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PROCESSING OF SORGHUM FROM DIFFERENT VARIETIES AND HYBRIDS FOR SEMOLINA AND THEIR PRODUCTS

Pengolahan Sorghum dari Beberapa Varietas dan Hibrida yang Berbeda untuk Membuat Semolina dan Produk Olahannya

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ABSTRACT

The present study was undertaken with the objective to standardise procedures for preparation of semolina (*rava)* from sorghum, to identify the best genotype for preparation of semolina and to study the nutritional quality parameters of semolina. For processing of sorghum, ten varieties and five hybrids were used for preparation of semolina and their products. A process has been standardized for semolina preparation using ultra grinding mill from sorghum grain. The semolina yield ranged from 46.51% to 54.29%. Hybrid CSH-15R gave the highest yield of semolina (54.29%). Starch content in semolina ranged from 59.93% to 66.43%. The new genotypes Phule Vasudha, Phule Yashoda and M 35-1 showed higher levels of starch content as compared to the other genotypes. The Phule Vasudha and Selection-3 showed higher levels of total soluble sugars in grains, as well as in semolina than the other genotypes. Phule Maulee gave higher level of crude fibre content (3.12%). The amino acid profile of sorghum grain and semolina showed very minor differences in the content due to the processing of sorghum grains into various products like semolina. The new genotypes of *rabi* sorghum showed comparable results for the mineral with that of hybrids. The organoleptic properties of the sweet (*shira)*, *upama* and *idali* prepared from semolina were judged on the basis of colour, texture and appearance, flavour, taste and overall acceptability of the products using semi-trained judges and 1 to 9 hedonic scales. All products prepared from semolina were like very much and gave highest rating of more than 8 hedonic scales. While considering the yield of semolina from sorghum grains as well as their nutritional composition and organoleptic properties of the niche products (*shira, upama, idali*) prepared from them, the varieties Phule Vasudha and Phule Yashoda were the best one as compared to the other varieties and hybrids and overall varieties were better than the hybrids.

[***Keywords*:** Sorghum, processing semolina, sweets (*shira*), *upama, idali*, nutritional quality]

ABSTRAK

Penelitian ini dilakukan untuk mendapatkan proses standar pengolahan semolina (rava) dari sorgum, mengidentifikasi genotipe terbaik untuk penyiapan semolina, dan mempelajari parameter kualitas gizi semolina. Untuk pengolahan sorgum, sepuluh varietas dan lima hibrida digunakan untuk penyiapan semolina dan produk olahannya. Sebuah proses telah distandarkan untuk mengolah semolina dari biji sorgum dengan menggunakan alat penggiling ultra dengan hasil semolina berkisar 46,51-54,29%. Hasil semolina tertinggi (54,29%) berasal dari hibrida CSH-15R. Kadar pati semolina berkisar 59,93-66,43%. Genotipe baru Phule Vasudha, Phule Yashoda, dan M 35-1 menghasilkan kadar pati lebih tinggi dibandingkan dengan genotipe lainnya. Total gula terlarut dalam biji dan semolina paling banyak dihasilkan oleh varietas Phule Vasudha dan Selection-3. Genotipe Phule Maulee mempunyai kadar serat kasar lebih tinggi (3,12%). Pengaruh pengolahan terhadap kandungan asam amino dari sorgum dan semolina menunjukkan perbedaan yang sangat kecil. Kandungan mineral sorgum genotipe baru sama dengan sorgum hibrida. Sifat-sifat organoleptik produk yang dibuat dari semolina, yakni shira, upama, dan idali, diuji berdasarkan warna, tekstur dan penampilan, aroma, dan rasa dengan menggunakan panelis yang terlatih dengan skala hedonik 1-9. Semua produk yang dibuat dari semolina sangat disukai oleh panelis dengan nilai kesukaan lebih dari 8. Berdasarkan rendemen, semolina serta komposisi gizi dan sifat organoleptik produk yang dibuat dari semolina (shira, upama, idali), Phule Vasudha dan Phule Yashoda adalah varietas terbaik dibandingkan dengan varietas lain dan hibrida, dan secara umum, semua varietas memberikan hasil yang lebih baik daripada hibrida.

[***Kata kunci*:** Sorgum, pengolahan semolina shira, upama, idali, kandungan gizi]

INTRODUCTION

Sorghum (*Sorghum bicolour* L. Moench) is one of the major cereal crop consumed in India after rice (*Oryza sativa*) and wheat (*Triticum aestivum*). Sorghum is commonly called as *jowar* or great millet. Sorghum is considered as coarse grain due to the presence of outer fibrous bran of seed. Sorghum is poor in lycine but rich in leucine.

