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ANALYSIS OF CORRELATION BETWEEN PHYSICAL, NUTRITIONAL, AND ANTINUTRITIONAL COMPONENTS IN MUNGBEAN GENOTYPES

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ABSTRACT

Mung bean (*Vigna radiata* L.) is a widely consumed pulse, especially in Asia, known for its high protein, fiber, vitamins, essential amino acids, and minerals like calcium, magnesium, and potassium. However, it also contains antinutritional factors such as trypsin inhibitors, tannins, phytic acid, saponins, and polyphenols, which can reduce its nutritional value. Therefore, it is crucial to evaluate genotypes with higher nutritional content and lower levels of antinutrients. The seeds of improved mungbean genotypes were analysed for physical characteristics, proximate composition, limiting amino acids, minerals and antinutritional constituents. The significant variations in seed coat colour of mungbean genotypes was observed and ranged from olive green to pale olive green or dark green, the hundred seed weight, seed volume seed density and grain hardness were ranged from 3.82-5.14 g, 3.60-5.20 ml, 1-1.27 g/ml, 306.25-429.93 N respectively The proximate analysis revealed significant differences in content of moisture (9-10%); crude protein (18.37-21.76%); crude fat (0.95-1.97%); crude fiber (3.50-4.50%); carbohydrate (61.70-63.01%); ash (3-3.60%). Limiting amino acids *viz.* methionine and tryptophan ranged from 0.81-0.94 and 0.69-0.91 g/16 g N respectively. Proteins of most of cultivars were found deficient in methionine and tryptophan as compared to FAO (1977) values *viz.* 2.4 and 1.2 g/16g N respectively. The content of phosphorus, calcium, magnesium, iron and zinc in mungbean genotypes were ranged between 270.28-353.46, 137.50-172.57, 162.82-190.75, 7.03-9.22, 0.95-1.30 mg/100g respectively. So, it was found that selected mungbean genotypes are good source of minerals like phosphorus, calcium and magnesium while iron and zinc content in these genotypes found to be sufficient. Analysis revealed significant differences in content of polyphenols (340.78-361.67 mg/100g). The genotypes with coloured seed coat contained higher number of polyphenols phytate phosphorus (63.20-69.65 mg/100g) with; trypsin inhibitor (12.10-14.17 TIU/mg). From these results it appears that genotypes are found to be promising for lowest content of these antinutritional constituents. Based on above results it can be concluded that genotypes Phule Chetak, Kopergaon, Vaibhav, PM-707-27 and PM-818-8 were found to be promising for nutritional composition, limiting amino acids, minerals and antinutritional constituents.

***Keywords*:** Mungbean, seed hardness, proximate composition, limiting amino acids, antinutrients

Introduction

Pulses are an important source of stable protein food for the poor and the vegetarians which constitute a major population of the country. Adult males and females should consume 60 g and 55 g of protein per day, respectively, according to the Recommended Dietary Allowances (RDA). Legumes are a substantial source of protein in underdeveloped nations and are the second most important dietary source after cereals worldwide (Onwurafor *et al.,* 2014). Grain legumes are being cultivated in India since time immemorial. The important pulse crops grown in India are Bengal gram, lentil, mungbean, black gram, cowpea, red gram, and pea.

Among these, mungbean (*Vigna radiata* (L.) *Wilczek*) is an ancient and well-known leguminous crop of Asia, on account of its nutritional quality and the suitability to cropping system. They have high total protein content (20-26%) and can be considered as a natural supplement to cereals. After fish (dry) which provides 335g protein per kg, grain legumes provide 220-250 g protein per kg. Hence legumes are considered as a "poor man's meat" (Sood *et al*., 2002; Jadhav and Gawande, 2015). It is an important pulse crop belonging to the family Fabaceae, sub-family papilionaceous and has diploid chromosome number 2n = 22. It is the native of Indo-Burma region of Hindustan centre (Mehandi *et al*., 2019). It is supposed to be spread from there in different parts of Asia, Africa, South and North America and Australia. Mungbean seeds are dispersed for fresh use and these sprouts are the cheapest source of protein, calcium, phosphorus and certain vitamins. It is cultivated as a sole crop as well as intercrop with minor millets, cotton, maize, sorghum etc.

Mung bean has similar composition to other members of legume family, with 24% protein, 1% fat, 63% carbohydrate and 16 % dietary fiber (Huang *et al*., 2013). Its different food products such as *dhal* (thick stews from dehulled and split grains), sweets, snacks, and Savory foods have evolved and became popular in the Indian subcontinent (Dahiya *et al*., 2013), whereas products like cake, sprouts, noodles, and soups evolved in oriental countries like China, Philippines as well as in and Thailand (Dahiya *et al*., 2013). Besides, mung bean is a very popular oriental food, which has important features with respect to other legumes such as its detoxifying, anti-inflammatory, antitumorigenic, cholesterol-lowering and diuretic properties (Hu, 2003).

Recent research indicates that mung bean consumption produces small increase in blood glycemic index in humans making it an attractive option for diabetic patients (Randhir & Shetty, 2007). It is also well documented that certain proteins in mung bean exert both antifungal and antibacterial activity (Wang *et al.,* 2004). Mung bean has a high protein content (20–33%) and it is almost free from flatulence producing factors (Penas *et al.,* 2010), and it has become a major source of protein, especially in developing countries. At present, there is an increasing interest of scientists in mung bean, which is focused on the characterization of its components and the relationship between its consumption and beneficial health effects in humans.

