

## PROCESSING OF SORGHUM FOR *FLAKES* AND THEIR PRODUCTS

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### Article Info

Received 23/10/2014

Revised 16/11/2014

Accepted 12/12/2014

**Key words:-** Sorghum.  
*Flakes* . *Chiwada* .  
*Poha* . Nutritional  
quality.

### ABSTRACT

The present study was undertaken with the objective to standardise procedures for preparation of *flakes* from sorghum, to identify the best genotype for preparation of *flakes* and to study the nutritional quality parameters of *flakes* and their products. Ten varieties and five hybrids were used for preparation of *flakes* and their products. A process standardized for *flakes* preparation using *flakes* machine. The *flakes* yield was ranged from 50.62 to 64.14 per cent. The Phule Anuradha gave highest yield 64.14 per cent. The crude protein content in grain and *flakes* ranged from 7.81 to 10.45 per cent and 6.89 to 9.71 per cent respectively. The starch content in grain ranged from 61.07 to 69.01 per cent and in *flakes* 59.95 to 67.87 per cent. The new genotypes Phule Vasudha, Phule Yashoda and M 35-1 showed higher level of starch content as compare to the other genotypes. The Phule Vasudha and Selection-3 showed higher level of total soluble sugars in grains and *flakes*. Phule Maulee gave higher level of crude fiber content (3.12 %). The amino acid profile of sorghum grain and *flakes* showed very minor differences in the content due to the processing. The new genotypes of *rabi* sorghum showed comparable results for the mineral with that of hybrids. The mineral content of *flakes* was changed due to the soaking and roasting treatment while processing the grains. The organoleptic properties of the *Chiwada* and *Poha* prepared from sorghum *flakes* were judged on the basis of colour and appearance, texture, flavour, taste and overall acceptability of the product using semi-trained judges and 1 to 9 hedonic scales. All products prepared from *flakes* were like very much and gave highest rating more than 8 hedonic scale. While considering the yield of *flakes* from sorghum grains as well as their nutritional composition and organoleptic properties of the niche products (*Chiwada* and *Poha*) prepared from them, the varieties Phule Vasudha and Phule Yashoda are the best one as compared to the other varieties and hybrids and overall varieties are better than the hybrids.

### INTRODUCTION

Sorghum (*Sorghum bicolor* 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. The crop is primarily produced in Maharashtra, Karnataka and Andhra Pradesh. Madhya Pradesh, Gujarat and Rajasthan are the

other states producing sorghum. Sorghum is considered as coarse grain due to the presence of outer fibrous bran of seed. Sorghum is poor in lysine but rich in leucine.

India is the largest producer of sorghum in the world with 6.98 million tons during 2010-11 and almost entire production of sorghum (95 %) in the country from above regions [1,2]. 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 [3].

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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. Nutritional importance of sorghum is 349 Kcal energy, 9.6 per cent protein, 3.8 per cent fat, 73.2 per cent carbohydrates, 2.4 per cent ash and 11 per cent moisture content [4].

Generally, sorghum has more protein than maize, a lower fat content and about the same amount and proportion of carbohydrates components, minerals present in the grain are calcium, magnesium, potassium and iron. Sorghum protein is superior to wheat protein in biological value and digestibility. Sorghum is totally free from gluten, contains more fibre and micronutrients. As sorghum is digested slowly it is an excellent health food for people suffering from diabetes in India [5].

Starch is 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 per cent. Starch from waxy varieties contains little amylose. Both waxy and regular starches contain free sugars upto 1 to 2 per cent. Sucrose being major constituent (0.85 %) followed by glucose (0.09 %), fructose (0.09 %) and maltose [6].

The percentage of different protein fractions to the total protein of sorghum grown in India is albumin 5; globulin 6.3; prolamin 46.4 and glutelin 30.4. Prolamins and glutelin are principally present in the endosperm. Amino acid analysis of various protein fractions shows that there is better distribution of all essential amino acids in globulins than in prolamins. 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 are mostly consists of triglycerides, which are rich in the unsaturated fatty acids, oleic and linoleic, their percentage being 33 and 47, respectively [7-9].

Processed food products of sorghum for human consumption are emerging such as *flakes*, *pasta*, *vermicelli*, *semolina* etc [10]. 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 major food crop in several countries, especially in Africa and in particular in Nigeria and the Sudan, which together account for about 63 per cent 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 [11]. 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 these crops competitive with other cereals in terms of utilization [12]. Wheat milling technology with suitable modification can be effectively used for grinding sorghum and millets.