India is the largest producer of sorghum in the world with 6.98 million tons during 2010-2011 and almost entire production of sorghum (95%) in the

country from the above regions (GOI 2011). Millets, sorghum and pulses are traditionally the staple grains for household consumption (Dayakar Rao *et al.* 2007). In rural areas of central Maharashtra, per capita annual consumption of sorghum is around 60 kg, accounting for almost half of per capita consumption of all cereals (Parthasarathy Rao *et al.* 2010).

About 700 million people are nourished by sorghum, since it constitutes a source of calories, protein and minerals. Progress has been made in developing high yielding varieties and hybrids with improved agronomic traits that resulted in excess production. The nutritional importance of sorghum is 349 kcal energy, 9.6% protein, 3.8% fat, 73.2% carbohydrates, 2.4% ash and 11% moisture content (Chavan and Salunkhe 1984).

Sorghum protein is superior to wheat protein in biological value and digestibility. Sorghum is totally free from gluten, contains more fibre and micro-nutrients. As sorghum is digested slowly it is an excellent health food for people suffering from diabetes in India (Klopfenstein and Hoseney 1995).

Starch is a major carbohydrate in the grain. The other carbohydrates present are simple sugars, cellulose and hemicelluloses. The amylose content of starch varies from 21% to 28%. Starch from waxy varieties contains little amylose. Both waxy and regular starches contain free sugars up to 1-2%. Sucrose being a major constituent (0.85%) followed by glucose (0.09%), fructose (0.09%) and maltose (Miller and Burns 1970).

The percentage of different protein fractions of the total protein of sorghum grown in India is albumin 5, globulin 6.3, prolamin 46.4 and glutelin 30.4. Sorghum protein is superior to wheat protein in biological value and digestibility. A vegetarian diet based on some varieties of sorghum is somewhat better than rice based diet. Sorghum lipids mostly consist of triglycerides, which are rich in the unsaturated fatty acids, oleic and linoleic, their percentage being 33 and 47, respectively (Salunkhe *et al.* 1977; Hall 2000; Kleih *et al.* 2000).

Processed food products of sorghum for human consumption are emerging, such as flakes, pasta, vermicelli, semolina etc. (Dayakar Rao and Singh 2010). Many sorghum varieties and hybrids are developed in India to increase yield and for processing of sorghum, e.g. Wani, Gulbhendi, Dagdi, Phule Panchami for pops, Phule Uttara used for *hurda* purpose and SPV-84 for syrup and jaggary.

Sorghum will continue to be a major food crop in several countries, especially in Africa in particular in Nigeria and Sudan, which together account for about 63% of Africa's sorghum production. These grains will be used for traditional as well as novel foods. However, there is a need to look into the possibilities of alternative uses. Though sorghum and millets have good potential for industrial uses, they have to compete with wheat, rice and maize (Desikachar 1977). Sorghum could be in great demand in the future if the technology for specific industrial end uses is developed.

Sorghum can be adopted for other food products by using appropriate processing methods. It may be possible to select grain types with improved milling quality that will make this crop competitive with other cereals in terms of utilization (Reichert and Young 1976). Wheat milling technology with suitable modification can be effectively used for grinding sorghum and millets.

The use of sorghum in common foods such as *sweets, upama, idali* (a steamed product) and *dosa* (a leavened product) can be popularized for wider use in sorghum-growing areas (Subramanian and Jambunathan 1982). A few important sun-dried or extruded and sun-dried products from sorghum are *papad, badi* and *kurdigai* sold in the market. These products usually have a shelf-life of over one year. They can be popularized through marketing channels similar to those used for rice products (Chavan and Patil 2010).

A number of different processes are used in the preparation of ready-to-eat cereals, including flaking, puffing and shredding, and granule formation in wheat, corn and rice (Desikachar 1975; Dayakar *et al.* 2014). There is no any research work on preparation of semolina from sorghum and their products. By suitable processing it might be feasible to produce semolina (*rava)* from sorghum. Therefore, an attempt has been made to prepare sorghum semolina and their products.

MATERIALS AND METHODS

Sorghum Grains

The grains of ten sorghum varieties *viz.,* Phule Revati, Phule Vasudha, Phule Chitra, Phule Yashoda, Phule Maulee, Phule Anuradha, CSV-22, CSV-18, Selection-3, Maldandi and five hybrids *viz*., CSH-15-R, SPH-1620, SPH-1647, SPH-1664 and SPH-1665 were obtained from the Senior Sorghum Breeder, All India Co-ordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Preparation of Semolina from Sorghum Grains

Semolina (*rava)* from sorghum grains was prepared by taking sorghum grains then cleaned (Fig. 1a). Then it was subjected to reduce the size by break rules and then purification for separation of semolina and flour by using different sieves. Chemical analysis of sorghum grains and semolina were done for protein, total sugar, crude fibre, starch, amino acids and minerals using standard methods of AOAC (1990) and NIR Spectrometer, Spectra Analyzer serial No. 05; 281, ZEUTEC Opto Elektronik GmbH, Germany.

