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Germination and fermentation effect on compositional and functional characteristics of sorghum flour

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Sorghum popularly known as "*Jowar*" in India. This study was conducted to explore the impact of malting and fermentation on compositional and functional properties of sorghum flour. This investigation was carried out on *Parbhani moti* (SPV 1411) and *Phule revati* (SPV 1830) sorghum varieties. Furthermore, there are four sorghum flour sample prepared *viz.*, regular, malted, fermented and malted fermented flour of each variety. From results it is observed that malting and fermentation increases the moisture content from 12.18 per cent to 12.61 per cent and protein content from 9.2 per cent to 13.23 per cent. In other hand it leads to decrease the ash content of the sorghum flour. The highest fibre content is found in the fermented flour (2.23 %) than that of malted flour (1.88 %) in *Parbhani moti* variety. In term of *Phule revati*, fibre content (2.54 %) is found higher on malted flour. Also, the water absorption increases in the malted and fermented flour as the bulk density decreases.

Key Words : Malting, Fermentation, Protein content, Bulk density

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INTRODUCTION

Sorghum popularly known as "*Jowar*" in India. Sorghum is an important source of dietary energy and a main food staple in semi-arid regions of Africa and Asia (Ezeogu *et al.*, 2005). Traditionally this flour has been used as a cereal food to create pancakes, porridges, beer and flatbreads throughout different cultures, such as *Jowar* roti in India. In Africa, India and China, sorghum comes third among cereals for human consumption after rice and wheat (Elkhalifa *et al.*, 2002). Sorghum or *Jowar* is also used for production of ethanol, grain alcohol, starch, adhesives and paper. Sorghum is also used as food and feed for livestock. Sorghum and wheat composite flour is now common for making flat bred (*Chapatti*) and other deep-fried preparations such as buns from fermented or unfermented dough. The nutritional value of sorghum is equivalent to that of corn and that is why it is gaining importance as livestock feed. Sorghum cultivation is gaining popularity due to its nature of extreme drought tolerance. Sorghum is very nutritious just like corn and can be used as green fodder, dry fodder, silage. Sorghum or *Jowar* is having local names throughout the country like Jwari (Marathi), Juar (Bengali, Gujarati, Hindi), Jonnalu (Telugu), Cholam (Tamil, Malayalam), Janha (Oriya).

Sorghum is a genus of flowering plants in the grass family *Poaceae*. Sorghum is an important food crop in Africa, Central America and South Asia, and is the fifth most important cereal crop grown in the world after rice,

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wheat, maize and barley (Mutegi *et al.*, 2010). Sorghum is a cereal native to sub-Saharan Africa and grows well in temperate and tropical areas of the world where other staple cereals such as maize, wheat and rice cannot grow well. About 45 million hectares of area are harvested for sorghum and production of sorghum worldwide is about 63 million tonnes. USA is the number one producer followed by Nigeria, Sudan, Mexico, Ethiopia, India, Argentina, China, Niger, Australia (FAO, 2016).

Millions of people eat sorghum (*Sorghum bicolor* L.) as staple food. Sorghum is a principle source of energy, protein, mineral including trace component like zinc and iron in diet for African and Indian population (Mohammed *et al.*, 2011). Besides these nutrients, sorghum also contains high amount of phenolic acid, flavonoid, antioxidant and condensed tannin (Awika and Rooney, 2004; Dykes and Rooney, 2007; Serna-Saldivar and Rooney, 1995). Sorghum is considered as food with low nutritional value (Raihanatu *et al.*, 2011). Sorghum also contains high amount of phenolic acid, flavonoid, antioxidant, and condensed tannin. Further, sorghum contains anti-nutritional factors like tannin, cyanogenic glucoside, phytic acid, trypsin inhibitor and oxalate (Etuk *et al.*,2012 and Mohammed *et al.*, 2011). Due to these and other reasons, sorghum is categorized as of low nutritional value and a food for the poor.

Malting is simply defines as conversion of raw grain into malt. The malt is mainly used for brewing or whisky making but can also be used to make malt vinegar or malt extract. Malting of sorghum is done by soaking 12 hours it in water, allowing it to sprout and then drying it to stop further growth. Malting has been shown to be one of the most effective and convenient ways for improvement of nutritional value of cereals (Adeyemo *et al.*, 1992; Akpapunam *et al.*, 1996 and Gernah *et al.*, 2011). Malting inhibits the antinutrients in cereals, legumes, roots and tubers. Malting is the controlled germination followed by controlled drying of the kernels. The main objective of malting is to promote the development of hydrolytic enzymes, which are not present in non-germinated grain. Malting has produced improvement in flavor profile and colour (Rooney and Waniska, 2004).

