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Nutritional quality evaluation of improved varieties of black gram (*Phaseolus mungo*)

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Abstract
Black gram (*Phaseolus mungo*) is a legume belonging to family *Fabaceae* and genus *Phaseolus*. Black gram is a nutritious legume and also a good source of protein. Keeping in view the advantages of whole black gram seeds, the improved varieties of black gram i.e. Pant U-8, Pant U-9, Pant U-31 and Pant U-35 seeds were taken for the present study. The physical properties such as seed weight, volume, density, hydration capacity, hydration index, swelling capacity and swelling index of all the four improved varieties of black gram was analyzed. The nutritional quality of whole black gram seeds include proximate composition, dietary fibre, calcium and iron content was analyzed. The anti-nutritional factors such as trypsin inhibitors and tannin content were also analyzed. Result of the study showed that weight, volume and density of whole black gram varieties ranged from 2.99 to 3.54 (g/100 seeds), 2.84 to 3.81 (ml/100 seeds) and 0.88 to 1.19 (g/ml) respectively. Hydration capacity and hydration index were in the range of 0.02g/seed to 0.03g/seed and 0.70 to 0.92 respectively. Swelling capacity and swelling index ranged from 0.04 ml/seed to 0.046 ml/seed and 1.30 to 1.64 respectively. The moisture content of black gram varieties varied from 8.54 to 9.14 per cent, total ash from 3.38 to 4.21 per cent, crude protein from 23.91 to 26.01 per cent, crude fat from 0.93 to 1.21 per cent, crude fibre from 3.98 to 5.73 per cent, carbohydrates from 54.41 to 57.45 per cent and physiological energy from 330.78 to 340.65 kcal/100g. Insoluble dietary fibre was in the range of 13.13 to 15.6 per cent, soluble dietary fibre from 4.06 to 4.4 per cent and total dietary fibre was in the range of 17.2 to 20 per cent. Results of mineral analysis showed that calcium content of four black gram varieties varied from 66.66 to 133.33 mg/100g and iron content from 5.58 to 8.29 mg/100g. Trypsin inhibitor content of the four improved varieties ranged from 90.33 TIU/ g to 94.53 TIU/ g and tannin content ranged from 6.80 to 7.24 mg per 100 gm.

Keywords: Black gram, physical properties, proximate composition, dietary fibre, anti-nutritional factors

Introduction
Black gram (*Vigna mungo* or *Phaseolus mungo*) is generally recognized as urad bean, mash bean, black lentil or white lentil (Souframanien and Gopalakrishna, 2004) [25]. It is one of the less studied legumes (Grewal and Jood, 2006) [9] but is generally used in India, East Africa, Pakistan, Greece & Iran (Bhattacharya *et al.*, 2004) [6]. In the Indian subcontinent black gram is a highly prized legume. Black gram is extensively grown in the Indian subcontinent and slightly in Australia, Thailand and South Pacific countries. Production of black gram is 2 million metric tons annually. Black gram like other pulses, is a nitrogen fixing plant and to improve the quality of soil, it is grown with cereal crops by inter cropping. Being rich in protein it is used as staple food with cereals such as wheat and rice. It is used as whole, split beans and dehusked split beans (*dhal*) (Ajila and Rao, 2009) [2], fermented (alone), fermented in combination with white polished rice or cooked, steamed or fried. Dehusked cotyledons are used as fermented alone or in combination with polished white rice in preparations like *dhosa, idli* and as non-fermented preparations like *papad, baris* and cooked dal. Sweets are prepared traditionally from whole/dehusked black gram flour and jaggery (*ladoo, halwa* and *imarti*) and are regarded as healthy food in India (Senthil *et al.*, 2006, Tiwari *et al.*, 2007) [23].
Black gram being rich in protein, contains double the amount of protein (20-25%) as compared to cereals. It contains good amounts of proteins like albumin and globulin and amino acids like tryptophan and lysine. It is also rich in fibre, several vitamins (thiamin, riboflavin and niacin) and minerals like iron and calcium (Panhwar, 2005; Girish and Rao, 2012) [8, 20]. Black gram contains non-reducing oligosaccharides, fructose, raffinose, sucrose, ajugose, stachyose and verbascose (Suneja *et al*., 2011) [27]. Black grams are processed into dehusked cotyledon by the removal of seed coat, aleurone layer, plumule and germ. Black gram proteins are digested in an easy manner and they are also rich in vitamins and phosphoric acid. Black gram flour prepared by roasting had the lowest % shrinkage, the lowest fat absorption and higher yield

