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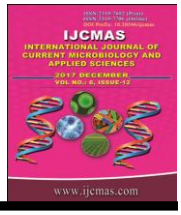

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Nutritional Quality of Newly Developed *Kharif* Sorghum Genotypes

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A B S T R A C T

For higher yield, resistance to pest and disease and having good nutritional quality some new sorghum genotypes developed at various ICAR, research centers were grown at AICRP on sorghum During *Kharif*-2016, total 30 sorghum genotypes from advanced varietal trials (AVT) and advanced hybrid trials (AHT) were evaluated for flour, dough, *roti* and nutritional quality parameters. On the basis of physical and nutritional quality parameters among the new sorghum genotypes from AVT; SPV 2308, SPV 2366, SPV 2358 and DSV 6 and from AHT; SPH 1779, SPH 1789 and SPH CSH 14 were found promising for flour, dough, *roti* and nutritional quality parameters. These genotypes can be used in the breeding programme to get good quality grains.

Introduction

In India sorghum is traditionally consumed in the form of unleavened pan cake/ Roti/Bhakari. Because of sorghum is a staple food in many parts of the country. Though sorghum grains are nutritious, the consumption of this cereal is decreasing due to non-availability of easy cooking raw materials from the sorghum. The other major reasons are; dying traditional food habits, requirement of special skill for preparing sorghum rotis. For many years sorghum eating population particularly in rabi growing areas, the roti made from Maldandi (M 35-1) is preferred for taste and softness, over other genotypes. But now days some new genotypes of rabi sorghum are developed which gives better nutritional as well as organoleptic quality of the roti than the M 35-1. The most common products are leavened and unleavened breads, porridges, boiled grains and steam cooked products such as couscous. Sorghum flour also makes an excellent fry coating for fish, chicken and beef. Sorghum is also used in the preparation of several snacks and for popping, chewing, and malting (Rao and Murty, 1981). Sorghum *roti* is very popular in villages and small towns as an accompaniment to gravy meat and vegetable curries and is one of the traditional recipes of India. It is round, flat,

unleavened bread often used in the cuisine of western and central India, especially in the states of Gujarat, Sorghum *roti* is known by various names in the different languages of India: *chapati* (Hindi), *bhakri* (Marathi), *rotla* (Gujarati), *rotte* (Telugu), etc. (Subramanian and Jambunathan, 1981; Chavan *et al.*, 2016a, b). Because sorghum flour is gluten-free flour, it is very tough to spread the dough without breaking the shape and one really needs hands-on experience and many failed attempts to get the skill. No leavening agents, oil/ghee are added. Just fresh sorghum flour, warm water and touch of fire - pure grain power in its glory. Arabinoxylans have been isolated from different cereals and responsible to play important role in maintaining water balance and rheological properties of dough (Michniewicz *et al.,* 1991; Vietor *et al.,* 1992; Nandini *et al.,* 2001).

There is a considerable variation in sorghum for levels of proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine, and niacin (Chavan *et al.*, 2009, 2010; Chavan *et al.*, 2016c, d, e). Sorghum has chemical composition similar to or better than rice and wheat in some respects. The grains contain high fiber and non-starchy polysaccharides and starch with some unique characteristics. Protein quality and essential amino acid profile of sorghum is better than many of the cereals. Sorghum in general is rich source of B-complex vitamins. Developing new sorghum 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 newly developed grain sorghum genotypes by systematic breeding programme and compared with the local check. A study was done on the flour, dough, roti and nutritional quality of AVT-19 and AHT-11 trials of Kharif-2016, sorghum genotypes grown at Dharwad to identify superior genotypes.

Materials and Methods

Material: Sorghum grains

Newly developed sorghum grain samples from advanced varietal trials (AVT) and advanced hybrid trials (AHT) were obtained from all India Co-ordinated Sorghum Improvement Project, Dharwad, Karnataka, India during *Kharif*-2016 season from advanced varietal and hybrid trials.

Methods: Cleaning sorghum grains

The sorghum grains were cleaned to remove all extraneous material.

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.

Physical parameters

The physical parameters such as hectoliter weight (kg/hl), water absorption of flour (%), Kneading quality (Scale 1-3), Spreading quality (Scale 1-3), water required for dough (%) were estimated by standard methods of AOAC, (1990).

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 and fine flour was made in to 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 *rotis* were then kept in bamboo basket covered with cloth piece 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 immediately after preparation of *roties* at room temperature by semi trained panel of 10 judges on a 9 point hedonic scale (Amerine *et al.,* 1980). The storage study was carried out and weight loss was measured at every 4, 8, 12 and 24 h.

