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NUTRITIONAL AND ORGANOLEPTIC EVALUATION OF HURDA GRAIN SORGHUM

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ABSTRACT

Sorghum (*Sorghum bicolor* L. Moench) is a major cereal crop in the semi-arid or regions of Africa and Asia. It is drought and heat resistant than most of other cereals. In developing countries, it is a cheapest and primary source of calories. The tender jowar a grain in Marathi is called as “hurda”, which provides various nutrients and minerals that is beneficial to human health. The present investigation entitled was undertaken during Rabi season of 2022-23 at Sorghum Improvement Project and Department of Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri. In the present study, fourteen hurda grain sorghum genotypes were evaluated for their nutritional attributes and organoleptic evaluation. The present study proposes that hurda grain sorghum genotypes are highly rich in nutrients which are beneficial for human health. The study confirms some superior genotypes *viz*. RSSGV-89, RSSGV-83, RSSGV-90 and RSSGV-91 based on higher content of crude protein, sugars, total phenol, DPPH scavenging activity along with their morphological and organoleptic traits was found superior over the commercial checks Phule Madhur and Phule Uttara, which should be evaluate for further research work and which might be an important way for increasing the nutritional status of the people.

Key words : Nutritional, Sorghum, Hurda, Genotypes.

Introduction

Sorghum is the major millet grown globally constituting 65 per cent of total millets. In the world sixteen countries produced one million metric tons or more of sorghum in 2020 including Mali and Cameroon. United state is the highest producing country with 15.27 per cent share. United States, Nigeria, Ethiopia, Sudan, India and Mexico produce together more than 57 per cent of world’s total sorghum globally and India’s contribution is 7.64 per cent (Prabha *et al*., 2023). In India, Maharashtra is the highest sorghum producing state with 45.75 per cent of the total sorghum production in the country. Maharashtra along with Karnataka, Rajasthan, Tamil Nadu and Andhra Pradesh produce about 89 per cent production in the country. The highest yield has been recorded in Andhra Pradesh (3070 kg/ha) followed by Telangana (1855 kg/ha) and Madhya Pradesh (1636 kg/ha) and lowest 911 Kg/ha in Maharashtra (Prabha *et al*., 2023). The tender jowar grains in Marathi are called as “hurda and in Kannada is called as “seethani” and in Gujarati, it is called as “ponk”. Hurda is roasted food product prepared from sorghum by roasting on coal in mud pits, which gives it an earthy taste. For hurda preparation, the sorghum is harvested at milky grain stage. This freshly roasted hurda is then eaten with an accompaniment of various types of chutneys made up of sesame, groundnut, dry coconut, garlic and red chillies. Additives like jaggery, revdi, lime and black papper powder, shev make the taste more pleasant. According to a recent guardian article, American chefs say that, sweet grain sorghum is the next Wonder grain. The extol its health benefits, its versatility in cooking and its eco-friendliness due to being exceptionally drought tolerant (ICRISAT, 2013).

Commercialization of hurda grain sorghum cultivation is possible, if the required policy support in the form of incentives from Government for both producer and

processor are extended. Also, development of genotypes with different maturity durations and higher ratoon ability for widening the harvest window are crucial for commercialization (Anonymous, 2023). With an increasing population of people suffering from celiac disease, diabetes, obesity and other metabolic syndrome, there are opportunities and challenges for the food industry to develop healthier cereal products through utilizing novel ingredients and improving processing technologies (Handbook of Food Chemistry, 2015). On account of its nutritional significance and its easy adaptability to a wide range of growing conditions and lesser water requirements, sorghum has the potential to be incorporated in the diets of human populations around the world, more specifically to that intolerant to wheat (Kulamarva *et al*., 2008). There is a need to popularize sorghum with its high minerals and fiber content and with low or slow starch digestibility makes an ideal food for diabetic and obese population in the urban as well as rural society. It was therefore felt to develop and identify the genotype for hurda purpose which will give benefit to the farmers and consumers. Nowadays agro-tourism business is increasing in the rural areas and in the contest supplying sorghum hurda as a niche product to get the more profit to the farmers and producers. The farmers are demanding the variety having easy threshability with sweet hurda grain. At present farmers used the Phule Madhur variety and Surthi cultivar for hurda purpose under commercial purpose. This cultivar is having better threshability with less sweetness and poor grain and fodder yield potential. Hence, it is necessary to identify the best genotype of sweet grain sorghum having high in nutritional composition which gives, consumer acceptability and high yield and profit to the farmers. High production in small land holding improves the economic status of the small and marginal farmers. Nutritional and organoleptic evaluation of hurda grain sorghum helps to find out the best genotype for commercial purpose.

