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Original Research Article

Preparation and Nutritional Quality of Sorghum Papads

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A B S T R A C T

Study was under taken to develop protocol for preparation of sorghum *papad*, to study the nutritional composition, sensory characteristics of sorghum *papad*, to identify the superior genotype of sorghum for *papad* preparation and to study the nutritional quality parameters of sorghum grains as well as its *papad*. Five varieties and two hybrids were used for preparation of sorghum *papad*. The crude protein content in grain and *papad* ranged from 10.28 to 11.37% and 10.11 to 11.35%, respectively. The variety M-35-1 gave numerically higher level of protein. The fat content in grain ranged from 1.21 to 1.90%. The genotype Dadar local gave higher level of fat (1.90%) as compared to other genotype, the oil content in sorghum *papad* ranged from 23.59 to 35.42%. The hybrid SPH-1620 gave numerically higher level of fat percentage as compare to other genotypes. The new genotype RPASV-3 identified for the preparation of sorghum *papads* showed slightly higher level of protein, fibre and phenolics content. The total sugar, fat and ash content are less than other cultivar studied. The organoleptic properties of *papads* prepared from sorghum flour were judged on the basis of colour, appearance, texture, flavour, taste and overall acceptability of the product using semi-trained judges and 1 to 9 hedonic scales. While considering nutritional composition of sorghum grain as well as organoleptic properties of the niche product (*papad*) prepared from them. The genotype RPASV-3 is found best for overall accepted characters and also having good frying qualities like puffiness, crispiness and expansion and having low oil absorption capacity than other six genotype as well as black gram and finger millet *papads*.

Introduction

Sorghum (*Sorghum bicolour* L. Moench) is one of the major cereal crop consumed in India after rice (*Oryza sativa*). It is of African origin. It is diploid chromosome number (2n = 20) belongs to family Graminae. Sorghum is mostly grown in dryland region. It is grown in both *kharif* and *rabi* season. Inflorescence is called panicle.

India is the third largest producer of sorghum in the world with 6.30 million tons

during 2011 and about 95 per cent production from states like Maharashtra and Southern States of Karnataka and Andhra Pradesh, Madhya Pradesh, Gujrat and Rajasthan (Anonymous, 2010). Sorghum contains special constituents such as phytochemicals, dietary fibre as well as resistant starch which are essential to human nutrition. Starch is one of the major carbohydrates in the sorghum grain. Sorghum protein is superior to wheat protein in biological value and digestibility. Sorghum is poor in lysine but rich in leucine. Malting, fermentation and by mixing of flour from other grains or pulses improves the nutritional quality of sorghum (Kazanas and Fields, 1981 and Au and Fields, 1981). Sorghum is good source of *Lactobacilli* which is used in souring of foods mostly in traditional food drinks. Sorghum can be processed to further improve its' food as well as feed value and techniques such as grinding, crushing, steaming, steam flaking, popping and extruding all used to enhance the grain for food and feed purposes.

Sorghum can be adapted for other food products by using appropriate processing methods. Dehulling and milling practices to improve the quality of foods made from sorghum. 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 (Reichert and Young, 1976). The use of sorghum in common foods such as *idli* (a steamed produt), *dosa* (a leavened products) can be popularized for wider use in sorghum growing areas (Subramanian and Jambunathan, 1982). A few important sun-dried or extruded products from sorghum such as *papad* can be prepared and 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 as well as other cereals, pulses products.

Sorghum provides non-glutinous flours which are useful for avoiding damage to the lining of intestine and easy for absorption of nutrient. People with celiac disease must eat a gluten free diet, which makes sorghum flour ideal for cooking and baking. Sorghum foods are least allergenic and mostly digestible as slowly. It is an excellent health food for people suffering from diabetes in India (Klopfensten and Hosency, 1995). Sorghum is rich in carbohydrate and B-complex vitamins. It is poor in vitamin A and rich in dietary fibre. It also reduces risk of heart diseases. Sorghum food helps to manage polycystic ovary syndrome in women. It also provides antioxidants for controlling cancer and reduces blood cholesterol level. Sorghum is good source of vitamins and minerals.

Papad is one of the popular snack items and it is very tasty so it is used in every Indian diet since older days. It is consumed either as such often frying or roasting or as adjunct along with vegetable soups and curries. In Bangladesh, *papad* is consumed often after frying. It is usually made from a blend of cereal flour, edible starch and pulse flour with common salt, spices, edible oil, alkaline and mucilaginous additives (Miaruddin *et al.*, 2006). The largest numbers of *papad* are made from different pulses and also from certain cereals. Basically *papads* are prepared from blackgram dhal, mung dhal etc. Blackgram dhal *papad* is the largest selling *papad* in the local and national market and these *papads* are staple in every Indian's home and are served as an appetizer. The demand for *papad* is greater scope for introduction of varieties for *papad* prepared from cost effective raw ingredient such as grain sorghum. *Papad* is one of the Indian

traditional food items that can be prepared in advance and served as and when needed. *Papad* is a thin crispy wafer like dish that goes well with meals and snacks. In India production of cereals is abundant; there is a need to find diversified uses in order to maximize their utilization and to cater the fast changing taste of new generation.

Materials and Methods

The grains of five *rabi* sorghum varieties *viz*., RPASV-3, Pandhari Chickni, Dadar local, M-35-1, Phule Revati and two hybrids *viz*., SPH-1620, CSH-15R were obtained from Senior Sorghum Breeder, All India Co-ordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. Chemical analysis of sorghum grains for protein, total sugar, crude fiber, starch, amino acids, minerals, phenolics, ash and fat were done using NIR Spectrophotometer, Spectra Analyzer Serial No: 05; 281, ZEUTEC Opto Elektronik GmbH, Keiler 211, 24768 Rendsburg, Germany.

Cleaned sorghum grains were subjected to milling in laboratory by grinding mill. Whole sorghum flour was used for preparation of *papad*. Chemical analysis of *papad* for protein and fat were done using standard methods of AOAC (2000).

Standardization of formula (ingredients in g/kg) for preparation of sorghum papad: For standardization of formula various combinations were used and the best one selected for further utilization. Sorghum flour blended with ingredients salt, *papadkhar*, asafoetida, sesame seed, black pepper, water and made dough. This dough was utilized in the preparation of *papads*. All the standardized ingredients were kept constant throughout all treatments.

