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Evaluation of functional properties of different pearl millet cultivars

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Abstract
The present study was undertaken to evaluate various functional properties of different pearl millet varieties and hybrids. The various functional properties like water absorption, oil absorption, gelation capacity, gel consistency, emulsification capacity, flour solubility, swelling power and cooking time of five different pearl millet cultivars *Viz.*, Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 were evaluated. The highest water absorption capacity was found in Phule Adishakti variety (1.86 ml/g) and lowest was observed Dhanshakti variety (1.54 ml/g). The oil absorption, gelation capacity. Gel consistency emulsification capacity, flour solubility and swelling power of five different pearl millet varieties ranged from1.54 to 1.86 ml,/g, 1.23 to 1.57 ml/g, 8.48 to 10.50%, 53.55 to 62.22 mm, 0.50 to 0.75 g/g, 9.93 to 13.53 and 109.90 to 114.49% respectively. The highest cooking time showed by Phule Adishakti variety (27.55min) and lowest was recorded in HC-20 (21.52 min).

Keywords: Functional properties, *viz*, swelling power, oil absorption, water absorption

Introduction
In India, almost 46% of the grain production of pearl millet goes for human food use, 37.5% for cattle feed, 7.7% for poultry feed 8.8% for alcohol industry and only a small fraction (0.4%) is used for seed purpose. Compared to the availability of ready-to-eat products from rice, wheat and corn, the products based on minor cereals such as sorghum and pearl millet are still scanty. Sorghum and pearl millet possess unique nutritional characteristics, specifically, they are gluten-free, represent good source of carbohydrates, rich in dietary fibre, phenolic compounds and also minerals (Saturni *et al.*, 2010) [29]. These grains, apart from the sorghum and pearl millets are used in many traditional foods namely roti, dumpling and porridges and some of the novel food uses include preparation of bakery products (Dod *et al.*, 2003) [11].
Functions properties describes how ingredients behaves during preparation and cooking, how they affects the finished product in terms of how it looks, tastes, feel. The water absorption capacity plays an important role in the development of food products because it influences to a large extent their interaction with water. The use of starch in various food applications depend on its physicochemical and functional properties which are determined by its structure that depends on its granule and crystalline properties (Nuwamanya *et al.*, 2010ab) [23, 24].
Beleia *et al*. (1980) [5] examined the swelling power of pearl millet starch and reported a range from 14.1 to 16.4 at 95 ^{0}C. Starches with low swelling and solubility at temperatures below 75 ^{0}C had high swelling and solubility at temperatures from 80 to 95 ^{0}C. These phenomena could be related to the two-stage relaxation of bonding forces within the starch granules during swelling. Swelling power and solubility were linearly associated with increase of temperature (Suma and Urooj, 2015) [38]. Hoover *et al.* (1996) [15] studied swelling factor and amylose leaching increased with rise in temperature and most predominant between 60 to 70 ^{0}C and concluded that the low swelling factor and amylose leaching could be attributed to higher content of lipid complexed amylose chains or to the presence of a larger number of crystallites within the granule interior. Balasubramanian *et al.* (2014) [4], Sharma *et al.* (2015) [31] and Sharma *et al.* (2016) scrutinized that swelling and solubility properties were also contributed by amylopectin content and chemical aspects by examining swelling and solubility of native and modified pearl millet starches.
Syneresis is an index for degree of starch retrogradation at low temperature. The freeze–thaw stability of millet starch was quantified by (Yanez *et al.*, 1991 and Hoover *et al.*, 1996) [41, 15] and calculated by the amount of water separated from starch gel after freeze–thaw cycles (syneresis).

Perera and Hoover (1999) [26] reported that, increase in percentage syneresis during storage had been attributed to the interaction between leached amylose and amylopectin chains, which leads to the development of junction zones and reflect or scatter a significant amount of light. Miles *et al.* (1985ab) [19, 20] studied that amylose aggregation and crystallization completed within the first few hours of storage, while amylopectin aggregation and crystallization occurs during later stages. Hoover *et al.* (1996) [15] studied that chain length of amylopectin and amylose of pearl millet starches also affects the differences in freeze-thaw stability. Balasubramanian *et al.* (2014) [4] compared the freeze thaw stability of native pearl millet starch and concluded that type of modification effect the inter chain bonding in starch resulting in reduction of syneresis in modified starch than native.