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 [13]. Cereal *flakes* are popular breakfast products and at present they are mostly made from corn. By suitable processing it might be feasible to produce *flakes* from sorghum. Ready to eat products like *flakes* are very popular being crisp and friable in texture. Cereal *flakes* are one of the most popular type of ready to eat cereals. The relatively smaller size and quick hydration of millets make them most suitable for the production of *flakes*. The technology for preparation of *flakes* from sorghum and their nutritional values information are not available. The information on utilization of sorghum *flakes* as *chiwada* and *poha* are not available. By suitable processing it might be feasible to produce *flakes* from sorghum. Therefore, attempt has been made to prepare sorghum semolina and their products.

## MATERIALS AND METHODS

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 Flakes from sorghum grains*

Flakes making machine were used for the preparation of sorghum *flakes* from the Directorate of Sorghum Research, Rajendranagar, Hyderabad.

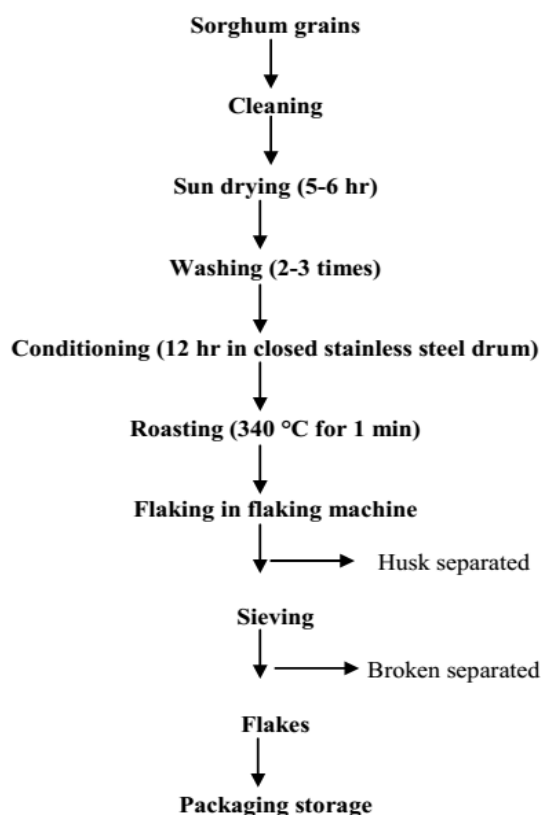
### **Chemical constituents of sorghum grains and flakes**

Chemical analysis of sorghum gains and *flakes* for protein, total sugar, crude fiber and starch were done using standard methods [14] and amino acids, minerals were determined using NIR Spectrometer, Spectra Analyser Serial No : 05; 281, Zeutec Opto Elektronik GmbH, Keiler str. 211, 24768 Rendsburg, Germany.



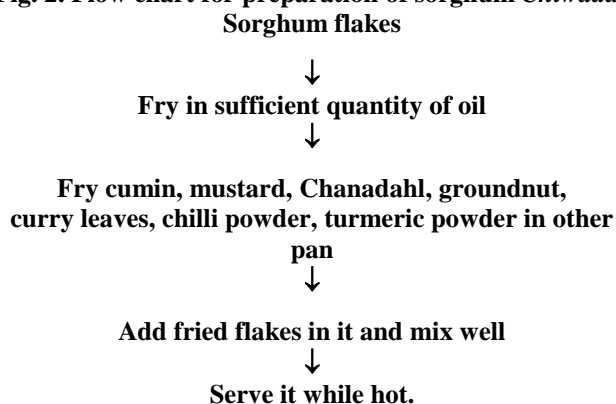
## Preparation of sorghum flakes and their products