Preparation of dough and papads: Sorghum grain cleaned and ground in to flour then sieved to 60 mesh sieve and add ingredients (papdkhar + salt + sesame seed + asafoetida + cumin powder + black pepper; selected formula No. 5 as a standard by using organoleptic evaluation). Then mixed flour in boiling water, stirred well, mixed into smooth dough, divided dough into small portion (10-12g each ball). Then steamed the ball in steamer/pressure cooker (15 psi for 10-15 min). Then placed these balls in plastic sheet, placed these balls in *papad* press machine and pressed into 0.10 or 0.15 cm thick sheet. After that *papads* dried at room temperature, packed in plastic bags and stored at room temperature for further study. Market sample *papads* of finger millet and black gram were used as a control.

Organoleptic evaluation of papad: Organoleptic evaluation of *papad* for colour and appearance, flavour, texture, taste and overall acceptability was carried out by using standard method 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 *papad*. The mean of ten judges was considered for evaluating the quality.

Physico-chemical characteristics of papad: Total number of *papads*, colour *of papads*, thickness of *papad*, diameter *of papad*, weight of *papad*, puffiness, crispiness, expansion of *papad*, bulk density parameters were measured using standard method of AOAC (2000).

Microbial quality and statistical analysis of papad: Total microbial count was recorded by standard plate count (SPC) method. The Glucose Yeast Extract Peptone Agar was prepared and used as growth medium for yeast and potato dextrose agar medium was used for mould. The petridishes were incubated at 30 $\pm$ 2 oC for 48 hr for counting fungal colonies. To take a

colony count, magnifying lenses were used. The statistical design adopted to study the different aspects was Completely Randomized Design (CRD) using 7 treatments with 3-10 replications depending on the parameter studied. The results were tabulated and analyzed according to the procedure of Panse and Sukhatme (1965).

Results and Discussion

Nutritional constituents of sorghum grain*:* During the present investigation protocol developed for the preparation of *papad*. The most promising genotypes were screened to identify one suitable for the *papad* production. The nutritional composition of RPASV-3, Pandhari Chikni, Dadar local, M-35-1, Phule Revati, SPH-1620 and CSH-15R in respect of their various parameters are given here. The crude protein content in grain ranged from 10.28 to 11.37%. The variety M-35-1 recorded numerically higher level of protein (11.37 %) in the grain and was at par with Phule Revati (11.36%), RPASV-3 (11.27%) and hybrid CSH-15R (10.77%; Table 1). The variation in the protein content among the sorghum genotypes is due to their genetic background/variability but it is non-significant. The results were in line with those obtained earlier workers (Beta *et al.* 1995; Chavan *et al.* 2009; Chavan and Patil, 2010). The fat content in grain ranged from 1.21-1.90%. The genotype Dadar local gave significantly higher level of fat (1.90 %) in the grain which was at par with Pandhari Chikni (1.74 %), M-35-1 (1.68 %) and SPH-1620 (1.65 %). The starch content in grain ranged from 58.56 to 61.56%. The genotype Pandhari Chikni gave numerically higher level of starch per cent (61.56%) in grain and at par with Dadar local (61.44%) followed by Maldandi (61.31%) and SPH-1620 (60.44%; Table 1). Chavan *et al.* (2009) reported starch content varied from 58.13 to 73.08 per cent. The carbohydrate in grain sorghum mainly constitutes the starch ranging from 56 to 75% (Subramanian and Jambunathan, 1984). The starch content is negatively and significantly correlated with protein content the physiochemical characteristics of starch are influenced by amylose content is significantly correlated with protein content, the physiochemical characteristics of starch are influenced by amylose content in sorghum (Miller and Burns, 1970). The starch content in hybrid ranged 74.41 to 75.95 per cent (Deshpande *et al.*, 2003). Present results are similar to the literature. The total sugar content in grain ranged from 1.12 to 2.47%. The variety M-35-1 gave significantly higher level of total sugar (2.47%) in the grain and at par with Dadar local (2.27%) followed by CSH-15R (1.78%) and SPH-1620 (1.76%). Ibrahim *et al.* (2010) recorded total soluble sugar content from 0.54 to 3.38%, from 0.54 to 4.89% and from 0.41 to 4.41% in Hamra, Shahla and Baida, sorghum varieties. The fibre content in grain ranged from 3.15 – 3.71%. The hybrid CSH-15R gave numerically higher level of fibre (3.71%) in the grain and at par with RPASV-3 (3.61%) followed by SPH-1620 (3.56%) and Dadar local (3.33%). Ratnavathi *et al.* (2000) reported crude fibre among the thirteen cultivars varied from 1.57% (M-35-1) to 2.4% (SPV-462).

Vannalli *et al.* (2008) revealed that proximate composition of sorghum grain for crude fibre ranged from 1.21 to 2.74%. Chavan *et al.* (2009) reported crude fibre content ranged from 1.90 to 2.64%. The ash content in grain ranged from 2.33 to 3.07%. The hybrid CSH-15R gave significantly higher level of Ash (3.07%) in the grain and at par with SPH-1620 (3.01%) followed by Pandhari Chikni (2.84%) and Dadar Local (2.49%). All results for ash content are non-significant. This indicates that all genotypes are having similar amount of ash content which is good source for the mineral

elements. Vannalli *et al.* (2008) revealed that proximate composition of sorghum grain for ash ranged from 1.14 to 1.72%. Yewale (2013) observed a range of ash content of sorghum grain ranged from 0.90 to 3.82 per cent. The phenolics content in grain ranged from 0.92 to 1.63%t. The genotype RPASV-3 gave numerically higher level of phenolics (1.63%) followed by Pandhari Chikni (1.54%) and Dadar local (1.34%). Now-a-days phenolics components which are coming under secondary metabolites act as a neutraceutical component. Therefore high phenolics content have high importance in the human nutrition. The content of phenolics in grain sorghum has been studied by several investigators. Variations in the phenolics content of grain sorghum from 4.8 to 8.2% (Harris *et al.*, 1970) and 2.69 to 6.88% (Jambunathan and Mertz, 1973) have been reported in high tannin cultivars. Mc Millian *et al.* (1972) observed a range of tannins from 0.12 to 0.8% in broad spectrum of available sorghum. The present results are in accordance with the literature.