(Modi *et al.*, 2003) [19].
Due to the therapeutic activity of black gram, they have been used as medicinal or cosmetic material since ancient times. It is used to treat rheumatism, infections of the nervous system and diseases of liver. Whole black gram is used for skin and hair care in the form of paste either alone or combined with fenugreek or sandalwood paste (Sharma & Mishra, 2009) [24].
Even though black gram is rich in protein, antinutrients are present which is the greatest shortcomings that limit the food and nutritional characteristics of pulses (Liener, 1994) [16]. Black gram consists of many antinutrients such as protease inhibitors, raffinose family oligosaccharides (RFOs), stachyose, verbascose, phytates, tannins, saponins, lectins etc (Jain *et al.*, 2009) [10]. Black gram seeds contain polyphenols and tannins in their seed coat so their seeds are dark in color. These antinutritional factors reduce the absorption and bioavailability of the nutrients in human diet. So to lower the level of these antinutritional factors, many attempts have been made. 25% reduction in polyphenol and phytic acid content was observed by soaking black gram and green gram. Dehulling of pulses like black gram, pigeon pea, green gram and chick pea resulted in 83-97% loss of tannin (Kakati *et al.*, 2010) [11].
With the aim of increased productivity and better nutrient content and availability, research is being carried out to evolve new varieties of black gram. There is very limited information about the nutritive value of these newly evolved improved varieties of black gram. Therefore the present study was undertaken to evaluate different varieties of black gram for their nutrient composition.

Materials and Methods

Procurement of raw materials

Four improved varieties of Black gram (*Phaseolus mungo* or *Vigna mungo*) were obtained from CRC (Crop Research Centre), G.B. Pant University of Agriculture and Technology, Pantnagar. The improved varieties studied were: Pant U-8, Pant U-9, Pant U-31 and Pant U-35.

Preparation of sample

All the four black gram varieties were cleaned of extraneous material and were stored in clean air tight glass jars. The whole grain samples were ground using mixer grinder and passed through a sieve of 44 mesh size. The flour was stored in air tight containers for further analysis.

Determination of physical properties of improved varieties of black gram (Williams *et al.*, 1983) [30]

Seed weight

Seed weight was recorded by weighing one hundred seeds and was calculated as mean weight.

Seed volume

In a 50ml measuring cylinder, hundred seeds were put and 25ml of water was added. Volume of seed was calculated as:

$$\text{Seed volume} = \frac{\text{Total volume} - 25}{100}$$

Density

Density is calculated from the weight and volume of hundred seeds.

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}}$$

Hydration capacity

One hundred seeds were put in a flask of 125ml and to make the volume to 100ml water was added. The flasks were closed with a stopper and were left overnight at room temperature. The seeds were dried and reweighted after draining excess water. Hydration capacity was recorded as:

$$\text{Hydration capacity} = \frac{\text{Weight after soaking} - \text{Weight before soaking}}{100}$$

Hydration index

$$\text{Hydration index} = \frac{\text{Hydration capacity}}{\text{Original seed weight (g)}}$$

Swelling capacity

Hundred seeds were put in a flask of 125ml flask and to make the volume up to 100ml water was added. The flask were closed by stopper and left overnight at room temperature. The seeds were dried of water. The seeds were again put in 100ml measuring cylinders and 50ml water was added. The increase in volume and swelling capacity was recorded.