Light transmittance provides the information on the behavior of starch paste, when the light passes through it (Sandhu *et al.*, 2007) [28]. Higher light transmittance implies a more transparent paste. Starch paste clarity is among the important attributes of starch, which is essential in foods, such as jellies and fruit pastes, to obtain the desired consistency. Paste clarity varies considerably with source of starch, amylose/amylopectin ratio, chemical or enzymatic modifications and addition of solutes (Craig *et al.*, 1989 and Wu *et al.*, 2014) [10, 40]. Nuwamanya *et al.* (2011) [25] reported low paste clarity for millet starch among the cereal starches and can be attributed to the high protein and tannin contents, which suits cereal starches for use in gravies and thickened foods where low transparency is expected. Bhupender *et al.* (2013) [6] reported low value of light transmittance ranged from 1.1 to 2.6% for different pearl millet cultivars within seven days of storage period and concluded low.

Hence to determined various functional properties plays an key role for preparation of of food products, to get sound idea about effect of temperature on food products rheology and also how flour behave during processing with other ingredients.

Materials and Methods

The present investigation was carried out in department of food science and technology, MPKV, Rahuri (Maharashtra). The raw material like pearl millet grains of five different varieties was procured from college of Agriculture Dhule (Maharashtra) and convered into flour and various functional properties were determined.

Absorption Capacity

Water absorption was determined by the method of Singh and Singh (1991) [34]. One gram of sample was mixed with 10 ml of distilled water for 30 minutes. The contents were then centrifuged at 3000 rpm for 20 minutes and the volume of the supernatant was recorded. The results were expressed as ml/g sample.

Oil Absorption Capacity

Oil absorption capacity was determined by the method Rosario and Flores (1981) [27] with minor modification by Iyer and Singh (1997) [16]. One gram sample was mixed with 15 ml oil for 30 minutes. The contents were allowed to stand in a water bath at 30 ^{0}C for 30 minutes. The contents were then centrifuged at 3000 rpm for 20 minutes and the volume of the supernatant was recorded. Refined groundnut oil was used for the determined of oil absorption and results were expressed as ml/g.

Gelation Capacity

The gelation capacity was determined according to the method of Singh and Singh (1991).The sample suspensions containing 8-15% (w/v) flour in 0.5% increments were prepared in 10 ml of distilled water. The test tubes were heated for 1 hr in boiling water bath, rapidly cooled under running cold tap water. These test tubes were refrigerated for 3 hr at 5 ^{0}C. The least gelation concentration was determined as that concentration at which the sample did not fall down or slip from an inverted test tube.

Emulsification Capacity

Emulsification capacity was determined by the method of Singh and Singh (1991) [34] with minor modification by Iyer and Singh (1997) [16]. One gram sample was mixed with 50 ml of distilled water in a beaker for 2 minutes with continuous high speed magnetic stirring. After complete dispersion refined groundnut oil was constantly added from a burette to the beaker which was constantly stirred until the emulsion broke i.e. the mixture separated into 2 layers. Emulsification capacities were expressed as gram of oil per gram of sample or per gram of protein.

Flour Solubility

Flour solubility was determined by the method of Subramanian *et al.* (1986) [37]. The flour sample (0.5g) was weighed and transferred into centrifuge tube, and 20 ml distilled water (VE) was added. The tube was placed in a heating block at 90 ^{0}C for 1 hr and shaken periodically. After cooling, the contents were centrifuged at 5000 rpm for 10 minutes. The aliquot was decanted into a test tube. 10 ml aliquot (VA) was pipette into pre-weighed dry moisture dish (W4). The content was evaporated to dryness at 110^{0}C. After cooling, the weight of the material was determined (W5) and the results were expresses as the per cent solubility.

$$\text{Solubility (per cent)} = \frac{(W5 - W4) \times VE}{VAx0.5g}$$

Swelling Power

Swelling power of the flour was determined by the method of Subramanian *et al.* (1986) [37]. The flour sample (0.5g) was weighed and transferred into centrifuge tube and 20 ml distilled water was added. The tube was placed in a heating block at 90 °C for one hour. The tubes were periodically shaken. After cooling, the contents were centrifuged at 5000 rpm for10 minutes. The aliquot was decanted into a test tube for the determination of water soluble fraction. The inner sides of the centrifuge tube were wiped out by tissue paper for excess moisture and then the weight of the tube with swelled materials was recorded. The swelling power of the flour was calculated as a ratio of the final weight to the initial weight and multiplies by 100.