Materials and Methods

Experimental site

The site for the experimental field was selected at Sorghum Improvement Project, MPKV, Rahuri and nutritional analysis was conducted in the laboratory of Department of Biochemistry, Post Graduate Institute, MPKV, Rahuri located in Maharashtra State.

Seed material and experimental details

Fourteen hurda grain sorghum genotypes included in this investigation were obtained from Sorghum Improvement Project, M.P.K.V., Rahuri. The seed was sown in three replications using plot size of 4.4 × 2.4 cm with four rows and 15 cm distance in two plants and 60 cm distance in two rows. Nutritional attributes were evaluated at Sorghum and Biochemistry Department Laboratory for three growth stages viz; dough stage, hard dough stage and maturity stage. Organoleptic evaluation of hurda grain was conducted at soft dough stage only.

Nutritional parameters

Moisture content

Moisture content was determined by employing the standard method of analysis (AOAC, 2000). 10 g flour sample was weighed in a Petri dish and dried in an oven at 105ºC till a constant weight was obtained. The sample was weighed after cooling it in a desiccator and moisture (%) of grain powder sample was calculated as below formula.

$$\text{Moisture (\%)} = \frac{W_1 - W_2}{W} \times 100$$

Where, W_1 = Weight (g) of the dish with the material before drying

W_2 = Weight (g) of the dish with the material after drying and W = Weight (g) of the sample.

Crude fiber content

Crude fibre content in the sample was determined using the standard method of analysis (AOAC, 1965). During the acid and subsequent alkali treatment, oxidative hydrolytic degradation of the native cellulose and considerable degradation of lignin occur. The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The loss in weight gives the crude fibre content.

Crude protein content

Crude protein content was estimated by multiplying per cent nitrogen by 6.25. Total nitrogen in flour was estimated by Micro-Kjeldahl method (AOAC, 2000).

Reducing sugar

Reducing sugars were determined by Somogyi modified method (Somogyi, 1952 and Krishnaveni *et al*., 1984).

Total sugar

Total sugar percentage was calculated by the method suggested by Sadasivam and Manickam (1992).

Total phenol

Phenol content was estimated by the method suggested by Bray and Thorpe (1954). Phenols react with phosphomolybdic acid in Folin-Ciocalteau's reagent in alkaline medium and produce blue colored complex (molybdenum blue).

DPPH scavenging activity

Antioxidant activity was estimated by the method suggested by Blois (1992).

Grain separation percentage

Grain weight/panicle was recorded by selecting five panicles of each treatment and separate out the grains from the panicles of each treatment, separated grains measured by using weighing balance, expressed as in gram.

Overall Acceptability

The organoleptic evaluation in respect of overall acceptability was carried out based on nine-point hedonic scale as given below for grain colour, grain texture and grain taste.

S. no.	Quality grade distribution	Score
1	Like extremely	9
2	Like very much	8
3	Like moderately	7
4	Like slightly	6
5	Neither like or nor dislike	5
6	Dislike slightly	4
7	Dislike moderately	3
8	Dislike very much	2
9	Dislike extremely	1

Statistical analysis

All the experiments were planned using randomized block design (RBD) with three replications each and mean, range of nutritional parameters have been reported (Panse and Sukhatme, 1967).

Results and Discussion

Moisture content is one of the most critical factors that determine the quality of hurda sorghum grains. The results on moisture content in the grains of hurda sorghum varieties at different growth stages are presented in Table 1. The moisture content ranged from 38.22 to 56.79 per cent with a mean value of 48.17 per cent in the soft dough stage and 21.89 to 34.89 per cent with a mean of 28.09 per cent in the hard dough stage and 10.44 to 13.12 per cent with a mean of 11.93 per cent at maturity stage. The highest moisture content was recorded in genotype RSSGV-89 (56.79 %), while the lowest moisture content was observed in genotype RSSGV-84 (38.22%) in the soft dough stage. In the hard dough stage, the highest moisture content was recorded in genotype RSSGV-89 (34.89%) whereas the minimum moisture content was found in genotype RSSGV-84 (21.89%). In the mature stage the highest moisture content was observed in genotype RSSGV-89 (12.59%) whereas minimum moisture content was recorded in genotype RSSGV-84 (7.26%). Overall experimental findings showed that moisture content is highest at soft dough stage as compared to hard dough stage and maturity stage.