$$\text{Swelling capacity} = \frac{\text{Volume after soaking} - \text{Volume before soaking}}{100}$$

Swelling index

Swelling index was recorded as

$$\text{Swelling index} = \frac{\text{Swelling capacity}}{\text{Swelling volume (ml)}}$$

Nutritional composition analysis

The four varieties of black gram were analyzed for proximate composition, minerals like iron and calcium and dietary fibre. Estimation of antinutritional factors such as trypsin inhibitor and tannin was also done. All the estimations were done in triplicates.
Proximate composition was determined by AOAC (1995) [1] standard method. Iron content was estimated using Atomic Absorption Spectrophotometer (AAS) by AOAC (1995) [1] standard method. Titration method given by AOAC (1995) [1] was used to determine the calcium present in the sample. Total Dietary fibre content of sample was estimated by the method given by Asp and Johanson (1981) [5].
Antinutritional factors such as trypsin inhibitor activity was determined by the method developed by Liu and Markakis (1989) [17] and tannins in black gram were estimated by the method of AOAC (1970) [3].

Statistical analysis

All the determinations were carried out in triplicates. One way ANOVA analysis was applied to find out the critical difference between the mean scores of nutrient composition of improved varieties of Black gram.

Results and Discussion

Physical properties of improved varieties of whole black gram

The results on physical properties of improved varieties of whole black gram have been presented in Table 1.

Seed weight

The seed weight of the four improved varieties of black gram ranged from 2.99 g/100 seeds to 3.54 g/100 seeds (mean 3.32g/100 seeds). The highest seed weight was seen in Pant U-35 and Pant U-31 had the lowest seed weight. Statistical analysis of data showed that Pant U-8, Pant U-9 and Pant U-35 differed significantly from Pant U-31.

Veni *et al.* (2015) [29] reported 3.36 to 5.39 g/100 seeds of seed weight in whole black gram which was similar to the value obtained in the present study. In a study by Ghosh, A. and Panda, S. (2006) [7] black gram seed weight ranged from 4.0 g to 4.6 g/100 seeds which was found to be higher than that reported in the present study.

Seed volume

The seed volume of the four improved varieties of black gram ranged from 2.84 ml/100 seeds to 3.81 ml/100 seeds (mean 4.36 ml/100 seeds). The highest seed volume was seen in Pant U-9 and the lowest seed volume was obtained in Pant U-8 and Pant U-31. Statistical analysis of data showed that all varieties differed significantly except Pant U-31.

In a study by Kaur *et al.* (2004) [13], seed volume of black gram ranged between 3.5-4.3 (cc/100 seeds) which was similar to the value obtained in the present study. Ghosh, A. and Panda, S. (2006) [7] reported 3.2 ml to 4.3 ml per 100 seeds of seed volume which was similar to the value obtained in the present study. According to Veni *et al.* (2015) [29] seed volume varied from 3.06 to 4.58 ml per 100 seeds.

Density

The seed density of the four improved varieties of black gram ranged from 0.88 g/ml to 1.19 g/ml (mean 1.02 g/ml). The highest seed density was seen in Pant U-8 and lowest in Pant U-9. Statistical analysis of data shows that there is significant difference between all the varieties of whole black gram.

In a study by Ghosh, A. and Panda, S. (2006) [7] seed density varied from 1.07 g/cm^3 to 1.30 g/cm^3 which was similar to the value obtained in the present study. According to Veni *et al.* (2015) [29] seed density varied from 1.003g/cc to 1.483g/cc. According to Kaur *et al.* (2004) [13], seed density ranged between 1.21- 1.33(g/cc) which was found to be higher than that reported in the present study.

Hydration capacity

The hydration capacity of the four improved varieties of black gram varied from 0.02 g/ seed to 0.03 g/seed (mean 0.02 g/seed). The highest hydration capacity was seen in Pant U-9 and the lowest hydration capacity was seen in Pant U-31. Statistical analysis of data shows that Pant U-31 differed significantly from Pant U-8 whereas there is non-significant difference between Pant U-8, Pant U-9 and Pant U-35.