The seed colour usually dark olive green, bright green skin or yellow and the beans are small, cylindrical or ovoid, globular or oblong in shape, but some cultivar produced brow or speckled black seed. Green gram is an excellent source of protein (25%), high in dietary fiber, rich source of vitamins, minerals and its essential amino acids. They are the rich source of Ca, Mg, Fe, P and K. Green gram is a valuable addition to a crop rotation both from its nutritional benefits as a grain as a vegetable, and its compatibility with other crops (Nagrale *et al*., 2018). Unlike most other legumes, consumption of mungbean results in little flatulence because of the easy digestibility of the protein and carbohydrate (Nair *et al*., 2013). Generally, the consumption of mungbean and sprouts maintains the microbial flora in the gut, and reduces the risks of toxic substance absorption, hypercholesterolemia, coronary heart disease and cancer (Ganesan and Xu, 2018). Keeping in view the above facts the present research has been planned to nutritional qualities and antinutritional contents in mungbean genotypes.

Material and Methods

Seed material

The seeds of ten promising mungbean namely Phule Chetak, Phule Suvarn, Kopergaon, Vaibhav, PM-302-46, PM-707-27, PM-504-20-27, PM-818-8, PM-202-7, PKV-AKM-4 were obtained from Principal Scientist, Pulse Improvement Project, M.P.K.V., Rahuri, which were grown during the year 2022-23

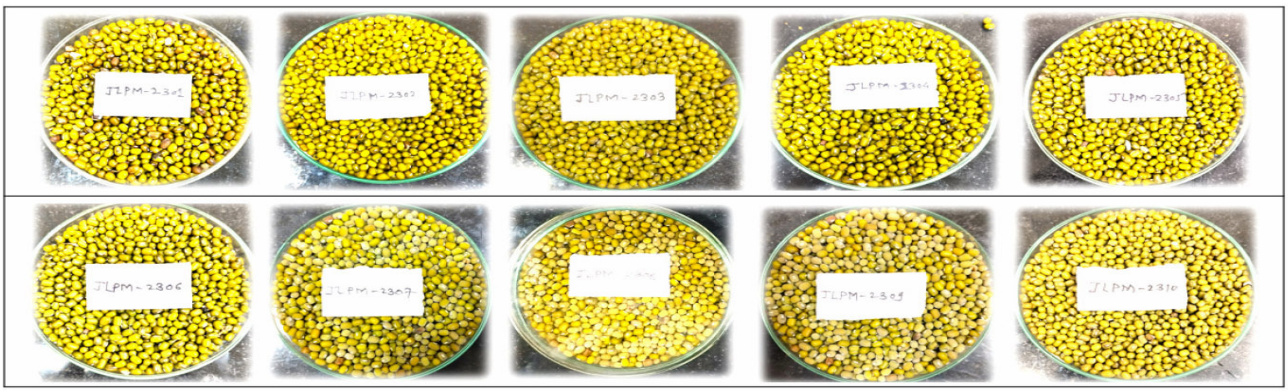

Fig. 1 : Mungbean used for study

Physical properties

Seed colour was determined by using Munsell colour chart. Hundred seeds weight was calculated by using weighing balance in the laboratory. Seed volume was determined by volume displaced by hundred seeds with help of measuring cylinder. Seed density was determined by dividing seed weight by seed volume. Grain hardness was measured by pressing average size well fitted seed under the grain hardness tester (Manufactured by Kiya Seisakusho Ltd., Japan). Force was applied to crack grain by turning the knob. The force in newton displayed on dial at the time of cracking the grain was noted down.

Proximate composition

Seed samples from different chickpea cultivars were estimated for their moisture, crude protein, crude fat, crude fiber and ash content as per standard methods of analysis (AOAC, 1990). Carbohydrate content was determined by difference.

Limiting amino acids

Methionine was estimated by the method described by Mc Carthy and Paille (1959). Tryptophan was determined by the colorimetric method as described by Spice and Chambers (1949).

Mineral composition: Ca, Mg, Zn, Fe, And P

Micronutrients such as Mg, Ca, Zn, Fe in the digested sample were estimated by using the atomic absorption spectrophotometer (Mclaren and Crawford, 1950).

For the determination of P and Mg and micronutrient 1.0 g of defatted sample was digested with di-acid mixture (HNO_3 + HCl) in the ratio of 9:4 and acid extract were used for determination of P, Mg and other micronutrients. (Singh *et al.* 1999).

Antinutritional composition

Determination of phytate phosphorus was performed according to the method of Wheeler and Ferrel (1971). The tannin content was determined by Folin-Denis reagent as described by Swain and Hills (1959). Trypsin inhibitor activity in green gram was determined using BAPANA and the method outlined by Kakade *et al.* 1974.

Result and Discussion

Physical properties of mungbean genotypes

Physical characteristics of pulses are important quality parameters for consumers and these characteristics collectively are referred to as consumer preferences (Singh *et al.* 1993). In pulses seed size, shape and colour, needs to be in accordance with consumer demands. For this reason, there are specific cultivars popular for different regions in the country.

In the present study the physical characteristics *viz,* grain weight, colour, volume, density and hardness were assessed. Variation in grain weight, volume and density of green gram genotypes studied may be due to the genetic variability. Physical characteristics of green gram genotypes are presented in Table.1 and 2 respectively.

Seed colour

In present study the seed colour was studied by using Munsell colour chart, as indicated in Table. 1 Eight genotypes namely, Phule Chetak, Phule Suvarn, Kopergaon, VAIBHAV, PM-707-27, PM-504-20-27, PM-202-7, PKV-AKM-4 showed olive green colour on chart and two genotypes, PM-302-46 and PM-818-8 showed pale olive green colour as per chart.