Preparation of Sweet (*Shira*) from Sorghum Semolina

Recipe for preparation of sorghum sweet (s*hira)* was sorghum semolina 50 g, sugar 50 g, cashew nut 10 g, almond 10 g, cardamom 2 g, vegetable ghee 25 g and water 100ml (Fig. 1b). Sorghum semolina was roasted until it became slightly brown. In another pot ghee was warmed and sufficient water was boiled and then roasted semolina, sugar, salt were added and after cooking spread almond, cashew nut and served it while hot.

Preparation of *Upama* from Sorghum Semolina

Recipe for the preparation of sorghum *upama* was sorghum semolina 50 g, gram flour ½ spoon, black gram flour ½ spoon, peanuts 20 g, tomato 10 g, onion 15 g, green chilli 2 g, mustard 0.2 g, curry leaves 2-3 leaves, oil 10 g, salt 1 g and water 100 ml (Fig. 1c). Sorghum semolina rose till it becames brown; cut onion, chilli, coriander leaves, curry leaves; placed deep fry pan on gas; added oil and heated to warm, added mustard, onion, chilli, curry leaves, gram dhal powder, black gram dhal powder; fried thoroughly, added sufficient water in it and boiled it, added semolina, salt, cooked for 15-20 minutes, after cooking spread coriander leaves on it, served it while hot.

Preparation of *Idali* from Sorghum Semolina

Recipe for preparation of sorghum *dali* was sorghum semolina 50 g, black gram (dhal) 25 g, oil ½ spoon, salt 2 g and water 100 ml Soaked black gram dhal for 8-10 HR, then drained out the water, ground into fine paste, soaked semolina for 1-2 hours, added ground black gram dahl, salt in soaked semolina, mixed

Semolina | Sweets (*shira*)

Upama | *Idali*

Fig 1. Common foods processed from sorghum.

thoroughly (using a mixer) (Fig. 1d). Kept one night for fermentation, applied teaspoon oil to the *idali* mould and poured *idali* batter in it, steamed it in *idali* cooker for 10-15 minutes, taken out and removed *idali* from the moulds and served hot with chutney.

Organoleptic Evaluation of Semolina Products

Organoleptic evaluation of sweet (s*hira), upma* and *idali* for colour and appearance, flavour, texture, taste and overall acceptability was carried out using standard methods of Amerine *et al.* (1965). For this 10 semi-trained judges were used and 1 to 9 point hedonic scale was used for rating the quality of the sorghum product.

Statistical Analysis

All product preparations, chemical constituents and organolephtic parameters were analyzed by using three and ten replications respectively. The data obtained in the present investigation were statistically analyzed by using completely randomized design given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Recovery of Semolina from Sorghum Grains

Semolina yield ranged from 46.51% to 54.29%. The hybrid genotypes gave higher yield of semolina than the varieties used in the experiment. Hybrid CSH 15R gave a significantly higher yield of semolina (54.29%), while among the varieties Selection-3 gave highest semolina yield (50.61%) and at par with M 35-1 (49.57%) followed by Phule Yashoda (49.40%), Phule Revati (49.24%) and Phule Vasudha (49.16%) than other varieties and hybrids (Table 2).

Chemical Constituents of Sorghum Grain and Semolina

The crude protein content in sorghum grain and semolina ranged from 7.81% to 10.45% and 5.43% to 8.35%, respectively (Tables 1 and 2). Maldandi variety gave a significantly higher level of protein (10.45%) in the grain and at par with CSV-22 (10.42%) followed by Selection-3 (10.39%) and Phule Vasudha (10.16%). In semolina, Phule Vasudha gave significantly

Table 1. Nutritional composition of sorghum grains*.

Genotype	Crude protein (%)	Starch (%)	Total sugar (%)	Crude fibre (%)
Variety				
Phule Revati (RSV-1006)	9.47	65.57	1.93	2.78
Phule Vasudha (RSV-423)	10.16	69.01	1.63	2.84
Phule Chitra (SPV-1546)	9.74	61.79	1.82	3.21
Phule Yashoda (SPV-1359)	9.49	67.66	2.32	2.82
Phule Maulee (RSLG-262)	9.83	61.27	1.93	3.41
Phule Anuradha (RSV-458)	9.13	62.62	1.93	3.16
CSV-22	10.42	60.38	1.95	3.20
CSV-18	9.45	66.92	1.85	2.76
Selection-3	10.39	61.07	2.12	3.18
Maldandi (M 35-1)	10.45	68.93	1.83	2.92
Hybrid				
CSH-15R	8.75	63.56	1.74	2.83
SPH-1620	8.30	63.71	1.75	2.72
SPH-1647	8.16	63.32	1.45	2.72
SPH-1664	7.81	64.65	1.83	2.56
SPH-1665	8.16	63.55	1.41	2.59
Range	7.81-10.45	61.07-69.01	1.41-2.32	2.56-3.41
Mean	9.31	64.26	1.78	2.91
SE ±	0.014	0.137	0.010	0.021
CD at 5%	0.043	0.398	0.031	0.063
CV (%)	0.480	0.643	1.823	2.245

*All results are mean values of three determinations.