According to Khalid, H. and Intikhab, J. (2013) [15] hydration capacity of black gram ranges between 0.02-0.05 (g/seed) which was similar to the value obtained in the present study. In a study by Ghosh, A. and Panda, S. (2006) [7] hydration capacity varied from 0.03 g/seed-0.04 g/seed which was similar to the value obtained in the present study. According to Veni *et al.* (2015) [29] hydration capacity varied from 0.02 g/seed to 0.04 g/seed.

Hydration index

The hydration index of the four improved varieties of black gram ranged from 0.71 to 0.92 (mean 0.83). The highest hydration index was seen in Pant U-9 and the lowest hydration index in Pant U-31. Statistically non-significant difference was found among all the varieties of whole black gram.

According to Khalid, H. and Intikhab, J. (2013) [15] hydration index of black gram ranged between 0.51-1.03 which was similar to the value obtained in the present study. In a study by Ghosh, A. and Panda, S. (2006) [7] hydration index varied from 0.78- 0.95 which was found to be lower than that reported in the present study. According to Veni *et al.* (2015) [29] hydration index varied from 0.49 to 1.23.

Swelling capacity

The swelling capacity of the four improved varieties of black gram ranged from 0.04ml/seed to 0.04 ml/seed (mean 0.04). The highest swelling capacity was seen in Pant U-8, Pant U-9 and Pant U-35 and the lowest swelling capacity was seen in Pant U-31. Statistically non-significant difference was found among all the varieties of whole black gram.

In a study by Ghosh, A. and Panda, S. (2006) [7] swelling capacity varied from 0.03- 0.04 mm/seeds which was similar to the value obtained in the present study. According to Veni *et al.* (2015) [29] swelling capacity varied from 0.03 to 0.04 which was similar to the value obtained in the present study. According to Khalid, H. and Intikhab, J. (2013) [15], swelling capacity ranged between 0.08 mm/seeds - 0.12 mm/seeds.

Swelling index

The swelling index of the four improved varieties of black gram ranged from 1.30 to 1.64 (mean 1.41). The highest swelling index was seen in Pant U-8 and the lowest swelling index was seen in Pant U-35. Statistically non-significant difference was found among all the varieties of whole black gram.

In a study by Ghosh, A. and Panda, S. (2006) [7] swelling index varied from 0.80- 1.02 which was found to be lower than that reported in the present study. According to Veni *et al.* (2015) [29] swelling index varied from 0.62 to 1.26 which was similar to the value reported in the present study. According to Khalid, H. and Intikhab, J. (2013) [15], swelling index ranges between 1.50- 2.18 which was found to be higher than that reported in the present study.

Table 1: Physical properties of improved varieties of whole black gram seeds

Physical properties	Pant U-8	Pant U-9	Pant U-31	Pant U-35	S.Em.±	CD at 5%
Weight (g/seed)	3.40±0.06 ^{a}	3.37±0.12 ^{a}	3.00±0.06 ^{b}	3.51±0.16 ^{a}	0.632	0.206
Volume(ml/100 seeds)	2.85±0.16 ^{a}	3.81±0.15 ^{b}	2.85±0.15 ^{a}	3.58±0.10 ^{c}	0.807	0.263
Density (g/ml)	1.19±0.04 ^{a}	0.88±0.06 ^{b}	1.05±0.07 ^{c}	0.98±0.02 ^{d}	0.313	0.102
Hydration capacity (g/seed)	0.03±0.00 ^{a}	0.03±0.00 ^{a}	0..02±0.00 ^{b}	0.03±0.00 ^{a}	0.159	0.518
Hydration index	0.81±0.08 ^{a}	0.93±0.06 ^{a}	0.71±0.06 ^{a}	0.89±0.12 ^{a}	0.491	0.160
Swelling capacity(ml/seed)	0.05±0.01 ^{a}	0.05±0.01 ^{a}	0.04±00 ^{a}	0.05±0.01 ^{a}	0.372	0.121
Swelling index	1.64±0.15 ^{a}	1.31±0.26 ^{a}	1.39±0.10 ^{a}	1.30±0.16 ^{a}	0.102	0.334

All results are mean±standard deviation for three individual determinations. Means in each row for different varieties of black gram followed by different letters are significantly different ($P \leq 0.05$).