The effect of moisture content on engineering properties of sorghum grain during storage moisture constitutes one of the most influential factors due to their relationship with the biological factors that cause post-harvest damage affecting the nutritional and economical values Gely and Panago (2017). Shinde *et al*. (2016) revealed similar results where moisture content of variety RSSGV-46 had recorded more moisture content of 57.26 per cent as compared to Phule Uttara, Gulbhendi and Surthi with moisture content of 56.19 per cent, 55.57 per cent and 50.87 per cent, respectively.

The variation in the fiber content of the hurda grains from different varieties ranged from 2.24 to 2.82 per cent with a mean value of 2.58 per cent in the soft dough stage and the fiber content ranged from 2.38 to 2.91 per cent with a mean value of 2.64 per cent in the hard dough stage and the genotypes showed the fiber content ranged from 2.41 to 3.00 per cent with a mean value of 2.73 per cent in the maturity stage (Table 2). The highest fiber

Table 1 : Moisture content in grains of hurda sorghum genotypes at different growth stages.

S. no.	Name of genotype	Moisture (%)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	42.37	24.13	11.34
2	RSSGV-83	54.95	34.69	12.97
3	RSSGV-84	38.22	23.94	10.88
4	RSSGV-85	40.26	21.89	10.44
5	RSSGV-86	45.21	25.58	11.89
6	RSSGV-87	48.84	27.31	12.13
7	RSSGV-88	46.34	26.92	10.87
8	RSSGV-89	56.79	34.89	13.12
9	RSSGV-90	50.32	29.44	12.34
10	RSSGV-91	49.46	28.22	12.02
11	RSSGV-92	44.95	24.50	11.82
12	RSSGV-93	45.21	25.58	11.63
13	Phule Madhur (c)	56.57	34.43	13.03
14	Phule Uttara (c)	54.92	31.72	12.57
	Range	38.22-56.79	21.89-34.89	10.44-13.12
	Mean	48.17	28.09	11.93
	S.E. ±	0.75	1.49	0.27
	CD at 5%	2.18	4.34	0.78

Table 2 : Crude fiber content in grains of hurda sorghum genotypes at different growth stages.

S. no.	Name of genotype	Crude fiber (%)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	2.38	2.45	2.52
2	RSSGV-83	2.76	2.81	2.92
3	RSSGV-84	2.24	2.43	2.50
4	RSSGV-85	2.36	2.38	2.41
5	RSSGV-86	2.51	2.59	2.66
6	RSSGV-87	2.63	2.71	2.80
7	RSSGV-88	2.57	2.65	2.72
8	RSSGV-89	2.82	2.91	3.00
9	RSSGV-90	2.71	2.79	2.88
10	RSSGV-91	2.68	2.75	2.82
11	RSSGV-92	2.45	2.51	2.59
12	RSSGV-93	2.41	2.47	2.55
13	Phule Madhur (c)	2.80	2.83	2.97
14	Phule Uttara (c)	2.78	2.80	2.85
	Range	2.24-2.82	2.38-2.91	2.41-3.00
	Mean	2.58	2.64	2.73
	S.E. ±	0.06	0.07	0.12
	CD at 5%	0.17	0.23	0.35

Table 3 : Crude protein content in grains of hurda sorghum genotypes at different growth stages.

S. no.	Name of genotype	Crude Protein (%)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	9.37	7.53	5.46
2	RSSGV-83	11.78	9.28	7.70
3	RSSGV-84	8.93	6.09	5.25
4	RSSGV-85	9.15	7.31	5.03
5	RSSGV-86	10.03	8.18	6.12
6	RSSGV-87	10.46	8.62	6.56
7	RSSGV-88	10.25	8.40	6.34
8	RSSGV-89	11.83	9.35	7.67
9	RSSGV-90	10.90	8.06	7.00
10	RSSGV-91	10.68	8.84	6.78
11	RSSGV-92	9.81	7.96	5.90
12	RSSGV-93	9.59	7.75	5.68
13	Phule Madhur (c)	11.56	9.15	7.65
14	Phule Uttara (c)	11.12	9.10	7.43
	Range	8.93-11.83	6.09-9.35	5.03-7.70
	Mean	10.39	8.26	6.44
	S.E. ±	0.12	0.10	0.28
	CD at 5%	0.35	0.28	0.82