Table 2. Sorghum semolina recovery and their nutrient contents.

Genotype	Semolina recovery (%)	Flour (%)	Nutrient content in semolina			
			Crude protein (%)	Starch (%)	Total sugar (%)	Crude fibre (%)
Variety						
Phule Vasudha (RSV-423)	49.16	50.84	**8.35**	64.30	1.16	2.76
Phule Revati (RSV-1006)	49.24	50.76	7.61	64.16	1.05	**2.59**
Phule Vasudha (RSV-423)	49.16	50.84	**8.35**	64.30	1.16	2.76
Phule Chitra (SPV-1546)	48.90	51.10	6.73	61.25	1.37	3.15
Phule Yashoda (SPV-1359)	49.40	50.60	6.37	64.76	2.12	2.75
Phule Maulee (RSLG-262)	48.91	51.09	6.64	60.75	1.43	3.26
Phule Anuradha (RSV-458)	48.73	51.27	7.24	61.83	**1.68**	3.13
CSV-22	46.51	53.49	8.06	59.93	1.46	3.12
CSV-18	48.44	51.56	7.14	65.05	1.33	2.63
Selection-3	**50.61**	**49.39**	7.43	60.51	1.91	3.12
Maldandi (M 35-1)	49.57	50.43	7.41	**66.43**	1.75	2.87
Hybrid						
CSH-15R	**54.29**	**45.71**	6.61	63.09	**1.61**	2.78
SPH-1620	51.32	48.68	6.64	63.04	1.60	2.65
SPH-1647	50.96	49.04	7.26	63.21	1.24	**2.63**
SPH-1664	52.69	47.31	5.43	**64.20**	1.42	2.44
SPH-1665	52.38	47.62	6.08	63.20	1.19	2.48
Range	46.51-54.29	45.71-53.49	5.43-8.35	59.93-66.43	1.05-2.12	2.44-3.26
Mean	50.08	49.92	7.00	63.04	1.45	2.82
SE ±	0.479	0.475	0.011	0.009	0.007	0.008
CD at 5%	1.385	1.373	0.033	0.028	0.022	0.024
CV%	2.877	2.858	0.500	0.046	1.631	0.893

*All results are mean values of three determinations.

superior protein (8.35%) followed by CSV-22 (8.06%), Phule Revati (7.61%) and Selection-3 (7.43%) than another. FAO (1995) and Beta *et al.* (1995) observed protein content in whole sorghum grain in the range of 7-15%. Robertson and Perez-Maldonado (2006) reported that crude protein in sorghum ranged from 9.14% to 13%. Chavan *et al.* (2009) observed protein content in sorghum ranged from 9.6% to 14%. Similar results were observed by Viraktamath *et al.* (1972), Eggum *et al.* (1983) and Ratnavathi *et al.* (2000).

Starch

The starch content in grain and semolina ranged from 61.07% to 69.01% and 59.93% to 66.43%, respectively. In the grain Phule Vasudha gave a significantly higher level of starch content (69.01%) and at par with Maldandi (68.93%) followed by Phule Yashoda (67.66%), CSV-18 (66.92%) and Phule Revati (65.57%). The statistical analysis showed that the starch content in varieties and hybrids was significantly different. Maldandi gave a significantly higher level of starch in semolina (66.43%) followed by CSV-18 (65.05%), Phule Yashoda (64.76%), Phule Vasudha (64.30%) and SPH-1664 (64.20%). The results obtained in the present investigation are in agreement with the literature (Miller and Burns 1970; Eggum *et al.* 1983; Ratnavathi *et al.* 2010; Chavan *et al.* 2009). Starch gives the consistency of the product and absorbs more water for swelling and increasing the volume.

Total Sugars

In grain, Phule Yashoda gave significantly higher total sugar (2.32%) followed by Selection-3 (2.12%), CSV-22 (1.95%), Phule Revati (1.93%), Phule Maulee (1.93%) and Phule Anuradha (1.93%). In *rava*, Phule Yashoda gave statistically superior higher level of total sugar (2.12%) followed by Selection-3 (1.91%), Maldandi (1.75%), Phule Anuradha (1.68%) and CSH-15R (1.61 %) (Subramanian and Jambunathan 1984; Deshpande *et al.* 2003; Chavan *et al.* 2009; Ibrahim *et al.* 2010). Sugars are attributing the taste to the product. Therefore, higher levels of sugars are good for sweet products.