Fig. 1. Flow chart for preparation of sorghum flakes



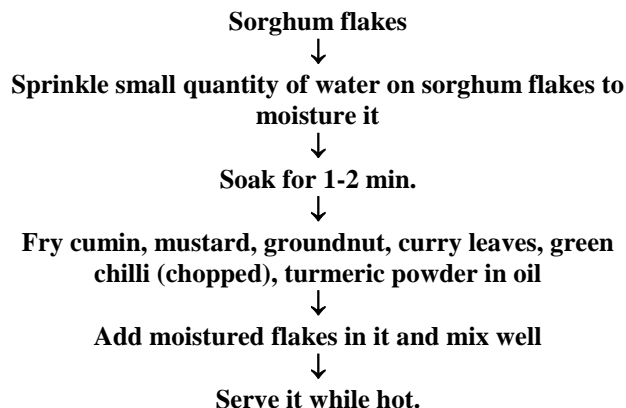
Preparation of sorghum flakes Chiwada Recipe for the preparation of sorghum flakes chiwada: flakes 50g, oil 10g, turmeric powder 0.5g, chanadhal 5g, peanuts 10g, mustard and cumin 0.2g, chilli powder 2g, curry leaves 2-3 leaves and salt 1g. Chiwada was prepared as per following method (Fig. 2).

Fig. 2. Flow chart for preparation of sorghum Chiwada



Preparation of sorghum Poha Recipe for sorghum poha: Flakes 50g, peanuts 10g, oil 10g, onion 10g, coriander leaves 2g, salt 1g, green chilli 2g, cumin 1g and mustard 1g. Preparation procedure is as follows (Fig. 3).

Fig. 3. Flow chart for preparation of sorghum Poha



Organoleptic evaluation of Chiwada and Poha Organoleptic evaluation of Chiwada and Poha for colour and appearance, flavour, texture, taste and overall acceptability was carried out using standard method of Amerine et al [15]. For this 10 semitrained judges were used and 1 to 9 point hedonic scale was used for rating the quality of the sorghum product.

### Statistical analysis

All nutritional constituents and organoleptic parameters were analyzed by using three and five replications respectively. The data obtained in the present investigation was statistically analyzed by using Completely Randomized Design given by Panse and Sukhatme [16].

## RESULTS AND DISCUSSION

During the present investigation procedure standardized for the preparation sorghum flakes. The most promising genotype also tried to identify for the flakes production.

### Recovery of flakes from sorghum grains

The flakes yield was ranged from 50.62 to 64.14 per cent. The Phule Anuradha gave significantly highest yield 64.14 per cent of flakes and at par with Phule Maulee (63.43 %) and followed by Phule Chitra (62.42 %) and M 35-1 (62.32 %) (Table 1). While preparation of flakes from various sorghum genotypes the other various parts are classified as broken and husk.

### Chemical constituents of sorghum grain and flakes

The crude protein content in grain and flakes ranged from 7.81 to 10.45% and 6.89 to 9.71% respectively. Maldandi variety gave 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 %). FAO [17] and Beta et al [18] was observed content of the protein in whole sorghum grain in the range of 7 to 15 percent [19-23]. In flakes, Maldandi variety gave statistically superior in protein (9.71 %) followed by Selection-3 (9.62 %), Phule Vasudha



(9.25%), CSV-22 (9.12 %) and Phule Revati (8.83) than other hybrids and varieties (Tables 2 and 3).

### Starch

The starch content in grain and *flakes* ranged from 61.07-69.01 and 59.95-67.87 per cent respectively. In the grain Phule Vasudha gave 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 had significant difference [24]. In *flakes* Maldandi gave statistically superior level of starch (67.87 %) followed by Phule Vasudha (67.68 %), Phule Yashoda (66.34 %), CSV-18 (65.52 %) and Phule Revati (65.11 %).

### Total sugars

Total sugar contain in grain and *flakes* ranged from 1.41-2.32 and 1.06-1.88 per cent, respectively. 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 %) [25-27]. In *flakes* (Table-3), selection-3 gave significantly higher level of total sugar (1.88 %) and at par with Phule Yashoda (1.87 %) followed by CSV-22(1.74 %), Maldandi (1.74 %) and Phule Maulee (1.73 %).

### Crude fiber

The crude fiber content in grain and *flakes* ranged from 2.56-3.41% and 2.14-3.12% respectively [28]. In *flakes* Phule Maulee gave significantly higher level of crude fiber (3.12 %) and at par with CSV-22 (3.10 %) followed by Phule Anuradha (3.04 %), selection-3 (2.95 %) and Phule Chitra (2.93 %). The fiber content in the sorghum *flakes* showed lower range than the grains due to the loss during processing.