Amino acids profile of sorghum grain

The results of amino acids content in sorghum grains are represented in Table 2. Histidine content in the grain varies from 1.83 to 2.13 g/16 g N. The hybrid CSH-15R (2.13 g/16 g N) and variety M-35-1 (2.12 g/16 g N) recorded higher histidine content followed by Dadar local and Phule Revati (2.09 g/16 g N). The lowest histidine content was observed in RPASV-3 (1.83 g/16 g N). Histidine content reported by Moss *et al.* (1988), Robertson *et al.* (2006) and Chavan and Patil (2010) were 2.0 – 2.3, 1.2 - 2.2 and 2.06 g/16 g N, respectively. Isoleuoine content in sorghum grain ranged from 3.10-4.09 g/16 g N. The genotype Dadar local gave higher isoleucine content (4.09 g/16 g N) followed by M-35-1 (3.94 g/16 g N), hybrid SPH-1620 (3.10 g/16 g N) and Pandhari Chikni (3.36 g/16 g N) gave lowest content of isoleucine. Isoleucine content reported by Mosse *et al.* (1988), Robertson *et al.* (2006) and Chavan and Patil (2010) were 4.1-4.4, 3.2-4.7 and 3.83 g/16 g N, respectively. Leucine content in sorghum grain ranged from 11.67 to 13.75 g/16 g N. The genotype Dadar local gave higher level of leucine content (13.75 g/16 g N) followed by Pandhari Chikni and M-35-1 (13.46 g/16 g N). The genotype RPASV-3 recorded lower level of leucine content (11.67 g/16 g N). Leucine content by Mosse *et al.* (1988), Robertson *et al.* (2006) and Chavan and Patil (2010) were 12.7 to 14.7, 10.4 to 16.7 and 12.27 g/16 g N, respectively. Lysine content in sorghum grain ranged from 2.55-2.89 g/16 g N. The genotype Pandhari Chikni recorded higher level of lycine (2.89 g/16 g N) followed by M-35-1 (2.69 g/16 g N) and hybrid CSH-15R (2.66 g/16 g N). Hybrid SPH-1620 gave lower level of lycine content (2.55 g/16 g N). Lycine content reported by Mosse *et al.* (1988), Robertson *et al.* (2006) and Chavan and Patil (2010) were 2.1-2.5, 2.3-3.6 and 2.60 g/16 g N, respectively. Methionine content in sorghum grain ranged from 1.34 to 1.55 g/16 g N. The genotype Pandhari Chikni exhibited higher level of methionine content (1.55 g/16 g N) followed by RPASV-3 (1.43 g/16 g N) and M-35-1 (1.34 g/16 g N) gave lower level of methionine content. Methionine content reported by Mosse *et al.* (1988), Robertson *et al.* (2006) and Chavan and Patil (2010) were 5.2 - 5.7, 3.0 - 5.4 and 1.55 g/16 g N, respectively. Other all amino acids are also in the range of literature values.

Mineral content: Calcium content in the sorghum grain ranged from 21.77 to 36.44 mg/100g. The genotype Dadar local recorded higher level of calcium content (36.44 mg/100g) followed by Phule Revati

(34.75 mg/100g) and M-35-1 (34.72 mg/100g. The genotype RPASV-3 exhibited lower level of calcium content (21.77 mg/100g). Anonymous (1995) reported calcium content in sorghum grain was 26 mg/100g. Chavan and Patil (2010) observed calcium content in sorghum grain was 25 mg/100g. Iron content in the sorghum grain ranged from 4.11 to 4.98 mg/100g (Table 3). The genotype RPASV-3 recorded higher level of iron content (4.98 mg/100g) followed by M-35-1 (4.88 mg/100g. Phosphorus content in different genotype of sorghum grain ranged from 491 to 517 mg/100g. The hybrid SPH-1620 had higher level of phosphorus content (517 mg/100g) followed by RPASV-3 (513 mg/100g). Potassium content in different genotype of sorghum ranged from 506 to 564 mg/100g. The genotype RPASV-3 recorded higher level of potassium content (564 mg/100g) followed by Phule Revati (556 mg/100g). Chavan and Patil (2010) observed potassium content in the sorghum grain was 537 mg/100g. Winchester and Makokha (2011) reported potassium content in the sorghum grain was 350-524 mg/100g. Zinc content in different genotype of sorghum grain ranged from 3.68 to 4.73 mg/100g. The genotype Pandhari Chikni showed higher level of zinc (4.73 mg/100g). Chavan and Patil (2010) observed zinc content in the sorghum grain was 3.91 mg/100g. Present results indicated that sorghum grains are good source of the mineral content which has very high importance in the human diet. Therefore inclusion of sorghum in daily diet will help to supply necessary amount of minerals to human body.

Standardization of formula (ingredients g/kg) for sorghum papad: Standardization of formula for *papad* preparation used different ingredients in different proportion and made five formulae and prepared *papad* from these formulae. While formulating the ingredients various combinations were tried in the preliminary trials. During the formulations colour, texture, flavour, taste and overall acceptability of the sorghum *papad* were considered as the base parameters. For comparison following five formulas were taken and from these only one was selected as the best one (Formula No.5).

Organoleptic evaluation of sorghum papad prepared from different five formulae: After organoleptic evaluation formula No. 5 was overall accepted in accordance with colour, texture, flavour and taste and it is selected for further *papad* preparation from all five varieties and two hybrids (Table 4).

