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Research Article

NUTRITIONAL QUALITY OF ADVANCED SORGHUM GENOTYPES

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ABSTRACT

Sorghum grains are mostly used for the *roti* preparation. The M 35-1 (*Maldhandi*) a sorghum cultivar is known for its good quality of *roti* due to having pearly white grain colour, its flour having higher water holding capacity, and good organoleptic taste. However, this cultivar is low yielder. To evolve sorghum high yielding genotype coupled with these good *roti* qualities, systematic breeding program was planned and executed to overcome this problem. Twenty two newly developed genotypes of sorghum along with check M 35-1 were studied for various nutritional quality parameters, with special reference to the *roti* quality. Considering nutritional quality and organoleptic evaluation parameters studied for *roti* quality, the newly developed genotype SPH 1801 was found comparable with M 35-1 and SPH 1830, SPV 2403, SPV 2412 and SPH 1832 were found to be promising for protein, sugar, water absorption, and soluble protein content as well as for *roti* quality parameters. Therefore, they can be used for further improvement in nutritional quality of sorghum genotypes through breeding program.

INTRODUCTION

Grain sorghum [*Sorghum bicolor* (L.) Moench] is an important food crop particularly in arid and semi-arid tropics. It is a dual-purpose crop providing staple food for human consumption (35%) and rest of as a fodder for livestock, alcohol production, as well as preparation of industrial products (Awika and Rooney 2004). Many millions of people in Africa and Asia depend on sorghum as the stuff of life. Being a drought-tolerant crop, it can give dependable and stable yields in both *kharif* (rainy) and *rabi* (post rainy) seasons. It thrives with less rainfall than is needed for rice and maize and can be grown where no other major cereal can be grown. Altogether, sorghum is one of several really indispensable crops required for the survival of man. In India, sorghum is mainly consumed in the form of unleavened pancake (*bhakri/roti*). However, several indigenous processed foods such as *bhatwadi*, *papadi*, *and roti* are prepared and consumed in the semi-arid tropics. Besides, sorghum has large potential for its use in the fermentation industry, puffed products and in weaning foods for the children of developing countries. According to an FAO (2005) report, sorghum was grown globally on an area of about 46 millions ha with a production of about 60 million tons. However in India, sorghum is cultivated on an area about 9.10 million ha with a production of 7.65 million tons (Anon 2006a, b). Sorghum grains are important source of dietary proteins, carbohydrates, minerals and B group vitamins particularly to the vegetarian diets in India (Salunkhe *et al*. 1984; Chavan and Salunkhe, 1984; Chavan *et al*., 1989; Chavan and Patil, 2010; Chavan *et al*., 2015).

There is a considerable variation in sorghum for levels of protein, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine, and niacin, all these parameters imparts sorghum grain quality (Hulse, 1980; Bankar *et al*., 1986). Post rainy season (*rabi*) sorghum is known for its quality due to which is mostly preferred for human consumption by the masses and are characterized by lustrous, pearly white, attractive grains. Developing genotypes with high yield potential coupled with nutritionally superior quality grains is the prime objective of the breeding programme. This paper deals with the details of nutritional quality of grain sorghum (post rainy season) genotypes developed through a systematic breeding programme and compared with traditional ones.

MATERIAL AND METHODS

Material: Sorghum grains

Sorghum grain samples were obtained from all India Coordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India during *rabi* season-2015-16 from advanced varietal trials samples.

Methods: Cleaning sorghum grains

The sorghum grains were cleaned to remove all extraneous material.

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Milling of sorghum grains

Cleaned sorghum grains were subjected to milling in laboratory grinding mill. Whole sorghum flour was used for nutritional quality parameters testing and preparation of *roti* product.

Nutritional quality of sorghum grain

The sorghum grain flour was then analyzed for crude protein, total sugars, soluble protein, and free amino acids and phenolics contents using standard procedure of AOAC, (1990).

Preparation of sorghum roti

The flour was made from milling grains used for to prepare dough with water. The 100 g sorghum flour was taken for preparation of *roti.* The dough was well kneaded, divided into small balls, flattened on a hard wooden or metal surface sprinkled with a small quantity of flour and was baked on both sides on a hot pan (Shobha *et al.,* 2008). The prepared *roties* were then kept in bamboo basket and stored at room temperature for studying the extension of shelf life.