Statistical analysis

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

Results and Discussion

Total nineteen AVT and eleven AHT advanced genotypes which included varieties and hybrids were compared with local check genotype. The results on flour, dough, *roti* and nutritional quality are presented in Tables 1 to 4.

Hectoliter weight

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. The hectoliter weight ranged from 78.40 to 81.41 kg/hl for AVT and 78.48 to 82.36 for AHT trials respectively. The SPH 1779 genotype gave higher hectoliter weight than rest of the genotypes studied in AVT and AHT trials (Tables 1 and 3).

Water absorption capacity

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*. The water absorption capacity of flour ranged from 71 to 93% for AVT and 73 to 86 for AHT trials. The genotype SPV 2358 gave higher water absorption percentage than other genotypes.

Crude protein

The crude protein content ranged from 9.18% (SPV 2357) to 11.69% (SPV 2301) in the advanced varietal genotypes studied with their checks. In AHT protein content ranged from 8.55% (SPH 1820) to 12.01% (SPH 1816) which is higher than the local check studied (Tables 1 and 3).

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 0.17% [SPV 2373] to 0.94% [SPV 2293) in AVT trials. In AHT soluble protein ranged from 0.41 (SPH 1779) to 0.90% (SPH 1813). All the genotypes were significantly different in their soluble content.

Total soluble sugars

In AVT trials the total soluble sugars ranged from 1.45% (CSV 17) to 2.45% (SPV 2363). In AHT total sugar content ranged from 1.54 (SPH 1817) to 2.10% (CSH 25). All the genotypes studied were significantly different. The higher sugar percentage in sorghum flour representing good amylolytic activity while preparation of *roti*.

Table.1 Nutritional constituents responsible for *roti* quality prepared from different genotypes of *Kharif* -2016 (AVT) sorghum

Genotype/ Entry code	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 (%)
SPV 2358	DB	RO	79.91	93	9.94	0.45	1.86	66.44	80.70	1.46
CSV 17	DB	RO	81.17	85	10.71	0.37	1.45	67.67	78.11	2.25
SPV2364	DB	RO	81.02	84	11.00	0.45	2.14	63.09	79.11	1.66
SPV 2370	DB	RO	80.62	86	11.17	0.42	1.78	58.04	63.71	1.93
SPV 2373	DB	RO	80.31	76	10.15	0.17	1.49	63.09	92.02	1.69
SPV 2357	DB	RO	80.08	77	9.18	0.83	1.89	65.65	75.17	1.56
SPV 2308	DB	RO	80.55	76	10.33	0.56	1.90	61.47	82.83	1.59
SPV 2301	DB	RO	81.09	74	11.69	0.49	2.17	59.51	76.25	2.43
SPV 2366	DB	RO	78.40	73	10.04	0.68	2.22	66.48	78.88	1.42
CSV 27	DB	RO	80.59	76	11.45	0.57	2.20	62.32	86.22	2.37
SPV 2293	DB	RO	78.52	78	10.57	0.94	2.19	70.71	73.25	2.04
SPV 2307	DB	RO	80.61	75	10.39	0.23	2.00	62.54	82.68	1.60
SPV 2372	DB	RO	78.95	72	10.98	0.66	1.88	64.66	91.45	1.84
SPV 2362	DB	RO	80.09	76	10.88	0.51	2.21	68.72	85.51	1.99
CSV 20	DB	RO	80.61	74	10.58	0.64	2.21	66.82	83.59	1.66
SPV 2363	DB	RO	81.33	77	11.44	0.20	2.45	60.87	95.28	1.71
SPV 2296	DB	RO	80.66	73	11.30	0.58	2.28	66.76	87.70	2.06
CSV 23	DB	RO	79.86	71	10.95	0.33	1.76	60.85	83.73	1.96
DSV 6	DB	RO	81.41	78	11.01	0.41	2.21	63.03	78.42	1.46
Range	-	-	78.40-81.41	71-93	9.18-11.69	0.17-0.94	1.45-2.45	58.04-70.71	63.71-95.28	1.42-2.43
Mean	-	-	80.30	78	10.72	0.50	2.02	64.14	81.82	1.83
S.E. $\pm$	-	-	0.85	5	0.60	0.19	0.26	3.24	7.15	0.29
C.D. at 5 %	-	-	2.56	16	1.81	0.59	0.79	9.75	21.47	0.90