Cooking Time

The cooking time of pearl millet grains was the boiling period during which the grains become tender as described by the consumer. This was determined by the method of Singh *et al.* (1984) [35]. Cooking time was determined by boiling the pearl millet grains in distilled water using condenser. Suitable amount (10.0 + 0.5 g) of pearl millet was boiled in 75 ml of distilled water and the volume of the water was maintained during cooking by adding boiling water. Boiled samples were removed at an interval of 1 minute and examined for their softness by pressing between forefinger and thumb to determine its cooking time. Cooking time was the minimum time interval at which the grain was considered to be completely cooked as judged above.

Results and Discussion

Physical properties of different Pearl millet varieties

The knowledge of physicochemical properties of millet cultivars is very important for processing and nutritional security point of view. The physical characteristics of grains are determined for various reason like to determine grain dimensions, which is very important in cleaning, specifically threshing operations. Grain density is useful to get idea for transporters, marketers, and per cent floaters is an indirect method of determining grain density, which is also used to determine hardness, which is very important property to determine grain quality. The chemical properties like carbohydrates are playing key role in extruded product development. Pearl millet is specifically known for their micronutrient content like rich source of iron, zinc and calcium, hence to study chemical properties of pearl millet is very important, which will aids in fulfillment of nutritional security (Table 1).

Table 1: Physico-chemical properties of different pearl millet varieties

Varieties	1000 kernel weight(g)	Seed Density (g/ml)	Hydration Capacity (mg/seed)	Hydration Index	Swelling capacity (µl/seed)	Swelling Index
Phule Adishakti	13.20±0.12	1.28±0.03	4.00±0.00	0.40±0.02	6.00±0.00	0.26±0.01
Dhanshakti	9.32±0.30	1.20±0.05	3.00±0.00	0.36±0.00	5.00±0.00	0.30±0.10
Pule Mahashakti	9.42±0.20	1.27±0.09	4.00±0.00	0.38±0.04	4.00±0.00	0.51±0.06
Pioneer 86M32	8.88±0.23	1.22±0.04	3.00±0.00	0.41±0.00	5.00±0.00	0.50±0.03
HC-20	7.45±0.07	1.14±0.06	3.00±0.00	0.43±0.00	6.00±0.00	0.48±0.04
SE±	0.08	0.01	0.02	0.005	0.08	0.004
CD at 5%	0.25	0.04	0.08	0.01	0.25	0.01

*Each value represents average of three determinations.

Physicochemical properties are one of the important aspects, for food processing, packaging, storage and transport operations and which will also aids in various post-harvest operations of cereal grains. The various physicochemical properties of different pearl millet varieties *viz.*, Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 were determined (Table 1). The various physical properties like 1000 kernel weight, bulk density, hydration capacity, hydration index, swelling capacity and swelling index of five different pearl millet varieties ranged from 7.45 to 13.20 g, 1.14 to 1.28g/ml, 3.00 to 4.00mg/seed, 0.36 to 0.43, 4.00 to 6.00µl/seed and 0.26 to 0.51, respectively. The highest 1000 kernel weight recorded in Phule Adishakti variety (13.20 g), while lowest was observed HC-20 (7.45 g), among the five pearl millet varieties. Anju (2005) [2] recorded the thousand kernel weight ranged from 9.05 to 12.67 g. Sehgal and Kawatra (2002) [30] were found that, wider the values of seed weight ranged from 6.75 to 8.76 g, 5.53 to 13.13 g and Chiek *et al*. (2006) [9] and Chaudhari (2011) [8] were found seed weight ranged from 11.61 to 11.95 g. The values 1000 kernel weight of present investigations are higher than Sehgal and Kwatra (2002) [30], Anju (2005) [2], Cheik *et al*. (2006) [9] and Chaudhary (2011) [8].

