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RESEARCH ARTICLE

EFFECT OF LOCATION ON NUTRITIONAL QUALITY OF SORGHUM GRAIN AND *ROTI*

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ABSTRACT

Fourteen sorghum genotypes grown at Dharwad and Udaipur during *Kharif* season-2015 were evaluated for nutritional and *roti* quality. The nutritional constituents proteins, sugars, starch, free amino acids and phenolics were found at higher level in Udaipur sample. From Dharwad center CSV 23, CSV 6, SPV 2296 and SPV 2305 were found promising for *roti* as well as for nutritional quality. From Udaipur SPV 2293, CSV 20, DSV 6 and SPV 2305 were found promising for *roti* and nutritional quality. The sorghum genotype SPV 2305 was found well for nutritional and *roti* quality at both the locations.

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INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is the king of cereals and is one of the important food crops in dry lands of tropical Africa, India and China (Shobha *et al.,* 2008). India ranks second in the world for sorghum production and first with respect to many regionally important crops like millets and pseudo-cereals. Sorghum is the principal staple food of Maharashtra, and is also an important food of Karnataka, Madhya Pradesh, Tamil Nadu and Andhra Pradesh. Sorghum can be milled to produce starch or grits (semolina) from which many ethnic and traditional dishes can be made. 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). 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). 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.

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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 (Chavan *et al*., 1988; 2010; 2015). 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). 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). Typically *bhakri* is accompanied by various curries, chutney (*thecha* – a thick paste of really hot green or red chilies) and raw onion (Murty and Subramanian, 1981). *Bhakri* has its own advantages from dietary point of view. Being made from cereals, it is high in dietary fiber but at the same time very easy to digest (Chavan *et al*., 1989, 2010 and Chavan and Salunkhe, 1984)**.** However it was necessary to study the effect different locations on the

nutritional and *roti* quality therefore, present study was under taken to identify superior genotype for future development.

MATERIALS AND METHODS

Material: Sorghum grains

Sorghum grains were obtained from two locations Dharwad and Udaipur for nutritional and *roti* quality testing. These sorghum grain samples were collected during *Kharif*-2015 season.

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.

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 A.O.A.C., (1990).

Preparation of sorghum *roti*

The flour was made from milling grains, sieved 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 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

a. Nutritional quality

Total fourteen advanced sorghum genotypes were compared with local check genotype for nutritional quality and *roti* quality. 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 77.52 to 80.11 kg/hl for Dharwad while 72.00 to 76.46 Kg/hl for Udaipur center samples. The SPV 2296 genotype gave higher hectoliter weight than rest of the genotypes studied (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 85 to 115 (ml/100g). The genotype SPV 2298 gave higher water absorption percentage than other genotypes.

Crude protein: The crude protein content ranged from 7.49% (SPV 2294) to 11.07% (DSV 6 Local check) in the advanced varietal genotypes studied with their checks. None of the new sorghum genotype was found superior over the check. But some genotypes grown at Udaipur found more protein content than 10 percent than the genotypes grown at Dharwad. This might be due to the location and climate effect. The details of the protein content are given in 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 0.02% [SPV 2308] to 1.39% [SPV 2250) in new developed genotype. All the genotypes were significantly different in their soluble content (Tables 1 and 3). The relationship between the physiochemical characters and *roti* quality indicated that quantity of water-soluble protein; soluble sugars and amylose jointly influence the *roti* quality similar results were reported by Subramanian and Jambunathan (1982).

Total soluble sugars: The total soluble sugars ranged from 1.27% (CSV 17 and SPV 2305) to 2.20% (SPV 2307). The change in the sugar accumulation in the sorghum genotype may be due to genetic makeup and location as well as soil and climate effect. All the genotypes studied were significantly different. The higher sugar percentage in sorghum flour representing good amylolyptic activity while preparation of *roti*. Higher level of sugars present in the sorghum flour holds more water and makes *roti* softer. Total soluble sugars are mostly responsible for good taste of the *roti* (Tables 1 and 3).

Starch: The starch content of the new sorghum genotypes ranged from 41.51% (CSV 20) to 65.93% (SPV 2299). Amylose and amylopectin components of the starch play major role during cooking of *roti* and development of good flavor to the sorghum *roti*. Higher starch content gives good colour and amylopetic activity during *roti* preparation.

Free amino acids: The free amino acids in the studied new genotypes of sorghum ranged from 67.36 mg/100g flour (SPV 2298) to 87.40 mg/100g flour (CSV 23). The advanced sorghum genotypes were significantly different in the free amino acid content.