Physical characteristics of sorghum, black gram and finger millet papads: The total number of *papads* obtained from 1 kg of five varieties and two hybrids were weighed and numbers of papad are recorded from each genotype. The highest number of *papads* obtained from RPASV-3 (65), Pandhari Chikni (65) and Dadar local (65) genotype per kg and lowest number of *papads* obtained from hybrids SPH-1620 (57) and CSH-15R (56) per kg (Table 5). Colour of raw *papad* prepared from different five varieties and two hybrids recorded by visual observation. Among them the genotype RPASV-3 showed red brown coloured *papad*. The genotype Pandhari chikni recorded faint white coloured *papad*. The genotype Dadar local and M-35-1 gave faint yellow coloured *papad*. The variety Phule Revati and hybrid CSH-15R and SPH-1620 recorded yellowish coloured *papads*. Fingermillet *papad* gave faint yellow coloured and blackgram *papad* gave yellowish coloured *papad* (Plate 1 & 2). The colour of *papad* from each genotype varies according to their grain colour. This colour difference is from their genetic makeup. The genotype RPASV-3 exhibited faint red brown colour which is similar to that of

finger millet. The market *papad* samples of finger millet are transport and it might be prepared from the finger millet extract (mostly starch) therefore their puffing volume is more. The *papad* prepared from whole grain flour of RPASV-3 gave very good colour and appearance, so they can be used as a good snack food. The thickness of *papads* from all genotypes was measured by Vernier Caliper in mm. Among that the papads prepared from Phule Revati (0.061mm) and CSH-15R (0.061mm) genotype recorded higher level of thickness followed by Pandahri Chikni (0.60mm) and RPASV-3 (0.059mm). *Papads* of finger millet gave 0.058mm and black gram 0.057mm thickness. The thickness of *papads* depends upon the preparation; because these all *papads* were prepared manually.

Diameter of papads: The diameter of raw *papad* ranged from 14.1 to 16.5cm and diameter of fried papad ranged from 10.97 to 34.54cm. The genotype RPASV-3 recorded significantly highest level of diameter both before (16.5cm) and after frying (34.54cm) followed by Pandhari Chickni (Before frying 16.4cm and after frying 29.88cm) and Phule Revati (Before frying 14.9cm and after frying 29.53cm. Diameter of *papad* is mostly dependent on the starch ability of the gelatinized starch quantity and quality present in the sample. Therefore, the raw and fried *papads* have different diameter. During frying of *papads* the starch present in the *papad* get expanded. The expansion of the starch is mostly dependent upon their structure and combination of amylose, amylopectin as well as sudden change during frying. Therefore these all *papads* gave different values for expansion depending upon above parameters. But this parameter gives the crispiness of the *papad*. Those *papad* have high expansion during frying gives more crispiness.

Weight of papad: The unit weight of raw and fried *papads* of different seven genotypes were recorded by taking the weight of ten *papads* of each variety and from that finally mean weight of *papad* was calculated. The mean weight of *papad* before frying ranged from 16.2 to 20.4g and mean weight of *papad* after frying ranged from 19.1 to 25.2g. The highest weight of *papads* before frying was observed in hybrid CSH-15 R (20.4g) followed by variety Phule Revati (20.1g). The highest weight of *papads* after frying was observed in variety Phule Revati (25.2g) and hybrid SPH-1620 (25.2g). The lowest weight was observed in genotypes RPASV-3 (19.1g) and Dadar local (21.3g). Weight of finger millet *papad* increased from 3.6 (before frying) to 14.6g (after frying) and in black gram *papad* weight increased from 6.7 (before frying) to 10.1g (after frying). Due to lack of research work on sorghum *papad* preparation as well as physical characteristics studies, the available literature found on sorghum flour preparation of with other millet flour for preparation of *papads* are given below. Nazni and Pradheepa (2010) prepared black gram *papads* with incorporation of sorghum at 0, 5, 10, 15 and 20% and other all ingredients were kept constant. They found that the samples were highly acceptable by the judges and physical properties were almost same with control *papads*. The present results showed that the whole sorghum flour can be used for the preparation of *papads* with good physical-chemical and nutritional quality properties.

Frying quality of papad

Oil absorption: Oil absorption capacity is an important characteristic to judge the frying quality of *papad*. Oil absorption

capacity is determined by amount of oil absorbed by the *papad* after frying. For determination of oil absorption capacity weight of *papad* before frying and weight of *papad* after frying were taking into consideration. The oil absorption capacity was highest in genotype Dadar Local (30.67%) followed by SPH-1620 (26.00%). The oil absorption capacity was lowest in genotype RPASV-3 (17.90 %; Table 5). In case of black gram (50.75%) and finger millet (30.55%) *papads* oil absorption capacity was highest than all seven genotypes of sorghum. While food product preparation higher oil absorption can create problem for that product during storage and reduce the shelf life. Therefore less oil required for *papad* frying is more beneficial. In case of sorghum *papads* of the genotype RPASV-3 required less amount of oil for frying and that gives additional benefit to the product. Now-a-days low oil/fat content in the diet is more beneficial for health. Therefore sorghum *papads* are far better than the other *papads* which are available in the market i.e. black gram and finger millet.

Puffiness: Puffiness is the frying quality which determines the expansion of *papad* after frying. Among the all seven genotype, the genotype RPASV-3 was highest Puffiness (22.2%) followed by Pandhari Chikni (21.3%) and M-35-1 (20.1%). The genotype Dadar Local showed lowest puffyness (17.00%) than all seven genotypes. As compare with finger millet *papads*, it gave highest puffiness (107.14%) but black gram *papads* gave lowest puffiness (11.03%).

Crispiness: Crispiness is the frying quality which shows the rheological characteristics of the product during sensory evaluation by mouth feel. Among the five genotypes and two hybrids the genotype RPASV-3 was scored highest crispiness to mouth feel. Finger millet *papad* was scored highest crispiness to mouth as compared with all seven genotypes of sorghum *papad* and black gram *papad*. Crispiness of the food product mostly based on the puffing of starch during frying. If the puffiness is higher than it gives very smooth and crunchy type crispiness. Crispiness of the snack food products is mostly acceptable by the all type of consumers. Among the sorghum genotype RPASV-3 gave good quality *papads* with higher crispiness than other genotypes. As compare with finger millet *papads* its crispiness is lower than finger millet *papads* due to less amount of puffiness by lower amount of starch content. Finger millet *papads* mostly prepared from the extract, so it contain higher amount of starch than sorghum. But while comparing all organoleptic parameters RPASV-3 genotype gave comparable *papad* quality to the finger millet.

Expansion: The mean expansion percentage of all seven genotype ranged from 17.00 to 22.2%. Among the sorghum *papads* the expansion % of genotype RPASV-3 was significantly higher (22.2%) followed by Pandhari Chikni (21.3%) and M-35-1 (20.1%). Finger millet papad gave higher expansion 107.14% among all sorghum and black gram *papads*.

Bulk density: Among the all seven genotype RPASV-3 had highest bulk density (0.045g/cm^3) followed by Phule Revati (0.044g/cm^3) and CSH-15R (0.044g/cm^3). As compare with finger millet *papads* it gave lowest bulk density (0.044g/cm^3) than genotype RPASV-3 (0.045g/cm^3). The black gram *papads* gave lowest bulk density (0.043 g/cm^3) than Phule Revati (0.044g/cm^3) and hybrid CSH-15R (0.044g/cm^3).