Density is nothing but mass per unit volume and which is having the key role in food packaging and processing. The seed density of Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 were 1.28, 1.20, 1.27, 1.22 and 1.14 g/ml, respectively. The value of bulk seed density reported by Varsha (2003) [39] was 1.56 g/ml and which is higher than values of present investigation. Anju (2005) [2] reported the bulk density of different pearl millet varieties and ranged from 0.89 to 0.92 g/ml, which is lower than the values of present investigation.

The hydration capacity of five different pearl millet varieties was lies between 3 to 4. The highest hydration capacity found in Phule Adisdhakti variety and lowest reported in Dhanshakti variety of pearl millet. The hydration index of Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 rangedfrom 0.40, 0.36, 0.38, 0.41 and 0.43, respectively. The swelling capacity of five different pearl millet varieties ranged from 4.00 to 6.00. The highest swelling capacity found in Phule Adishakti variety followed by HC-20, Dhanshakti, Pioneer 86M32 and Phule Mahashakti varieties of pearl millet. Swelling index of different pearl millet varieties *viz.*, Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer86M32 and HC-20 were 0.26, 0.30, 0.51, 0.50 and 0.48, respectively.

The results of hydration and swelling capacity reported by Sehgal and Kawatra (2002) [30] in the ranges of 0.002 to 0.006 g/seed and 0.004 to 0.009 ml/seed, respectively, whereas, 0.010 to 0.15 g/seed and 0.008 to 0.012ml/ seed of different pearl millet varieties reported by Anju (2005) [2]. Sibian *et al*. (2013) [32] reported 0.002 g/seed of hydration capacity and 0.006 ml/seed of swelling capacity in pearl millet grains. Hydration capacity (0.01 g/100g) and swelling capacity (0.01 g/100g), in different varieties of pearl millet was reported by Chaudhary (2011) [8]. Hydration and swelling capacity of present study is in agreement with the values reported by Sibian *et al*. (2013) [32], Sehgal and Kawatra (2002) [30] and Chaudhary (2011) [8], however it was lower than the values reported by Anju (2005) [2]. Swelling and hydration capacity of seeds depend on seed density.

Sehgal and Kawatra (2002) [30] reported the hydration and swelling index of eleven different pearl millet varieties ranged from 0.181 to 0.500 and 0.357 to 0.538, respectively, while Anju (2005) [2] reported the hydration and swelling index was 0.86 to 1.27 and 0.58 to 0.83, respectively. Chaudhari (2011) [8] found 1.13 to 1.24 hydration index and 0.58 to 0.80 swelling index, respectively. Sibian *et al*. (2013) [32] observed the hydration index and swelling index of pearl millet grains was 0.749 to 0.856, respectively. The results of hydration index and swelling index are closely matches with Sehgal and Kawatra (2002) [30]. However it was lower than the values of hydration and swelling index observed by Anju (2005) [2], Chaudhari (2011) [8] and Sibian *et al*. (2013) [32].

The results of statistical analysis showed the significant difference in thousand kernel weight, seed density, hydration capacity, hydration index, swelling capacity and swelling index of five different pearl millet varieties. The results of physicochemical properties of different pearl millet varieties are closely agreement with Sehgal and Kawatra (2002) [30], Varsha (2003) [39], Anju (2005) [2], Chiek *et al*. (2006) [9] and Chaudhari (2011) [8].

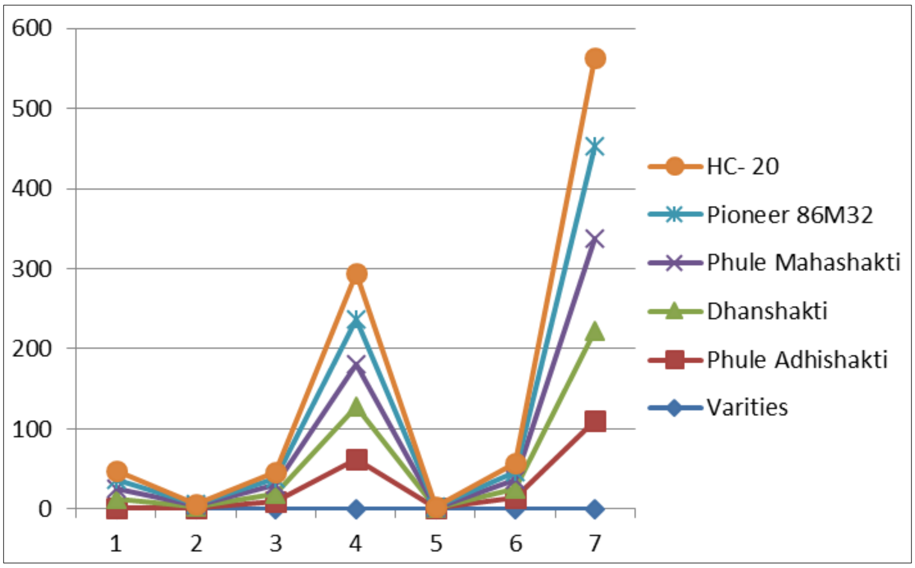
Chemical Composition of different Pearl millet varieties