The chemical breakdown of a substance by bacteria, yeasts or other micro-organisms is known as the fermentation process. Fermentation comes from the latin word fermentare *i.e.* meaning "to leaven". Fermentation is a microbial metabolic, aerobic process, involving carbohydrate as the substrate and can be either by yeast to produce alcoholic beverages or by bacteria to produce non-alcoholic products. Like malting, fermentation has been used to improve the flavour, texture and palatability of foods. Various studies have shown that fermentation can increase in the concentrations of vitamins, minerals and protein (Taylor and Dewar, 2000), increase soluble protein (Chavan *et al.*, 1988), provide better essential amino acids composition (Au and Fields, 1981) and cause changes in food quality indices including texture, flavour, appearance, nutrition and safety. Fermentation can also improve mineral availability and increase vitamin B content particularly thiamine (Mungula *et al.*, 2003).

METHODOLOGY

The sorghum variety *Parbhani Moti* (SPV 1411) and *Phule Revati* (SPV 1830) was procured from VNMKV, Parbhani and MPKV, Rahuri, respectively. The material like non- fat yoghurt were procured from local market containing active cultures including *L. acidophilus* and were used for preparation of fermented sorghum flour.

Sorghum regular flour preparation:

Grain sorghum kernels from every sorghum variety were cleaned by first physically arranged to evacuate disfigured, little, broken, tidy, sand, stones and other foreign materials. The kernels were then immediately washed by in cool water, mixed by hand and screened out of the water. After cleaning and kernel integrity assessment, sorghum varieties were milled using a laboratory millto get regular sorghum flour samples. After which it passed through a 0.4mm mesh screen.

Malted flour preparation:

The sorghum grains (2,000 g) were soaked in tap water for 24 hrs at room temperature with two changes of water to remove dirt and husk. Later, the soaked grain was spread out thinly on a jute bag saturated with water, covered with another jute bag and allowed to germinate in the dark for two days at room temperature (27^0C) and water spraying on the grains was needed during germination process to control the grain's moisture. At the end of the process, the germinated grains were tray dried at 40^0C for 8 hours to obtain final moisture content. The root portions were manually removed. Then dried germinated sorghum seeds were ground to a fine

homogeneous powder in the laboratory mill and passed through a 0.4 mm mesh screen. The milled samples of germinated sorghum flour were packed in plastic bags and stored at room temperature until use (Elkhalifa and Bernhardt, 2010).

Fermented flour and malted fermented flour preparation:

To start the fermentation process, the regular flour samples were mixed with 600 ml of tap water at ratio of 1:2 [grain (g) to liquid (ml)] and 30 g of non-fat yogurt (obtained from a local market containing active cultures including *L. acidophilus*) to obtain a final mixture of 930 g of slurry. The slurry was stirred by hand and covered with aluminum foil then fermented at 250C for 72 hours. Then the slurry was transferred to a tray and spread into a thin layer. The tray were put into a tray dryer at 400C for 8 hours. The dried material in the form of fermented cakes was allowed to cool before breaking into small pieces and milling (laboratory) into fermented flour samples passed through a 0.4 mm mesh screen. Further it packaged in plastic bags and store it in room temperature (Mella, 2011).

Malted fermented flour preparation:

While in case of malted fermented sorghum flour preparation, just a difference is that instead of using regular flour malted sorghum flour is used and all procedure is same like preparation of fermented flour.

Composition alanalysis of sorghum flour:

The sorghum flour was used for the estimation of moisture, fat, protein, ash, fibre and carbohydrate was by using standard procedures (AOAC, 2005) as referred below.