Crude Fibre

The crude fibre content in grain and semolina ranged from 2.56% to 3.41% and 2.44% to 3.26%, respectively. In grain, Phule Maulee gave statistically superior level of crude fibre (3.41%) followed by Phule Chitra (3.21%), CSV-22 (3.20%), Selection-3 (3.18%) and Phule Anuradha (3.16%). The statistical analysis showed that there is a significant difference in the crude fiber contents among the varieties and hybrids. In *rava*, Phule Maulee gave a statistically superior level of crude fibre (3.26%) followed by Phule Chitra (3.15%), Phule Anuradha (3.13%), CSV-22 (3.12%) and Selection-3 (3.12%) (Ratnavathi *et al.* 2000; Vannalli *et al.* 2008; Chavan *et al.* 2009). The crude fibre content in the diet plays important role for digestion and bowl movement. It also helps in avoiding constipation problems as well as some other stomach diseases. The results obtained in the present investigation are parallel to the literature.

Amino Acid Content in Sorghum Grain and Semolina

The amino acid contents in sorghum grain and semolina were similar (Tables 3 and 4). The non-essential amino acids *viz.,* proline, alanine, tyrosine, glutaminic acid, glycine, serine, aspartic acids, threonine, glutamine, asperagine etc. were also present in the sorghum grain. There was a significant difference between the amino acid contents of the varieties and hybrids. The results obtained in the present investigation are in agreement with the literature (Mosse *et al.* 1988; Robertson *et al.* 2006; Chavan and Patil 2010).

Minerals Contained in Sorghum Grain and Semolina

Calcium content in the sorghum grain ranged from 11.56 to 27.81 mg 100 g^{-1}. Selection-3 gave higher level of calcium content (27.81 mg 100 g^{-1}) followed by Phule Chitra (21.54 mg 100 g^{-1}) and SPH-1665 (20.5 mg 100 g^{-1}) (Table 5). Sorghum grains as well as their semolina are the good source of calcium, iron, phosphorus, potassium and other minor elements also. FAO (1995), Chavan and Patil (2010), Winchester and Makokha (2011) reported similar results. The mineral contents in sorghum grain and semolina were slightly different from each other (Table 6). This might be due to the processing of sorghum grains into semolina while preparing these products there is a production of flour that also contain mineral elements. Therefore the concentration of these minerals might change slightly. The statistical analysis showed significant difference in the mineral contents of grain and semolina within the varieties as well as hybrids.

Organoleptic Evaluation of *Shira*, *Upama* and *Idali* Prepared from Semolina

Overall acceptability for sweet (*shira)* Phule Vasudha and Phule Yashoda gave the highest score (8.2) followed by Phule Chitra (7.6), Maldandi (7.6) and SPH-1620 (7.6). Overall acceptability of *upama* ranged from 6.8 to 8.2. Phule Vasudha had the highest (8.2) overall acceptability followed by Phule Yashoda (8.0), CSV-22 (8.0), Selection-3 (8.0) and Maldandi gave the lowest (6.8) overall acceptability among the all varieties and hybrids. Overall acceptability of *idali* among different varieties and hybrids ranged from 7.0 to 8.2. Phule Vasudha and Phule Yashoda (8.2) gave the highest overall acceptability followed by CSV-22 (7.8), Phule Revati (7.6), Selection-3 (7.6) and SPH-1664 (7.6) (Table 7).

CONCLUSION

While considering the yield of semolina from sorghum grains as well as their nutritional composition and organolephtic properties of the niche products such as sweet (*shira*), *upama* and *idali* prepared for them, the varieties Phule Vasudha and Phule Yashoda are the best one as compared to the other varieties and hybrids. For above all niche products prepared from the sorghum semolina, the varieties are better than the hybrids.

Table 3. Amino acid composition of sorghum grains (g/16 g N).