Hundred seed weight

Hundred grain weight of green gram genotypes ranged from 3.82 to 5.14 g and there was significant varietal difference. Phule Chetak recorded highest seed weight value i.e., 5.14g. this value is par with PM-504-20-27 (4.80 g), PM-818-8 (4.58 g) and PM-202-7 (4.87 g). Lowest seed weight was observed in Kopergaon (3.82g).

Seed volume

As revealed from the results (Table. 2), there was significant variation observed in grain volume among green gram genotypes. It was ranged from 3.60 to 5.20 ml. Lowest seed volume observed in PKV-AKM-4 (3.60 ml) followed by PM-302-46 (3.73 ml), Kopergaon (3.75 ml), PM-504-20-27 (3.80 ml), while highest seed volume recorded in Vaibhav (5.20ml) followed by PM-707-27 (4.70 ml), PM-202-7 (4.15 ml).

Table 1 : Seed coat colour of mungbean genotypes

Name of genotype	Munsell colour chart notations	
Olive Green		
Phule Chetak	5Y 5/2	
Phule Suvarn	5Y 5/3	
Kopergaon	5Y 4/3	
Vaibhav	5Y 5/3	
PM-707-27	5Y 5/1	

PM-504-20-27	5Y 5/2	
PM-202-7	5Y 5/3	
PKV-AKM-4	5Y 4/3	

Pale olive green		
PM-302-46	5Y 6/4	
PM-818-8	5Y 6/4	

Table 2 : Physical properties of mungbean genotypes

Name of genotype	Hundred seeds weight (g)	Seed volume (ml)	Seed density (g/ml)	Seed hardness (N)
Phule Chetak	5.14	4.03	1.27	312.82
Phule Suvarn	4.12	3.88	1.08	429.73
Kopergaon	3.82	3.75	1.03	413.17
Vaibhav	4.07	5.20	1.09	345.25
PM-302-46	3.91	3.73	1.05	329.77
PM-707-27	4.71	4.70	1.00	402.00
PM-504-20-27	4.80	3.80	1.26	429.93
PM-818-8	4.58	4.05	1.13	367.01
PM-202-7	4.87	4.15	1.17	306.25
PKV-AKM-4	4.20	3.60	1.17	405.82
Mean	**4.40**	**4.06**	**1.12**	**371.33**
Range	**3.82-5.14**	**3.60-5.20**	**1.00-1.27**	**306.25-429.93**
S.E.±	**0.07**	**0.06**	**0.05**	**1.08**
CD at 5%	**0.21**	**0.19**	**0.16**	**3.08**

Seed hardness

Seed hardness is one of the important indexes of grain classification. It has close relationship with grain powder, flour quality, seed storage and processing, resist insect pest (Dai *et al.* 2015). The values of seed hardness of mungbean genotypes obtained by using Stable microsystem texture analyzer, indicated in table. 2 and fig. 2. It was ranged from 306.25 to 429.93 N. Highest seed hardness was recorded in PM-504-20-27 (429.93 N) followed by Phule Suvarn (429.73 N), Kopergaon (413.17 N) and lowest seed hardness was observed in PM-202-7 (306.5 N).

Among the various physical characteristic's studies seed colour, seed hardness, seed weight and seed density are found to be major determinants of the quality of pulses. Pulses with higher values of seed weight and seed density are found to be more acceptable among consumers.

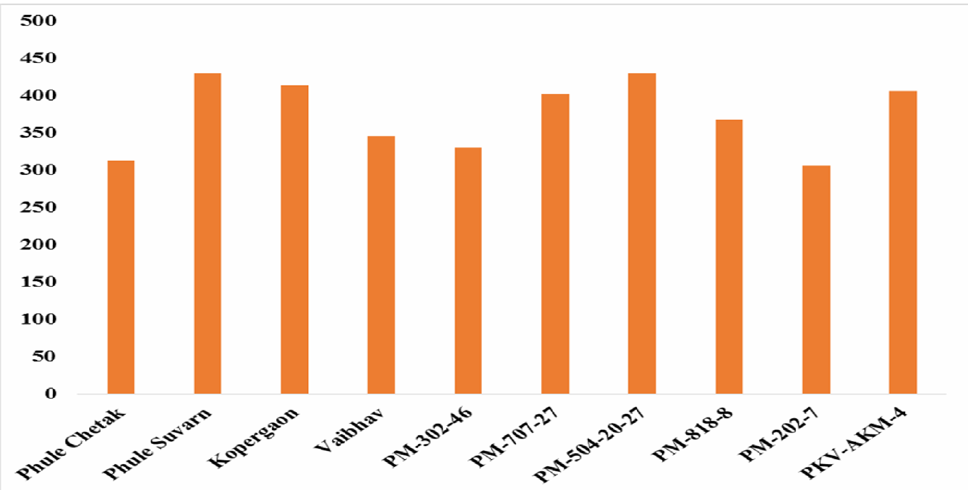

Fig. 2 : Seed hardness of mungbean genotypes

Proximate composition of the mungbean genotypes

Moisture

Moisture content is one of the most critical factors that determines the quality of mungbean seeds. The results on moisture content in the seeds of mungbean genotypes are presented in Table. 3 and Fig. 3. The moisture content ranged from 9.0-10.50 percent with a mean value of 9.60 percent. The highest moisture content of 10.5 percent was observed in PM-302-46 followed by the genotypes Kopergaon (10.27%) and PM-302-46 (10%), while the lowest moisture content of 9.0 percent was observed in PM-202-7 followed by PM-818-8 (9.20%) and PKV-AKM-4 (9.40%).

