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RESEARCH ARTICLE

PREPARATION AND NUTRITIONAL QUALITY OF SORGHUM *CHAKALI*

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ABSTRACT

The present study was undertaken with the objectives to develop protocol for preparation of sorghum *Chakali* to study the organoleptic properties of sorghum *Chakali*, identify the superior genotype of sorghum for *Chakali* preparation and to study the nutritional quality parameter of sorghum grains as well as its *Chakali*. Five varieties and two hybrids were used for preparation of sorghum *Chakali.* The experiments were laid in completely randomized design with seven treatments and three to ten replications. The crude protein content in grain and *Chakali* ranged from 8.25 to 9.45 per cent and 13.64 to 18.28 per cent, respectively. The variety M 35-1 gave numerically higher level of protein. The total sugar content in grain ranged from 1.62 to 1.95 per cent and in *Chakali* ranged from 2.49 to 3.75 per cent. Phule Anuradha showed higher level of total sugar in grain and *Chakali* than the other genotypes. The crude fiber content in grain and *Chakali* ranged from 2.70 to 3.25 and 2.15 to 3.75 per cent, respectively. The fat content in grain and *Chakali* ranged from 1.25 to 1.66 and 37.24 to 40.02 per cent, respectively. The ash content in sorghum grain and *Chakali* ranged from 4.01 to 46.45 and 2.22 to 3.34 per cent, respectively. Preliminary study with various combinations (0 to 100 % sorghum flour addition) was conducted for preparation of *Chakali* preparation and from that combination 50% addition of sorghum flour for the preparation of *Chakali* was found most suitable. Then five varieties and two hybrids with 50% combination for *chakali* preparation were judged for genotype identification. The organoleptic properties of *Chakali* prepared from sorghum flour were judged on the basis of colour, appearance, texture, flavour, taste and overall acceptability of the product by semi-trained judges on 9 point Hedonic Scale. The products prepared from sorghum flour i.e. *Chakali* was liked very much and gave highest rating of more than 8. While considering the yield of *chakali* from sorghum grains as well as their nutritional composition and organoleptic properties of the niche products prepared from them, the variety, Phule Vasudha was the best one as compared to the other varieties and hybrids.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is one of the major cereal crop consumed in India after rice (*Oryza sativa* L.) and wheat (*Triticum aestivium* L.). Sorghum is commonly called as jowar or great millet. The crop is primarily produced in Maharashtra and Southern states like Karnataka and Andhra Pradesh. These three states together accounted for close to 80 per cent of all India production. Madhya Pradesh, Gujarat and Rajasthan are the other states producing sorghum. India is the third largest producer of sorghum in the world with 5.54 million tons in 2013-14 and almost entire production of sorghum (95 per cent) in the country comes from 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 70 kg, accounting for almost half of per capita consumption of all cereals (Parthasarathy Rao *et al*., 2010). Sorghum is considered as coarse grain due to presence of outer fibrous bran of the seed. 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, 10.4 g protein, 1.9 g fat, 72.6 g carbohydrates, 25 mg calcium, 4.1 mg iron, 0.37 mg thiamine, 0.13 mg riboflavin per 100 g of grain (Chavan and Salunkhe, 1984; Chavan and Patil, 2010; Chavan *et al*., 2009).

Sorghum protein is superior to wheat protein in biological value and digestibility. Sorghum is totally free from gluten contain more fiber and micronutrients. As sorghum digested slowly is an excellent health food for people suffering from diabetes in India (Klopfenstein and Hoseney, 1995). Starch is major carbohydrate in the grain. The other present are simple

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sugar, cellulose and hemicelluloses. The amylose content of starch varies from 21 to 28%. Starch from waxy varieties contain little amylose. Both waxy and regular starches contain free sugar upto 1 to 2 %. Sucrose being major constituent (0.85 %) followed by glucose (0.09 %), fructose (0.09 %) and maltose (Chavan *et al*., 1988).

