Regional Effect on Nutritional Quality of Sorghum Genotypes

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A B S T R A C T

Sorghum is a staple food of most of the arid zone area people. Therefore, at all India level coordinated research programme was planned for development of sorghum genotypes having high yield and good nutritional quality parameters and these selected genotypes were grown at Rahuri and Dharwad center during Rabi 2016-17 for the study. All parameters were studied using standard methods. Considering the flour, dough, roti and nutritional quality parameters among the new sorghum genotypes from Rahuri center SPV 2408, SPV 2479, SPV 2412, SPV 2405 and from Dharwad center SPV 2412, SPV 2469, SPV 2408, CSV 29R and SPV 2481 were found promising. The new genotypes SPV 2408 and SPV 2412 showed good performance at both research centers. Therefore, these genotypes should be considered for further research programme and development of new sorghum genotypes.

Keywords
Advanced sorghum genotypes, Nutritional quality, Roti, Flour, Dough, regional effect.

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 (Rao et al., 1981; Chavan et al., 2016a, b, c). 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; Klopfenstein and Hoseney, 1995). 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.

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. 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.

Materials and Methods

Material: Sorghum grains

Newly developed sorghum grain samples from advanced varietal trials (AVT) were collected from all India Co-ordinated Sorghum Improvement Project, Rahuri, Maharashtra and Dharwad, Karnataka, India during Rabi-2016-17 season for flour, dough, grain, roti and nutritional quality evaluation and further prospective.

Methods: Cleaning sorghum grains

The sorghum grains were cleaned to remove all extraneous material and damaged grains.

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 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 twenty three advanced genotypes were compared with local check genotype. The physical and nutritional parameters were evaluated using standard methods for judging the superiority of the genotype for further improvement in sorghum. The results on flour, dough, roti and nutritional quality are presented in tables 1 to 4.

Nutritional quality

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 72.58 to 78.27 kg/hl for Rahuri centers’ genotypes while 78.78 to 81.90 for Dharwad centers’ genotypes respectively. The DSV 4 genotype gave higher hectoliter weight than rest of the genotypes studied at both centers (Tables 1 and 3). Similar results are recorded by Chavan et al., (2016d, e).

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 due to keep the roti smooth and soft for longer time. Staling effect will be extended for longer time and it will remain fit for consumption. The water absorption capacity of flour ranged from 70 to 94% for Rahuri centers genotypes and 70 to 105 for Dharwad centers genotypes. The genotype DSV 4 gave higher water absorption percentage than other genotypes (Tables 1 and 3). These results are in agreement with previous research workers such as Michniewicz et al., (1991) and Chavan et al., (2016d, e).