### Amino acids content in sorghum grain and flakes

There was a significant difference between the amino acid contents of the varieties, hybrids and flakes. This difference might be due to the processing effect. The non-essential amino acids *viz.*, proline, alanine, tyrosine, glutamic acid, glycine, serine, aspartic acids, threonine, glutamine, asparagine etc. are also present in the sorghum grain and flakes (Tables 4 & 5). The results obtained in the present investigation are in agreement with the literature [29,30].

### Minerals content in sorghum grain and flakes

Calcium content in the sorghum grain ranged from 11.56-27.81 mg/100 g (Tables 6 and 7). Selection-3 gave higher level of calcium content (27.81 mg/100 g) followed by Phule chitra (21.54 mg/100 g) and SPH-1665 (20.5 mg/100 g) [31]. Iron content in the sorghum grain ranged from 3.47 to 4.76 mg/100 g. Phule Anuradha gave higher level of Iron content (10.26 mg/100 g) followed by SPH-1647 (9.76 mg/100 g) and CSV-18 (9.74 mg/100 g). Chavan and Patil [19] observed iron content in the sorghum grain was 4.48 mg/100 g. There is no much research work on the sorghum *flakes*. Therefore the literature is also not available on preparation of sorghum *flakes* and their nutritional composition. So the attempt has been made to prepare sorghum *flakes* and to find out their nutritional value. The mineral contents in sorghum grain and *flakes* are slightly different from each other. This might be due to the processing of sorghum grains into *flakes*, while preparing these products there is a production of flour, broken and husk that also contain mineral elements. Therefore the concentration of these minerals might change slightly. The statistical analysis showed significant difference in the mineral content of grain, *flakes* and within the varieties as well as hybrids.

### Organoleptic evaluation of chiwada and poha prepared from flakes of sorghum grains

*Chiwada* Overall acceptability score of *chiwada* ranged from 6.4-8.0 (Table 8). Phule Vasudha and Phule Yasodha gave highest score (8.0) followed by Phule Revati (7.8), Phule Chitra (7.8), CSV-22 (7.8) Selection-3 (7.8) and SPH-1665 (7.8). Overall acceptability of *poha*, score ranged from 6.6-8.2 (Table 8). Selection-3 had highest overall acceptability (8.2) than other varieties and hybrids followed by Phule Vasudha (8.0), Phule Yashoda (8.0), Phule Chitra (7.8), CSV-22 (7.8), CSV-18 (7.8), SPH-1620 (7.8) and SPH-1664 (7.8).

There is no research work done on the sorghum *flakes* and their products such as *chiwada* and *poha* preparation as well as their organoleptic properties studies. So no literature on this aspect is available. In the present research work, we tried to prepare products and also judge the consumers acceptability. Therefore, these sorghum value added products should be popularized through various media and make awareness among the consumers is very essential.

**Table 1. Recovery of flakes from different genotypes of sorghum**

Genotype	Flakes (%)	Broken (%)	Husk (%)
<b>Variety</b>			
Phule Revati (RSV-1006)	53.55	18.32	28.13
Phule Vasudha (RSV-423)	54.60	17.46	27.94
Phule Chitra (SPV-1546)	62.42	10.79	26.79
Phule Yashoda (SPV-1359)	58.78	14.35	26.87
Phule Maulee (RSLG-262)	63.43	13.56	23.01
Phule Anuradha (RSV-458)	64.14	8.45	27.41



CSV-22	51.73	18.41	29.86
CSV-18	50.62	17.52	31.86
Selection-3	51.89	18.35	29.76
Maldandi (M 35-1)	62.32	9.79	27.89
<b>Hybrid</b>			
CSH-15R	61.04	17.49	21.47
SPH-1620	53.37	22.40	24.23
SPH-1647	60.03	14.32	25.65
SPH-1664	61.76	15.25	22.99
SPH-1665	58.55	19.04	22.41
Range	50.62-64.14	8.45-22.40	21.47-31.86
Mean	57.88	15.71	26.41
SE ±	0.436	0.315	0.298
CD at 5% (n=3)	1.261	0.911	0.863
CV%	2.264	6.027	3.395

**Table 2. Nutritional composition of sorghum grains**

Genotype	Crude protein, %	Starch, %	Total sugars, %	Crude fiber, %
<b>Variety</b>				
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
<b>Hybrid</b>				
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% (n=3)	0.043	0.398	0.031	0.063
CV%	0.480	0.643	1.823	2.245