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 per cent. 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. A vegetarian diet based on some varieties of sorghum is somewhat better than rice based diet. In the last two decades the nature and composition of utilization of sorghum grain has undergone a change from staple food to industrial uses as livestock and poultry feed, potable alcohol, starch and ethanol production (Kleih *et al.*, 2000).

Processed food products for human consumption are emerging such as *chakali, sharkarpali, papads, sweets, edile* etc. (Chavan *et al*., 2010; Chavan *et al*., 2015). Many sorghum verities and hybrids are developed in India to increase yield and for processing of sorghum e.g. Wani, Gulbhendi, and Dagdi varieties are used for *Hurda* (roasted grains) purpose and SPV-84 for syrup and jaggery (Reddy *et al.*, 1984). 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 % of Africa's sorghum production. These grains are 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. Sorghum could be in great demand in the future if the technology for specific industrial end uses is developed.

The use of sorghum in common foods such as *idali* (a steamed product), *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. Incentives should be provided to food industry to use sorghum for novel processed food products like snacks, bread, biscuits, *flakes, papad, rava* etc. and traditional processed products (Hall, 2000).

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). Improved processing methods for flaking have to be developed for the utilization of the increased grain sorghum production.

The grain characteristics required to produce traditional food products of high quality have been reported (Rooney and Murty, 1982 and Rooney *et al.*, 1986). Cereal *chakali* is popular in Diwali festival products and at present they are mostly made from gram, rice etc. By suitable processing it might be feasible to produce *chakali* from sorghum. Ready to eat products like *chakali* is very popular being crisp and friable in texture.

The relatively smaller size and quick hydration of millets make them most suitable for the production of *chakali.* The technology for preparation of *Chakali* from sorghum and their nutritional values information are not available. Therefore the present study was undertaken to develop protocol for preparation of *chakali*, to study the organoleptic properties of *chakali* and identify the best sorghum genotype for preparation of *chakali*.

MATERIALS AND METHODS

The grains of five sorghum varieties *viz.*, Phule Anuradha, Phule Vasudha, Phule Revati, CSV-22, M35-1 and two hybrids, CSH-15-R, SPH-1620 were obtained from the All India Co-ordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. Other ingredient such as green gram, black gram, Bengal gram, rice and masala purchased from local grocery shop. The various chemicals used were of the analytical grade, procured from M/s. Sarabhai M. Chemicals, M/s. Baroda, E. Merck (India) and M/s. Qualigen's or S.d. Fine Chemical Ltd., Mumbai.

Cleaned sorghum grains were subjected to milling in laboratory by grinding mill. Whole sorghum flour was used for preparation of *Chakali*. Chemical analysis of sorghum grains for protein, total sugar, crude fiber, fat and ash were done using NIR Spectrometer, Spectra Analyzer serial No: 05; 281, ZEUTEC Opto Elektronik GmbH, Keiler str. 211, 24768 Rendsburg, Germany. Chemical analysis of sorghum *Chakali* for protein, crude fiber, and ash, fat was done using standard methods (AOAC, 1990) and total sugar determined by the method of Nelson (1944).

Preparation of Chakali: Sorghum and various pulses combinations were taken for the preparation of *Chakali*. The detail procedure is given in Figure 1.

Treatment	Sorghum flour	*Chakali* mix (R + B + U + G)
T_1	00	100
T_2	10	90
T_3	20	80
T_4	30	70
T_5	40	60
T_6	50	50
T_7	60	40
T_8	70	30
T_9	80	20
T_{10}	90	10
T_{11}	100	00

Whereas, R = Rice, B = Bengal gram, U: Black gram Dal, G: Green gram

For the preliminary trials M35-1 variety of sorghum was utilized for the identification of the best combination for preparation of *chakali*. The best combination identified using organoleptic properties for the preparation of *chakali* from other sorghum genotypes.