Millets are the good source of micronutrients and which helps to fight against, the nutritional security. Hence the thorough knowledge about chemical composition of millets is very essential. The five different varieties of pearl millet *viz.*, Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 were analyzed for chemical composition and have been depicted in (Table 2). The chemical components like moisture, protein, fat, ash, and crude fiber and carbohydrates content of different pearl millet varieties like Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 were varied between 11.08 to 11.65, 10.46 to 12.13, 4.85 to 5.50, 2.24 to 3.10, 1.51 to 2.05 and 66.50 to 68.80 g/100g, respectively (Table 2). Among the five different pearl millet varieties, the highest protein content was found in Phule Adishakti (12.13g), followed by Dhanshakti, Phule Mahashakti, HC-20 and Pioneer 86M32,respectively. The results obtained of protein content of different pearl millet varieties of present` investigation are closely agreement with (10.46 to 12.13) by Modu *et al*. (2005) [21] and (8.66 to 17.11) by Chiek *et al*. (2006) [9]. In case of fat content of five different pearl millet varieties, the highest fat content was found in Dhanshakti variety of pearl millet (5.50 g), whereas, lowest was observed in HC-20 (4.85 g). The results of fat content of different pearl millet varieties of present study are closely matches with, the results reported by Anju (2005) [2] and Singh (2003) [33] and having the fat content ranges from 5.03 to 6.31 per cent. More ever the fat content of different pearl millet varieties of present investigation is also more closely matches with the Fasasi (2009) [12] i.e. 5.7%. Pearl millet is the good source of fat content, which is having 75% of fatty acids are unsaturated fatty acids, along with that, it also contain omega3, linolenic fatty acid (C18:3n-3) (LNA) and which is consist of about 4% of total fat content of pearl millet (Burton *et al*., 1972; Rooney, 1978 and Klopenstein and Hoseney, 1995) [7], given higher content of n-3fatty acids in pearl millet than other cereal grains. Ash content is one of the important parameter of millet grains because, it indicates the total mineral content.

Table 2: Chemical composition of different pearl millet varieties

Varieties	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrates (%)
Phule Adishakti	10.50±0.11	12.13±0.27	5.20±0.18	2.61±0.27	2.05±0.14	67.40±0.21
Dhanshakti	11.08±0.12	11.64±0.18	5.50±0.15	2.48±0.01	1.51±0.04	67.71±0.41
Phule Mahashkti	11.65±0.22	11.11±0.15	5.36±0.18	2.62±0.27	1.66±0.02	66.50±0.15
Pioneer 86M32	11.64±0.21	10.46±0.14	4.95±0.32	2.24±0.06	1.80±0.02	68.80±0.30
HC-20	11.51±0.10	10.82±0.11	4.85±0.51	3.10±0.28	1.70±0.03	66.90±0.80
SE±	0.1	0.1	0.05	0.02	0.018	0.44
CD at 5%	0.33	0.33	0.16	0.08	0.05	1.35

*Each value represents average of three determinations.