**Table 3. Nutrient content in sorghum flakes**

Genotype	Crude protein (%)	Starch (%)	Total sugars (%)	Crude fiber (%)
<b>Variety</b>				
Phule Revati (RSV-1006)	8.83	65.11	1.06	2.14
Phule Vasudha (RSV-423)	9.25	67.68	1.54	2.34
Phule Chitra (SPV-1546)	8.45	61.26	1.62	2.93
Phule Yashoda (SPV-1359)	8.70	66.34	1.87	2.54
Phule Maulee (RSLG-262)	8.11	60.81	1.73	3.12
Phule Anuradha (RSV-458)	8.19	61.55	1.63	3.04
CSV-22	9.12	59.95	1.74	3.10
CSV-18	8.82	65.52	1.64	2.62
Selection-3	9.62	60.56	1.88	2.95
Maldandi (M 35-1)	9.71	67.87	1.74	2.86
<b>Hybrid</b>				
CSH-15R	8.53	63.35	1.59	2.76
SPH-1620	8.13	63.42	1.59	2.67
SPH-1647	7.92	63.17	1.22	2.63
SPH-1664	6.89	64.62	1.53	2.49
SPH-1665	7.34	63.06	1.20	2.52
Range	6.89-9.71	59.95-67.87	1.06-1.88	2.14-3.12



Mean	8.50	63.62	1.53	2.71
SE ±	0.008	0.009	0.007	0.008
CD at 5% (n=3)	0.023	0.027	0.022	0.024
CV%	0.285	0.045	1.498	0.950

**Table 4. Amino acid composition of sorghum grains (g/16 g N)**

Genotype Variety	Cys	Glu	Gly	His	Ile	Leu	Lys	Met	Phe
Phule Revati (RSV-1006)	0.92	20.77	3.04	2.08	3.80	12.30	2.56	1.38	4.32
Phule Vasudha (RSV-423)	0.94	20.76	2.94	2.11	3.84	12.33	2.52	1.33	4.37
Phule Chitra (SPV-1546)	0.92	20.85	2.93	2.05	3.91	13.22	2.65	1.35	4.44
Phule Yashoda (SPV-1359)	0.95	20.83	3.22	2.06	3.95	12.41	2.50	1.37	4.11
Phule Maulee (RSLG-262)	0.87	20.60	3.06	2.06	3.85	12.77	2.65	1.34	4.45
Phule Anuradha (RSV-458)	0.94	20.45	2.99	2.05	3.92	13.04	2.58	1.36	4.37
CSV-22	0.85	21.03	2.84	2.01	4.02	12.86	2.63	1.40	4.41
CSV-18	0.95	20.55	2.84	2.07	3.82	12.51	2.56	1.38	4.48
Selection-3	0.80	20.85	2.62	2.07	3.94	12.37	2.60	1.39	4.64
Maldandi (M 35-1)	0.87	20.56	2.89	2.09	3.90	13.16	2.52	1.44	4.26
<b>Hybrid</b>									
CSH-15R	0.90	21.05	2.91	2.12	3.90	13.19	2.40	1.38	4.45
SPH-1620	0.96	20.86	3.08	2.08	3.79	12.52	2.49	1.30	4.55
SPH-1647	0.95	20.77	2.84	2.12	3.81	12.98	2.58	1.39	4.35
SPH-1664	0.91	21.17	3.14	2.07	4.13	12.43	2.38	1.35	4.44
SPH-1665	0.95	21.08	3.37	1.98	4.08	12.26	2.36	1.41	4.65
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
Mean	0.92	20.81	2.98	2.07	3.91	12.69	2.55	1.37	4.42
SE ±	0.007	0.013	0.009	0.006	0.007	0.008	0.011	0.007	0.009
CD at 5% (n=3)	0.021	0.038	0.026	0.017	0.020	0.024	0.033	0.020	0.026
CV%	2.446	0.192	0.933	0.875	0.555	0.201	1.383	1.587	0.616