Crude protein

The crude protein content ranged from 7.74% (SPV 2472) to 11.95% (SPV 2408) in the initial advanced varietal genotypes studied with their checks at Rahuri center. The protein content ranged from 7.79% (CSV 29R) to 11.03% (DSV 4) at Dharwad center (Tables 1 and 3). The genotype SPV 2408 gave highest protein content among the genotypes studied at both centers.
Table 1. Nutritional constituents responsible for roti quality prepared from different Rabi-2016-2017 (IAVT) cultivars of sorghum (Rahuri 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 2473 | CW                  | O                            | 75.95                      | 90                        | 8.75              | 1.57               | 1.54            | 52.27      | 67.52                       | 1.65         |
| SPV 2468 | CW                  | O                            | 76.92                      | 90                        | 9.51              | 2.26               | 2.02            | 57.12      | 73.91                       | 2.49         |
| SPV 2475 | CW                  | O                            | 78.26                      | 90                        | 9.58              | 1.65               | 2.02            | 53.34      | 74.73                       | 1.95         |
| SPV 2479 | CW                  | O                            | 75.95                      | 70                        | 9.24              | 1.50               | 1.71            | 57.59      | 77.71                       | 1.99         |
| CSV 22   | CW                  | O                            | 76.77                      | 70                        | 9.07              | 1.48               | 1.62            | 53.64      | 85.45                       | 1.91         |
| SPV 2478 | CW                  | O                            | 73.85                      | 84                        | 8.82              | 1.88               | 1.67            | 56.28      | 76.36                       | 2.04         |
| SPV 2405 | CW                  | O                            | 75.74                      | 92                        | 8.94              | 1.50               | 1.62            | 54.58      | 81.34                       | 1.79         |
| SPV 2407 | CW                  | O                            | 75.26                      | 80                        | 9.82              | 1.62               | 2.10            | 57.38      | 80.94                       | 2.13         |
| SPV 2472 | CW                  | O                            | 74.93                      | 90                        | 7.74              | 1.83               | 1.43            | 59.30      | 73.21                       | 1.68         |
| SPV 2408 | CW                  | O                            | 75.80                      | 86                        | 11.95             | 1.32               | 2.27            | 51.47      | 76.73                       | 2.59         |
| SPV 2459 | CW                  | O                            | 75.81                      | 90                        | 8.50              | 1.71               | 1.66            | 51.58      | 72.94                       | 1.96         |
| SPV 2480 | CW                  | O                            | 72.58                      | 90                        | 8.36              | 1.89               | 1.50            | 54.11      | 63.02                       | 2.05         |
| SPV 2471 | CW                  | O                            | 73.87                      | 80                        | 10.69             | 1.23               | 1.66            | 47.11      | 73.17                       | 2.56         |
| SPV 2412 | CW                  | O                            | 75.00                      | 90                        | 9.17              | 1.57               | 1.46            | 43.16      | 73.52                       | 1.87         |
| SPV 2406 | CW                  | O                            | 74.17                      | 92                        | 6.84              | 2.06               | 1.13            | 56.50      | 58.04                       | 2.01         |
| M 35-1   | CW                  | O                            | 78.27                      | 84                        | 9.36              | 1.63               | 2.03            | 53.48      | 70.92                       | 2.04         |
| SPV 2476 | CW                  | O                            | 77.34                      | 80                        | 9.86              | 1.47               | 1.80            | 50.36      | 75.60                       | 1.99         |
| SPV 2474 | CW                  | O                            | 77.43                      | 94                        | 10.94             | 1.34               | 2.08            | 45.30      | 77.74                       | 2.33         |
| CSV 29R  | CW                  | O                            | 76.55                      | 84                        | 9.21              | 1.51               | 1.86            | 57.02      | 75.34                       | 2.04         |
| SPV 2477 | CW                  | O                            | 76.01                      | 90                        | 9.08              | 1.83               | 1.83            | 55.95      | 66.26                       | 2.31         |
| SPV 2481 | CW                  | O                            | 75.93                      | 90                        | 9.67              | 1.63               | 1.91            | 51.09      | 82.79                       | 2.30         |
| SPV 2470 | CW                  | O                            | 74.58                      | 74                        | 9.38              | 1.76               | 2.04            | 58.49      | 84.39                       | 2.02         |
| Phule Vasudha | CW | O                        | 74.60                      | 80                        | 8.83              | 1.68               | 1.62            | 62.44      | 69.96                       | 1.98         |
| **Range** | -                   | -                            | 75.28-78.27                | 70-94                     | 7.74-11.95        | 1.23-2.26         | 1.13-2.27      | 43.16-62.44 | 63.02-85.45                 | 1.65-2.59    |
| **Mean** | -                   | -                            | 75.69                      | 85.08                     | 9.25              | 1.65               | 1.77            | 53.96      | 74.25                       | 2.06         |
| **S.E. ±** | -                  | -                            | 1.37                       | 6.73                      | 0.99              | 0.22               | 0.25           | 4.37       | 6.39                        | 0.24         |
| **C.D. at 5 %** | -  | -                        | 4.14                       | 20.20                     | 3.00              | 0.69               | 0.78           | 13.12      | 19.18                       | 0.74         |