Organoleptic evaluation of sorghum papads: Colour is very important parameter in judging the property of fried *papad* that

not only reflects the suitable raw material used for the preparation but also provides information about the formulation and quality of product. The mean colour and appearance sore of all seven genotype were different from each other. The score ranged between 6.4 to 7.4 with mean 7.0. The genotype Pandhari Chikni (7.4) and hybrid SPH-1620 (7.4) scored highest for colour and appearance followed by the genotype RPASV-3 (7.2; Table 6). Colour of any food material mostly important for the attraction of the consumer. The colour of *papad* prepared from the genotype RPASV-3 have distinct faint red brown colour, which was more attractive than other *papads* prepared during this study. This colour of *papad* is due to the reddish brown sorghum grains of RPASV-3. Consumer can easily identify the *papads* prepared from this sorghum variety in the market. Therefore this sorghum variety has this advantage for specific niche/snack product preparation.

Texture/Crispiness: Texture is combined sensation of all the rheological and structural parameters of the product during chewing and biting. It includes handfeel and monthfeel. The mean texture score of all seven genotype ranged from 6.4 to 7.8. The genotypes RPASV-3 scored highest (7.8) and Dadar local reported lowest score (6.4) among the genotypes.

Flavour: Flavour is main criteria that make the product to be liked or disliked. The perception of flavour is a combination of taste, smell, impression and texture. The flavour scored of all seven genotype ranged from 6.8 to 7.6 with mean 7.02. The genoypte Pandhari Chickni scored highest (7.6) followed by RPASV-3 (7.0), Dadar local (7.0), Phule Revati (7.0) and SPH-1020 (7.0). The lowest score was M-35-1 (6.8) and CSH-15 R (6.8). 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 *papads* as well as some chemical reactions occur during frying. The new sorghum genotype RPASV-3 gave very pleasant flavour to the fried papad which was highly acceptable to the consumers (judged by the judges).

Taste: Taste of food product is sensation perceived by the taste buds and influenced by the texture, flavour, taste and composition of product. It is one of the essential parameter related to acceptability of the food product. The taste score for seven genotype of sorghum ranged from 6.2 to 7.8 with mean of 7.07. The significantly highest taste score was observed for genotype RPASV-3 (7.8) followed by Pandhari Chikni (7.6) and CSH-15R (7.2). The lowest score was in M-35-1 (6.2) which is on par with Phule Revati (6.6). Taste of food product is the prime parameter for consumers' acceptance. Those food products gave very pleasant, sweet and freshness enhancer taste are mostly preferred by the consumers. As a snake product sorghum papad prepared from RPASV-3 gave highest acceptability as compare to other papads prepared during this research study.

Overall acceptability: Overall acceptability is the total reflection of the scores obtained for colour, texture/crispiness, flavour and taste of the *papad*. The overall acceptability scored ranged between 6.4 to 7.6 with mean 6.85. The overall acceptability scores were highest for genotype RPASV-3 (7.6) followed by Pandhari Chikni (7.4) and CSH-15R (7.0). There is no research work done on sorghum *papad* preparation as well as their organoleptic properties studies. So no literature on this aspect is available. But other literature found on sorghum flour with other millet flour *papads* are given here. Nazni and Pradeepa (2010) the mean

acceptability score obtained by the sensory evaluation of jawar *papads*. Among the different variation of jawar *papad*, control has got a highest score 8.80 followed by the variation S_2 with a score of 8.30 and the least score 7.90 is obtained by both the variation S_4 and S_5 for appearance attributes. Regarding the colour attributes the highest score 8.90 is obtained by control followed by variation S_2 with the score of 8.10. The texture attribute was found to be maximum for the control with a score of 8.80 and followed by the variation S_2 with the score of 7.50. Regarding the taste attribute, the highest score of 9.00 is obtained by the control which is followed by the variation S_4 with the scores of 8.10. The overall acceptability of control ranked first with a score of 8.90 and is followed by the variation S_4 with a score of 8.30.

Ingredients	Formula No. 1	Formula No. 2	Formula No. 3	Formula No. 4	Formula No. 5
Salt	Suhana papad masala pack used (Market pack)	8	16	24	32
Papadkhar		2	5	8	10
Black pepper		1.20	6	4	1.20
Sesame seed		20	50	50	20
Asafoetida		0.30	1.4	4	0.50
Cumin seed		-	-	50	-
Water requirement (ml)		1000	1000	1000	1000

Table.1 Nutritional composition of sorghum grains

Genotype	Crude Protein (%)	Lipids (%)	Starch (%)	Total Sugars (%)	Fiber (%)	Ash (%)	Phenolics (%)
Varieties							
RPASV-3	11.27	1.63	58.96	1.12	3.61	2.36	1.63
Pandhari chikni	10.28	1.74	61.56	1.49	3.15	2.84	1.54
Dadar local	10.33	1.90	61.44	2.27	3.33	2.49	1.34
M-35-1	11.37	1.68	61.31	2.47	3.17	2.33	1.18
Phule Revati	11.36	1.21	58.56	1.46	3.36	2.47	1.24
Hybrids							
SPH-1620	10.43	1.65	60.44	1.76	3.56	3.01	0.92
CSH-15R	10.77	1.52	60.13	1.78	3.71	3.07	0.94
Range	10.28-11.37	1.21-1.90	58.56-61.56	1.12-2.47	3.15-3.71	2.33-3.07	0.92-1.63
Mean	10.83	1.61	60.34	1.76	3.40	2.65	1.26
SE ±	0.46	0.20	1.12	0.43	0.21	0.10	0.25
CD at 5%	N.S.	0.59	N.S.	1.31	N.S.	0.30	N.S.