Nutrient composition

Proximate composition

Results on proximate composition of improved varieties of black gram have been presented in Table 2.

Moisture

The moisture content of the four improved varieties of whole black gram ranged from 8.54 to 9.14 per cent (mean 8.72 per cent). Pant U-8 was found to contain the maximum, whereas Pant U-9 showed minimum moisture content. Statistically non-significant difference was found among all the varieties of whole black gram.

Longvah *et al.* (2017) [18] reported 8.70±0.33 per cent moisture content in whole black gram which was found to be similar to that reported in the present study. Girish *et al.* (2012) [8] reported 11.41±0.08 per cent moisture content which was found to be higher than that reported in the present study. According to Kakati *et al*. (2010) [11] black gram contain 8.70 per cent moisture.

Total ash

The total ash content of the four improved varieties of whole black gram ranged from 3.38 to 4.21 per cent (mean 3.87 per cent). Pant U-31 was found to contain the maximum, whereas Pant U-9 showed minimum total ash content. It was observed that Pant U-8 differed significantly from Pant U-9 whereas there is non-significant difference between Pant U-31 and Pant U-35.

Aparna *et al.* (2000) [4] stated the mean values of total ash present in black gram as 2.80 per cent which was found to be lower than that reported in the present study. Longvah *et al.* (2017) [18] reported 3.35±0.03 per cent ash content in whole black gram which was similar to the value obtained in the present study. According to Srivatsava (2015) [26], black gram contains 4.5 – 5.5 per cent total ash.

Crude fat

The crude fat content of the four improved varieties of whole black gram ranged from 0.93 to 1.21 per cent (mean 1.05 per cent). Pant U-35 was found to contain the maximum, whereas Pant U-8 showed minimum crude fat content. Statistically non-significant difference was found among all the varieties of whole black gram.

Longvah *et al.* (2017) [18] reported 1.58±0.06 per cent crude fat content in whole black gram which was found to be higher than that reported in the present study. Girish *et al.* (2012) [8] reported 1.44±0.02 per cent fat content which was found to be higher than that reported in the present study. In a study by Kakati *et al*. (2010) [11], black gram contain 1.54 per cent crude fat.

Crude protein

The crude protein content of the four improved varieties of whole black gram ranged from 23.91 to 26.01 per cent (mean 24.81 per cent). Pant U-31 was found to contain the maximum, whereas Pant U-8 showed minimum crude protein content. Statistically it was shown that there was significant difference between all the varieties of whole black gram.

Girish *et al.* (2012) [8] reported 26.75±0.25 per cent protein content which was found to be higher than that reported in the present study. Longvah *et al.* (2017) [18] reported 21.97±0.63 per cent protein content in whole black gram which was found to be lower than that reported in the present study. In a study by Srivatsava (2015) [26], black gram contains 25-28 per cent protein.

Crude fibre

The crude fibre content of the four improved varieties of whole black gram ranged from 3.98 to 5.73 per cent (mean 4.82 per cent). Pant U-31 was found to contain the maximum, whereas Pant U-35 showed minimum crude fibre content. Statistical analysis of data showed that Pant U-8 differed significantly from Pant U-31 and Pant U-35 whereas there is non-significant difference between PantU-8 and Pant U-9.