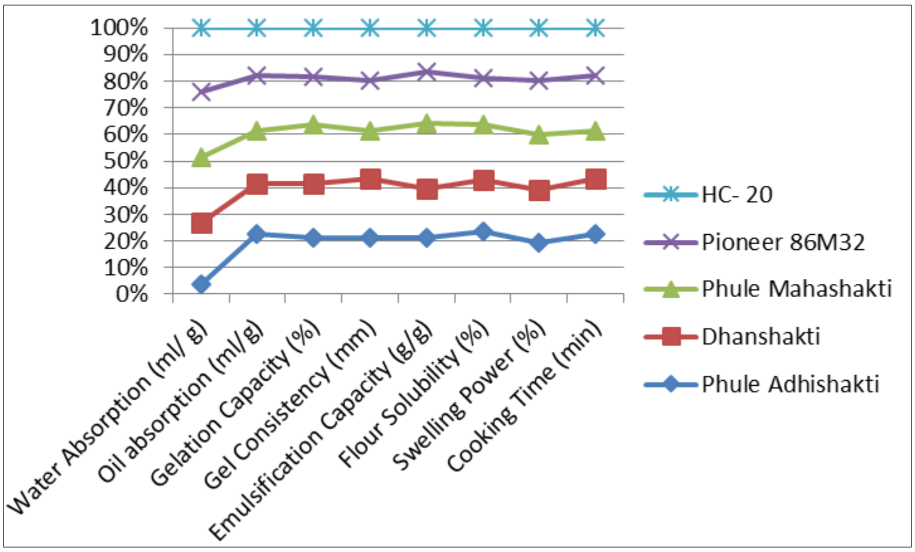
Graph 1: Chemical composition of different pearl millet varieties

The ash content of Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 varieties of pearl millet were 2.61,2.48,2.62,2.24 and 3.10 percent, respectively, the highest ash content found in HC-20 variety of pearl millet, while lowest was observed in Pioneer 86M32 (Chiek *et al*., 2006; Choudhary, 2011; Sonkusale, 2012 and Godara, 2013) [9, 8, 36, 13] were reported the ash content of different pearl millet varieties ranged from 2.16 to 3.44%, 2.20 to 2.63g/100g, 2.63g /100g and 2.5g/100g, respectively. The results of present investigation of ash content of different pearl millet varieties are closely agreement with, results of ash content reported by Singh (2003) [33], Chiek *et al*. (2006) [9], Chaudhari (2011) [8], Sonkusale (2012) [36] and Godara (2013) [13]. The crude fiber content of five different pearl millet varieties ranged from 1.51 to 2.05 g, the highest crude fiber content was found in Phule Adishakti variety of pearl millet, while lowest was found in Dhanshakti variety of pearl millet. The results of present study of crude fiber content of five different pearl millet varieties are closely matches with results reported by Fasasi (2009) [12]; 1.51 to 1.80% by Choudhary (2011); 1.51% by Sonkusale (2012) [36]; 1.5% and by Godara (2013) [13]. The carbohydrate content of five different pearl millet varieties ranged from 66.50 to 68.80g, the highest carbohydrate content was found in Pioneer 86M32 (68.80g) and lowest was found in Phule Mahashakti variety of pearl millet (66.50 g). The Malik *et al*. (2002) studied four different pearl millet varieties and reported that, the carbohydrate content ranged from 49.48 to 71.38%. However, the Chiek *et al*. (2006) [9] reported the carbohydrate content of 14 different pearl millet varieties ranged from 71.80 to 81.0%. The results of statistical analysis of present study showed the significant difference in moisture, protein, fat, ash, crude fiber and carbohydrates of five different pearl millet varieties used for present investigation.

Functional properties of different pearl millet varieties

Functional properties are one of the important properties, which play a key role to describe how ingredients are behaving during preparations and cooking, how it effects on finished product in terms of how looks, tastes and feels. The various functional properties *viz.*, water absorption, oil absorption, gelation capacity, gel consistency, emulsification capacity, flour solubility, swelling power and cooking time were determined (Table 3). The water absorption of five different pearl millet varieties ranged from 1.54 to 1.86 ml/g. The highest water absorption was reported by Phule Adishakti, whereas, lowest was observed in Dhanshakti variety of pearl millet. Oil absorption of different pearl millet varieties like Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 were 1.57, 1.30, 1.36, 1.44 and 1.23 ml/g, respectively. The water absorption and oil absorption of Phule Adishakti variety of pearl millet is higher than Dhanshakti and Phule Mahashakti variety.