N. S. = Non-Significant

Table.2 Amino acid content in sorghum grain (g/16 g N)

Genotype	Cys	Glu	Gly	His	Ile	Leu	Lys	Met	Phe
Variety									
RPASV-3	0.87	20.54	2.61	1.83	3.79	11.67	2.61	1.43	4.90
Pandhari chikni	1.14	20.82	3.24	1.98	3.36	13.46	2.89	1.55	4.59
Dadar local	0.70	21.49	2.31	2.09	4.09	13.75	2.61	1.36	5.02
M-35-1	0.72	21.32	2.29	2.12	3.94	13.46	2.69	1.34	5.00
Phule Revati	0.86	21.08	2.36	2.09	3.72	12.57	2.61	1.37	5.12
Hybrid									
SPH-1620	0.88	21.25	2.76	2.03	3.10	12.21	2.55	1.36	5.69
CSH-15R	0.87	21.37	2.48	2.13	3.76	13.28	2.66	1.35	5.07
Range	0.70-1.14	20.54-21.49	2.29-3.24	1.83-2.13	3.10-4.09	11.67-13.75	2.55-2.89	1.34-1.55	4.59-5.69
Mean	0.86	21.12	2.578	2.038	3.68	12.91	2.66	1.39	5.05
S.E. ±	0.13	0.31	0.312	0.09	0.313	0.716	0.102	0.06	0.30
CD at 5%	0.39	N.S.	N.S.	0.29	0.94	N.S.	0.30	0.20	0.91
Genotype	Pro	Ser	Thr	Trp	Tyr	Ala	Arg	Asp	Val
Variety									
RPASV-3	5.30	3.57	3.08	1.15	2.87	7.75	3.82	8.59	4.13
Pandhari chikni	4.96	4.12	3.30	0.76	3.44	5.48	5.69	9.04	3.33
Dadar local	6.12	3.14	2.96	1.05	2.77	7.84	5.21	6.69	5.15
M-35-1	6.12	3.05	2.92	1.12	2.68	8.03	5.23	6.65	5.35
Phule Revati	5.99	3.08	2.99	1.19	2.84	7.95	5.08	7.05	3.98
Hybrid									
SPH-1620	6.24	3.47	2.98	1.15	2.75	8.05	5.10	7.08	3.83
CSH-15R	6.18	3.17	2.95	1.08	2.87	8.02	5.40	6.56	4.21
Range	4.96-6.24	3.05-4.12	2.92-3.30	0.76-1.19	2.68-3.44	5.48-8.05	3.82-5.69	6.56-9.04	3.33-5.35
Mean	5.84	3.37	3.02	1.07	2.88	7.58	5.07	7.38	4.28
S.E. ±	0.46	0.35	0.12	0.13	0.23	0.86	0.54	0.93	0.66
CD at 5%	N.S.	N.S.	0.36	0.40	0.70	N.S.	1.64	N.S.	2.00

N.S. = Non-significant

Table.3 Mineral composition of sorghum grains (mg/100 g)

Genotype	Ca	Fe	Mn	Mg	P	K	Cu	Na	Zn
Variety									
RPASV-3	21.77	4.98	1.77	238	513	564	0.90	23.63	4.12
Pandhari chikni	30.19	4.14	2.41	221	505	512	1.09	29.55	4.73
Dadar local	36.44	4.36	2.82	225	494	506	1.02	17.99	3.87
M-35-1	34.72	4.88	2.83	221	491	515	1.03	17.67	3.86
Phule Revati	34.75	4.15	2.76	223	498	556	0.90	25.54	3.75
Hybrid									
SPH-1620	34.50	4.74	3.04	224	517	535	0.93	24.38	3.68
CSH-15R	34.42	4.11	2.87	222	499	531	1.04	22.65	3.79

Range	21.77-36.44	4.11-4.98	1.77-3.04	221-238	491-517	506-564	0.90-1.09	17.67-29.55	3.68-4.73
Mean	32.39	4.43	2.64	224	502	531	0.98	23.05	3.97
S.E. ±	4.68	0.34	0.39	5.54	8.97	20.60	0.07	3.87	0.33
CD at 5%	14.05	N.S.	1.19	N.S.	N.S.	N.S.	N.S.	11.6	1.00

N.S. = Non significant

Table.4 Organoleptic evaluation of various papads prepared by using five formulas

Formula No.	Colour and appearance	Texture	Flavour	Taste	Overall acceptability	Ranking
Formula No.1	7.7	7.4	8.0	8.2	7.8	3
Formula No.2	8.2	8.4	8.3	8.5	8.3	2
Formula No.3	7.2	7.1	7.6	7.8	7.4	4
Formula No.4	6.6	6.7	7.0	7.2	6.8	5
Formula No.5	8.4	8.7	8.5	8.8	8.6	1

* 1 to 9 hedonic scale (Amerine et al., 1965)

Table.5 Physical characteristics of sorghum, blackgram and finger millet papads

Name of genotype	No. of papad / kg	Colour of papad	Thick-ness of papad (mm)	Diameter of papad (cm)		Expansion (%)	Weight of papad (g)		Increase weight (%)	Bulk density (in box) (g/cm^3)
				Before frying	After frying		Before frying	After frying		
RPASV-3	65	Red brown	0.059	16.5	34.54	22.2	16.2	19.1	17.90	0.045
Pandhari Chikani	62	Faint white	0.060	16.4	29.88	21.3	18.9	23.8	25.93	0.042
Dadar Local	65	Faint yellow	0.056	14.1	20.57	17.0	16.3	21.3	30.67	0.043
M-35-1	65	Faint yellow	0.057	15.8	27.21	20.1	19.4	23.4	20.62	0.043
Phule Revati	64	Yellowish	0.061	14.9	29.53	19.3	20.1	25.2	25.37	0.044
SPH-1620	57	Yellowish	0.058	16.4	10.97	18.2	20.0	25.2	26.00	0.043
CSH-15R	56	Yellowish	0.061	16.1	20.49	19.4	20.4	25.1	23.03	0.044
Finger millet (market sample)	-	Faint yellow	0.058	11.2	23.2	107.14	3.6	14.6	30.55	0.044
Black gram (market sample)	-	Yellowish	0.057	13.6	15.1	11.03	6.7	10.1	50.75	0.043

Table.6 Organoleptic evaluation of sorghum papad*

Genotype	Colour and appearance	Texture/ crispiness	Flavour	Taste	Overall acceptability
Variety					
RPASV-3	7.2	7.8	7.0	7.8	7.6
Pandhari Chikni	7.4	7.2	7.6	7.6	7.4
Dadar local	7.0	6.4	7.0	6.8	6.6
M-35-1	6.6	6.6	6.8	6.2	6.4
Phule Revati	6.4	6.8	7.0	6.6	6.6
Hybrid					
SPH-1620	7.4	7.2	7.0	7.0	7.1
CSH-15R	7.0	7.2	6.8	7.2	7.0
Range	6.4-7.4	6.4-7.8	6.8-7.6	6.2-7.8	6.4-7.6
Mean	7.0	7.02	7.02	7.07	6.85
S.E. ±	0.35	0.43	0.25	0.52	0.44
CD at 5%	N.S.	N.S.	0.74	1.55	N.S.