Suneja *et al.* (2011) [27] reported the mean values of crude fibre present in black gram as 3 per cent which was found to be lower than that reported in the present study. Longvah *et al.* (2017) [18] reported 4.4 per cent fibre content in whole black gram which was found to be lower than that reported in the present study. In a study by Kakati *et al*. (2010) [11], black gram contained 4.90 per cent crude fibre.

Carbohydrate by difference

The carbohydrate content of the four improved varieties of whole black gram ranged from 54.41 to 57.45 per cent (mean 56.52 per cent). Pant U-8 was found to contain the maximum, whereas Pant U-35 showed minimum carbohydrate content. Statistical analysis of data showed that Pant U-8 differed significantly from Pant U-31 whereas there is non-significant difference between Pant U-8, Pant U-9 and Pant U-35.

Aparna *et al.* (2000) [4] reported the mean values of carbohydrate content present in black gram as 44.30 per cent which was found to be lower than that reported in the present study. Longvah *et al.* (2017) [18] reported 43.99±0.76 per cent carbohydrate content in whole black gram which was found to be lower than that reported in the present study. According to Srivatsava (2015) [26], black gram contains 62 – 65 per cent carbohydrate which was found to be higher than that reported in the present study.

Physiological energy

The physiological energy of the four improved varieties of whole black gram ranged from 330.78 to 340.65 Kcal/100g (mean 335.82 Kcal/100g). Pant U-8 was found to contain the maximum, whereas Pant U-35 showed minimum physiological energy content. It was observed that Pant U-8 differed significantly from Pant U-9 and Pant U-35 whereas there is non-significant difference between Pant U-8 and Pant U-31.

Suneja *et al.* (2011) [27] reported 350 Kcal/100g of energy in whole black gram which was found to be higher than that reported in the present study. Panhwar (2005) [20], reported 350cal/100g of energy which was found to be higher than that reported in the present study.

Table 2: Proximate composition of improved varieties of whole black gram (Dry weight basis)

Proximate composition	Pant U-8	Pant U-9	Pant U-31	Pant U-35	S.Em.±	CD at 5%
Moisture (%)	9.13±0.16 [a]	8.53±0.32 [a]	8.62±0.30 [a]	8.60±0.23 [a]	0.150	0.491
Ash (%)	3.92±0.13 [a]	3.38±0.20 [b]	4.22±0.41 [a]	3.98±0.08 [a]	0.137	0.449
Crude fibre (%)	4.65±0.54 [a]	4.92±0.20 [a]	5.73±0.13 [c]	3.98±0.33 [d]	0.195	0.638
Crude fat (%)	0.93±0.39 [a]	1.06±0.64 [a]	1.01±0.04 [a]	1.21±0.02 [a]	0.217	0.707

Crude protein (%)	23.920±0.67 [a]	25.08±0.67 [b]	26.01±0.41 [c]	25.23±0.51 [d]	0.331	1.079
Carbohydrates (%)	57.45±0.27 [a]	57.02±1.74 [a]	54.41±0.25 [b]	57.21±0.68 [a]	0.550	1.793
Energy (Kcal/100g)	333.87±3.71 [a]	338.00±1.06 [b]	330.78±0.94 [a]	340.65±0.95 [c]	1.177	3.836

All results are mean±standard deviation for three individual determinations. Means in each row for different varieties of black gram followed by different letters are significantly different ($P \leq 0.05$).

Other nutritional parameters

The results of dietary fibre content of improved varieties of whole black gram have been presented in Table 3.

Dietary fibre

Insoluble dietary fibre

The insoluble dietary fibre content of the four improved varieties of whole black gram ranged from 13.13 to 15.6 per cent (mean 14.09 per cent). Pant U-31 was found to contain maximum while Pant U-35 contained minimum amount of insoluble dietary fibre. Statistically non-significant difference was found among all the varieties of whole black gram. Insoluble dietary fibre prevents constipation by promoting movement of material through digestive system thus increasing stool bulk.