Genotype	Cys	Glu	Gly	His	Ile	Leu	Lys	Met	Phe	Pro	Ser	Thr	Trp	Tyr	Ala	Arg	Asp	Val
Variety																		
Phule Revati (RSV-1006)	0.92	20.77	3.04	2.08	3.80	12.30	2.56	1.38	4.32	5.93	3.55	**2.97**	1.17	3.14	8.54	3.65	7.07	3.64
Phule Vasudha (RSV-423)	0.94	20.76	2.94	2.11	3.84	12.33	2.52	1.33	4.37	6.13	3.46	2.95	1.18	3.15	8.67	3.95	6.73	3.77
Phule Chitra (SPV-1546)	0.92	20.85	2.93	2.05	3.91	13.22	**2.65**	1.35	4.44	5.86	3.49	2.93	1.08	3.10	8.12	3.94	7.29	3.72
Phule Yashoda (SPV-1359)	0.95	20.83	3.22	2.06	3.95	12.41	2.50	1.37	4.11	6.06	3.61	2.94	1.04	3.23	8.48	3.92	7.62	3.74
Phule Maulee (RSLG-262)	0.87	20.60	3.06	2.06	3.85	12.77	2.65	1.34	4.45	5.86	3.56	2.94	1.11	3.04	8.36	3.87	6.55	4.35
Phule Anuradha (RSV-458)	0.94	20.45	2.99	2.05	3.92	13.04	2.58	1.36	4.37	5.92	3.58	2.97	1.14	3.12	8.46	3.15	7.00	3.44
CSV-22	0.85	21.03	2.84	2.01	4.02	12.86	2.63	1.40	4.41	5.93	3.42	2.94	1.17	3.06	8.07	3.76	7.56	4.14
CSV-18	0.95	20.55	2.84	2.07	3.82	12.51	2.56	1.38	4.48	6.22	3.40	2.96	1.16	3.13	8.27	3.69	7.28	3.83
Selection-3	0.80	20.85	2.62	2.07	3.94	12.37	2.60	1.39	4.64	5.83	3.15	2.96	1.20	2.84	8.49	4.57	6.63	4.54
Maldandi (M 35-1)	0.87	20.56	2.89	2.09	3.90	13.16	2.52	1.44	4.26	5.85	3.47	**3.06**	1.04	3.17	8.27	3.38	7.07	3.86
Hybrid																		
CSH-15R	0.90	21.05	2.91	2.12	3.90	13.19	2.40	1.38	4.45	6.36	3.60	2.97	1.07	3.27	8.49	3.37	6.95	3.47
SPH-1620	0.96	20.86	3.08	2.08	3.79	12.52	2.49	1.30	4.55	6.04	3.56	2.93	1.10	3.26	8.85	2.62	6.98	3.73
SPH-1647	0.95	20.77	2.84	2.12	3.81	12.98	2.58	1.39	4.35	6.25	3.37	2.96	1.08	3.25	8.36	3.48	6.95	3.14
SPH-1664	0.91	21.17	3.14	2.07	4.13	12.43	2.38	1.35	4.44	6.24	3.76	2.93	1.13	3.19	8.76	3.78	6.88	3.38
SPH-1665	0.95	21.08	3.37	1.98	4.08	12.26	2.36	1.41	4.65	6.28	3.84	2.97	1.06	3.13	8.55	3.91	6.93	3.22
Range	0.80-0.96	20.45-21.17	2.62-3.37	1.98-2.12	3.79-4.13	12.26-13.22	2.36-2.65	1.30-1.44	4.11-4.65	5.83-6.36	3.15-3.84	2.93-3.06	1.04-1.20	2.84-3.27	8.07-8.85	2.62-4.57	6.55-7.62	3.14-4.54
Mean	0.92	20.81	2.98	2.07	3.91	12.69	2.55	1.37	4.42	6.05	3.52	2.96	1.11	3.14	8.45	3.67	7.03	3.73
SE±	0.007	0.013	0.009	0.006	0.007	0.008	0.011	0.007	0.009	0.008	0.006	0.008	0.006	0.009	0.006	0.005	0.007	0.007
CD at 5% (n=3)	0.021	0.038	0.026	0.017	0.020	0.024	0.033	0.020	0.026	0.023	0.019	0.024	0.018	0.027	0.019	0.015	0.020	0.022
CV (%)	2.446	0.192	0.933	0.875	0.555	0.201	1.383	1.587	0.616	0.410	0.581	0.873	1.720	0.895	0.240	0.433	0.300	0.621

*All results are mean values of three determinations.

Table 4. Amino acid composition of semolina prepared from amino acid contentdifferent genotypes of sorghum.