Replications: 3; - = No sufficient seed.
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 hybrid/varieties of *Rabi*-2016-2017 (IAVT) cultivars of sorghum (Rahuri Center)

| Genotype | Water required for dough (ml) | Kneading quality | Spreading quality | Organoleptic quality parameters | Rank by DMRT | Loss in weight during storage (%) |
|----------|-----------------------------|------------------|-------------------|-------------------------------|-------------|----------------------------------|
|          |                             |                  |                   | Colour & appearance | Texture | Flavour | Taste | Overall acceptability | 4 hrs | 8 hrs | 24 hrs |
| SPV 2473 | 100                         | 1                | 1                 | 6.60             | 6.80    | 7.20    | 6.80  | 6.85               | 16    | 2.46  | 4.37  | 10.89  |
| SPV 2468 | 100                         | 1                | 1                 | 7.00             | 7.00    | 6.40    | 6.80  | 6.80               | 17    | 2.15  | 3.83  | 11.57  |
| SPV 2475 | 100                         | 1                | 1                 | 7.80             | 7.80    | 8.00    | 7.40  | 7.75               | 8     | 2.65  | 4.43  | 11.60  |
| SPV 2479 | 85                          | 1                | 1                 | 8.20             | 8.00    | 8.60    | 8.40  | 8.30               | 2     | 2.28  | 4.81  | 11.24  |
| CSV 22   | 80                          | 1                | 1                 | 6.40             | 6.00    | 5.60    | 5.60  | 5.90               | 20    | 2.31  | 4.22  | 10.82  |
| SPV 2478 | 95                          | 1                | 1                 | 6.20             | 7.00    | 5.80    | 6.80  | 6.45               | 19    | 2.32  | 4.10  | 11.23  |
| SPV 2405 | 100                         | 1                | 1                 | 8.40             | 7.80    | 8.00    | 8.40  | 8.15               | 4     | 2.91  | 4.38  | 11.33  |
| SPV 2407 | 90                          | 1                | 1                 | 7.60             | 7.20    | 6.80    | 7.00  | 7.15               | 13    | 2.23  | 4.12  | 11.65  |
| SPV 2472 | 100                         | 1                | 1                 | 8.60             | 7.40    | 6.80    | 7.00  | 7.45               | 11    | 2.24  | 4.15  | 11.15  |
| SPV 2408 | 95                          | 1                | 1                 | 8.20             | 8.20    | 8.20    | 8.80  | 8.60               | 1     | 2.26  | 4.53  | 12.42  |
| SPV 2459 | 100                         | 1                | 1                 | 7.80             | 7.60    | 7.60    | 7.80  | 7.70               | 9     | 2.29  | 4.24  | 10.23  |
| SPV 2480 | 100                         | 1                | 1                 | 7.20             | 7.60    | 6.60    | 6.80  | 7.05               | 14    | 2.37  | 4.46  | 11.08  |
| SPV 2471 | 90                          | 1                | 1                 | 8.00             | 7.80    | 7.20    | 7.60  | 7.65               | 10    | 2.53  | 4.86  | 10.71  |
| SPV 2412 | 100                         | 1                | 1                 | 8.80             | 8.60    | 7.60    | 7.80  | 8.20               | 3     | 2.33  | 4.32  | 10.43  |
| SPV 2406 | 100                         | 1                | 1                 | 8.00             | 8.00    | 8.00    | 7.20  | 7.80               | 7     | 2.55  | 4.38  | 10.82  |
| M 35-1   | 90                          | 1                | 1                 | 8.40             | 7.80    | 8.00    | 7.80  | 8.00               | 5     | 2.68  | 4.74  | 11.21  |
| SPV 2476 | 90                          | 1                | 1                 | 6.20             | 7.20    | 6.20    | 7.20  | 6.70               | 18    | 2.35  | 4.26  | 10.86  |
| SPV 2474 | 105                         | 1                | 1                 | 7.20             | 7.60    | 8.20    | 7.60  | 7.65               | 10    | 2.43  | 4.53  | 10.78  |
| CSV 29R  | 90                          | 1                | 1                 | 6.60             | 7.20    | 7.40    | 6.60  | 6.95               | 15    | 2.36  | 4.33  | 10.86  |
| SPV 2477 | 100                         | 1                | 1                 | 7.80             | 7.60    | 8.00    | 7.40  | 7.70               | 9     | 2.41  | 4.51  | 11.24  |
| SPV 2481 | 100                         | 1                | 1                 | 7.60             | 7.20    | 7.60    | 7.00  | 7.35               | 12    | 2.49  | 4.38  | 10.95  |
| SPV 2470 | 85                          | 1                | 1                 | 8.00             | 7.80    | 7.80    | 7.60  | 7.80               | 7     | 2.45  | 4.37  | 10.43  |
| Phule Vasudha | 90           | 1                | 1                 | 7.80             | 8.00    | 8.00    | 8.00  | 7.95               | 6     | 2.33  | 4.52  | 11.15  |
| Range    | 85-105                      | -                | -                 | 6.20-8.80        | 6.0-8.60 | 5.60-8.60 | 5.60-8.40 | 5.90-8.60 | - | 2.15-2.91 | 3.83-4.86 | 10.23-12.42 |
| Mean     | 91                          | -                | -                 | 7.60             | 7.47    | 7.29    | 7.34  | 7.42               | -     | 2.41  | 4.38  | 11.05  |
| S.E. ±   | 15                          | -                | -                 | 0.74             | 0.51    | 0.78    | 0.61  | 0.58               | -     | 0.16  | 0.22  | 0.46   |
| C.D. at 5%| 46                          | -                | -                 | 2.22             | 1.53    | 2.37    | 1.85  | 1.76               | -     | 0.49  | 0.67  | 1.40   |