**Table 4. contd.....**

Genotype Variety	Pro	Ser	Thr	Trp	Tyr	Ala	Arg	Asp	Val
Phule Revati (RSV-1006)	5.93	3.55	2.97	1.17	3.14	8.54	3.65	7.07	3.64
Phule Vasudha (RSV-423)	6.13	3.46	2.95	1.18	3.15	8.67	3.95	6.73	3.77
Phule Chitra (SPV-1546)	5.86	3.49	2.93	1.08	3.10	8.12	3.94	7.29	3.72
Phule Yashoda (SPV-1359)	6.06	3.61	2.94	1.04	3.23	8.48	3.92	7.62	3.74
Phule Maulee (RSLG-262)	5.86	3.56	2.94	1.11	3.04	8.36	3.87	6.55	4.35
Phule Anuradha (RSV-458)	5.92	3.58	2.97	1.14	3.12	8.46	3.15	7.00	3.44
CSV-22	5.93	3.42	2.94	1.17	3.06	8.07	3.76	7.56	4.14
CSV-18	6.22	3.40	2.96	1.16	3.13	8.27	3.69	7.28	3.83
Selection-3	5.83	3.15	2.96	1.20	2.84	8.49	4.57	6.63	4.54
Maldandi (M 35-1)	5.85	3.47	3.06	1.04	3.17	8.27	3.38	7.07	3.86
<b>Hybrid</b>									
CSH-15R	6.36	3.60	2.97	1.07	3.27	8.49	3.37	6.95	3.47
SPH-1620	6.04	3.56	2.93	1.10	3.26	8.85	2.62	6.98	3.73
SPH-1647	6.25	3.37	2.96	1.08	3.25	8.36	3.48	6.95	3.14
SPH-1664	6.24	3.76	2.93	1.13	3.19	8.76	3.78	6.88	3.38
SPH-1665	6.28	3.84	2.97	1.06	3.13	8.55	3.91	6.93	3.22
Range	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	6.05	3.52	2.96	1.11	3.14	8.45	3.67	7.03	3.73
SE ±	0.008	0.006	0.008	0.006	0.009	0.006	0.005	0.007	0.007
CD at 5% (n=3)	0.023	0.019	0.024	0.018	0.027	0.019	0.015	0.020	0.022
CV%	0.410	0.581	0.873	1.720	0.895	0.240	0.433	0.300	0.621

**Table 5. Amino acid composition of flakes prepared from different genotypes of sorghum (g/16 g N)**

Genotype Variety	Cys	Glu	Gly	His	Ile	Leu	Lys	Met	Phe
Phule Revati (RSV-1006)	1.08	22.63	3.25	2.74	3.86	14.76	1.95	1.54	3.64
Phule Vasudha (RSV-423)	0.97	22.75	3.25	2.74	3.76	14.43	1.93	1.47	3.85
Phule Chitra (SPV-1546)	1.13	22.12	3.61	2.74	3.36	12.54	1.92	1.46	3.25
Phule Yashoda (SPV-1359)	1.07	22.33	3.29	2.73	3.65	13.92	1.93	1.47	3.55



Phule Maulee (RSLG-262)	1.06	21.75	3.48	2.63	3.68	13.07	1.88	1.45	3.24
Phule Anuradha (RSV-458)	1.09	21.54	3.22	2.63	3.85	13.82	1.82	1.45	3.37
CSV-22	1.04	22.51	3.25	2.70	3.73	14.06	2.06	1.55	3.77
CSV-18	1.06	22.73	3.06	2.72	3.83	14.54	1.91	1.54	3.84
Selection-3	1.09	22.77	3.12	2.60	3.96	14.76	2.00	1.55	3.96
Maldandi (M 35-1)	0.97	22.76	3.03	2.76	3.95	15.06	1.96	1.47	3.87
<b>Hybrid</b>									
CSH-15R	1.02	22.05	3.46	2.62	3.65	13.06	1.95	1.48	3.45
SPH-1620	0.77	22.62	2.72	2.64	4.45	15.93	2.07	1.48	4.23
SPH-1647	0.96	22.27	3.15	2.68	3.84	14.57	1.85	1.44	3.64
SPH-1664	0.95	21.97	3.33	2.66	3.85	13.69	1.98	1.44	3.60
SPH-1665	0.96	22.29	3.12	2.68	3.95	14.14	1.96	1.44	3.72
Range	0.77-1.13	21.54-22.77	2.72-3.61	2.60-2.76	3.36-4.45	12.54-15.93	1.82-2.07	1.44-1.55	3.24-4.23
Mean	1.01	22.34	3.22	2.69	3.82	14.16	1.95	1.48	3.66
SE ±	0.005	0.009	0.007	0.005	0.008	0.007	0.005	0.006	0.007
CD at 5% (n=3)	0.015	0.028	0.020	0.015	0.024	0.022	0.015	0.019	0.021
CV%	1.577	0.130	0.659	0.614	0.656	0.163	0.833	1.350	0.594

Table 5. Contd.....