content was observed in genotype RSSGV-89 (2.82 %) while the lowest fiber content was observed in genotype RSSGV-84 (2.24%) in the soft dough stage. In the hard dough stage, the fiber content was recorded in genotype RSSGV-89 (2.91%) whereas the minimum fiber content was found in genotype RSSGV-85 (2.38%). In the mature stage the highest fiber was observed in genotype RSSGV-89 (3.00 %) whereas minimum fiber content was recorded in genotype RSSGV-85 (2.41%).

Crude fiber is an essential constituent required for proper bowel movement. Also, the involvement of dietary fiber in lowering the blood cholesterol levels has been reported. Jimoh and Abdullahi (2017) observed similar results in sorghum genotypes with crude fiber ranging from 1.65 to 7.94 per cent. The results were in agreement with those obtained by Vannali *et al*. (2008) while working on ten sorghum genotypes for the physiochemical analysis, obtained a high crude fiber content of 2.48 per cent in Giddamaladandi variety. Gajmal *et al*. (2021) had reported the crude fiber in a range of 2.24 to 2.59 per cent. Similar results were stated by Anerao *et al*. (2022), where fiber content in the white sorghum, yellow sorghum and red sorghum was recorded in the range of 2.80, 3.00 and 3.20 per cent, respectively.

Crude protein content

Crude protein of fourteen hurda sorghum genotypes evaluated and presented in Table 3. The crude protein content ranged from 8.93 to 11.83 per cent with a mean value of 10.39 per cent in the soft dough stage and 6.09 to 9.35 per cent with a mean of 8.26 per cent in the hard dough stage and 5.03 to 7.70 per cent with a mean of 6.44 per cent are recorded. The highest crude protein content was observed in genotype RSSGV-89 (11.83%) while the lowest crude protein content was observed in genotype RSSGV-84 (8.93%) in the soft dough stage. In the hard dough stage, the highest crude protein content was recorded in genotype RSSGV-89 (9.35%) whereas the minimum crude protein content was found in genotype RSSGV-84 (6.09%). In the mature stage the highest crude protein content was observed in genotype RSSGV-83 (7.70%) whereas minimum crude protein content was recorded in genotype RSSGV-85 (5.03%). The overall findings revealed that the crude protein content is highest in the soft dough stage as compared to hard dough stage and maturity stage.

Kafirins is an important protein in sorghum, which

Table 4 : Reducing sugar in grains of hurda sorghum genotypes at different growth stages.

S. no.	Name of genotype	Reducing Sugar (%)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	1.66	1.19	0.61
2	RSSGV-83	3.28	2.81	1.21
3	RSSGV-84	1.83	1.07	0.51
4	RSSGV-85	1.81	1.11	0.55
5	RSSGV-86	2.71	1.40	0.87
6	RSSGV-87	3.11	2.66	1.07
7	RSSGV-88	3.07	2.45	0.99
8	RSSGV-89	3.37	2.96	1.33
9	RSSGV-90	2.83	2.78	1.07
10	RSSGV-91	2.81	2.76	1.09
11	RSSGV-92	2.68	1.31	0.80
12	RSSGV-93	2.11	1.22	0.63
13	Phule Madhur (c)	3.31	2.93	1.31
14	Phule Uttara (c)	3.40	2.97	1.37
	Range	1.66-3.40	1.07-2.97	0.51-1.37
	Mean	2.71	2.12	0.96
	S.E. ±	0.11	0.18	0.06
	CD at 5%	0.33	0.53	0.18

Table 5 : Total sugar in grains of hurda sorghum genotypes at different growth stages.