These values for moisture content are in agreement with the reported values by earlier researchers: 8.78-9.30 percent (Bhatty *et al.,* 2000), 8.39 percent (Nimkar and Chattopadhyay, 2001); 9.7 percent (Mubarak, 2005); 9.4 percent (Habibulah *et al.,* 2007); 9.16 to 9.26 percent (Kakati *et al.* 2010); 10.11 percent (Onwuka *et al.,* 2010); 10.85 percent (Oburbaga and Anyika ,2012); 9.8 percent (Dahiya *et al.,* 2010); 10.86 percent (Pandiselvam *et al.,* 2017); 5.9-11.3 percent (Danial *et al.,* 2018); 11.33 percent (Upendra *et al.,* 2021); 10.1-10.6 percent (Olufelo and Eze., 2023).

Crude protein

Nutritional value of food protein is expressed in terms of a number of parameters such as chemical score, digestibility coefficient, biological value, protein efficiency ratio and net protein utilization. Mungbean protein has relatively better-balanced amino acid composition. However, nutritionally inferior to whole egg protein. The values for crude protein content in mungbean seed is presented in Table. 3 and Fig.3. These values indicated significant varietal variations in protein content. It was ranged from 18.37 to 21.76 with average value of 19.67 percent. The lowest value for protein is observed in PM-202-7 (18.37%) followed by Vaibhav (18.56 %), Phule Suvarn (18.81%) and the highest value of 21.76 per cent is found in PM-818-8 followed by PM-707-27 (20.56%) and Kopergaon (20.33%).

The values for protein content in mungbean varieties reported by earlier researchers are as follows: 26.78 percent (Mubarak, 2005); 23.7 percent (Habibulah *et al.,* 2007); 22.96 to 23.96 percent (Kakati *et al.,* 2010); 21.08 percent (Li *et al.,* 2010); 28.38 percent (Onwuka *et al.,* 2010); 27.67 percent (Oburbaga and Anyika, 2010); 23.8 percent (Dahiya *et al.,* 2015); 27.6 percent (Daniel *et al.,* 2018); 15.8-24.89 percent (Nagrale *et al.*2018); 26.78 percent (Upendra *et al.,* 2021); 17.36-24.98 percent (Wang *et al.,* 2021); 24.40-25.50 percent (Zafar *et al.,* 2023).

Crude fat

Linoleic and Linolenic acids are the important unsaturated fatty acids present in mungbean seeds and are required for growth physiological functions of the body. Values recorded for the crude fat content of different mungbean genotypes are mentioned in Table. 3 and Fig.3. It was ranged from 0.95-1.97 per cent. The genotype PKV-AKM-4 has highest crude fat content of 1.97 percent followed by Phule Chetak (1.90%), Phule Suvarn (1.70%), PM-707-27 (1.60%), while the genotype PM-818-8 has the lowest crude fat content at 0.95 percent. The mean crude fat content observed in mungbean genotypes was 1.50 percent.

The values for crude fat content for mungbean seeds by earlier researchers are as follows : 1.4 percent (Kylen and Mc Cready, 1975); 2.4 percent (Fordham *et al.,* 1975; Sharma *et al.,* 1991); and 1.3 percent (Gopalan *et al.,* 1982 and Singh and Singh, 1992); 1.14 to 1.73 percent (Suneeta *et al.,* 1983); 2.01 percent to 2.41 percent, 1.85 percent (Mubarak, 2005); 1.9 percent (Habibulah *et al.,* 2007); 1.60 to 1.67 percent (Kakati *et al.,* 2010); 1.89 percent (Onwuka *et al.,* 2010); 1.75 percent (Oburbaga and Anyika, 2010); 0.17-5.82 percent (Dahiya *et al.,* 2015); 1.9-2 percent (Daniel *et al.,* 2018); 1.52 percent (Upendra *et al*., 2021).

Crude fiber

For a healthy bowel movement, crude fiber is a necessary component. Additionally, it has been documented that dietary fiber helps to reduce blood cholesterol levels. Table 3 and Fig. 3 shows the reported values for the crude fiber content in mungbean genotypes. It was in range of 3.50 to 4.50 percent. This shows that mungbean genotypes possess varying amounts of crude fiber. PM-504-20-27 showed the greatest crude fiber content of 4.50 percent followed by PM-818-8 (4.40 %), PKV-AKM-4 (4.10 %), while Phule Suvarn has the lowest measured crude fiber content of 3.50 percent. The mean crude fiber content is of 4.06 percent.

These values for crude fibre content compared and concluded that all agree very well with the reported values for mungbean genotypes are as follows: 4.9 percent (Kylen and Mc Cready, 1975); 4.0 percent (Krishnamurthy and Rao, 1976); and 3.66 to 4.77 percent (Suneeta *et al.,* 1983); 1.2-8.1percent (Reddy *et al.,* 1984); 4.63 percent (Mubarak, 005); 6.8 percent (Habibullah *et al.,* 2007); 4.12 to 4.07 percent (Kakati *et al.,* 2010); 4.05 percent (Onwuka *et al.,* 2010); 4.34 percent (Oburbaga and Anyika, 2010); 3.8-6.15 percent (Dahiya *et al.,* 2015); 4.78 percent (Upendra *et al*., 2021); 3.22-6.76 percent (Zafar *et al.,* 2023).

Ash

The amount of minerals in the grain is indicated by its ash content. Table. 3 and Fig.3 indicates the recorded values for the ash content in various mungbean genotypes. With a mean value of 3.31 percent, the range of ash content in the flour derived from various genotypes was 3.00 to 3.60 percent. PM-302-46 recorded lowest ash content, 3.0 percent, while Phule Suvarn had the highest recorded ash content i.e., 3.60 percent. The mungbean genotypes varied significantly based on the ash content values.

