	11.35±0.37[a]	NS*
Soluble dietary fibre	1.69±0.003[a]	1.77±0.009[a]	1.85±0.12[a]	0.28
Insoluble dietary fibre	9.57±0.04[a]	9.52±0.09[a]	9.50±0.17[a]	0.10

Values are mean ±SE of three independent determinations
Similar superscripts in the column indicate that they do not differ significantly (p ≤0.05) *Not significant

Total mineral and available mineral contents
Data pertaining to total minerals present in sorghum varieties is presented in Table 4. The total calcium content in wheat control cereal bar (53.57 mg/100g) was significantly **(**$p \leq 0.05$) higher when compared to HC 308 (31.96 mg/100g) and HJ 513 (32.43 mg/100g). However, the available calcium percent

in both the varieties HC 308, HJ 513and wheat control cereal bar did not differ significantly among themselves. Total iron content in wheat control cereal bar (4.2 mg/100g) and HC 308(4.75 mg/100g) was almost similar but both had significantly lower iron content when compared to that of HJ 513(5.53mg/g).

Available iron percent in sorghum varieties HC308 (15.91), HJ 513 (16.03) and control (14.85) varied non-significantly ($p \leq 0.05$) among themselves. Zinc content of wheat (control) was found to be significantly ($p \leq 0.05$) higher than both of the sorghum varieties. Zinc contents of HC 308 and HJ 513were almost similar.

Table 4: Total minerals (mg/100g) and available minerals (%) contents of sorghum varieties (on dry matter basis)

Minerals	Sorghum varieties		Wheat (control)	CD ($p \leq 0.05$)
	HC 308	HJ 513		
Total calcium	31.96±0.87 [a]	32.43±0.70 [a]	53.57±0.31 [b]	2.88
Available calcium	34.46±0.37[a]	34.93±1.38[a]	32.08±0.75[a]	NS*
Total iron	4.75±0.14[a]	5.53±0.14[b]	4.2±0.05[a]	0.602
Available iron	15.91±0.14[a]	16.03±0.08[a]	14.85±0.14[a]	1.54
Total zinc	2.15±0.009[a]	2.18±0.002[a]	3.16±0.008[b]	0.225

Values are mean ±SE of three independent determinations
Similar superscripts in the column indicate that they do not differ significantly ($p \leq 0.05$) *Not significant

Conclusion

The physico-chemical properties of sorghum varieties viz., HC 308 and HJ 513 indicated that their swelling capacity was 0.29 and 0.26 ml/seed, respectively. Water absorption of HC-308 and HJ-513 was 1.16 and 1.03g per g, respectively. The water absorption capacity of sorghum flour could be attributed to high amount of carbohydrate and fibre in this flour. Oil absorption of HC-308 and HJ-513 was 2.90 and 2.86g per g, respectively. Both the sorghum varieties i.e HC-308 (10.74%) and HJ-513 (10.85%) had higher moisture content when compared to that of control i.e wheat (9.66%). Crude protein content of HC-308 and HJ-513 was 10.26 and 12.14 per cent, respectively. HJ-513 sorghum variety had higher crude protein content than HC 308 but almost similar to that of wheat control (11.55%). Crude fat contents of HC-308, HJ-513 and wheat (control) were found to be 2.89, 3.17 and 3.07 per cent, respectively which were almost similar. Crude fibre contents of HJ-513 (2.16%) and HC 308 (2.09 %) were significantly ($p \leq 0.05$) higher than that of the wheat control i.e.1.72 per cent. Ash contents of both the sorghum varieties i.e HC-308 (1.53%) and HJ-513 (1.75%) were almost similar to that of wheat control (1.63%). Carbohydrate contents of HC-308, HJ-513 and wheat control were 83.23, 80.78 and 82.03 per cent, respectively which were almost similar.

Total dietary fibre contents of HC-308 (11.26 g/100g) and HJ-513 (11.29 g/100g) were almost similar to each other as well as that of wheat control (11.35 g/100gm). Similarly, the soluble and insoluble dietary fibre contents (1.69 and 9.57; 1.77 and 9.52 g/100g) of HC-308 and HJ-513, respectively did not differ significantly when compared to that of wheat control (1.80 and 9.50g/100g).

The total calcium content in wheat (control) was higher (53.57 mg/100g) in comparison to 31.96 and 32.43 mg/100g present in HC-308 and HJ-513 varieties of sorghum, respectively. However, the available calcium percent in both the varieties HC-308, HJ-513 and wheat control were almost similar i.e. 34.46, 34.93 and 32. 08 per cent, respectively. Total iron content in wheat control (4.2 mg/100g) and HC-308 (4.75 mg/100g) did not differ significantly ($p \leq 0.05$) but both had significantly lower iron contents when compared to that of HJ-513 (5.53mg/g). Available iron per cent in sorghum varieties HC 308, HJ-513 and control (wheat) varied non significantly ($p \leq 0.05$)) with 15.91, 16.03 and 14.85 per cent, respectively. Zinc content of wheat (control) was found to be significantly ($p \leq 0.05$) higher than both of sorghum varieties; it was found to be 3.16, 2.15 and 2.18 mg/100g in wheat, HC-308 and HJ 513, respectively. Zinc contents of HC-308 and HJ-513 were almost similar.

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