S. no.	Name of genotype	Total Sugar (%)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	2.48	1.60	0.89
2	RSSGV-83	4.83	3.11	1.50
3	RSSGV-84	2.33	1.39	0.88
4	RSSGV-85	2.41	1.42	0.80
5	RSSGV-86	3.34	1.89	1.03
6	RSSGV-87	4.69	2.93	1.21
7	RSSGV-88	3.44	2.76	1.16
8	RSSGV-89	5.47	3.28	1.63
9	RSSGV-90	4.66	3.05	1.33
10	RSSGV-91	4.71	3.09	1.29
11	RSSGV-92	3.23	1.71	0.97
12	RSSGV-93	3.10	1.67	0.93
13	Phule Madhur (c)	5.06	3.21	1.51
14	Phule Uttara (c)	5.51	3.31	1.69
	Range	2.33-5.51	1.39-3.31	0.80-1.69
	Mean	3.95	2.46	1.20
	S.E. ±	0.26	0.15	0.07
	CD at 5%	0.75	0.44	0.22

accounts for 70 per cent of the sorghum protein storage. Kafirins have low starch digestibility it cannot be enzymatically assimilated in gastro intestinal tract because of their high polymerization level and broad disulphides (Belton *et al.*, 2006). However, sorghum is promising food source for people with obesity and diabetes because of their low starch and protein digestibility (Taylor *et al.*, 2007). It concluded that hurda having better nutritive quality than matured sorghum grain (Shinde *et al.*, 2016).

Reducing sugar %

The result relating to reducing sugar percentage was depicted in Table 4. The result revealed that the reducing sugar percentage of fourteen genotypes was found in the range of 1.66 to 3.40 per cent in the soft dough stage. In the hard dough stage, the reducing sugar percentage ranged from 1.07 to 2.97 per cent and in the maturity stage, the reducing sugar percentage was recorded with the range of 0.51 to 1.37 per cent. Reducing sugar percentage of check Phule Uttara was observed higher as compare to other genotypes in the soft dough, hard dough and maturity stages with the values of 3.40, 2.97 and 1.37 per cent, respectively. The genotype RSSGV-82 showed minimum reducing sugar percentage with 1.66 per cent in the soft dough stage and the genotype RSSGV-84 showed minimum reducing sugar percentage with 1.07 and 0.51 per cent in the hard dough stage and maturity stage, respectively. The overall findings concluded that the reducing sugar is decreased from soft hard dough stage to maturity stage.

Total sugar%

The result revealed that the total sugar percentage of fourteen genotypes was found in the range of 2.33 to 5.51 per cent in the soft dough stage. In the hard dough stage, the total sugar percentage ranged from 1.39 to 3.31 per cent and in the maturity stage, the total sugar percentage was recorded with the range of 0.80 to 1.69 per cent. Total sugar percentage of check Phule Uttara was observed higher as compare to other genotypes in the soft dough, hard dough and maturity stages with the values of 5.51, 3.31and 1.69 per cent, respectively. The genotype RSSGV-84 showed minimum total sugar percentage with values of 2.33 and 1.39 per cent in the soft dough and hard dough stages respectively. The genotype RSSGV-85 showed minimum total sugar percentage with a value of 0.80 per cent in the maturity stage (Table 5).

Sweetness of tender hurda grain sorghum comes

Table 6 : Total phenol content in grains of hurda sorghum genotypes at different growth stages

S. no.	Name of genotype	Total Phenol (mg/g)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	6.50	4.50	2.30
2	RSSGV-83	7.00	5.30	3.00
3	RSSGV-84	5.80	3.30	1.80
4	RSSGV-85	5.70	3.50	2.10
5	RSSGV-86	6.10	4.60	2.60
6	RSSGV-87	6.80	4.90	2.70
7	RSSGV-88	6.70	4.70	2.40
8	RSSGV-89	7.10	5.40	3.15
9	RSSGV-90	6.90	5.10	2.80
10	RSSGV-91	6.80	4.90	2.50
11	RSSGV-92	6.60	4.60	2.40
12	RSSGV-93	5.90	3.80	2.10
13	Phule Madhur (c)	7.00	5.30	2.90
14	Phule Uttara (c)	6.90	5.20	3.10
	Range	5.70-7.10	3.30-5.40	1.80-3.15
	Mean	6.56	4.65	2.56
	S.E. ±	0.19	0.14	0.17
	CD at 5%	0.54	0.41	0.50

Table 7 : DPPH scavenging activity in grains of hurda sorghum genotypes at different growth stages.