N.S. = Non significant*; 1 to 9 hedonic scale (Amerine et al. 1965)

Table.7 Chemical composition of sorghum, finger millet and blackgram papads

Name of genotype	Protein (%)	Oil (%)
RPASV-3	11.14	23.59
Pandhari chikni	10.20	30.48
Dadar Local	10.11	24.82
M-35-1	11.35	32.50
Phule Revati	11.25	32.18
SPH-1620	10.30	35.42
CSH-15R	10.33	25.42
Range	10.11-11.35	23.59-35.42
Mean	11.88	29.20
Finger millet *papad* (market sample)	9.10	57.72
Black gram *papad* (market sample)	22.00	34.35
S.E. ±	3.64	8.55
CD at 5 %	N.S.	N.S.

N.S. = Non significant

Table.8 Comparison of sorghum papad with black gram and finger millet papad*

Name of genotype	Colour and appearance	Texture	Flavour	Taste	Overall acceptability	Ranking
Sorghum papad (RPASV-3)	8.5	8.2	8.0	8.2	8.23	2
Finger millet papad	8.8	8.4	8.3	8.5	8.50	1
Black gram papad	8.0	7.8	7.6	7.8	7.80	3

* * Semi-trained 10 judges used and 1 to 9 hedonic scales (Amerine et al., 1965)

Plate.1 Sorghum papads before frying (1. RPASV-3; 2. Pandhari chikani; 3. Dadar local; 4. M 35-1; 5. Phule Revati; 6. SPH-1620; 7. CSH-15R; 8. Ragi/Finger millet; 9. Black gram)

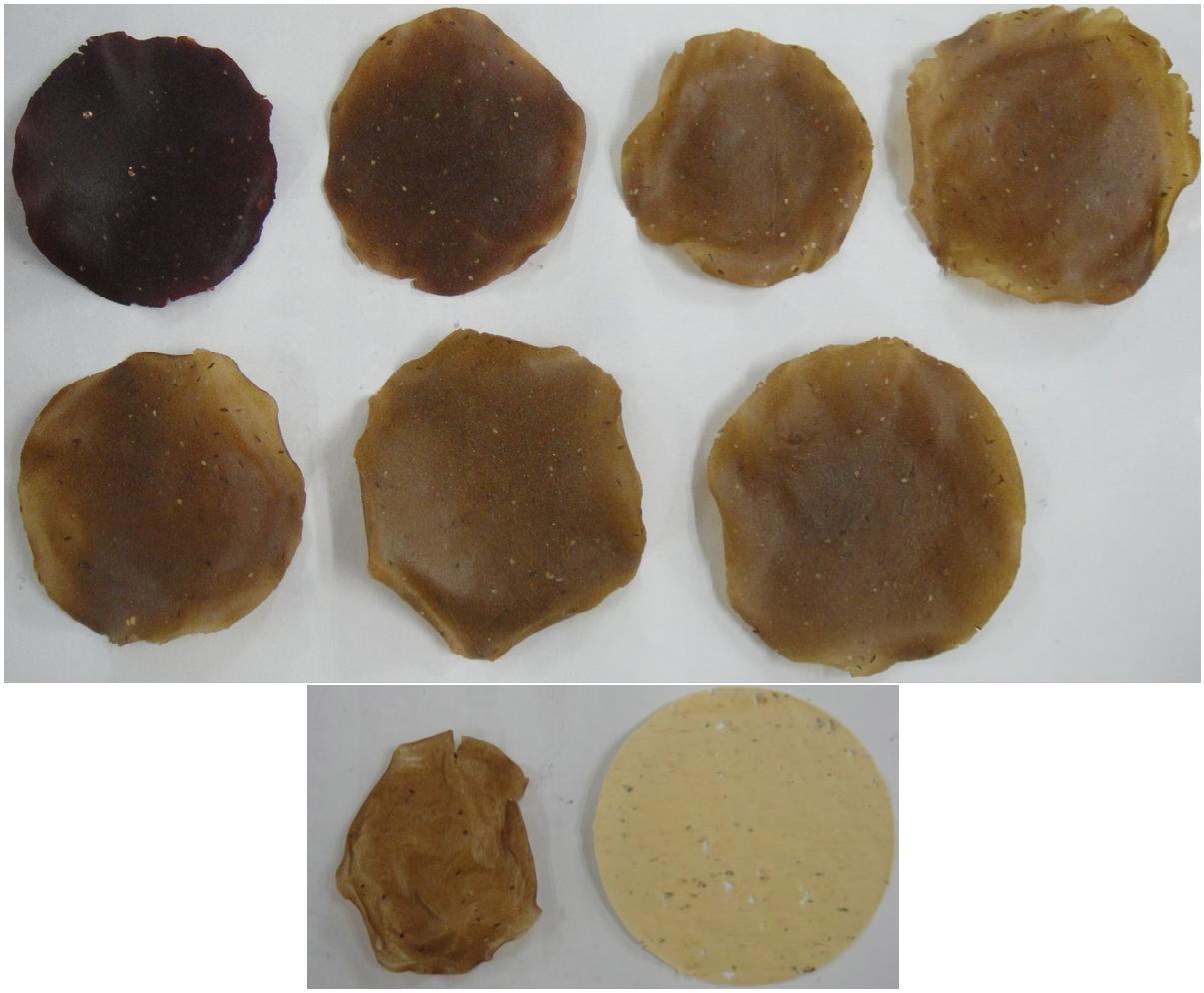
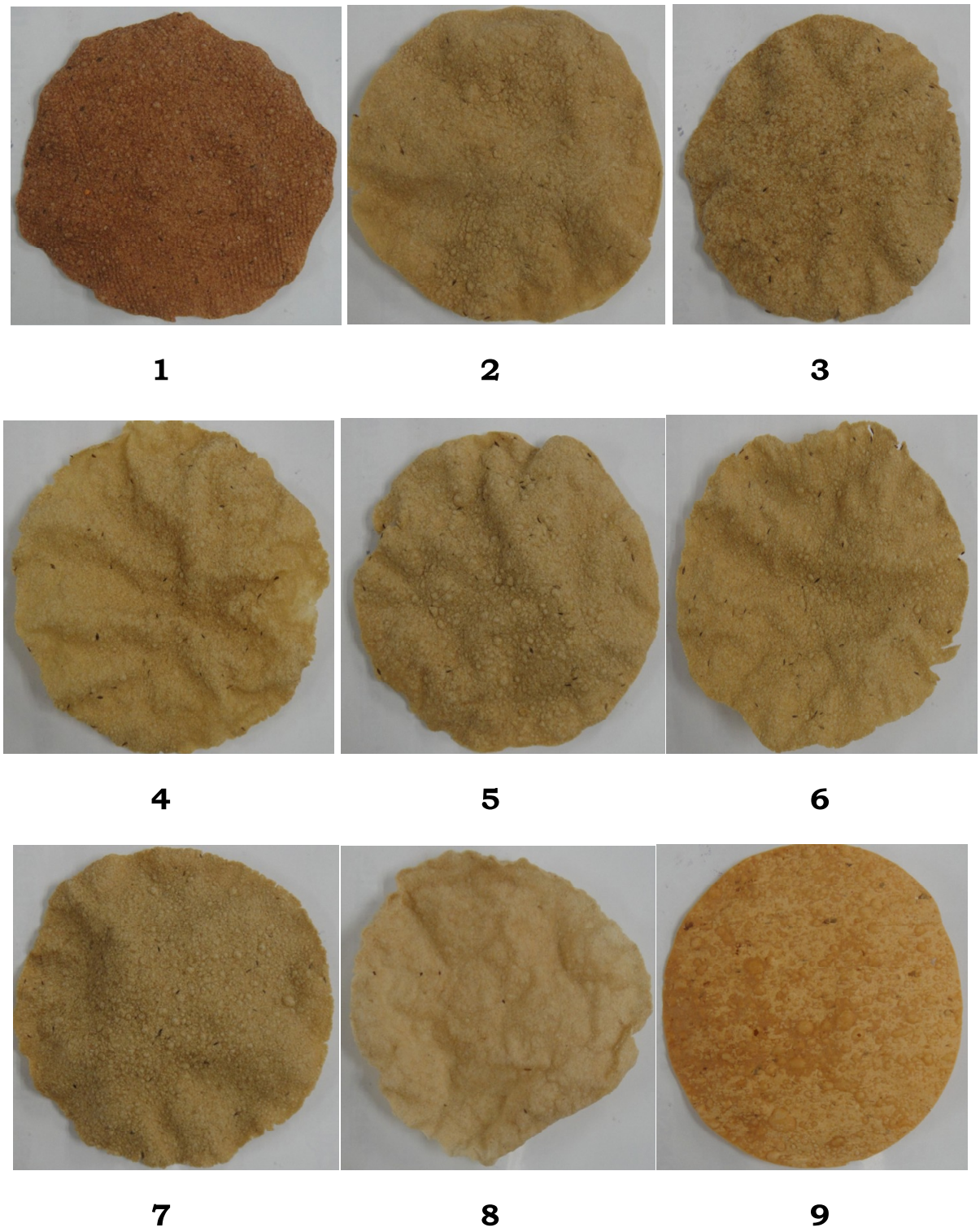