Ash content in different mungbean varieties reported by earlier researchers were varied from: 3.7 percent (Mubarak,2005); 3.9 percent (Habibullah *et al.,* 2007); 3.22-3.27 percent (Kakati *et al.,* 2010); 1.20 percent (Onwuka *et al.,* 2010); 3.1-4 percent (Tapash *et al.,*2011); 3.3 percent (Oburbaga and Anyika, 2012); 3-5.8 percent (Dahiya *et al.,* 2015); 3.1-3.5 percent (Danial *et al.,*2018); 3.1-4 percent (Nagrale *et al.,*2018); 3.71 percent (Upendra *et al.,* 2021); 2.78-3.5 percent (Wang *et al.,* 2021); 3.56-3.78 percent (Zafar *et al.*, 2023).

Total carbohydrates

The Table 3 and Fig.3 indicates the recorded values for the amount of carbohydrates of genotypes of mungbean. It was ranged between 61.07 to 63.01 percent. PM-202-7 had the highest carbohydrate content of 63.01 percent this value is at par with Phule Suvarn (62.89%), JLP-2306 (62.55%) while PM-818-8 recorded lowest carbohydrate content of 61.07 percent. Mean value for carbohydrates is 62.03 percent. The findings show that the different mungbean genotypes differ significantly in carbohydrate content.

Previous reported values for the carbohydrate content of mungbean grains are as follows: 55.1 to 62.2 percent (Shobhana *et al.,*1976); 60.84 percent (Krishnamurthy and Rao, 1976); 56.7 percent (Gopalan *et al.,* 1982) and (Singh and Singh, 1992); 62.55 to 64.55 percent (Sharma *et al.,* 1991); 62.3 percent (Mubarak *et al.,* 2005); 56.87 to 57.23 percent (Kakati *et al.,* 2010); 54.47 percent (Onwuka *et al.,* 2010); 53.38 percent (Oburbaga and Anyika, 2012); 53.3-67.1 percent (Dahiya *et al.,* 2015); 51.89 percent (Upendra *et al.,* 2021).

Table 3 : Proximate composition of mungbean genotypes

Name of genotype	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Carbohydrate (%) (by difference)
Phule Chetak	9.33	20.12	1.90	3.70	3.50	61.45
Phule Suvarn	9.43	18.81	1.50	3.50	3.60	62.89
Kopergaon	10.27	20.33	1.20	4.32	3.55	62.17
Vaibhav	9.57	18.56	1.40	4.00	3.00	61.59
PM-302-46	10.00	19.59	1.70	4.10	3.00	62.29
PM-707-27	10.50	20.56	1.60	3.90	3.50	62.55
PM-504-20-27	9.60	19.43	1.30	4.50	3.10	61.50
PM-818-8	9.20	21.76	0.95	4.40	3.30	61.07
PM-202-7	9.00	18.37	1.50	3.90	3.50	63.01
PKV-AKM-4	9.40	19.50	1.97	4.30	3.10	61.84
Mean	**9.60**	**19.70**	**1.50**	**4.06**	**3.31**	**62.03**
Range	**9.0-10.5**	**18.37-21.76**	**0.95-1.97**	**3.50-4.50**	**3.00-3.60**	**61.07-63.01**
S.E.±	**0.23**	**0.47**	**0.04**	**0.13**	**0.09**	**0.91**
CD at 5%	**0.60**	**1.19**	**0.12**	**0.40**	**0.26**	**1.82**

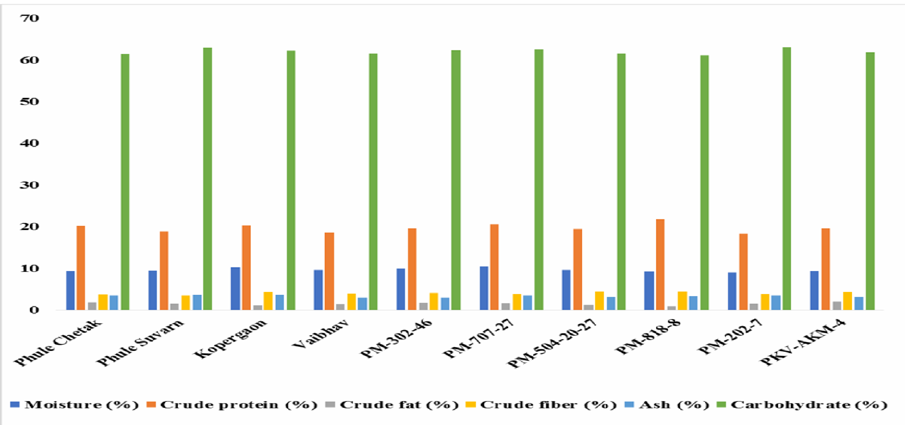

Fig. 3 : Proximate composition of mungbean genotypes

Limiting amino acid in mung bean genotypes

The amino acid composition of legume proteins has been widely examined and it has been reported that legume proteins are mainly deficient in sulphur-containing amino acids, methionine and tryptophan but are rich in lysine which is relatively deficient in cereals (Gupta, 1982). Thus, the combination of cereals and legumes provides a good balance of amino acids, since cereals supply adequate methionine and pulses supply lysine. Among the commonly cultivated pulses, green gram proteins are relatively had a better balanced in their amino acid composition. The values for methionine and tryptophan content in ten mungbean genotypes are presented in Table 4 and Fig. 4;

Methionine

As presented in Table.4 and Fig.4, the methionine content in selected genotypes is ranged from 0.81 to 0.94 g/16g N. The highest methionine content of 0.94 g/16g N is observed in PM-202-7 while the lowest methionine content is recorded in PKV-AKM-4 (0.81 g/16g N). The mean of methionine content of ten mungbean genotypes is 0.84 g/16g N.