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.
Table 3 Nutritional constituents responsible for *roti* quality prepared from different *Rabi*-2016-2017 (IAVT) cultivars of sorghum (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 2473  | CW                  | O                             | 79.32                     | 80                        | 8.95              | 0.74                | 1.90           | 59.55    | 84.42                      | 0.88         |
| SPV 2468  | CW                  | O                             | 79.86                     | 80                        | 8.75              | 0.95                | 2.32           | 69.16    | 81.18                      | 1.02         |
| SPV 2475  | CW                  | O                             | 81.19                     | 80                        | 9.63              | 1.47                | 2.10           | 55.52    | 77.93                      | 1.72         |
| SPV 2479  | CW                  | O                             | 80.71                     | 80                        | 8.99              | 0.91                | 1.96           | 58.98    | 85.33                      | 1.43         |
| CSV 22    | CW                  | O                             | 80.01                     | 80                        | 8.50              | 0.78                | 1.94           | 64.32    | 91.11                      | 1.06         |
| SPV 2478  | CW                  | O                             | 79.65                     | 90                        | 9.06              | 0.28                | 2.45           | 70.78    | 96.54                      | 0.54         |
| SPV 2405  | CW                  | O                             | 80.59                     | 90                        | 8.28              | 0.66                | 1.56           | 52.53    | 84.95                      | 1.02         |
| SPV 2407  | CW                  | O                             | 80.12                     | 90                        | 8.78              | 0.28                | 1.93           | 59.73    | 93.43                      | 0.96         |
| SPV 2472  | CW                  | O                             | 79.24                     | 80                        | 8.19              | 0.90                | 1.67           | 58.18    | 79.64                      | 1.08         |
| SPV 2408  | CW                  | O                             | 81.01                     | 90                        | 10.56             | 0.13                | 2.10           | 54.44    | 89.12                      | 1.23         |
| SPV 2459  | CW                  | O                             | 80.27                     | 80                        | 10.61             | 0.27                | 2.43           | 57.09    | 95.68                      | 1.28         |
| SPV 2480  | CW                  | O                             | 78.78                     | 90                        | 7.82              | 0.91                | 1.71           | 58.82    | 68.62                      | 0.99         |
| SPV 2471  | CW                  | O                             | 80.57                     | 90                        | 9.57              | 0.68                | 1.85           | 52.30    | 84.64                      | 1.67         |
| SPV 2412  | CW                  | O                             | 80.82                     | 90                        | 10.66             | 0.60                | 2.40           | 59.98    | 97.35                      | 1.02         |
| SPV 2406  | CW                  | O                             | 80.35                     | 90                        | 8.56              | 0.80                | 1.68           | 54.68    | 77.78                      | 1.34         |
| M 35-1    | CW                  | O                             | 81.29                     | 70                        | 9.92              | 0.44                | 2.20           | 56.49    | 86.80                      | 1.23         |
| SPV 2476  | CW                  | O                             | 80.71                     | 80                        | 9.64              | 0.58                | 1.76           | 58.47    | 88.35                      | 1.07         |
| SPV 2474  | CW                  | O                             | 79.94                     | 80                        | 9.53              | 0.19                | 1.87           | 50.09    | 85.68                      | 0.96         |
| CSV 29R   | CW                  | O                             | 79.93                     | 90                        | 7.79              | 0.46                | 1.62           | 56.36    | 81.51                      | 1.06         |
| SPV 2477  | CW                  | O                             | 80.75                     | 85                        | 9.03              | 0.92                | 1.96           | 52.16    | 81.09                      | 1.39         |
| SPV 2481  | CW                  | O                             | 81.07                     | 100                       | 10.21             | 0.36                | 2.10           | 53.12    | 91.33                      | 1.37         |
| SPV 2470  | CW                  | O                             | 79.88                     | 100                       | 9.71              | 0.60                | 2.25           | 61.38    | 89.98                      | 1.06         |
| DSV 4     | CW                  | O                             | 81.90                     | 105                       | 11.03             | 0.22                | 1.92           | 56.55    | 83.36                      | 1.25         |