Genotype	Cys	Glu	Gly	His	Ile	Leu	Lys	Met	Phe	Pro	Ser	Thr	Trp	Tyr	Ala	Arg	Asp	Val
Variety																		
Phule Revati (RSV-1006)	0.75	23.53	2.94	2.53	3.74	14.55	2.07	1.49	4.47	4.92	3.56	3.14	0.75	4.13	7.13	6.05	8.74	5.46
Phule Vasudha (RSV-423)	0.75	23.72	**3.15**	2.48	3.75	14.57	2.12	**1.56**	4.46	4.98	3.63	3.14	0.76	4.07	7.05	6.62	8.83	5.63
Phule Chitra (SPV-1546)	0.74	**24.06**	3.05	2.55	3.77	14.94	2.07	1.47	4.55	5.27	3.60	**3.16**	0.77	4.06	7.32	6.92	8.36	5.56
Phule Yashoda (SPV-1359)	**0.88**	23.83	3.14	2.56	3.63	14.36	2.13	1.52	4.45	5.07	3.65	3.13	0.74	4.06	7.15	6.76	8.84	5.28
Phule Maulee (RSLG-262)	0.78	23.75	2.95	2.47	3.63	14.73	2.16	1.47	4.47	5.37	3.45	3.18	0.85	4.06	7.36	6.83	8.24	5.47
Phule Anuradha (RSV-458)	0.73	23.60	3.07	2.46	3.94	14.93	2.07	**1.55**	4.54	4.92	3.74	3.17	0.75	4.09	7.29	6.33	8.52	5.06
CSV-22	0.74	23.84	2.94	2.49	3.85	14.74	2.14	1.49	4.58	4.84	3.64	3.11	0.73	3.92	7.06	6.63	8.82	5.84
CSV-18	0.72	23.57	2.86	2.37	3.74	14.39	**2.17**	1.47	4.37	5.07	3.47	3.15	0.83	3.90	7.10	5.83	8.64	5.07
Selection-3	0.76	23.24	3.08	2.49	3.83	14.28	**2.17**	1.57	4.47	5.10	3.74	**3.17**	0.80	4.04	7.27	5.93	8.53	5.77
Maldandi (M 35-1)	0.74	23.53	3.05	2.55	3.83	14.51	2.08	1.48	4.37	5.14	3.63	**3.16**	0.70	4.11	7.44	6.26	8.17	5.35
Hybrid																		
CSH-15R	0.85	23.95	2.82	2.55	3.63	14.72	2.15	1.46	4.62	5.09	3.47	3.09	0.74	4.05	7.13	6.72	8.37	4.95
SPH-1620	0.85	24.05	2.86	2.56	3.74	15.06	2.06	1.45	4.53	5.35	3.50	3.16	0.73	4.75	7.47	6.77	7.92	5.76
SPH-1647	0.86	23.86	2.94	2.55	3.65	14.34	2.07	1.49	4.47	5.28	3.53	3.08	0.82	3.97	7.38	6.47	8.29	5.36
SPH-1664	0.85	23.65	2.88	2.50	3.73	13.72	2.06	1.45	4.47	5.64	3.48	3.07	0.84	4.04	7.52	6.23	7.63	4.96
SPH-1665	0.76	23.92	2.75	2.52	3.74	14.75	2.11	1.47	4.52	3.39	3.46	3.05	0.72	4.05	7.42	6.55	8.27	5.15
Range	0.72-0.88	23.24-24.06	2.75-3.15	2.37-2.56	3.63-3.94	13.72-15.06	2.06-2.17	1.45-1.57	4.37-4.62	3.39-5.64	3.45-3.74	3.05-3.18	0.70-0.85	3.90-4.75	7.06-7.52	5.83-6.92	7.63-8.84	4.95-5.84
Mean	0.78	23.74	2.96	2.51	3.75	14.57	2.11	1.49	4.49	5.03	4.90	3.13	0.77	4.09	7.27	6.46	8.41	5.38
SE±	0.006	0.020	0.007	0.008	0.007	0.008	0.005	0.000	0.007	0.006	0.009	0.007	0.007	0.006	0.006	0.009	0.031	0.007
CD at 5%	0.017	0.059	0.022	0.025	0.021	0.024	0.017	0.019	0.021	0.019	0.027	0.021	0.021	0.019	0.019	0.027	0.090	0.022
CV (%)	2.309	0.261	0.770	1.073	0.592	0.171	0.847	0.365	0.499	0.395	0.802	0.707	2.862	0.506	0.279	0.441	1.112	0.431

*All results are mean values of three determinations.

Table 5. Mineral composition of sorghum grains (mg/100 g).

Genotype	Ca	Fe	Mn	Mg	P	K	Cu	Na	Zn
Variety									
Phule Revati (RSV-1006)	15.47	4.36	2.85	211	491	5100.80	20.13	3.62	
Phule Vasudha (RSV-423)	17.92	4.16	2.94	212	511	5340.86	21.26	3.66	
Phule Chitra (SPV-1546)	21.54	3.98	2.86	211	503	5100.92	19.36	3.76	
Phule Yashoda (SPV-1359)	18.38	3.85	3.06	215	513	5160.84	21.32	3.76	
Phule Maulee (RSLG-262)	18.40	4.63	2.77	223	483	5200.87	20.07	3.62	
Phule Anuradha (RSV-458)	11.56	4.26	2.52	225	496	4390.86	20.07	3.83	
CSV-22	19.82	4.09	2.92	213	503	5110.87	20.10	3.72	
CSV-18	17.29	4.74	2.87	224	504	5220.83	17.33	3.62	
Selection-3	27.81	3.47	2.95	212	518	5500.87	20.44	3.74	
Maldandi (M 35-1)	13.85	4.26	2.84	215	515	4910.88	21.92	3.63	
Hybrid									
CSH-15R	16.29	4.46	2.73	217	501	4950.95	17.84	3.64	
SPH-1620	17.63	4.14	2.95	214	500	5290.96	20.94	3.54	
SPH-1647	13.17	4.76	2.86	225	521	5240.89	21.32	3.56	
SPH-1664	18.55	3.86	2.86	218	521	5370.86	21.27	3.43	
SPH-1665	20.50	3.65	2.85	215	518	5270.86	23.15	3.61	
Range	11.56	3.47	2.52	211	483	439	0.80	17.33	3.43
	-27.81	-4.76	-3.06	-225	-521	-550	-0.96	-23.15	-3.83
Mean	17.87	4.18	2.85	217	506	494	0.87	20.43	3.64
SE ±	0.021	0.000	0.007	0.018	0.010	0.008	0.005	0.008	0.008
CD at 5%	0.062	0.021	0.021	0.052	0.029	0.024	0.015	0.025	0.024
CV%	0.364	0.240	0.770	0.020	0.005	0.005	1.847	0.131	0.692