Moisture content:

Moisture content was determined by using hot air oven drying method. 10 g of sorghum flour sample of each material was taken in pre-weighed empty Petri plate and dried in hot air oven at 105^0C till constant weigh were obtained (6-7 hrs). Then plates were cooled in desiccators. The moisture content was calculated by using formula:

$$\% \text{ moisture content} = \frac{\text{Final weight} - \text{Intial weight}}{\text{Weight of sample}} \times 100$$

Fat content:

The sample sorghum flour was transferred to a thimble paper and the top of the thimble was plugged with cotton. The thimble was next placed in the fat extraction chamber of the Soxhlet apparatus. A previously weighed flask was filled with solvent e.g. hexane and was attached to the extraction chamber. The condenser was attached to the assembly. Extraction was carried out at proper temperature for 5 hrs. The excess hexane was recovered by boiling it further. Then the flask was dried and the weight was recorded.Formula for calculation of fat content by using Soxhlet apparatus method.

$$\% \text{ fat contnet} = \frac{\text{Final weight of beaker} - \text{Empty weight of beaker}}{\text{Sample weight}} \times 100$$

Protein content:

The determination of protein content was carried out by Kjeldhal's method using 5 g of sorghum flour sample. The Kjeldhal methods based on wet combustion of the sample by heating with concentrated sulphuric acid in the presence of metallic other catalysts to effect the reduction of organic nitrogen in the sample to ammonia which retained in solution as ammonium sulphate. Then digested sample was distilled with NaOH and titrated with 0.1 N HCL. The percentage of nitrogen of was calculates by using following formula.

$$\% \text{ nitrogen} = \frac{\text{(Sample titre - Blank titre) x N of HCL x Volume of digest x100}}{\text{Weight of sample x Aliquot of the digest}}$$

Protein content = % Nitrogen x 6.25

Ash content:

About five g of the powder sample was accurately weighed into a pre-weighed silica crucible. It was then carbonized in silica crucible on burner followed by heating at about 600°C for 6 hrs in the muffle furnace to get complete white coloured ash, allowed to cool in the furnace. Then the crucible was transferred to a desiccator and weighed as possible to prevent moisture absorption. The ash was calculated using following formula:

$$\% \text{ Ash content} = \frac{\text{Weight before ashing} - \text{Weight after ashing}}{\text{Weight of sample}} \times 100$$

Fibre content:

Fibre estimation carried with the help of muffle furnace. Moisture and fat free sorghum flour sample (2 g) digested with 200 ml of 1.25 per cent H_2SO_4 by gentle boiling for half an hour. The contents filter and the residue washed several times with hot distilled water till it became free from acid. Acid free residue then transferred to the

same flask to which 200 ml of 1.25 per cent NaOH is added. The contents digested again for half an hour, filtered it and residue was again washed with hot distilled till it became alkali free. The residue dried in an oven overnight at 100 ºC and weighed and then placed in muffle furnace at 600 ºC (±50ºC) for 4 hours. The loss in weight after ignition the sample represents the fibre in the sample.

$$\% \text{ fibre content} = \frac{\text{Initial weight} - \text{loss in weight of sample}}{\text{Initial weight of sample}} \times 100$$

Carbohydrate content:

Carbohydrate was calculated by difference by using following formula:

% Carbohydrate content = 100 - (% Moisture + % Ash + % Fat + % Protein)

Functional analysis of sorghum flour:

Bulk density (*BD*) :

Bulk density of the sample was determined according to the method of Musa *et al.* (2008). Flour sample (30g) was weighed into a 25ml measuring cylinder and the volume occupied was measured and recorded.

$$\text{Bulk density} = \frac{\text{Mass (g)}}{\text{Volume (ml)}}$$

Dispersibility determination:

This was determined by the method described by Oluwole *et al.* (2016). The flour sample (10 g) was weighed into a graduated cylinder. Water was added to the make upto 100 ml mark. It was shaken vigorously, and allowed to stand for 3 hours then the volume of settled particles was recorded and percentage dispersibility was calculated as follows:

$$\text{Dispersibility (\%)} = \frac{50 - \text{Volume of settled particle}}{50} \times 100$$

Water absorption capacity (WAC):

Water absorption capacity was performed according to the method of Elkhalifa and Bernhardt (2013). One grams of each milled sample (W_1) were weighed into a pre-weighed centrifuge tube (W_2) and 10 ml of distilled water were added. Samples were vortexed and allowed to stand for 30 min at 25 ± 2°C before being centrifuged at 4,000 g for 25 min. Excess water was decanted by inverting the tubes over absorbent paper and samples were allowed to drain and reweighed (W_3). The percentage of water absorption capacity were calculated as:

$$\text{WHC (\%)} = \frac{W_3 - W_2}{W_1} \times 100$$

Oil absorption capacity (OAC):