**Range** - 78.78-81.90, **Mean** - 80.35, **S.E. ±** 0.71, **C.D. at 5 %** 2.16

Replications: 3; - = No sufficient seed.
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 hybrid/varieties of Rabi-2016-2017 (IAVT) cultivars of sorghum (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              |              |                                  |
|          |                             |                  |                  | Texture                          |              | 4 hrs                            |
|          |                             |                  |                  | Flavour                          |              | 8 hrs                            |
|          |                             |                  |                  | Taste                            |              | 24 hrs                           |
|          |                             |                  |                  | Overall acceptability            |              |                                  |
| SPV 2473 | 95                          | 1                | 1                | 6.80                             | 14           | 2.15                             |
| SPV 2468 | 93                          | 1                | 1                | 7.40                             | 6            | 2.54                             |
| SPV 2475 | 90                          | 1                | 1                | 7.80                             | 7            | 2.46                             |
| SPV 2479 | 95                          | 1                | 1                | 7.00                             | 13           | 2.95                             |
| CSV 22   | 92                          | 1                | 1                | 8.00                             | 9            | 2.19                             |
| SPV 2478 | 100                         | 1                | 1                | 7.80                             | 8            | 2.39                             |
| SPV 2405 | 100                         | 1                | 1                | 8.20                             | 10           | 2.96                             |
| SPV 2472 | 90                          | 1                | 1                | 7.80                             | 3            | 2.70                             |
| SPV 2408 | 100                         | 1                | 1                | 8.00                             | 2            | 2.46                             |
| SPV 2459 | 90                          | 1                | 1                | 8.40                             | 12           | 2.56                             |
| SPV 2480 | 100                         | 1                | 1                | 7.80                             | 2            | 2.46                             |
| SPV 2471 | 100                         | 1                | 1                | 7.60                             | 12           | 2.30                             |
| SPV 2412 | 98                          | 1                | 1                | 8.40                             | 1            | 2.76                             |
| SPV 2406 | 99                          | 1                | 1                | 7.80                             | 11           | 2.73                             |
| M 35-1   | 83                          | 1                | 1                | 7.80                             | 9            | 2.67                             |
| SPV 2476 | 94                          | 1                | 1                | 7.80                             | 8            | 2.93                             |
| SPV 2474 | 92                          | 1                | 1                | 7.80                             | 9            | 2.89                             |
| CSV 29R  | 100                         | 1                | 1                | 8.40                             | 4            | 2.87                             |
| SPV 2477 | 96                          | 1                | 1                | 8.00                             | 12           | 2.54                             |
| SPV 2481 | 106                         | 1                | 1                | 8.20                             | 4            | 2.80                             |
| SPV 2470 | 108                         | 1                | 1                | 7.80                             | 6            | 2.92                             |
| DSV 4    | 110                         | 1                | 1                | 8.00                             | 5            | 2.99                             |
| Range    | 83-110                      | -                | -                | 6.80-8.40                        | -            | 2.15-2.99                        |
| Mean     | 97.00                       | -                | -                | 7.85                             | -            | 3.43-8.28                        |
| S.E. ±   | 6.00                        | -                | -                | 0.38                             | -            | 9.29-11.32                       |
| C.D. at 5 % | 18.00                      | -                | -                | 1.15                             | -            | 10.25                            |