Sensory evaluation of sorghum roti

The sensory evaluation for different quality parameters like colour and appearance, flavour, texture, taste and overall acceptability was carried out after every 4, 8, 12 and 24 h by semi trained panel of 10 judges on a 9 point hedonic scale (Amerine *et al*., 1980).

Statistical analysis

All results obtained in the present study were analysed using standard methods of Panse and Sukatme, (1967).

RESULTS AND DISCUSSION

Nutritional quality

Twenty two sorghum genotypes were compared with local check. The results on flour, dough, *roti* and nutritional quality are presented in Tables 1 and 2.

Hectoliter weight: The hectoliter weight ranged from 75.13 to 78.23 kg/hl. SPH 1834 genotype gave highest hectoliter weight when compare with other genotypes at similar conditions (Table 1). The hectoliter weight gives the soundness of the grain as well as higher recovery of the flour. It is a unit weight of the grain in a specific volume.

Water absorption capacity*:* The water absorption capacity of flour ranged from 90 to 115% which indicate that they have variable water absorbing capacity. CSV 29R, SPH 1763, SPH 1828 and M 35-1 absorb more water than other genotypes. The water absorption capacity is positively correlated to the *roti* quality. The higher the water absorption capacity the superior was the quality of the *roti*. Similar results are presented by Subramanian and Jambhunathan (1981; 1982) and Vietor *et al*., (1992).

Crude protein**:** The crude protein content ranged from 9.46% (SPV 2410) to 12.35% (CPH 1801) in the advanced varietal genotypes studied with their checks. Protein is a major nutrient required for human nutrition and it is appreciable amount present in the newly developed sorghum genotypes. Higher amount of protein in the food grain is a good sign for nutritional point of view and which provides balancing the amino acid content which required for body building major proteins in the human body.

Table 1 Nutritional constituents responsible for roti quality prepared from advance genotypes of sorghum

Genotype	Colour of the grain	Appearance/ Shape of the grain	Hectoliter weight (Kg/hl)	Water absorption (ml/100g)	Crude Protein (%)	Soluble proteins (%)	Total sugars (%)	Starch (%)	Free amino acids (mg/100g)	Phenolics (%)
SPH 1834	CW	O	78.23	110	11.27	0.64	1.83	44.70	81.02	2.24
SPV 2409	CW	O	75.22	110	10.24	0.63	1.83	47.83	88.75	2.11
SPH 1799	CW	O	77.39	105	10.54	0.88	1.74	42.55	84.87	2.37
SPV 2405	CW	O	76.72	110	10.63	0.71	1.92	50.03	85.51	2.11
SPV 2408	CW	O	75.13	100	11.75	0.30	1.91	44.61	86.26	2.48
SPV 2403	CW	O	77.08	115	10.21	1.18	2.06	49.26	76.78	2.20
SPH 1802	CW	O	77.97	150	11.77	0.78	1.93	47.55	88.20	2.36
SPH 1801	CW	O	77.91	100	12.35	0.70	2.00	40.94	89.55	2.85
SPV 2412	CW	O	77.36	110	11.31	0.82	2.06	43.19	93.06	2.26
CSV 22	CW	O	76.85	100	9.94	0.82	1.83	46.23	90.97	2.24
SPH 1803	CW	O	77.40	95	10.56	0.90	1.93	45.12	83.17	2.42
CSV 29R	CW	O	77.51	115	10.41	0.59	1.81	47.03	91.26	2.08
SPH 1763	CW	O	77.02	115	11.51	0.60	1.83	43.35	88.94	2.61
SPH 1764	CW	O	76.77	90	10.75	0.89	1.69	40.54	84.36	2.48
SPV 2407	CW	O	76.20	110	10.86	0.54	1.87	47.07	86.97	2.35
CSH 15R	CW	O	75.26	100	11.29	0.64	1.69	41.27	89.84	2.93
SPH 1830	CW	O	76.40	110	11.20	0.81	2.04	47.92	87.38	2.49
SPH 1832	CW	O	77.33	110	10.93	0.43	1.86	47.94	90.33	2.39
SPH 1833	CW	O	75.04	105	10.26	1.09	1.76	48.10	73.81	1.76
SPV 2411	CW	O	77.05	100	10.45	1.27	2.27	53.79	86.86	2.39
SPH 1828	CW	O	78.22	115	11.32	0.83	2.04	46.58	82.92	2.58
SPV 2410	CW	O	75.46	100	9.46	1.23	1.94	58.13	77.82	2.24
M 35-1	CW	O	76.91	115	9.35	1.85	2.07	61.82	77.06	2.25
Range	-	-	75.13 -78.23	90-115	9.46-12.35	0.30 -1.85	1.69 -2.27	40.54 - 61.82	73.81- 93.06	1.76-2.93
Mean	-	-	76.80	105	10.86	0.79	1.90	46.53	85.85	2.36
S.E. ±	-	-	0.99	0.21	0.66	0.24	0.13	4.03	4.85	0.24
C.D. at 5 %	-	-	2.98	0.65	2.00	0.73	0.41	12.10	14.58	0.75