Recipe for preparation of sorghum Chakali

Ingredients	Quantity (g)
Sorghum flour	100
Rice	25
Green gram	25
Black gram	25
Bengal gram	25
Salt	2
Chilli powder	3
Cumin	5
Owa	5
Hot water (ml)	200
Oil (Used for frying)	200

Procedure

Sorghum grain, rice, pulses
↓
Cleaning
↓
Roasting
(upto light brown colour)
↓
Grinding
↓
Mixing flour with ingredient and water
(Salt, chilli powder, cumin and owa etc.)
↓
Dough preparation
↓
Filling in the dye
↓
Preparation of *chakali*
↓
Frying (Deep fat frying)
↓
Cooling
↓
Storage

Fig. 1: Flow sheet for preparation of sorghum *chakali*

Organoleptic evaluation of Chakali

The organoleptic properties evaluation of *chakali* for colour and appearance, texture, flavor, taste and overall acceptability was carried out using standard method of Amerine *et al.* (1965) for this ten 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 chemical constituents and organoleptic parameter were analyzed by using 3 and 10 replications respectively. The data obtained in the present investigation was statistically analyzed by using Completely Randomized Design given by Panse and Sukhatme (1967).

RESULT AND DISCUSSION

In the present investigation procedure was standardized for the preparation of *Chakali.* The most promising sorghum genotypes also tried to identify for the *Chakali* production. The nutritional quality and niche product development and their consumer acceptance also judged by using semi trained judges and 1 to 9 point Hedonic Scale.

Nutritional composition of sorghum grain: The crude protein content in grain ranged from 8.25 to 10.45 per cent. The variety M 35-1 gave significantly higher level of protein (10.45 %) in the grain and followed by CSV-22 (10.40 %), Phule Vasudha (10.15 %) and Phule Revati (9.45 %; Table 1). FAO (1995) and Beta *et al.* (1995) was observed content of the protein in whole sorghum grain range of 7 to 15 per cent. Robertson *et al.* (2006) reported that crude protein in experiment sorghum ranged from 9.14 to 13.00 per cent. Chavan *et al.* (2010) observed protein content in sorghum ranged from 9.6 to 14 per cent.

The total sugar content in grain ranged from 1.62 to 1.95 per cent. The variety Phule Anuradha gave significantly higher level of total sugar (1.95 %) in the grain and followed by Phule Revati (1.94 %), CSV-22 (1.94 %) and M35-1 (1.85 %). Ibrahim *et al.* (2010) recorded total soluble sugar content from 0.54 to 3.38 per cent, from 0.54 to 4.89 per cent and from 0.41 to 4.41 per cent in *Hamra*, *Shahla* and *Baida* sorghum varieties.

The fiber content in grain ranged from 2.70-3.25 per cent the hybrid CSV-22 gave significantly higher level of fiber (3.25 %) in the grain and followed by Phule Anuradha (3.20 %), M35-1 (2.90 %) and Phule Vasudha (2.85 %). Ratnavathi *et al.* (2000) reported crude fiber among the thirteen cultivars varied from 1.57 per cent (M35-1) to 2.4 (SPV-462). Vannalli *et al.* (2008) revealed that proximate composition of sorghum grain for crude fiber ranged from 2.47 per cent. Chavan *et al.* (2009) reported crude fiber content ranged from 1.90 to 2.64 per cent.

The fat content in grain ranged from 1.25 to 1.75 per cent. The variety Phule Vasudha gave significantly higher level of fat (1.75 %) in the grain and followed by M35-1 and SPH-1620 (1.65 %). The fat content in grain sorghum ranges from 2.1 to 7.6 per cent (Subramanian and Jambunathan, 1984). Kazanas and Fields (1981) reported that fat content increase non-significantly in sorghum meal due to fermentation treatment. The ash content in grain ranged from 4.01 to 4.45 per cent. The variety Phule Revati gave significantly higher level of ash (4.45 %) in the grain and followed by Phule Vasudha (4.40 %) and CSV-22 (4.30 %).