Oil absorption capacity was performed according to the method of Elkhalifa and Bernhardt (2013). One grams of each milled sample (W_1) were weighed into a pre-weighed centrifuge tube (W_2) and 10 ml of sunflower oil were added. Samples were vortexed and allowed to stand for 30 min at 25 ± 2°C before being centrifuged at 4,000 g for 25 min. Excess oil was decanted by inverting the tubes over absorbent paper and samples were allowed to drain and reweighed (W_3). The percentage of oil absorption capacity were calculated as:

$$\text{OHC (\%)} = \frac{W_3 - W_2}{W_1} \times 100$$

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Germination and fermentation effect on composition of sorghum flour:

Moisture content:

It was observed that malting and fermentation has a great impact on almost all proximate parameter of sorghum flour. From Table 1, the highest moisture content was observed in the fermented sorghum flour of *Parbhani moti* which is 12.56 per cent and lowest in regular flour 12.20 per cent. While from Table 2, 12.61 per cent is the highest moisture content present in the malted fermented sorghum flour from *Phule revati* sorghum flour. The increase in moisture content of flours might be due to the water added before processing (Nour *et al.,* 2015). The similar results are observed by the Mutahi (2012) and Nour *et al.* (2015).

Fat content:

The fat content 3.22 per cent which is the highest value comes from fermented sample from *Parbhani moti* sorghum flour. While 2.40 per cent are the fat content in the malted flour. In case of *Phule revati* sorghum flour, the higher fat content is present in fermented flour *i.e.* 3.73 per cent and lower in malted flour *i.e.* 2.76 per cent. This results were observed similar to the Mohammed *et*

al. (2011). There was a progressive decrease in the fat content of the raw materials to the malted sorghum. This could be traceable to development and production of lipase enzymes during malting which probably act on the fat (or lipids) to produce fatty acids in the malted products (Kirk-Uthmar, 2007).

Protein content:

In case of protein content, there is a slight increase in protein content during fermentation of sorghum. The highest protein content found in fermented sample of *Parbhani moti* and *Phule revati* sorghum variety is 13.23 per cent and 15.19 per cent, respectively. This rise in protein content during fermentation might be due to the synthesis of protein by micro-organisms. Similar results were observed by Yousif and El Tinay (2001) attributed the increase in protein availability to enzymatic breakdown of complex storage proteins into simpler soluble products. Generally, malting of the grains resulted in significant increase in crude protein. This is probably due to breakdown of protein compounds into Peptides and amino (Ade-Omowaye *et al.*, 2006) showing that the biochemical reactions occurring during malting also affects the protein among other molecules in the germinating grains. Kirk-Uthmar (2007) have reported that during malting protease enzymes were produced which possibly acted on the protein to produce peptides and amino acids from protein.

Ash content:

Due to malting and fermentation of sorghum flour sample, there has been a decrease in ash content of flour sample of malted and fermented. In *Parbhani moti* sorghum variety, the ash content was found in regular flour sample is 1.69 per cent, which is greater than the malted (1.55%), fermented (1.63%) and malted fermented (1.58%). Same trend observed in case of *Phule revati* sorghum variety. The decrease in ash content after fermentation of sorghum flour may be due to the utilization of ash during the growth of micro-organisms, but the decrease in ash content of sprouted sorghum may be due to the consumption of ash during the growth of the germ. The similar results were observed by Mohammed *et al.* (2011).

Fibre content:

Fibre is found higher in fermented flour *i.e.* 2.23 per cent in *Parbhani moti* variety. Whereas *Phule revati* has a higher crude fibre in malted flour (2.56%) than that of fermented flour (1.87%).The crude fibre appears in *Parbhani moti* have progressively increased from the raw sorghum grain to the malted sorghum grains. The

Table 1 : Compostitional analysis *of Parbhani moti* sorghum variety

Sr. No.	Parameter (%)	Values			
		Regular flour	Malted flour	Fermented flour	Malted fermented flour
1.	Moisture	12.20 ±0.09	12.44 ±0.04	12.56 ±0.06	12.55 ±0.05
2.	Fat	2.43 ±0.20	2.40 ±0.26	3.22 ±0.10	2.79 ±0.04
3.	Protein	9.2 ±0.4	10.73 ±0.56	13.23 ±0.55	13.10 ±0.29
4.	Ash	1.69 ±0.21	1.55 ±0.18	1.63 ±0.20	1.58 ±0.05
5.	Fibre	1.52 ±0.01	1.88 ±0.05	2.23 ±0.12	2.15 ±0.36
6.	Carbohydrate	74.48 ±0.12	72.88 ±0.22	69.35 ±0.22	69.97±0.11