The values for methionine content in the mungbean genotypes reported by other researchers are as follows: 1.0 g/16g N (Kuppuswamy *et al.,*1958); 1.5 g/16g N (Hanumanth Rao and Subramanian.,1970); 1.5 g/16g N (Nagpal and Bhatia.,1971); 0.55 to 1.78 g/16g N (Yohe and Poehlman.,19720); 97 to 1.72 g/16g N (Shobhana *et al.,*1976); 1.43 g/16g N (Chavan and Duggal., 1978); 1.39 g/16g N (Geerwani and Theophilus.,1980); 1.2 g/16g N (Bhatty.,1982); 0.86 to 1.60 g/16g N (Sood *et al.,*1982); 0.80 to 1.22 g/16g N (Sharma *et al.,*1991); 1.92 g/16g N (Mubarak *et al.,*2005); 0.5-1.9 g/16g N (Dahiya *et al.,*2015).

Table 4 : Limiting amino acids content in mung bean genotypes

Name of genotype	Methionine (g/16g N)	Tryptophan (g/16g N)
Phule Chetak	0.82	0.85
Phule Suvarn	0.85	0.89
Kopergaon	0.83	0.69
VAIBHAV	0.94	0.89
PM-302-46	0.85	0.91
PM-707-27	0.84	0.80
PM-504-20-27	0.84	0.77
PM-818-8	0.83	0.77
PM-202-7	0.89	0.89
PKV-AKM-4	0.81	0.73
Mean	**0.84**	**0.81**
Range	**0.81-0.94**	**0.69-0.91**
S.E.±	**0.04**	**0.03**
CD at 5%	**0.12**	**0.11**

Tryptophan

The tryptophan content in selected genotypes is ranged from 0.69-0.91 g/16g N. The highest tryptophan content of 0.91 g/16g N is observed in PM-302-46 while the lowest tryptophan content is recorded in Kopergaon (0.69 g/16g N). The mean of tryptophan content in mungbean genotypes is 0.81 g/16g N.

The values for tryptophan content in the mungbean genotypes reported by earlier investigators are as follows: 0.4 g/16g N (Patwardhan and Ramchandran, 1960); 0.52 to 0.75 g/16g N (Chatterjee and Abrol, 1975); 0.62 to 0.76 g/16g N (Shobhana *et al.,*1976); 0.5 g/16g N (Geervani and Theophilus, 1980); 0.4 to 0.8 g/16g N (Sood *et al.,*1982); 0.51 to 0.56 g/16g N (Sharma *et al.,*1991); 0.97 g/16g N (Mubarak, 2005); 0.5-1.2 g/16g N (Dahiya *et al.,*2015).

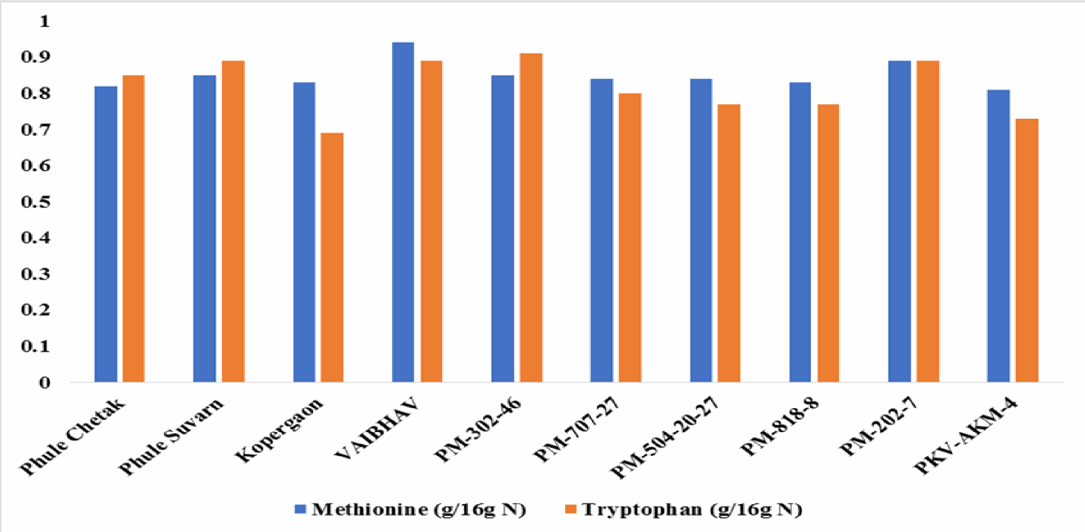

Fig. 4 : Limiting amino acids content in mung bean genotypes

Mineral composition of mungbean genotypes

Legumes are a rich source of minerals. Phosphorus, calcium and magnesium are the major minerals present in common pulses whereas zinc, copper, iron and manganese are the minor ones (Singh *et al.,* 1977). Mineral composition of mungbean genotypes is indicated in Table 5 and Fig. 5 respectively.

Phosphorus

The phosphorus content in the seeds of mungbean shows significant variation as shown in Table 5 and Fig. 5. So, phosphorus content in the mungbean genotypes ranged between 270.28 to 353.46 mg/100g. Highest value of 353.46 mg/100g was observed in Phule Suvarn followed by 343.50 mg/100g (Kopergaon), 334.60 mg/100g (PM-202-7) while lowest phosphorus content of 270.28 mg/100 g was observed in Vaibhav.