Genotype Variety	Pro	Ser	Thr	Trp	Tyr	Ala	Arg	Asp	Val
Phule Revati (RSV-1006)	6.86	3.56	3.15	1.06	4.74	7.91	7.06	4.03	4.57
Phule Vasudha (RSV-423)	6.57	3.46	3.15	1.07	4.58	7.83	7.25	4.13	4.54
Phule Chitra (SPV-1546)	7.84	3.77	3.09	1.26	4.81	8.58	7.74	2.56	4.95
Phule Yashoda (SPV-1359)	7.15	3.57	3.06	1.15	4.64	8.35	7.06	3.34	4.64
Phule Maulee (RSLG-262)	7.77	3.64	3.10	1.32	4.62	8.63	6.14	2.40	5.07
Phule Anuradha (RSV-458)	7.54	3.66	2.96	1.25	4.73	8.75	7.15	2.72	4.75
CSV-22	6.83	3.67	3.12	1.17	4.55	7.94	7.35	3.85	4.36
CSV-18	6.77	3.65	3.16	1.07	4.64	7.85	7.15	2.58	4.47
Selection-3	6.45	3.57	3.17	1.06	4.56	7.76	7.06	4.13	4.60
Maldandi (M 35-1)	6.64	3.64	3.03	1.06	4.63	7.86	7.37	3.75	4.34
<b>Hybrid</b>									
CSH-15R	7.42	3.57	3.13	1.05	4.66	8.42	7.15	2.74	5.04
SPH-1620	6.23	3.65	3.17	1.27	4.15	7.73	7.17	4.02	4.61
SPH-1647	6.93	3.43	3.03	1.05	1.65	8.14	6.46	3.62	4.62
SPH-1664	7.15	3.63	3.06	1.14	4.65	8.36	7.15	2.92	4.83
SPH-1665	6.97	3.58	3.04	1.25	4.49	8.22	7.21	3.35	4.63
Range	6.23-7.84	3.43-3.77	2.96-3.17	1.05-1.32	1.65-4.81	7.73-8.75	6.14-7.74	2.40-4.13	4.34-5.07
Mean	7.01	3.6	3.09	1.15	4.40	8.15	7.10	3.34	4.67
SE ±	0.007	0.006	0.006	0.007	0.008	0.006	0.007	0.006	0.007
CD at 5% (n=3)	0.021	0.019	0.020	0.021	0.025	0.019	0.022	0.018	0.022
CV%	0.323	0.549	0.671	1.902	0.592	0.242	0.326	0.584	0.510

Table 6. Mineral composition of sorghum grains (mg/100 g)

Genotype Variety	Ca	Fe	Mn	Mg	P	K	Cu	Na	Zn
Phule Revati (RSV-1006)	15.47	4.36	2.85	211	491	510	0.80	20.13	3.62
Phule Vasudha (RSV-423)	17.92	4.16	2.94	212	511	534	0.86	21.26	3.66
Phule Chitra (SPV-1546)	21.54	3.98	2.86	211	503	510	0.92	19.36	3.76
Phule Yashoda (SPV-1359)	18.38	3.85	3.06	215	513	516	0.84	21.32	3.76
Phule Maulee (RSLG-262)	18.4	4.63	2.77	223	483	520	0.87	20.07	3.62
Phule Anuradha (RSV-458)	11.56	4.26	2.52	225	496	439	0.86	20.07	3.83
CSV-22	19.82	4.09	2.92	213	503	511	0.87	20.10	3.72
CSV-18	17.29	4.74	2.87	224	504	522	0.83	17.33	3.62
Selection-3	27.81	3.47	2.95	212	518	550	0.87	20.44	3.74
Maldandi (M 35-1)	13.85	4.26	2.84	215	515	491	0.88	21.92	3.63
<b>Hybrid</b>									
CSH-15R	16.29	4.46	2.73	217	501	495	0.95	17.84	3.64
SPH-1620	17.63	4.14	2.95	214	500	529	0.96	20.94	3.54