Table 1 Nutritional composition of sorghum grain

Name of genotype	Protien (%)	Total sugar (%)	Crude fiber (%)	Ash (%)	Fat (%)
Phule Anuradha	9.15	1.95	3.20	4.30	1.30
Phule Vasudha	10.15	1.65	2.85	4.40	1.75
Phule Revati	9.45	1.94	2.75	4.45	1.25
CSV-22	10.40	1.94	3.25	4.35	1.35
M35-1	10.45	1.85	2.90	4.30	1.65
CSH-15-R	8.71	1.72	2.82	4.08	1.55
SPH-1620	8.25	1.75	2.70	4.01	1.65
Range	8.25-10.45	1.62-1.95	2.70-3.25	4.01-4.45	1.25-1.75
Mean	9.50	1.82	2.92	4.26	1.5
SE ±	0.027	0.028	0.028	0.028	0.028
CD at 5%	0.083	0.087	0.088	0.090	0.087
CV%	0.500	2.73	1.707	1.172	0.121

Three replications mean values.

***Nutritional composition of in gradient used in Chakali mix*:** The crude protein content in pulses and rice ranged from 9.5 to 24.5 per cent. Green gram and black gram gave significantly higher level of protein (24.5 %) followed by Bengal gram (21.5 %) and Rice (9.5 %; Table 2). Swaminathan *et al.* (1975)

reported that crude protein content in green gram ranged from 19.5 to 33.1 per cent. Gupta *et al.* (1982) reported that crude protein content in black gram ranged from 23.6 to 28.9 per cent. Chavan *et al.* (1989) reported that crude protein content in Bengal gram ranged from 20.5 to 30.5 per cent. Salunkhe *et al.* (1989) and Chavan *et al.* (2010) reported that crude protein content in rice ranged from 11.00 to 14.97 per cent.

Table 2 Nutritional composition of pulses and rice

In gradient in *Chakali* mix	Crude Protein (%)	Total sugar (%)	Crude fiber (%)	Ash (%)	Fat (%)
Green gram	24.5	3.5	4.4	3.5	1.2
Black gram	24.5	1.2	4.7	3.4	1.5
Bengal gram	21.5	3.5	1.2	2.9	5.5
Rice	9.5	3.53	1.5	0.8	1.0
Range	9.5-24.5	1.2-3.53	1.2-4.7	0.8-3.5	1-5.5
Mean	18.3	2.84	2.74	2.46	2.22
SE ±	0.020	0.019	0.020	0.020	0.020
CD at 5%	0.061	0.057	0.061	0.061	0.061
CV %	0.223	1.341	1.489	1.659	1.838

Three replications mean values.

The total sugar content in pulses and rice ranged from 1.2-3.53 per cent. Rice gave significantly higher level of total sugar (3.53 %) followed by Green gram and Bengal gram (3.5 %) and Black gram (1.2 %). Duke (1981) reported that total sugar content in green gram ranged from 2.69 to 5.88 per cent. Salunkhe *et al.* (1989) reported that total sugar content in black gram i.e. 3.0 per cent. He also reported that total sugar content in bengal gram ranged from 4.8 to 9.3 per cent. The crude fiber content in pulses and rice ranged from 1.2-4.7 per cent.

Black gram gave significantly higher level of crude fiber (4.7 %) followed by Green gram (4.4 %) and rice (1.2 %). Reddy *et al.* (1984) reported that crude fiber content in green gram ranged from 1.2 to 8.1 per cent. Salunkhe and Kadam (1989) reported that crude fiber content in black gram ranged from 4.24 to 5.47 per cent. Chavan *et al.* (1989) reported that crude fiber content in bengal gram ranged from 1.0 to 1.5 per cent. The ash content in pulses, rice and maida ranged from 0.8-3.5 per cent. Green gram gave significantly higher level of ash (3.5 %) followed by black gram (3.4 %) and Bengal gram (2.9 %). Salunkhe and Kadam (1989) reported that ash content in geen gram, black gram is 3.5 %, 3.4 % and Bengal gram ranged from 2.04 to 4.67 per cent.