S. no.	Name of genotype	DPPH scavenging activity (%)		
		Soft dough stage	Hard dough stage	Maturity stage
1	RSSGV-82	57.05	45.14	32.55
2	RSSGV-83	65.19	53.39	36.72
3	RSSGV-84	56.66	41.66	31.97
4	RSSGV-85	58.37	46.53	31.36
5	RSSGV-86	63.73	47.42	36.00
6	RSSGV-87	64.09	51.61	35.43
7	RSSGV-88	62.11	48.20	33.07
8	RSSGV-89	67.13	54.18	37.21
9	RSSGV-90	66.39	51.25	35.51
10	RSSGV-91	65.63	50.73	33.92
11	RSSGV-92	59.79	49.15	34.11
12	RSSGV-93	63.51	42.69	33.52
13	Phule Madhur (c)	65.11	52.07	36.89
14	Phule Uttara (c)	67.55	53.98	37.90
	Range	56.66-67.55	41.66-54.18	31.36-37.90
	Mean	63.02	49.14	34.73
	S.E. ±	0.96	1.52	1.00
	CD at 5%	2.79	4.43	2.92

from sugar content. Results regarding reducing and total sugars are similar to the values reported by Shinde *et al*. (2016) the result revealed that Phule Uttara showed maximum total sugar percentage of 5.36 per cent, superior over RSSGV-46 with 5.09 per cent. Chavan *et al*. (2017) reported that the total sugar percentage varied from 1.13 to 2.27 per cent. The results obtained in the present investigation are agreed with the earlier reports.

Total phenol content

The variation in total phenol content expressed in mg/g of the hurda grains from different varieties ranged from 5.70 to 7.10 mg/g with a mean value of 6.56 mg/g in the soft dough stage and the total phenol content ranged from 3.30 to 5.40 mg/g with a mean value of 4.65 mg/g in the hard dough stage and the genotypes showed the total phenol content ranged from 1.80 to 3.15 mg/g with a mean of 2.56 mg/g in the maturity stage. The highest phenol content was observed in genotype RSSGV-89 (7.10 mg/g), while the lowest total phenol content was observed in genotype RSSGV-85 (5.70 mg/g) in the soft dough stage. In the hard dough stage, the highest total phenol content was recorded in genotype RSSGV-89 (5.40 mg/g) whereas the lowest total phenol content was found in genotype RSSGV-84 (3.30 mg/g). In the mature stage the highest total phenol content was observed in genotype RSSGV-89 (3.15 mg/g), whereas lowest total phenol content was recorded in genotype RSSGV-84 (1.80 mg/g). The results revealed that the total phenol content is highest in the soft dough stage as compared to hard dough stage and maturity stage (Table 6).

The phenolic sorghum systems intensify in vitro cell apoptosis by the over-expression of apoptotic qualities and proteins, improved enzymatic action (Suganyadevia *et al*., 2011) and suppression of antiapoptosis (Woo *et al*., 2012). The protective effect of sorghum against dyslipidemia and cardiovascular diseases are contributed by phenolic chemicals (Chung *et al*., 2011). Similar trends in the results were reported by Abdelhalim *et al*. (2019) in wild species of sorghum ranged from 1.3 to 6.7 mg/g. Low concentration of total polyphenols may also enhance the bioavailability of trace elements, since they able to create linkage and form the mineral complex which reduces its extractability (Abdelrahman *et al*., 2007).

The antioxidants activity of sorghum phenolic compounds seems to play a key role in health promotion and disease prevention associated with

Table 8 : Grain separation percentage in hurda sorghum genotypes at soft dough stage.

S. no.	Name of genotype	Grain separation (%) at Soft dough stage
1	RSSGV-82	65.38
2	RSSGV-83	73.22
3	RSSGV-84	59.05
4	RSSGV-85	63.16
5	RSSGV-86	85.19
6	RSSGV-87	85.72
7	RSSGV-88	58.22
8	RSSGV-89	90.28
9	RSSGV-90	56.53
10	RSSGV-91	82.75
11	RSSGV-92	56.84
12	RSSGV-93	71.40
13	Phule Madhur (c)	92.61
14	Phule Uttara (c)	69.11
	Range	56.53-92.61
	Mean	83.29
	S.E. ±	2.74
	CD at 5%	8.00

DPPH scavenging activity

The data in respect to DPPH scavenging activity of fourteen hurda genotypes evaluated are reported in Table 7. The DPPH scavenging activity ranged from 56.66 to 67.55 per cent with a mean value of 63.02 per cent in the soft dough stage and 41.66 to 54.18 per cent with a mean of 49.14 per cent in the hard dough stage and 31.36 to 37.90 per cent with a mean of 34.73 per cent in the maturity stage are recorded. The highest DPPH scavenging activity was observed in the check Phule Uttara (67.55%), while the lowest DPPH scavenging activity was observed in genotype RSSGV-84 (56.66%) in the soft dough stage. In the hard dough stage, the highest DPPH scavenging activity was recorded in genotype RSSGV-89 (54.18%), whereas the lowest DPPH scavenging activity was found in genotype RSSGV-84 (41.66 %). In the mature stage the highest DPPH scavenging activity was observed in check variety Phule Uttara (37.90%), whereas lowest DPPH scavenging activity was recorded in genotype RSSGV-85 (31.36%).