Plate.2 Sorghum papads after frying (1. RPASV-3; 2. Pandhari chikani; 3. Dadar local; 4. M 35-1; 5. Phule Revati; 6. SPH-1620; 7. CSH-15R; 8. Ragi/Finger millet; 9. Black gram)



Chemical composition of sorghum papad

The crude protein content in sorghum *papad* ranged from 10.11 to 11.35%. The *papad* prepared from M-35-1 gave numerically higher level of protein percentage followed by Phule Revati (11.25%) and RPASV-3 (11.14%; Table 7).

The crude oil content in sorghum *papad* ranged from 23.59 to 35.42%. The hybrid SPH-1620 (35.4%) gave numerically higher level of oil percentage followed by M-35-1 (32.5%) and Phule Revati (32.2%). The genotype RPASV-3 (23.6%) recorded lower level of oil percentage. The protein content was highest in black gram *papad* (22.0%) followed by RPASV-3 (11.2%) *papad* genotype. The oil content was highest in finger millet *papad* (57.7%) followed by Black gram *papad* (34.4%) and lower oil content was in RPASV-3 variety (23.6%) of sorghum *papad*. The oil per cent in sorghum *papad* variety RPASV-3 was less as compared to black gram and finger millet *papad* hence the *papad* prepared from genotype RPASV-3 is good for consumption.

Comparison of sorghum papads with black gram and finger millet papads

Sensory evaluation of *papad* sorghum genotype RPASV-3 was done with finger millet and black gram *papads* (Table 8). Finger millet *papad* was overall accepted at rank 1 in accordance with colour and appearance, texture, flavour and taste followed by sorghum *papad* prepared from the genotype RPASV-3 and black gram *papad* but they are statically non-significant.

Microbial count of papad: Microbial studies were carried out after 3 month storage period of papads at room temperature. After taking observations, it was found that there was no any growth of yeast and mould.

Mostly the local genotypes of sorghum *viz.*, Pandhari Chikni and Dadar local are used for preparation of *papads* in the cottage industry but at very small scale. The new genotype RPASV-3 identified for the preparation of sorghum *papads* showed slightly higher level of protein, fibre and pehnolics content. The total sugar, fat and ash content are less than other cultivars studied. *Papads* prepared from the genotype RPASV-3 had good sensory qualities like texture/crispiness, taste and overall acceptability and also good frying quality like puffiness, crispiness and expansion as compared to other genotype. *Papads* of genotype RPASV-3 having low oil absorption capacity (17.9%) than other six genotype and especially from market *papads* (black gram and finger millet *papads*). Due to less moisture percentage (2-3%) in sorghum *papad* there was no any microbial contamination. The product remains safe throughout the storage period. From the present study it is concluded that the genotype RPASV-3 is best suited for the *papad* snack product preparation.

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