Calcium

As indicated in Table 5 and Fig. 5, calcium content in the mungbean genotypes ranged between 137.50 to 172.57 mg/100 g, with mean value of 154.81 mg/100g. Lowest value for calcium content was observed in Phule Chetak (137.50 mg/100g) followed by the genotypes namely Kopergaon (142.54 mg/100g), PM-302-46 (147.51 mg/100g), while highest calcium content was observed in Vaibhav (172.57 mg/100g).

Magnesium

The magnesium content in selected genotypes shows significant variation, as shown in Table.5 and Fig.5. Magnesium content in mungbean genotypes ranged between 162.82 to 190.75 mg/100g. Highest value of 190.75 mg/100g was observed in Vaibhav followed by 189.58 mg/100g (PM-302-46), 183.84 mg/100g (Phule Suvarn) while lowest phosphorus content of 162.82 mg/100 g was observed in PM-504-20-27.

Table 5 : Mineral's composition in mungbean genotypes

Name of genotype	Phosphorus (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
Phule chetak	326.37	137.50	170.00	8.02	0.95
Phule Suvarn	353.46	155.06	183.84	7.05	1.30
Kopergaon	343.50	142.54	180.58	8.84	0.98
Vaibhav	270.28	172.57	190.75	7.03	1.14
PM-302-46	322.45	147.51	189.58	8.40	1.25
PM-707-27	328.20	166.02	176.50	8.91	1.28
PM-504-20-27	331.70	160.75	162.82	8.74	0.95
PM-818-8	320.68	154.95	178.25	9.22	1.24
PM-202-7	334.60	149.20	180.01	7.40	1.06
PKV-AKM-4	278.10	165.75	169.50	8.22	1.18
Mean	**319.88**	**154.81**	**177.98**	**8.14**	**1.12**
Range	**270.28-353.46**	**137.50-172.57**	**162.82-190.75**	**7.03-9.22**	**0.95-1.30**
S.E.±	**1.04**	**1.46**	**1.07**	**0.10**	**0.03**
CD at 5%	**3.09**	**4.33**	**3.16**	**0.30**	**0.11**

Iron

As showed in Table.5 and Fig.5, Iron content in the mungbean genotypes ranged between 7.09 to 9.22 mg/100 g, with mean value of 8.14 mg/100g. Lowest value for calcium content was observed in Vaibhav (7.03 mg/100g) followed by the genotypes Phule Suvarn (7.05 mg/100g), PM-202-7 (7.40 mg/100g), while highest Iron content was observed in PM-818-8 (9.22mg/100g).

Zinc

Zinc content in selected mungbean genotypes ranged between 0.95-1.30 mg/100g as mentioned in Table.5 and Fig.5. The mean value of 1.12 mg/100g. Highest value of 1.30 mg/100g was observed in Phule Suvarn followed by 1.28 mg/100g (PM-707-27), 1.25 mg/100g (PM-302-46) while lowest phosphorus content of 0.95 mg/100 g was observed in PM-504-20-27. The mineral composition of green gram seeds reported by several workers is as follows: Fordham *et al*, 1975 (Calcium, 307 mg; phosphorus, 327 mg and potassium, 961 mg/100g of dry matter.

Rao and Deosthale (1981) examined the mineral composition of four Indian legumes. In green gram, they observed calcium, 55 mg/100g and phosphorus, 271 mg/100g. They also found that the cotyledons of these legumes were significantly lower in calcium content as compared to the whole grain.