*mean values ± standard deviation of three replication

Table 2: Compositional analysis of *Phule revati* sorghum variety

Sr. No.	Parameter (%)	Values			
		Regular flour	Malted flour	Fermented flour	Malted and fermented flour
1.	Moisture	12.18 ±0.03	12.37 ±0.02	12.54 ±0.02	12.61 ±0.01
2.	Fat	3.16 ±0.04	2.76 ±0.18	3.73 ±0.10	3.26 ±0.07
3.	Protein	11.55 ±0.02	12.6 ±0.43	15.19 ±0.17	14.96 ±0.05
4.	Ash	1.62 ±0.02	1.49 ±0.02	1.56 ±0.04	1.41 ±0.02
5.	Fibre	1.57 ±0.04	2.54 ±0.32	1.87 ±0.05	2.15 ±0.03
6.	Carbohydrate	71.49 ±0.009	70.78 ±0.19	66.98 ±0.06	67.76 ±0.02

*mean values ± standard deviation of three replication

present result were similar with Aluge *et al.* (2016). Crude fibre consists mainly of cellulose, lignin and hemicelluloses. Crude fibre has been known to promote health as it aids digestion in human. Crude fibre clears buildup of junks in the intestine and regulates bowel movement in humans. Numerous studies have shown that insoluble dietary fibre prevents constipation, increase the mass and volume of feaces, accelerates intestinal peristalsis and has an inhibitory effect on the development of tumors in the large intestine.

While with to respect to *Phule revati* the malted sorghum flour has more crude fibre than fermented sorghum flour *i.e.* 2.54 per cent and other sample has 2.14 per cent, 1.57 per cent, 1.87 per cent, respectively for malted fermented, regular and fermented flour sample. The reduction in crude fibre content of fermented flour may be due to sugar utilization in the seeds for metabolic sprouting activity leavening fibrous seeds and enzymatic degradation of the fibre during fermentation (Ikenebomah *et al.,* 1986). Similar observation has been reported for fluted pumpkin (Giami and Bekebain, 1992).

Carbohydrate content:

Carbohydrate content of sorghum flour samples ranges from 69.35 per cent to 74.48 per cent in *Parbhani moti* variety. While in case of *Phule revati* variety it ranges from 66.98 per cent to 71.49 per cent. From Table 1 and 2, it is seen that there is decrease in the carbohydrate content of malted and fermented flour sample to that of regular flour. The decrease in carbohydrate content of both fermented and sprouted sorghum flours might be due to utilization of some sugars during the growth metabolic activity (Nour *et al.*, 2015).

Germination and fermentation effect on functional characteristics of sorghum flour:

Bulk density:

Table 3 and 4 showed the results of the functional properties of the sorghum flour. The higher bulk density from *Parbhani moti* is from regular flour (0.76 g/ml) and lower in malted fermented flour (0.65 g/ml). While in case of *Phule revati* sorghum variety, the higher bulk density observed in regular flour (0.77 g/ml) and lower in (0.59 g/ml). Elkhalifa *et al.* (2005) also revealed reduction in bulk density of fermented sorghum flour. Bulk density is an important parameter for determining the easy ability of packaging and transportation of particulate or powdery foods. This reduction of bulk density is might be due to break down of starch during fermentation reduces starch content and it leads to decrease in bulk density. From this finding, Regular sorghum flour of both variety is more denser than the other samples *i.e.* malted, fermented and malted fermented.The bulk density of food materials is affected by the particle size and the density of the food. Bulk density is an important factor in food packaging. According to (Basman *et al.,* 2003), higher bulk density is desirable for greater ease of dispersibility of flours. Also, high bulk density limits the caloric and nutrient intake per feed of a child which can result in growth faltering. In contrast, however, low bulk density would be an

Table 3: Functional analysis of *Parbhani moti* sorghum variety

Sr. No.	Parameter	Values			
		Regular flour	Malted flour	Fermented flour	Malted fermented flour
1.	BD (g/ml)	0.76 ±0.03	0.70 ±0.01	0.66 ±0.02	0.65 ±0.02
2.	Dispersibility (%)	42.8 ±0.45	42.4 ±0.45	41.9 ±0.2	41.7 ±0.1
3.	WAC (%)	115.41 ±0.50	117.5 ±0.4	190.86 ±0.65	156.56 ±0.74
4.	OAC (%)	58.54 ±0.38	71.23 ±0.35	68.25 ±0.37	68.03 ±0.08