Ali *et al*. (2012) [1] found the water absorption capacity (120 ml/100g) and oil absorption capacity (121.7 ml/100g) of pearl millet. However, the results of water and oil absorption of present investigation is higher than the results reported by Ali *et al*. (2012) [1]. The gelation capacity of Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32 and HC-20 varieties of pearl millet were 10.00, 9.32, 10.50, 8.48 and 8.48%, respectively. The highest gel consistency was recorded in Dhanshakti variety of pearl millet (65.20 mm), while lowest was observed in Phule Mahashakti variety (53.55mm). The emulsification capacity of five different pearl millet varieties ranged from 0.50 to 0.75g/g, the highest emulsification capacity was observed in Phule Mahashakti (0.75 g/g) and lowest was observed in HC-20 variety of pearl millet (0.50g/g). Flour solubility of Phule Adishakti, Dhanshakti, Phule Mahashakti, Pioneer 86M32and HC-20 varieties of pearl millet were 13.53, 11.33, 12.00, 9.93 and 10.87%, respectively.



Graph 2: Functional properties of different pearl millet cultivars

Table 3: Functional properties of different pearl millet varieties.

Varieties	Water Absorption (ml/g)	Oil absorption (ml/g)	Gelation Capacity (%)	Gel consistency (mm)	Emulsification capacity(g/g)	Flour Solubility (%)	Swelling Power (%)	Cooking time (min)
Phule Adishakti	1.86±0.05	1.57±0.11	10.00±0.00	62.22±2.50	0.65±0.05	13.53±1.20	109.90±0.35	27.55±0.01
Dhanshakti	1.54±0.10	1.30±0.10	9.32±0.00	65.20±±5.60	0.55±0.06	11.33±0.83	111.60±1.85	25.32±0.08
Phule Mahashakti	1.58±0.12	1.36±0.04	10.50±0.00	53.55±0.88	0.75±0.05	12.00±0.68	116.26±0.65	21.58±1.52
Pioneer86M32	1.69±0.03	1.44±0.16	8.48±0.00	55.11±2.51	0.58±0.00	9.93±0.23	114.49±1.76	25.22±0.04
HC-20	1.67±0.13	1.23±0.00	8.48±0.00	58.23±1.06	0.50±0.00	10.87±0.20	110.89±1.83	21.52±0.02
SE±	0.016	0.017	0.15	0.5	0.007	0.16	0.5	0.35
CD at 5%	0.05	0.05	0.47	1.56	0.02	0.50	1.51	1.05

*Each value represents average of three determinations.

The highest swelling power reported by Phule Mahashakti (116.26%) and lowest recorded by Phule Adishakti variety of pearl millet (109.90%). Phule Adishakti variety of pearl millet had required highest cooking time (27.55 min), whereas, lowest was required for HC-20 (21.52 min). Malik and Singh (2001) [18] reported the water absorption capacity (1.42 to

1.59%), oil absorption capacity (0.97 to 0.99 g/g), swelling power (1.13 to1.18%) and flour solubility (7.0 to 8.3%) in hybrids and varieties of pearl millet. Malik and Singh (2001) [18] reported the gel consistency, gelation capacity and emulsifying capacity of pearl millet varieties and hybrid flour (51.50 to 55.50 mm, 8.66 to 100.16% and 1.30 to 1.63 g/g, respectively). Malik and Singh (2001) [18] also reported the 1.42 to 1.59% of water absorption capacity. The results of statistical analysis of present study showed the significant difference in water absorbtion, oil absorbtion, gelation capacity, gel consistency, emulsification capacity and flour solubility, swelling power and cooking time of five different pearl millet varieties. The results of functional properties of different pearl millet varieties are closely matches with the Hadimani *et al*. (1995) [14], Malik and Singh (2001) [18], Sehgal and Kawatra (2002) [30], Anju (2005) [2], Nkama *et al*. (2005) [3], Badau *et al*. (2005) [3], Cheik *et al*. (2006) [9] and Chaudhary (2011) [8].

Conclusion

Functional properties are playing an important role in new product development to get overall idea about how flour will react with temperature or any other processing treatment like water absorption, oil absorption, and gel formation, hence to get sound idea about products textural and sensory properties, functional properties are obligatory. Moreover functional properties of pearl millet flour is very important because pearl millet is one of the underutilized millet, hence to explore pearl millet into new value added convenience food products will helps to fulfill the nutritional security.

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