Replications: 3; Grain colour: Creamy = **C**, Creamy White = **CW**, Dull White = **DW**, White = **W**, Brown = **B**, and Dull Black = **DB. Grain Shape:** Round = **R**, Oval/Oblong = **O** and Wrinkle = **W.**

Table 2 Organoleptic quality of *roti* prepared from different advanced genotypes of sorghum

Genotype	Water required for dough (ml)	Kneading quality	Spreading quality	Organoleptic quality parameters					Rank by DMRT	Loss in weight during storage (%)		
				Colour & appearance	Flavour	Texture	Taste	Overall acceptability		4 hrs.	8 hrs.	24 hrs.
SPH 1834	100	1	1	7.20	7.00	6.40	6.60	6.80	**11**	2.35	4.26	10.86
SPV 2409	100	1	1	7.20	7.40	6.80	7.20	7.15	**7**	2.28	4.81	11.24
SPH 1799	90	1	1	5.80	6.80	6.60	6.80	6.50	**14**	2.65	4.43	11.60
SPV 2405	100	1	1	7.00	7.00	6.80	7.00	6.95	**9**	2.24	4.15	11.15
SPV 2408	90	1	1	7.00	7.20	6.60	7.40	7.05	**8**	2.32	4.10	11.23
SPV 2403	110	1	1	7.60	8.00	8.00	7.80	7.85	**3**	2.91	4.38	11.33
SPH 1802	100	1	1	7.00	7.00	7.40	7.20	7.15	**7**	2.23	4.12	11.65
SPH 1801	90	1	1	9.00	8.80	8.40	8.60	8.70	**1**	2.15	3.83	11.57
SPV 2412	100	1	1	8.20	7.40	8.00	7.80	7.85	**3**	2.26	4.53	12.42
CSV 22	90	1	1	7.20	7.40	7.40	8.00	7.50	**5**	2.37	4.46	11.08
SPH 1803	80	1	1	6.40	6.40	6.20	6.40	6.35	**15**	2.53	4.86	10.71
CSV 29R	110	1	1	7.20	7.40	7.20	7.40	7.30	**6**	2.55	4.38	10.82
SPH 1763	110	1	1	6.40	6.00	6.40	6.40	6.30	**16**	2.68	4.74	11.21
SPH 1764	80	1	1	7.20	6.60	6.80	7.00	6.90	**10**	2.46	4.37	10.89
SPV 2407	100	1	1	7.00	7.00	7.20	7.40	7.15	**7**	2.36	4.33	10.86
CSH 15R	90	1	1	7.20	6.80	7.00	7.20	7.05	**8**	2.41	4.51	11.24
SPH 1830	100	1	1	8.20	7.80	8.00	7.60	7.90	**2**	2.49	4.38	10.95
SPH 1832	100	1	1	8.00	7.60	7.60	7.60	7.70	**4**	2.33	4.52	11.15
SPH 1833	100	1	1	7.00	6.20	6.60	7.00	6.70	**12**	2.44	4.32	10.45
SPV 2411	90	1	1	6.00	6.60	6.80	6.80	6.55	**13**	2.36	4.15	11.65
SPH 1828	110	1	1	6.60	7.00	6.40	6.80	6.70	**12**	2.31	4.19	11.15
SPV 2410	90	1	1	6.00	6.80	6.80	6.40	6.50	**14**	2.38	4.13	11.23
M 35-1	105	1	1	8.80	8.70	8.60	8.80	8.70	**1**	2.38	4.10	10.35
Range	80-110	-	-	5.80-9.00	6.00-8.80	6.20-8.40	6.40 - 8.80	6.30-8.70	-	2.15-2.91	3.83-4.86	10.45-12.42
Mean	96.82	-	-	7.11	7.10	7.06	7.20	7.12	-	2.41	4.36	11.20
S.E. $\pm$	8.73	-	-	0.75	0.60	0.60	0.54	0.58	-	0.16	0.23	0.40
C.D. at 5 %	26.19	-	-	2.26	1.82	1.81	1.65	1.76	-	0.51	0.71	1.21