SPH-1647	13.17	4.76	2.86	225	521	524	0.89	21.32	3.56
SPH-1664	18.55	3.86	2.86	218	521	537	0.86	21.27	3.43
SPH-1665	20.5	3.65	2.85	215	518	527	0.86	23.15	3.61
Range	11.56-27.81	3.47-4.76	2.52-3.06	211-225	483-521	439-550	0.80-0.96	17.33-23.15	3.43-3.83
Mean	17.87	4.18	2.85	217	506	494	0.87	20.43	3.64
SE $\pm$	0.021	0.00	0.007	0.018	0.010	0.008	0.005	0.008	0.008
CD at 5% (n=3)	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	0.02	0.005	0.005	1.847	0.131	0.692

Table 7. Mineral composition of flakes prepared from different genotypes of sorghum (mg/100 g)

Genotype Variety	Ca	Fe	Mn	Mg	P	K	Cu	Na	Zn
Phule Revati (RSV-1006)	15.13	4.85	4.46	178	574	262	0.96	6.63	3.5
Phule Vasudha (RSV-423)	17.37	5.07	4.38	173	536	256	0.96	5.55	3.64
Phule Chitra (SPV-1546)	17.13	3.39	4.86	145	540	312	0.75	8.97	3.39
Phule Yashoda (SPV-1359)	15.63	4.84	4.45	169	539	264	0.85	6.57	3.57
Phule Maulee (RSLG-262)	17.37	3.83	4.53	148	539	292	0.75	4.58	3.47
Phule Anuradha (RSV-458)	12.56	5.12	3.93	158	510	234	0.75	1.54	3.50
CSV-22	18.24	4.54	4.47	172	545	286	0.94	1.47	3.64
CSV-18	15.73	5.12	4.45	182	546	276	0.97	7.19	3.56
Selection-3	17.07	5.46	4.32	186	535	249	0.96	4.07	3.75
Maldandi (M 35-1)	13.72	5.17	4.33	182	547	266	0.93	5.63	3.57
<b>Hybrid</b>									
CSH-15R	16.92	4.15	4.53	158	529	296	0.73	5.93	3.48
SPH-1620	24.07	5.96	3.84	187	501	261	1.06	2.48	3.84
SPH-1647	14.63	5.57	4.38	177	525	263	0.85	3.16	3.61
SPH-1664	15.72	5.06	4.37	169	515	270	0.83	4.14	3.55
SPH-1665	19.18	4.85	4.33	171	518	272	0.88	2.09	3.60
Range	12.56-24.07	3.39-5.96	3.84-4.86	158-187	501-574	234-312	0.73-1.06	1.47-8.97	3.39-3.84
Mean	16.69	4.86	4.37	170	533	271	0.88	4.67	3.57
SE $\pm$	0.007	0.051	0.008	0.009	0.008	0.016	0.007	0.007	0.008
CD at 5% (n=3)	0.022	0.144	0.024	0.027	0.025	0.046	0.021	0.021	0.023
CV%	0.141	3.167	0.572	0.016	0.004	0.018	2.46	0.487	0.671

Table 8. Overall organoleptic evaluation of chiwada and poha prepared from flakes of different genotypes of sorghum

Genotype Variety	Overall acceptability for Chiwada	Overall acceptability for Poha
Phule Revati (RSV-1006)	7.8	7.6
Phule Vasudha (RSV-423)	8.0	8.0
Phule Chitra (SPV-1546)	7.8	7.8
Phule Yashoda (SPV-1359)	8.0	8.0
Phule Maulee (RSLG-262)	7.4	7.0
Phule Anuradha (RSV-458)	7.6	7.2
CSV-22	7.8	7.8
CSV-18	7.6	7.8
Selection-3	7.8	8.2
Maldandi (M 35-1)	6.4	6.8
<b>Hybrid</b>		
CSH-15R	7.2	7.6
SPH-1620	7.4	7.8
SPH-1647	7.0	6.6
SPH-1664	7.6	7.8
SPH-1665	7.8	7.6
Range	6.4-8.0	6.6-8.2
Mean	7.52	7.54
SE $\pm$	0.129	0.146
CD at 5% (n=5)	0.366	0.415
CV%	8.618	9.737





**Figure 4. Sorghum flakes**



**Figure 5. Sorghum Chiwada from sorghum flakes**



**Figure 6. Sorghum poha from sorghum flakes**



## CONCLUSION

While considering the yield of *flakes* from sorghum grains as well as their nutritional composition and organoleptic properties of the niche products prepared from 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 preparation from the sorghum *flakes*, it was observed that the varieties are better than the hybrids.

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