The fat content in pulses, rice and maida ranged from 1.0 to 5.5 per cent. Bengal gram gave significantly higher level of fat (5.5 %) followed by Black gram (1.5 %) and Rice (1.0 %). Baker *et al.* (1961) reported that fat content in green gram ranged from 2.14 to 3.0 per cent. Mahadevappa and Raina (1978) reported that black gram content 1.6 per cent fat. Salunkhe and Kadam (1989) reported that crude fat content in Bengal gram ranged from 3.1 to 6.9 per cent.

Incorporation of pulses and cereals for the preparation of *Chakali* is very useful and beneficial for the human nutrition. Because some of the amino acids deficient in cereals (e.g. lysine, threonine) can be get from the pulses and the similar way those amino acids deficit in pulses (e.g. methionine and cysteine) can be get from cereals.

Table 3 Organolaptic evaluation (score) of *chakali* prepared from sorghum flour of different combination

Chakali mix (%): Sorghum flour (%)	Colour and appearance	Flavor	Crispiness	Taste	Overall acceptability	Ranking
100-00	6.84	7.35	7.42	7.81	7.35	9
90–10	7.25	7.41	6.75	7.44	7.20	11
80-20	8.12	7.81	7.54	7.87	7.83	2
70-30	7.65	7.57	7.58	7.27	7.51	7
60-40	7.41	7.45	8.02	7.54	7.60	6
50-50	8.15	7.84	8.32	8.34	8.03	1
40-60	7.64	7.42	8.34	7.45	7.71	5
30-70	7.67	7.78	7.94	7.81	7.80	3
20-80	7.52	7.34	8.30	7.73	7.77	4
10-90	6.81	7.44	7.65	7.21	7.27	10
00-100	7.41	7.34	7.57	7.54	7.46	8
Range	6.81-8.15	7.34-7.84	6.75-8.34	7.21-8.34	7.20-8.03	
Mean	7.48	7.52	7.76	7.63	7.59	
SE ±	0.028	0.024	0.061	0.058	0.023	
CD 5%	0.084	0.070	0.179	0.171	0.067	
CV%	0.667	0.554	1.378	1.324	0.525	

Ten replications mean values.

Table 4 Organolaptic evaluation of *chakali* prepared from sorghum flour of different sorghum genotypes

Genotype	Colour and appearance	Flavor	Crispiness	Taste	Overall acceptability
Control	8.33	8.13	8.43	7.45	8.08
Phule Anuradha	7.53	7.81	7.45	7.33	7.53
Phule Vasudha	8.36	8.26	8.51	8.23	8.35
Phule Revati	7.88	8.07	8.53	8.05	8.13
CSV-22	7.93	7.81	8.06	8.15	7.98
M35-1	8.25	7.93	8.08	8.15	8.10
CSH-15-R	7.75	7.53	7.91	7.84	7.76
SPH-1620	7.63	7.73	7.91	7.91	7.78
Range	7.53-8.36	7.53-8.26	7.45-8.53	7.45-8.23	7.53-8.35
Mean	7.96	7.91	8.11	7.88	7.96
SE ±	0.020	0.016	0.018	0.019	0.023
CD 5%	0.061	0.499	0.055	0.058	0.070
CV%	0.44	0.364	0.397	0.429	0.512

Ten replications mean values.

Therefore preparation of niche product *Chakali* from the combination of green gram, black gram, Bengal gram, rice and sorghum is very beneficial for human health nutrition. In addition to this sorghum gives several health benefits through *Chakali* food product.