Replications: 5 minimum; - = No sufficient seed. **Kneading quality of dough, score:** Good = **1**, Fair = **2**, Poor = **3**. **Spreading quality of *roti*, score**: Easy spreading without crack = **1**, Slightly difficult to spread with minute cracks = **2**, Difficult to spread with cracks = **3**.

Sensory score: Like extremely (Excellent) - **9**, Like very much (Very good) - **8**, Like moderately - **7**, Like slightly-**6**, Neither like nor dislike - **5**, Dislikes lightly - **4**, Dislike moderately - **3**, Dislike very much - **2**, Dislike extremely-**1**.

Majority of the genotypes having more than 10% protein content and which is higher than the check genotype used in this study (Table 1). Similar results are presented by Rao Prasada and Murty, (1981), Chavan *et al*., (1988; 2009; 2010).

Soluble protein: The soluble protein content in the flour mostly responsible for the holding more water and developing smoothness to the *roti*. The soluble protein content in the flour ranged from 0.30% [SPV 2408] to 1.85% [M 35-1) in advanced developed sorghum genotypes. All new sorghum genotype developed having lower values for soluble proteins than the check. All the genotypes were significantly different in their soluble content.

Total soluble sugars: The total soluble sugars ranged from 1.69% (SPH 1764) to 2.27% (SPV 2411) in advanced sorghum genotypes studied. All the genotypes studied were significantly different for soluble sugar content. The higher sugar percentage in sorghum flour representing good amylolyptic activity while preparation of *roti*. Total soluble sugars are mostly responsible for good taste of the *roti* (Tables 1).

Starch: Starch is a major component of the sorghum grain. It also contribute major role in the *roti* preparation and quality. The starch content of the advanced varietal genotypes ranged from 40.54% (SPH 1764) to 58.13% (SPV 2410). Higher starch content gives good colour, appearance and amylopetic activity during *roti* preparation.

Free amino acids: The free amino acids in the studied advanced genotypes of sorghum ranged from 73.81 mg/100g flour (SPH 1833) to 93.06 mg/100g flour (SPV 2412).

The advanced sorghum genotypes were significantly different in the free amino acid content. This component mostly responsible for aroma development while roasting combines with moisture, soluble proteins and sugars. While protein synthesis at last stage the amino acids remain free from the combination or linkage formation in the true protein.

Phenolics: The phenolics content in the advanced studied genotypes of sorghum ranged from 1.76% (SPH 1833) to 2.93% (CSH 15R). The phenolics mostly responsible for astringent taste to the product but now a days it acts as antioxidants which prevent cancer development in human body. Therefore, phenolics present in the food grain are more beneficial than the anti nutrient.

Roti quality

All grain samples of advanced rabi-2015-16 season grown at Mahatma Phule Krishi Vidyapeeth, Rahuri were used for the *roti* preparation and then used for organoleptic evaluation (colour and appearance, texture, falvour/aroma, taste and overall acceptability using 1 to 9 hedonic scale rating). On the basis of these parameters and overall acceptability Duncan Multiple Range Taste was used to give the numbering for ranking the genotypes. For smoothness of the *roti* storage study was also conducted and water loss was measured at 4, 8 and 24hrs (Table 2). The water required for dough preparation for *roti* ranged from 80 to 110 ml/100g flour. All genotypes showed good kneading and spreading quality while *roti* preparation (Glover *et al*., 1986; Klopfenstein and Hoseney, 1995; Nandini and Salimath, 2001). The overall acceptability was calculated on the basis of colour and appearance, texture, falvour and taste score average. On the basis of Duncan Multiple Range Taste SPH 1801 gave at par results with M 35-1 check genotype used in this study. Similar results are reported by Murty and Subramanian, (1981); Michniewiz *et al*., (1991), Chavan *et al*., (2009; 2010; 2015).

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