Table 1. Nutritional constituents responsible for *roti* quality prepared from different genotypes of *Kharif* sorghum grown at Dharwad Center

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 (%)
SPV 2294	DB	RO	78.12	95	7.49	0.19	1.55	58.48	69.63	1.88
SPV 2299	DB	RO	77.52	110	7.86	0.37	1.98	65.93	70.24	1.72
SPV 2307	DB	RO	79.59	95	8.92	0.23	1.75	50.69	83.87	1.48
SPV 2250	DB	RO	77.68	100	8.11	0.04	2.00	62.00	74.17	1.76
CSV 23	DB	RO	79.68	100	10.50	0.10	1.88	50.33	79.72	2.19
SPV 2296	DB	RO	80.11	95	9.07	0.05	1.81	58.92	76.49	1.80
CSV 17	DB	RO	78.82	90	9.58	0.06	1.27	51.42	73.30	2.40
CSV 20	DB	RO	77.94	100	7.99	0.08	1.62	55.81	73.70	1.44
SPV 2298	DB	RO	78.01	115	8.88	0.15	1.47	51.46	67.36	1.78
SPV 2293	DB	RO	75.95	100	7.78	0.05	1.52	61.42	73.50	1.97
CSV 27	DB	RO	77.71	85	9.50	0.09	1.64	52.55	77.56	2.21
SPV 2308	DB	RO	78.22	85	7.96	0.02	1.56	54.65	73.33	1.75
SPV 2305	DB	RO	78.04	100	7.93	0.24	1.27	53.46	71.53	1.31
DSV 6	DB	RO	79.41	100	8.57	0.16	1.74	52.25	78.17	1.15
Range	-	-	77.52-80.11	85-115	7.49-10.50	0.02-0.37	1.27-2.00	50.33-65.93	67.36-83.87	1.15-2.40
Mean	-	-	78.34	97.86	8.58	0.13	1.65	55.67	74.47	1.77
S.E. ±	-	-	1.05	7.9	0.83	0.09	0.22	4.73	4.20	0.33
C.D. at 5 %	-	-	3.16	23.86	2.50	0.29	0.66	14.19	12.63	1.02

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* sorghum grown at Dharwad Center

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 2294	85	1	1	6.6	6.6	6.8	7.2	6.80	**12**	2.49	4.85	10.97
SPV 2299	100	1	1	7.4	7.6	7.2	7.8	7.50	**10**	2.55	4.67	10.18
SPV 2307	85	1	1	7.8	7.4	7.4	8.0	7.65	**8**	2.75	4.66	10.55
SPV 2250	85	1	1	7.4	7.4	7.8	7.6	7.55	**9**	2.66	4.32	10.48
CSV 23	85	1	1	8.8	8.6	8.4	8.4	8.55	**1**	2.39	4.76	10.35
SPV 2296	75	1	1	8.2	8.2	8.4	8.8	8.40	**3**	2.85	4.45	10.75
CSV 17	70	1	1	8.2	7.6	8.4	8.0	8.05	**5**	2.96	4.23	10.78
CSV 20	80	1	1	7.6	7.2	8.0	7.8	7.65	**8**	2.53	4.85	10.35
SPV 2298	105	1	1	7.4	8.2	7.8	8.0	7.85	**6**	2.83	5.48	10.41
SPV 2293	98	1	1	7.0	7.2	7.2	7.8	7.30	**11**	2.46	4.28	10.57
CSV 27	68	1	1	8.0	8.2	8.2	8.4	8.20	**4**	2.44	4.52	10.75
SPV 2308	65	1	1	7.6	7.6	7.6	8.2	7.75	**7**	2.75	4.62	10.28
SPV 2305	80	1	1	8.4	8.4	8.0	8.0	8.20	**4**	2.73	4.64	10.45
DSV 6	80	1	1	8.4	8.6	8.0	8.8	8.45	**2**	2.66	4.35	10.55
Range	70-105	-	-	6.6-8.8	6.6-8.6	6.8-8.4	7.2-8.8	6.80-8.55	-	2.39-2.96	2.28-5.48	10.18-10.78
Mean	82.93	-	-	7.77	7.78	7.80	8.05	7.85	-	2.64	4.61	10.53
S.E. ±	11	-	-	0.57	0.57	0.48	0.42	0.47	-	0.16	0.31	0.21
C.D. at 5 %	34	-	-	1.74	1.74	1.45	1.27	1.42	-	0.50	0.93	0.64

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**. **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* sorghum grown at Udaipur Center