*mean values ± standard deviation of three replication

Table 4 : Functional analysis of *Phule revati* sorghum variety

Sr. No.	Parameter	Values			
		Regular flour	Malted flour	Fermented flour	Malted and fermented flour
1.	BD (g/ml)	0.77 ±0.01	0.74 ±0.04	0.62 ±0.02	0.59 ±0.02
2.	Dispersibility (%)	42.8 ±0.45	42.4 ±0.45	41.9 ±0.2	41.7 ±0.1
3.	WAC (%)	124.32 ±0.85	128.59 ±0.58	192.46 ±0.53	163.56 ±0.42
4.	OAC (%)	65.59 ±0.64	89.47 ±0.50	77.41 ±0.56	80.51 ±0.73

*mean values ± standard deviation of three replication

advantage in the formulation of complementary foods (Ugwu and Ukpabi, 2002). Low bulk density flour was suitable for infant formulations (Nelson-Quartey *et al.*, 2007). Low bulk weaning foods produced by germination and fermentation might be useful in many bakery products (Okoye *et al.,* 2010).

Disprsibility:

In case of dispersibility, the higher dispersiblity is found in regular flour (42.8 %) from *Parbhani moti* sorghum variety and *Phule revati* sorghum variety. From Table 3 and 4, there is slight loss in dispersibility of sorghum flour. The dispersibility of a mix in water indicates its reconstitution ability. The higher the dispersibility, the better the reconstitution property. The lower dispersibility findings are observed in malted fermented flour (41.7%) in both the varieties. This lower value might be due to partial hydrolysis of starch and denaturation of protein during fermentation and roasting processes (Msheliza *et al.,* 2018). The results obtained are in agreement with the Oluwole *et al*. (2016). This is might be due to reconstitution of flour or starch in water. The higher the dispersibility, the better the sample reconstitutes in water and gives a fine constituent during mixing (Adebowale *et al.,* 2012).

Water absorption capacity:

Table 3 and 4 shows the water absorption capacity of the sorghum flour. There is a significant increase in the water absorption capacity of germinated (117.5%), fermented (190.86%) and malted fermented sorghum flour (156.56%) than that of regular flour (115.41%) in *Parbhani moti* flour samples. In *Phule revati* variety flour samples, water absorption capacity of fermented flour (192.46%) is increased rapidly as compared to regular flour (124.32%), germinated flour (128.59%) and malted fermented flour (163.56%). The results are agreed with the findings of Elkhalifa and Bernhardt (2013) and Ojha *et al.* (2017). Water absorption of the flour is mainly depends upon protein, carbohydrate, their interaction and nature (Onuegbu *et al.,* 2013). There was no significant increase in WAC of malted flour, which might be due to less availability of polar amino acids in flours and due to lose association of amylose and amylopectin in the native granules of starch (McWatters *et al.,* 2003). Traynham *et al.* (2007) revealed that WAC would affect the flour's thickness, viscosity, maintenance of freshness and handling characteristics. The high water absorption capacity and its ability to increase water absorption when added to composite flour makes it a useful ingredient in food preparations such as soups, dairy products, beverages, coffee creamers, candies, gravies and baked products (Sirivongpaisal, 2008).

Oil absorption capacity:

Oil absorption capacity of the regular sorghum flour of *Parbhani moti* variety was found to be 58.54 per cent and that of the germinated flour, fermented flour and malted fermented flour was found to be significantly increased to 71.23 per cent, 68.25 per cent and 68.03 per cent, respectively. In *Phule revati*, the highest oil absorption capacity is found in malted flour *i.e*. 89.47 per cent. This similar results are observed by the Afify *et al.* (2015). The increase in oil absorption capacity of the flour might help to maintain and improve mouth feel, if such flours are used as meat extenders etc. The reason behind this increase is solubilization and dissociation of protein increase lipophilic constituent during germination and oil absorption capacity is increased (Deepali *et al.,* 2013).

Conclusion:

Thus, in the light of scientific data of the present investigation it is concluded that *Phule revati* (SPV 1830) variety of sorghum which is superior than *Parbhani Moti* (SPV 1411). Malting and fermentation of sorghum flour slightly increases moisture content and protein content while decreases the ash content. Moisture content increases because water added before processing of the flour. Increase in the protein content is due to breakdown of protein compounds into peptides due to microbial activity. Malted and fermented sorghum flour used in this research is suitable for infant formulation as it contains low bulk density than regular flour. Also, low bulk weaning foods produced by germination and fermentation flour sample used in many bakery products.

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