Organoleptic evaluation of chakali prepared from different combination of sorghum and rice + urad dal + Bengal gram + Green gram flours: Colour and appearance score for *chakali* ranged from 6.81 to 8.15 (Table 3). The *Chakali* mix and sorghum flour combination at 50:50 ratio showed the best colour and appearance (8.15) followed by 80:20 (8.12) and 70:30 (7.65) ratios. Flavor score for *chakali* ranged from 7.34 to 7.84. The *chakali* mix and sorghum flour combination 50:50 ratio showed the best flavor score (7.84) followed by 80:20 (7.81) and 30:70 (7.78) ratios. Crispiness score for *chakali* ranged from 6.75 to 8.34. The *Chakali* mix and sorghum flour combination 40:60 ratio showed the best crispiness (8.34). Followed by 50:50 (8.32) and 20:80 (8.30) ratios. These scores are statistically at par. Taste score for *chakali* ranged from 7.21 to 8.34. The *Chakali* mix and sorghum flour combination 50:50 ratio showed the best taste (8.34) followed by 80:20 (7.87) and control (7.81). Overall acceptability considering colour and appearance, flavor, crispiness and taste for *chakali*, 50 + 50 combination gave highest score (8.03) followed by 80:20 (7.83) and 30:70 (7.80) ratios.

Measuring the sensory properties and determining the importance of these properties, as a basis for predicting acceptance by the consumer represent major accomplishments for sensory evaluation. Veena *et al.* (2004) in Maharashtra State flat thin cakes called *Roti* are often made from sorghum/millet flour and used as the basis for meals. It is possible to incorporate 50–75% barnyard millet flour in preparation of *rotis, idlies, dosa, chakli.* Boye *et al.* (2010) addition of pulses not only enhances the nutritive value and sensory attributes but also improves the appearance and extrusion quality due to its water and fat binding capacity. Deshpande and Jha (2014) Ready- to- eat snack food *chakli* was prepared using sorghum, pearl millet and finger millet with defatted soy-flour and medium fat soy flour. Incorporation of 50 % millet and 15-20 % DFSF/MFSF was acceptable.

A niche product prepared using pulses and cereals gives good organoleptic properties due to the development of pleasant flavour, crispiness and taste during frying by several chemical reactions such as caramalization, browning, millard reaction between chemical components present in cereal and pulses. Therefore such types of food product are more beneficial for human health.

Table 5 Chemical composition of sorghum *chakali*

Genotype	Protein (%)	Total sugar (%)	Fat (%)	Crude fiber (%)	Ash (%)
Control	18.28	3.75	40.02	2.15	3.3
Phule Anuradha + R + U + B + G	14.09	2.78	38.39	3.75	2.6
Phule Vasudha + R+U+B+G	14.50	2.49	38.75	3.52	2.6
Phule Revati +R+ U+B+G	14.25	2.74	39.4	3.47	2.48
CSV-22 + R+U+ B+G	14.42	2.70	39.37	3.45	3.00
M35-1 + R+U+ B+G	14.74	2.65	37.58	3.54	2.22
CSH-15-R +R+U +B+G	13.87	2.60	38.02	3.49	2.46
SPH-1620 +R+U +B+G	13.64	2.63	37.24	3.45	3.04
Range	13.64-18.28	2.49-3.75	37.24-40.02	2.15-3.75	2.22-3.3
Mean	14.72	2.79	38.60	3.34	2.71
SE ±	0.022	0.023	0.020	0.022	0.023
CD 5%	0.066	0.070	0.061	0.066	0.070
CV%	0.259	0.898	0.091	1.141	1.505

Whereas: R = Rice, U = Black gram dal, B = Bengal gram, G = Green gram. Three replications mean values.

Table 6 Economics of *chakali* making

Item	Rate (Rs/kg)	Quantity (g)	Cost (Rs.)
Raw material			
Sorghum	20	500	10.00
Rice	40	125	5.00
Green gram	90	125	11.25
Black gram	78	125	9.75
Oil	75	1000	75.00
Salt, chilli powder, cumi, owa	-	-	15
Labour charges	30	-	30
Fuel and packaging misscellaneous	-	-	20
Total yield (kg)	-	1.6 kg	181.5
Cost/kg (*chakali*)	-	-	113.4

There is no research work done on sorghum *Chakali* preparation as well as their organoleptic properties studies. So no literature on this aspect is available. But other literature found on rice, pulses with other millet flour *Chakali* are as Bodyfelt *et al.* (1988) sensory evaluation is considered to be an important analytical tool in the present day competitive corporate environment.