*All results are mean values

Table 6. The mineral composition of semolina prepared from different genotypes of sorghum (mg/100 g).

Genotype	Ca	Fe	Mn	Mg	P	K	Cu	Na	Zn
Variety									
Phule Revati (RSV-1006)	24.06	3.80	4.16	193	570	405	0.96	13.45	4.12
Phule Vasudha (RSV-423)	28.96	3.45	4.09	192	581	381	1.05	15.07	4.34
Phule Chitra (SPV-1546)	31.09	3.33	4.26	192	572	383	1.07	12.64	4.15
Phule Yashoda (SPV-1359)	29.12	2.74	4.31	184	586	397	1.05	15.05	4.25
Phule Maulee (RSLG-262)	29.21	3.47	4.15	192	566	370	1.04	11.82	4.05
Phule Anuradha (RSV-458)	25.59	3.64	3.92	184	567	353	1.06	11.92	4.26
CSV-22	29.37	3.45	4.07	197	580	385	1.04	12.35	4.24
CSV-18	22.82	3.92	4.07	191	582	401	0.95	14.07	4.13
Selection-3	24.77	3.93	3.54	151	564	373	1.05	11.55	4.34
Maldandi (M 35-1)	22.85	3.96	4.07	192	594	383	1.08	12.76	4.12
Hybrid									
CSH-15R	28.72	3.27	4.08	185	576	389	1.04	15.61	4.16
SPH-1620	29.95	3.34	4.13	187	578	370	1.03	11.07	4.15
SPH-1647	26.63	3.83	3.92	196	573	399	1.05	14.13	4.06
SPH-1664	29.42	3.28	3.81	199	592	405	0.96	18.06	3.86
SPH-1665	29.15	3.35	4.13	187	574	378	1.05	15.72	4.06
Range	22.82	2.74	3.54	151	564	370	0.95	11.07	3.86
	-31.09	-3.96	-4.31	-199	-594	-405	-1.07	-18.06	-4.34
Mean	27.44	3.52	4.04	188	577	385	1.03	13.68	4.15
SE ±	0.009	0.017	0.007	0.010	0.013	0.009	0.007	0.008	0.009
CD at 5%	0.028	0.050	0.022	0.036	0.037	0.028	0.021	0.024	0.027
CV%	0.106	0.957	0.568	0.017	0.006	0.007	2.163	0.186	0.672

*All results are mean values of three determinations.

Table 7. Overall organoleptic evaluation of sweet, *upama* and *idali* prepared from semolina of different genotypes of sorghum.

Genotype	Overall acceptability for sweet (*shira*)	Overall acceptability for *upama*	Overall acceptability for *idali*
Variety			
Phule Revati (RSV-1006)	6.6	7.6	7.6
Phule Vasudha (RSV-423)	**8.2**	**8.2**	**8.2**
Phule Chitra (SPV-1546)	7.6	7.4	7.4
Phule Yashoda (SPV-1359)	**8.2**	**8.0**	**8.2**
Phule Maulee (RSLG-262)	7.2	7.4	7.4
Phule Anuradha (RSV-458)	6.6	7.2	7.0
CSV-22	6.8	8.0	7.8
CSV-18	7.4	7.4	7.2
Selection-3	7.4	8.0	7.6
Maldandi (M 35-1)	7.6	6.8	7.0
Hybrid			
CSH-15R	7.2	7.0	7.4
SPH-1620	7.6	7.8	7.4
SPH-1647	7.4	7.0	7.0
SPH-1664	7.2	7.4	7.6
SPH-1665	7.4	7.8	7.4
Range	6.6-8.2	6.8-8.2	7.0-8.2
Mean	7.36	7.52	7.48
SE ±	0.101	0.128	0.117
CD at 5%	0.288	0.363	0.333
CV%	6.928	8.549	7.871

*All results are mean values of ten determinations. Semitrainde judges and 1 to 9 hedonic scales were used.

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