According to Girish *et al.* (2012) [8], whole black gram contained 36.76±0.55 insoluble dietary fiber which was found to be higher than that reported in the present study. Longvah *et al.* (2017) [18] reported 15.47±0.05 per cent of insoluble dietary fibre which was found to be higher than that reported in the present study.

Soluble dietary fibre

The soluble dietary fibre content of the four improved varieties of whole black gram ranged from 4.06 to 4.4 per cent (mean 4.19 per cent). Pant U-31 was found to contain maximum while Pant U-35 contained minimum amount of soluble dietary fibre. Statistically non-significant difference was found among all the varieties of whole black gram. Soluble dietary fibre helps in lowering blood cholesterol and glucose level as it dissolves in water to forma gel-like material.

According to Girish *et al.* (2012) [8], whole black gram contained 3.13±0.05 soluble dietary fiber which was found to be lower than that reported in the present study. Longvah *et al.* (2017) [18] reported 4.94±0.07 per cent of soluble dietary fibre which was found to be higher than that reported in the present study.

Total dietary fibre

Data on total dietary fibre content of the four improved varieties of whole black gram ranged from 19.2 to 20.8 per cent (mean 20 per cent). Pant U-31 was found to contain maximum while Pant U-35 contained minimum amount of total dietary fibre. Statistically non-significant difference was found among all the varieties of whole black gram.

According to Girish *et al.* (2012) [8], whole black gram contained 39.90±0.60 total dietary fiber which was found to be higher than that reported in the present study. Longvah *et al.* (2017) [18] reported 20.41±0.06 per cent of total dietary fibre which was found to be higher than that reported in the present study. Kamath and Belavady (1980) [12] reported 13.6 percent of total dietary fiber in black gram which was found to be lower than that reported in the present study.

Table 3: Total dietary fibre of improved varieties of whole black gram

Nutrient	Pant U-8	Pant U-9	Pant U-31	Pant U-35	S.Em.±	CD at 5%
Insoluble dietary fibre (%)	13.20±1.25 [a]	14.47±1.79 [a]	15.60±1.06 [a]	13.13±1.03 [a]	0.760	2.479
Soluble dietary fibre (%)	4.02±0.20 [a]	4.13±0.31 [a]	4.40±0.40 [a]	4.07±0.12 [a]	0.159	0.521
Total dietary fibre (%)	17.22±1.40 [a]	18.60±1.78 [a]	20.00±1.44 [a]	17.20±1.06 [a]	0.832	2.713

All results are mean±standard deviation for three individual determinations. Means in each row for different varieties of black gram followed by different letters are significantly different ($P \leq 0.05$).

Minerals

The results on calcium and iron content of improved varieties of whole black gram have been presented in Table 4.

Calcium

The calcium content of the four improved varieties of whole black gram seed ranged from 66.66 to 133.33 mg/100g (mean 94.43 mg/100g). It was found that calcium content was highest in Pant U-31 whereas lowest in Pant U-35. Statistically non-significant difference was found among all the varieties of whole black gram.

Aparna *et al.* (2000) [4] reported 196 mg/100g calcium content which was found to be higher than that reported in the present study. Longvah *et al.* (2017) [18] reported 86.18±8.99 mg per 100gm of calcium content in whole black gram which was similar to the value obtained in the present study.

Iron

The Iron content of the four improved varieties of whole black gram seed ranged from 5.58 to 8.29 mg/100g (mean 6.97 mg/100g). It was found that iron content was highest in Pant U-31 whereas lowest in Pant U-35. Statistically it was shown that there was significant difference between all the varieties of whole black gram.

Panhwar (2005) [20] reported 8.7mg/100g iron content which was found to be higher than that reported in the present study. Longvah *et al.* (2017) [18] reported 5.97±0.56 mg per 100gm of iron content in whole black gram which was found to be lower than that reported in the present study. In a study by Kawale (1995) [14], black gram contains 8.66 mg/100g of iron.