Organoleptic evaluation of chakali prepared from different genotype of sorghum: The results of organoleptic evaluation of sorghum *Chakali* are presented in Table 4 and Plate 1. Colour and appearance score for *Chakali* ranged from 7.53 to 8.36. The variety Phule Vasudha showed the highest colour and appearance score (8.36) followed by M35-1 (8.25) and CSV-22 (7.93) genotypes. Hoitinkim Singson *et al.* (2014) reported sensory data of various sample of *chakali* from markets which were prepared from different combinations of grain flour. The score for colour and appearance was 4 to 7.90. Yenagi *et al.* (2010) given the sensory data of *chakali* prepared from combination of rice and little millet as 1:1 proportion. The score for colour and appearance was 7.2.

Flavour score for *chakali* ranged from 7.53 to 8.26. The variety Phule Vasudha showed the best flavor (8.26) followed by Phule Revati (8.07) and M35-1 (7.93). Flavour is also very sensitive parameter for acceptance for the food product. If the food product is giving pleasant flavour consumer accept that food product without any hesitation. Flavour is mostly depends on

the frying oil quality for specially fried *Chakali* as well as some chemical reactions occur during frying. Yenagi *et al.* (2010) given the sensory data of *chakali* prepared from combination of rice and little millet as 1:1 proportion. The score for flavour was 7.1.

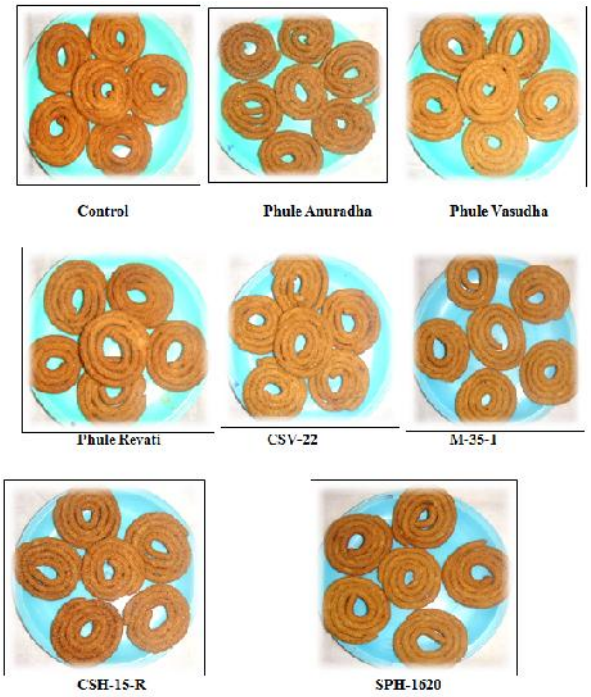

Plate 1 *Chakali* prepared from different genotype of sorghum (*Chakali* mix + sorghum flour, 50:50 ratio w/w).

Crispiness is combined sensation of all the rheological and structural parameters of the product during chewing and biting. It includes handfeel and monthfeel. Crispiness score for *chakali* ranged from 7.45 to 8.53. The variety Phule Revati showed the best crispiness (8.53) followed by Phule Vasudha (8.51) and M35-1 (8.08). For crispiness the variety Phule Vasudha (8.51) and Phule Revati (8.53) were statistically at par. Hoitinkim Singson *et al.* (2014) reported sensory data of various sample of *chakali* from markets which were prepared from different combinations of grain flour. The score for texture and crispiness was 3.1 to 7.60. Yenagi *et al.* (2010) given the sensory data of *chakali* prepared from combination of rice and little millet as 1:1 proportion. The score texture was 7.