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.
Higher protein content is a good character for nutritional value of that genotype and also for human nutrition. These results are in agreement with previous research workers such as Michniewicz et al., (1991) and Chavan et al., (2016d, e).

**Soluble protein**

The soluble protein content in the flour mostly responsible for the holding of more water and developing smoothness to the roti. While cooking soluble proteins, carbohydrates and free amino acids take part in the various reactions and develop specific aroma to the roti. The soluble protein content in the flour ranged from 1.23% (SPV 2471) to 2.26% (SPV 2468) at Rahuri center trials while soluble protein ranged from 0.13 (SPV 2408) to 1.47% (SPV 2479) at Dharwad center trials. All the genotypes were significantly different in their soluble content. These results are in agreement with previous research workers such as Michniewicz et al., (1991) and Chavan et al., (2016d, e).

**Total soluble sugars**

At Rahuri trials the total soluble sugars ranged from 1.13% (SPV 2406) to 2.27% (SPV 2408). At Dharwad trials total sugar content ranged from 1.56 (SPV 2405) to 2.45% (SPV 2478). All the genotypes studied were significantly different. The higher sugar percentage in sorghum flour representing good amylolytic activity while preparation of roti. Total soluble sugars are mostly responsible for good taste of the roti (Tables 1 and 3). These results are similar to Chavan et al., (2016d, e).

**Starch**

The starch content of the advanced varietal genotypes ranged from 43.16% (SPV 2412) to 62.44% (Phule Vasudha) at Rahuri center. At Dharwad center starch ranged from 50.09% (SPV 2474) to 70.78% (SPV 2478). Higher starch content gives good colour and amylolytic activity during roti preparation. Roti remain soft for longer time and increase self-life. Similar results are reported by Vietor et al., (1992) and Nandini and Salimath (2001).

**Free amino acids**

The free amino acids in the studied genotypes at Rahuri trials ranged from 63.02 mg/100g flour (SPV 2480) to 85.45 mg/100g flour (CSV 22). At Dharwad center trials free amino acids ranged from 68.62 mg/100g flour (SPV 2480) to 97.35 mg/100g flour (SPV 2412). The initial and 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. These results are in agreement with previous research workers such as Michniewicz et al., (1991) and Chavan et al., (2016d, e).

**Phenolics**

The phenolics content in the studied genotypes at Rahuri center trials ranged from 1.65% (SPV 2473) to 2.59% (SPV 2408). At Dharwad trials phenolics content ranged from 0.54% (SPV 2478) to 1.72% (SPV 2475). 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., (186), Chavan et al., (1988) and Chavan et al., (2009; 2010).

**Roti quality**

All grain samples of Rahuri center and Dharwad center trials of Rabi-2016-17 season
grown at Rahuri and Dharwad center were used for the roti preparation and then used for organoleptic evaluation (colour and appearance, texture, flavor/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 24 hrs. The results regarding weight loss in roti are presented in tables 2 and 4. These results are in accordance with the previous research work done by Murty and Subramanian (1981), Subramanian and Jambunathan (1981; 1982), Salunkhe et al., (1984) and Shobha et al., (2008).

Considering the flour, dough, roti and nutritional quality parameters among the new sorghum genotypes from Rahuri center SPV 2408, SPV 2479, SPV 2412, SPV 2405, M 35-1 and from Dharwad center SPV 2412, SPV 2469, SPV 2408, CSV 29R and SPV 2481 were found promising. At both research centers SPV 2408 and SPV 2412 showed good performance without any adverse effect of region. Therefore, these genotypes should be considered for further research programme and development of new sorghum genotypes.

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