Table 4: Mineral content of improved varieties of whole black gram

Minerals	Pant U-8	Pant U-9	Pant U-31	Pant U-35	S.Em.±	CD at 5%
Calcium (mg/100g)	88.89±19.25 [a]	100.00±33.34 [a]	111.11±19.24 [a]	77.77±19.25 [a]	13.609	44.356
Iron (mg/100g)	6.62±0.33 [a]	7.40±0.17 [b]	8.30±0.20 [c]	5.58±0.09 [d]	0.123	0.403

All results are mean±standard deviation for three individual determinations. Means in each row for different varieties of black gram followed by different letters are significantly different ($P \leq 0.05$)

Antinutritional factors estimation

The results on antinutritional factors estimation of improved varieties of whole black gram have been presented in Table 5.

Trypsin inhibitor

Trypsin inhibitors are proteins of low molecular weight which irreversibly bind the enzymes such as trypsin and chymotrypsin and inhibits protein digestibility (Roy *et al.*, 2010) [22]. The trypsin inhibitor content of the four improved varieties of whole black gram ranged from 90.33 TIU/ g to 94.53 TIU/ g (mean 93.21 TIU/ g). Pant U-9 was found to contain maximum while Pant U-35 contained minimum amount of trypsin inhibitor. Statistically non-significant difference was found among all the varieties of whole black gram.

According to Suneja *et al*. (2011) [27], trypsin inhibitor activity was found in the range of 71.6 units/g to 106.5 units/g. The values reported for trypsin inhibitors in the present study falls under this range. Kakati *et al*. (2010) [11] reported 2442.38-2463.25(TIU/100g) of trypsin inhibitor which was found to be higher than that reported in the present study.

Tannin

The tannin content of the four improved varieties of whole black gram ranged from 6.80 to 7.24 mg per 100 gm (mean 6.945 mg/g). Pant U-8 was found to contain maximum while Pant U-9 contained minimum amount of tannins. Statistically non-significant difference was found among all the varieties of whole black gram.

According to Suneja *et al*. (2011) [27], tannin content was found in the range of 5.3mg/g to 9.2 mg/g seeds which was similar to the values in the present study. Rehman (2000) [21] reported 930–1165 g of tannin content which was found to be higher than that reported in the present study.

Table 5: Antinutritional content of improved varieties of whole black gram

Antinutrition factors	Pant U-8	Pant U-9	Pant U-31	Pant U-35	S.Em.±	CD at 5%
Trypsin inhibitors (TIU/g sample)	93.67±3.45 [a]	94.53±2.42 [a]	94.33±2.89 [a]	90.33±2.66 [a]	1.663	5.422
Tannins (mg/g)	6.91±0.11 [a]	6.83±0.20 [a]	7.24±0.44 [a]	6.81±0.37 [a]	0.177	0.579

All results are mean±standard deviation for three individual determinations. Means in each row for different varieties of black gram followed by different letters are significantly different ($P \leq 0.05$)

Conclusion

In the present study four improved varieties of whole black gram (namely Pant U-8, Pant U-9, Pant U-31 and Pant U-35) were evaluated for physical properties, nutrient composition, dietary fibre, mineral and antinutritional factors.

Among the physical properties, highest seed weight was seen in Pant U-35. Seed volume and hydration index were highest in Pant U-9. Density and swelling index were highest in Pant U-8. Hydration capacity and swelling capacity were highest in Pant U-8, Pant U-9 and Pant U-35. The results of proximate composition of improved varieties of black gram revealed that moisture content, carbohydrate content and energy value were highest in Pant U-8. Total ash content, total protein content and total fiber content were highest in Pant U-31. Total dietary fibre, soluble dietary fibre and insoluble dietary fibre were highest in variety Pant U-31. Results of mineral analysis showed that calcium and iron content was highest in Pant U-31. Trypsin inhibitor content was highest in Pant U-9 and tannin content was highest in Pant U-8.

Keeping in view the nutrient content of whole black gram its utilization in various food products may be increased so that their nutritional value may be enhanced.

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