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 (%)
SPV 2294	W	RO	76.05	110	10.20	1.06	2.00	44.84	78.55	1.78
SPV 2299	W	RO	72.44	110	9.48	1.25	2.11	45.35	71.98	1.60
SPV 2307	W	RO	74.95	105	10.55	1.04	2.20	43.14	82.90	1.80
SPV 2250	W	RO	72.57	100	9.94	1.39	2.11	43.87	76.86	1.89
CSV 23	W	RO	74.04	110	10.72	0.14	1.72	43.27	87.40	1.61
SPV 2296	W	RO	75.32	100	10.62	0.81	2.04	45.17	83.66	2.07
CSV 17	W	RO	76.05	90	9.83	0.98	1.53	42.76	85.19	1.71
CSV 20	W	RO	75.48	100	9.95	0.99	1.83	41.51	78.27	2.04
SPV 2298	W	RO	72.53	95	10.37	1.13	2.13	46.50	71.14	1.53
SPV 2293	W	RO	74.83	90	9.60	1.04	1.87	48.25	81.24	1.67
CSV 27	W	RO	72.00	105	9.91	0.41	1.58	42.54	78.77	1.56
SPV 2308	W	RO	75.64	95	10.56	0.86	1.92	42.57	78.50	1.97
SPV 2305	W	RO	75.17	90	10.98	0.87	1.98	43.69	86.13	2.22
DSV 6	W	RO	76.46	100	11.07	0.82	1.94	46.21	84.76	1.92
Range	-	-	72.00-76.46	90-110	9.48-11.07	0.14-1.39	1.53-2.20	41.51-48.25	71.14-87.40	1.53-2.22
Mean	-	-	74.53	100	10.27	0.91	1.93	44.26	80.38	1.81
S.E. ±	-	-	1.47	7.0	0.48	0.30	0.19	1.80	4.81	0.20
C.D. at 5 %	-	-	4.44	21.2	1.45	0.92	0.59	5.40	14.45	0.61

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* sorghum grown at Udaipur Center

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 2294	100	1	1	7.6	7.4	7.8	7.6	7.60	**5**	2.17	4.24	9.48
SPV 2299	100	1	1	7.0	7.2	7.2	7.6	7.25	**9**	2.81	4.89	10.81
SPV 2307	90	1	1	7.4	7.6	7.2	7.4	7.40	**7**	2.53	4.64	11.30
SPV 2250	80	1	1	6.8	7.2	7.2	6.6	6.95	**11**	2.56	4.92	10.26
CSV 23	100	1	1	8.0	7.8	7.4	8.0	7.80	**4**	2.90	4.76	10.07
SPV 2296	90	1	1	7.0	7.8	7.2	7.4	7.35	**8**	2.84	4.35	9.78
CSV 17	80	1	1	7.2	7.6	7.2	7.4	7.35	**8**	2.27	4.94	10.43
CSV 20	90	1	1	7.6	8.0	7.8	8.2	7.90	**2**	2.43	4.62	9.85
SPV 2298	80	1	1	7.6	7.4	7.2	7.8	7.50	**6**	2.82	4.23	9.88
SPV 2293	80	1	1	8.0	8.0	7.8	8.2	8.00	**1**	2.66	4.15	10.61
CSV 27	90	1	1	7.0	7.0	6.6	7.4	7.00	**10**	2.58	4.69	11.61
SPV 2308	80	1	1	7.6	7.0	7.4	7.4	7.35	**8**	2.69	4.77	10.92
SPV 2305	80	1	1	8.0	7.6	7.8	7.8	7.80	**4**	2.38	4.25	9.95
DSV 6	80	1	1	8.2	7.4	7.8	8.0	7.85	**3**	2.81	4.73	10.11
Range	80-100	-	-	6.8-8.2	7.0-8.0	6.6-7.8	6.6-8.2	6.95-8.00	-	2.17-2.90	4.15-4.94	9.48-11.61
Mean	87	-	-	7.5	7.5	7.4	7.6	7.51	-	2.60	4.58	10.36
S.E. ±	7.95	-	-	0.43	0.31	0.34	0.40	0.31	-	0.21	0.27	0.59
C.D. at 5 %	23.86	-	-	1.30	0.96	1.04	1.22	0.95	-	0.66	0.82	1.78

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**.

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**.

This component mostly responsible for aroma development while roasting combines with moisture, soluble proteins and sugars.

Phenolics: The phenolics content in the studied new genotypes of sorghum ranged from 1.15% (DSV 6) to 2.40% (CSV 17). 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, its presence in the food system is a positive sign for acting as antioxidants in the food system and prevents oxidation of the food components in the human body.

b: *Roti* quality

The new sorghum genotypes grown at Dharwad and Udaipur during *kharif*-2015 season 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 (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. For nutritional and *roti* quality similar results are reported by previous scientists (Subramanian and Jambhunathan, 1982; Bankar, *et al*., 1986; Glover et al., 1986; Klopfenstein and Hoseney, 1995; Chavan *et al*., 2015).

Conclusion

During *Kharif*-2015 fourteen new sorghum genotypes grown at Dharwad and Udaipur were evaluated for nutritional and *roti* quality using standard methods. Due to the different locations, soil type and climatic conditions as well as genetic response only one genotype SPV 2305 performed better than the other genotypes studied at both the center/locations (Table 2 1 to 4).

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