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 genotypes of *Kharif*-2016 (AVT) 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
SPV 2358	75	1	1	8.6	7.6	7.8	8.2	8.05	**2**	2.39	4.25	10.27
CSV 17	75	1	1	7.0	7.0	7.6	7.6	7.30	**10**	2.45	4.17	10.18
SPV2364	70	1	1	8.6	7.2	7.6	8.0	7.85	**5**	2.25	4.26	10.15
SPV 2370	70	1	1	8.0	7.4	8.2	7.8	7.85	**5**	2.36	4.12	10.28
SPV 2373	60	1	1	7.2	6.8	7.6	6.6	7.05	**12**	2.34	4.26	10.15
SPV 2357	65	1	1	7.6	7.8	7.4	7.2	7.50	**7**	2.25	4.15	10.25
SPV 2308	65	1	1	8.6	7.8	8.0	8.2	8.15	**1**	2.46	4.03	10.28
SPV 2301	60	1	1	7.4	6.8	7.4	7.2	7.20	**11**	2.23	4.25	10.15
SPV 2366	65	1	1	8.8	8.0	7.4	8.4	8.15	**1**	2.33	4.18	10.11
CSV 27	65	1	1	7.0	7.8	7.2	7.8	7.45	**8**	2.16	4.18	10.27
SPV 2293	65	1	1	7.8	8.0	7.4	7.0	7.55	**6**	2.24	4.22	10.35
SPV 2307	60	1	1	7.6	7.0	7.4	7.2	7.30	**10**	2.35	4.32	10.18
SPV 2372	60	1	1	7.4	6.8	6.6	6.8	6.90	**13**	2.23	4.24	10.15
SPV 2362	60	1	1	8.0	8.0	8.4	7.4	7.95	**4**	2.26	4.15	10.25
CSV 20	60	1	1	7.6	7.2	7.6	7.4	7.45	**8**	2.12	4.12	9.89
SPV 2363	65	1	1	7.6	7.2	7.2	7.2	7.30	**10**	2.23	4.31	10.01
SPV 2296	60	1	1	7.6	7.4	7.2	7.2	7.35	**9**	2.31	4.21	10.11
CSV 23	60	1	1	8.2	7.2	7.6	7.2	7.55	**6**	2.21	4.11	10.21
DSV 6	65	1	1	8.4	7.8	8.0	7.8	8.00	**3**	2.33	4.21	10.23
Range	60-75	-	-	7.0-8.8	6.8-8.0	6.6-8.4	6.6-8.4	6.90-8.15	-	2.12-2.46	4.11-4.32	9.89-10.35
Mean	65	-	-	7.8	7.4	7.6	7.5	7.57	-	2.29	4.20	10.18
S.E. ±	4	-	-	0.54	0.41	0.39	0.48	0.36	-	0.08	0.07	0.10
C.D. at 5 %	14	-	-	1.64	1.25	1.19	1.45	1.10	-	0.27	0.21	0.31

Replications: 5 minimum

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. DMRT= Duncan multiple range test.

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.

Table.3 Nutritional constituents responsible for *roti* quality prepared from different genotypes of *Kharif*-2016 (AHT) sorghum

Genotype/ Entry code	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 1779	DB	RO	82.36	68	9.43	0.41	1.76	68.07	82.61	1.25
CSH 30	DB	RO	81.62	76	9.82	0.55	1.70	63.72	65.47	1.29
SPH 1778	DB	RO	80.45	78	10.23	0.56	1.87	65.12	74.79	1.60
SPH 1816	DB	RO	80.81	73	12.01	0.52	2.10	60.82	76.24	2.69
SPH 1820	DB	RO	79.36	76	8.55	0.80	1.79	70.40	72.70	1.67
CSH 16	DB	RO	81.03	74	10.54	0.67	1.69	66.41	76.40	2.26
SPH 1789	DB	RO	81.38	76	10.25	0.51	2.07	62.63	89.56	1.35
SPH 1817	DB	RO	80.98	78	10.36	0.77	1.54	66.08	75.45	1.87
SPH 1813	DB	RO	81.88	86	9.58	0.90	2.03	64.65	76.95	1.54
CSH 25	DB	RO	80.97	76	10.84	0.69	2.10	67.63	76.89	2.24
CSH 14	DB	RO	78.48	78	9.65	0.66	1.68	63.44	66.44	1.71
Range	-	-	78.48-82.36	73-86	8.55-12.01	0.41-0.90	1.54-2.10	60.82-70.40	65.47-89.56	1.25-2.69
Mean	-	-	80.85	76	10.11	0.64	1.85	65.36	75.77	1.77
S.E. $\pm$	-	-	1.05	4	0.84	0.13	0.18	2.60	6.35	0.43
C.D. at 5 %	-	-	3.17	12	2.54	0.42	0.57	7.81	19.06	1.31