Rao *et al*. (2018) reported similar results with DPPH scavenging percentage, while studying characterization

Table 9 : Organoleptic evaluation of hurda sorghum varieties at soft dough stage.

S. no.	Name of genotype	Organoleptic evaluation			
		Grain colour	Grain texture	Grain taste	Overall acceptability
1	RSSGV-82	9	8	6	7
2	RSSGV-83	8	7	8	8
3	RSSGV-84	8	7	6	7
4	RSSGV-85	9	8	7	8
5	RSSGV-86	7	8	6	6
6	RSSGV-87	7	6	6	6
7	RSSGV-88	8	8	7	7
8	RSSGV-89	9	9	9	9
9	RSSGV-90	9	7	8	8
10	RSSGV-91	7	6	6	6
11	RSSGV-92	7	7	5	6
12	RSSGV-93	9	8	8	8
13	Phule Madhur (c)	9	8	9	9
14	Phule Uttara (c)	9	8	9	9
	S.E. ±	0.08	0.12	0.07	0.12
	CD at 5%	0.22	0.34	0.19	0.35

sorghum consumption. The antioxidant activity is strongly related to the total phenolic contents, particularly the condensed tannin content in sorghum (Awika *et al*., 2003). Oxidative stress, which is an imbalance of free radicals and antioxidants, is the leading cause of various chronic diseases (Lee *et al*., 2011).

of phenolic compounds and antioxidant activity in sorghum grains. The result showed that the black pericarp variety Shawaya and the brown pericarp variety IS-11316 had the total phenolic content resulting in overall highest antioxidant activity. As previously reported by Mukkun *et al*. (2021) the local black sorghum contains high

polyphenols compounds with high antioxidant activity that, it has high potential to be developed in functional foods.

Grain separation percentage

The result obtained on grain separation percentage of fourteen hurda grain sorghum genotypes evaluated is present in the Table 8. Perusal of the data revealed that the grain separation percentage of fourteen hurda grain sorghum genotypes ranged from 56.53 to 92.61 per cent. The maximum grain separation percentage was observed in the check variety Phule Madhur (92.61%), while the minimum grain separation percentage was observed in genotype RSSGV-90 (56.53%) in the soft dough stage.

Grain separation percentage is important parameter in hurda purpose sorghum, which indicates the threshability of sorghum grains (Chavan *et al*., 2013). The results of this investigation are in close conformity with the observation obtained by Samarth *et al*. (2018). The observations taken on phonological traits in which easy threshable grain percentage found to be high in Phule Madhur (92.7%). The grain separation percentage ranged from 88 to 92.7 per cent.

Overall acceptability

Overall acceptability of fourteen hurda grain sorghum genotypes were evaluated using nine-point hedonic scale are presented in Table 9. The genotypes RSSGV-89 and the checks Phule Madhur, Phule Uttara recorded maximum overall acceptability having score 9 (Like extremely) followed by RSSGV-83, RSSGV-85, RSSGV-90 and RSSGV-93 having score 8 (like very much).

Overall acceptability of hurda grain having importance for fetching more price of the commodity for commercialization. Shinde *et al*. (2016) reported that the variety Phule Madhur was found to be very good having more than 8.6 overall acceptability scales for sorghum hurda. Similar results were reported by Chavan *et al*. (2013) found that, considering all quality parameters, the overall acceptability of PVR SG-101 was found to be highest followed by Surti Latur and Phule Madhur.

Conclusion

Among twelve hurda sorghum genotypes and two checks, genotypes RSSGV-89, RSSGV-83 and checks Phule Uttara, Phule Madhur was recorded significantly superior in nutritional analysis. In organoleptic evaluation, the Phule Madhur, Phule Uttara and RSSGV-89 were found superior among all hurda grain sorghum genotypes. The experimental findings concluded that soft dough stage significantly superior over the hard dough stage and maturity stage for nutritional perspective and hurda sorghum acceptability.

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