Taste of food product is the prime parameter for consumer's acceptance. Those food products gave very pleasant, sweet and freshness enhancer taste are mostly preferred by the consumers. Taste score for *chakali* ranged from 7.45 to 8.23. The variety Phule Vasudha showed the highest taste (8.23) followed by M35-1 (8.15) and CSV-22 (8.15). Hoitinkim Singson *et al.* (2014) reported sensory data of various sample of *chakali* from markets which were prepared from different combinations of grain flour. The score for taste was 3.8 to 7.70. Yenagi *et al.* (2010) given the sensory data of *chakali* prepared from combination of rice and little millet as 1:1 proportion. The score for taste was 7.3.

Overall acceptability score is based on colour and appearance, flavour, crispiness and taste parameters. Those samples are giving higher score to these sensory parameters they score higher for the overall acceptability score. Therefore white selecting the best sample overall acceptability parameters play an important role. Overall acceptability for *chakali* the variety Phule Vasudha gave highest score (8.35) followed by Phule Revati (8.13) and M35-1 (8.10). Hoitinkim Singson *et al.* (2014) reported sensory data of various sample of *chakali* from markets which were prepared from different combinations of grain flour. The score for overall acceptability was 3.2 to 7.80. Yenagi *et al.* (2010) given the sensory data of *chakali* prepared from combination of rice and little millet as 1:1 proportion. The score for overall acceptability was 7.

Chemical composition of chakali prepared using chakali mix and sorghum flour

***Crude protein*:** Protein content in *chakali* ranged from 13.64 to 18.28 %, Table 5. M35-1 gave highest protein content (14.74 %) followed by Phule Vasudha (14.50 %) and CSV-22 (14.42 %; Table 5). Chavan *et al.* (2010) reported the protein contain 11.20 % in chakali prepared from sorghum, wheat, rice, green gram, black gram and soybean.

***Total sugar*:** Total sugar content in *chakali* ranged from 2.49 to 3.75 %. The variety Phule Anuradha gave highest total sugar content (2.78 %) followed by Phule Revati (2.74 %) and CSV-22 (2.70 %).

Fat content: Fat content in *chakali* ranged from 37.24 to 39.75 %. The variety Phule Revati gave highest fat content (39.4 %) followed by CSV-22 (39.37 %) and Phule Vasudha (38.75 %). Chavan *et al.* (2010) reported the fat contain 18.20 % in chakali prepared from sorghum, wheat, rice, green gram, black gram and soyabean. Hoitinkim Singson *et al.* (2014) Reported that fat content varied from 17.6- 42.3 per cent with a mean of 31.71 per cent and there was a significant difference between the samples.

Crude fiber: Crude fiber content in *chakali* ranged from 2.15 to 3.52 %. The variety Phule Anuradha gave highest crude fiber content (3.75 %) followed by M35-1 (3.54 %) and Phule Vasudha (3.52 %). Chavan *et al.* (2010) reported the crude fiber contain 1.40 % in chakali prepared from sorghum, wheat, rice, green gram, black gram and soybean.

Ash content: Ash content in *chakali* ranged from 2.22 to 3.3 %. The hybrid SPH-1620 gave highest ash content (3.04 %) followed by CSV-22 (3.00 %) and Phule Anuradha (2.6 %).

Nutritional constituents are at different level in each genotype of sorghum. This is due to the genetic variability in that genotype. Other ingredients such as rice, green gram, black gram, urid dal are used with sorghum flour for the preparation of niche product *chakali*. These parameters/ingredients content also affect the content of nutrients in the final food product. While considering overall nutritional composition and organoleptic parameters Phule Vasudha was found superior over the other genotypes used in this study.

Economics of chakali: The result on cost analysis of sorghum *chakali* is presented in Table 6. The cost of *chakali* was calculated as per existing prices at the time of the study. The cost of production of *chakali* was 113.4/kg. These costs did not include rent, transport charges, sale commission and local taxes etc.

CONCLUSION

While considering the yield of *chakali* from sorghum grains as well as their nutritional composition and organoleptic properties the varieties, Phule Vasudha at 50:50 ratio of *chakali* mix to sorghum flour was the best one as compared to the other varieties and hybrids as well as the cost of chakali was Rs. 113.40/Kg.

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