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.4 Organoleptic quality of *roti* prepared from different genotypes of *Kharif*-2016 (AHT) sorghum

Genotype	Water required for dough (ml)	Kneading quality	Spreading quality	Organoleptic quality parameters					Rank by DM RT	Loss in weight during storage (%)		
				Colour & appearance	Flavour	Texture	Taste	Overall accept ability		4 hrs	8 hrs	24 hrs
SPH 1779	60	1	1	8.6	8.0	8.2	8.0	8.20	**1**	2.14	4.10	10.38
CSH 30	70	1	1	7.8	7.2	7.8	7.6	7.60	**4**	2.20	4.13	10.28
SPH 1778	70	1	1	7.6	7.0	7.2	6.8	7.15	**6**	2.25	4.23	10.21
SPH 1816	65	1	1	7.2	7.2	6.8	7.2	7.10	**7**	2.24	4.13	10.15
SPH 1820	60	1	1	6.6	6.4	6.4	6.8	6.55	**9**	2.15	4.18	10.22
CSH 16	60	1	1	6.8	7.0	6.4	7.0	6.80	**8**	2.32	4.24	11.21
SPH 1789	60	1	1	8.2	7.4	8.2	7.8	7.90	**2**	2.15	4.13	11.25
SPH 1817	65	1	1	7.4	7.2	7.0	6.8	7.10	**7**	2.26	4.27	10.19
SPH 1813	80	1	1	6.0	6.8	6.6	6.4	6.45	**10**	2.25	4.12	10.26
CSH 25	65	1	1	7.8	7.2	7.4	7.8	7.55	**5**	2.15	4.23	10.11
CSH 14	60	1	1	7.6	7.8	7.6	7.6	7.65	**3**	2.24	4.13	10.25
Range	60-80	-	-	6.0-8.6	6.4-8.0	6.4-8.2	6.4-8.0	6.45-8.20	-	2.15-2.26	4.10-4.27	10.11-11.25
Mean	65	-	-	7.4	7.2	7.2	7.3	7.28	-	2.21	4.17	10.41
S.E. $\pm$	6	-	-	0.70	0.41	0.63	0.50	0.52	-	0.05	0.05	0.39
C.D. at 5 %	18	-	-	2.12	1.25	1.89	1.52	1.59	-	0.17	0.17	1.18

Replications: 5 minimum

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. DMRT= Duncan multiple range test.

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.

Total soluble sugars are mostly responsible for good taste of the *roti* (Tables 1 and 3).

Starch

The starch content of the advanced varietal genotypes ranged from 58.04% (SPV 2370) to 70.71% (SPV 2293). In AHT starch ranged from 60.82% (SPH 1816) to 70.40% (SPH 1820). Higher starch content gives good colour and amylolytic activity during *roti* preparation.

Free amino acids

The free amino acids in the studied genotypes of AVT trials ranged from 63.71 mg/100g flour (SPV 2370) to 95.28 mg/100g flour (SPV 2363). In AHT trials free amino acids ranged from 65.47 mg/100g flour (CSH 30) to 89.56 mg/100g flour (SPH 1789). 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.

Phenolics

The phenolics content in the studied genotypes of AVT trials ranged from 1.42% (SPV 2366) to 2.43% (SPV 2301). In AHT trials phenolics content ranged from 1.25% (SPH 1779) to 2.69% (SPH 1816). The phenolics mostly responsible for astringent taste to the product but nowadays it acts as antioxidants which prevent cancer development in human body. These nutritional quality parameters results are in agreement with Glover *et al.,* (1986), Chavan *et al.,* (1988) and Chavan *et al.,* (2010).

Roti quality

All grain samples of AVT and AHT trials of *kharif*-2016 season grown at Dharwad center were used for the *roti* preparation and then used for organoleptic evaluation (colour and appearance, texture, flavour/aroma, taste and overall acceptability using 1 to 9 hedonic scale rating (Tables 2 and 4). 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. These results are in accordance with the previous research work done by Subramanian and Jambunathan (1982), Salunkhe *et al.,* (1984) and Shobha *et al.,* (2008).

During *Kharif*-2016 total 30 sorghum genotypes from AVT (19) and AHT (11) were evaluated for flour, dough, *roti* and nutritional quality parameters using above parameters (Tables 1 to 4). On the basis of these characters among the new sorghum genotypes from AVT; SPV 2308, SPV 2366, SPV 2358 and DSV 6 and from AHT; SPH 1779, SPH 1789 and CSH 14 were found promising for flour, dough, *roti* and nutritional quality.

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