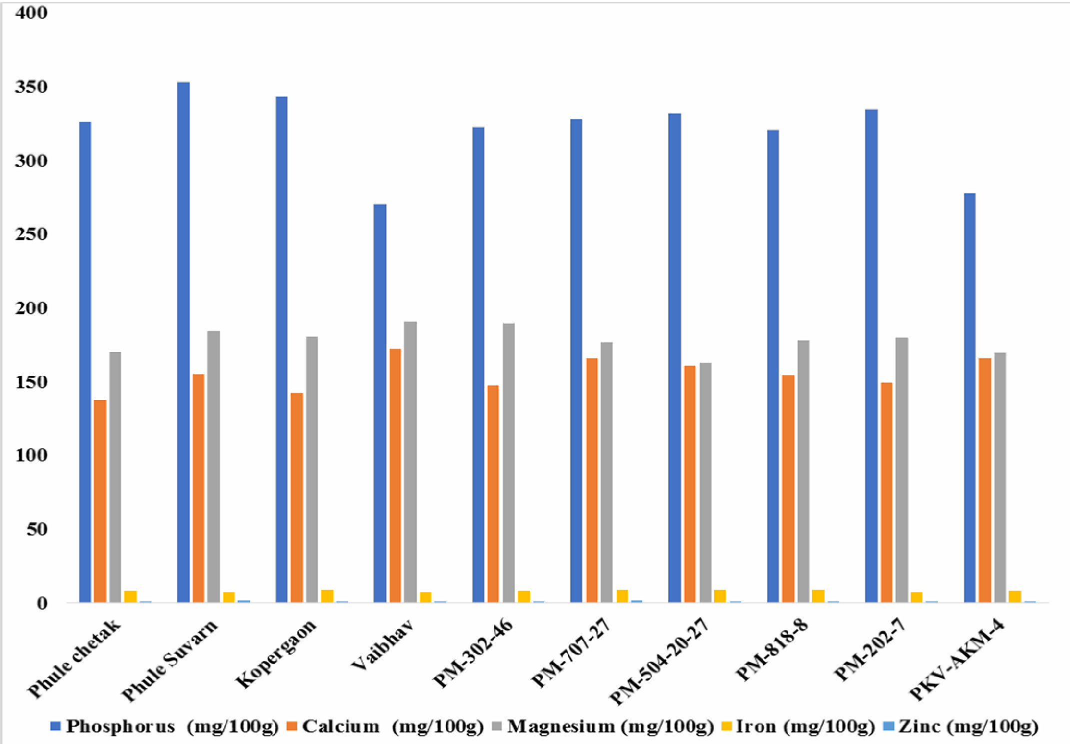

Fig. 5 : Minerals composition in mungbean genotypes

Antinutritional content in mungbean genotypes

Polyphenols

Plant-derived these components have played an important role in the treatment and avoid human diseases. Therefore, the biological screening provides a scientific basis for validating the traditional utilization of medicinal plants. These bioactive constitutes of grain legumes make them suitable for creating new functional foods (Aguilera *et al.,* 2011). Antioxidant activity of phenolic compounds present in edible grain legume seeds have been investigated in recent studies (Karamać *et al.,* 2004, Amarowicz *et al.,* 2008, Orak *et al.,* 2016).

In the present study polyphenols content in seeds of mungbean genotypes are depicted in Table 6 and Fig. 6. The polyphenol content in mungbean genotypes was ranged from 340.78-361.67 mg/100g. The highest polyphenol content of 361.67 mg/100g is observed in Phule suvarn while the lowest polyphenol content was recorded in PM-504-20-27 (340.78 mg/100g). The mean obtained for polyphenol content in selected mungbean genotypes is 352.47 mg/100g.

The values for polyphenols content in the mungbean genotypes reported by earlier investigators are as follows: 808 mg/100g (Kataria *et al.,* 1989); 325 mg/100g (Tajoddin *et al.,*2013); 285-808 mg/100g (Dahiya *et al.,*2015); 310-340 mg/100g (Debashmita *et* *al.,*2018); 771.39 mg /100g (Upendra *et al.,*2021). The present results for polyphenols content in mungbean genotypes used are quite related to these reported values.

Phytate phosphorus

Phytic acid, commonly known as phytate, is widely distributed in plant seeds and grains. It is primarily present as a salt of mono- and divalent cations (K^+, Ca^{++} and Mg^{++}). Phytate rapidly accumulates in the seed during the ripening period (Deshpande and Cheryan, 1984) and hence may result in lowering the digestibility of proteins (Knuckles *et al.,* 1985) and also reduce the starch digestibility (Yoon *et al.,* 1983). It plays an important role in improving the nutritional status of grains (Lorenz, 1983). The phytate content of legumes varies from 0.40 to 2.0 per cent depending upon the species and the variety and most of it is present in the outer aleurone layers of the cotyledons or the endosperm (Deshpande *et al.,* 1982).

Present study phytate phosphorus content in seeds of ten mungbean genotypes are depicted in Table 6 and Fig.6, the phytate phosphorus content in mungbean genotypes is ranged between 63.20 to 69.65 mg/100g. The highest phytate content of 69.65 percent was observed in PM-202-7 while the lowest phytate content was observed in (63.20 mg/100g).

Various researchers have reported the evaluated values phytate content in mungbean are: 63.2 mg/100g (Ravindran *et al.,*1976); 58 mg/100g (Mubarak *et al,* 2005); 66.47 mg/100g to 69.24 mg/100g (Kakati *et al.,* 2010); 57.62 mg/100g (Oburbaga and Anyika, 2010); 44.80 mg/100g (Dahiya *et al.,* 2015); 65 to 68 mg/100g (Dhole *et al.,* 2015); 62.27 mg/100g (Sing *et al.,* 2015); 72.2-94 mg/100g (Bindu *et al.,* 2018); 62.65 mg/100g (Upendra *et al.,* 2021). These values are in good agreement with the phytate phosphorus in mungbean genotypes observed in the present investigation.

Table 6 : Antinutritional content in mungbean genotypes

Name of genotype	Polyphenol (mg/100g)	Phytate Phosphorus (mg/100g)	Trypsin inhibitor (TIU/mg)
Phule Chetak	355.79	63.79	12.10
Phule Suvarn	361.67	64.55	14.17
Kopergaon	348.43	67.46	12.47
Vaibhav	359.39	68.78	12.25
PM-302-46	340.66	63.20	13.73
PM-707-27	351.23	68.38	13.93
PM-504-20-27	351.78	65.96	12.37
PM-818-8	343.28	63.31	13.35
PM-202-7	355.14	69.65	13.57
PKV-AKM-4	357.97	66.26	13.15
Mean	**352.47**	**66.09**	**13.08**
Range	**340.78-361.67**	**63.20-69.65**	**12.10-14.17**
S.E.±	**0.04**	**0.05**	**0.03**
CD at 5%	**0.13**	**0.16**	**0.11**

Trypsin inhibitor

Trypsin inhibitors are the characteristic constituents of legume grains and are known to affect the digestibility and protein quality of legumes (Macrae, *et al*, 1993). Legumes TIs are classified in 2 families according to their molecular size: Kunitz (KTIs), with molecular weights around 20 kDa and Bowman-Birk (BBTIs) of approximately 8 kDa. Soyabean has both families' trypsin inhibitor whereas mung bean, cowpea, lentil, etc. have only BBTIs family trypsin inhibitor (Vanderven *et al.,* 2005).

The trypsin inhibitor activity of mungbean genotypes as showed in Table 6 and Fig. 6, which is ranged between 12.10-14.17 TIU /mg. The highest value for trypsin inhibitor of 14.17 TIU/mg is observed in Phule Suvarn while the lowest trypsin inhibitor content is observed in Phule Chetak (12.10 TIU/mg) followed by Vaibhav (12.25 TIU/mg), PM-504-20-27 (12.37 TIU/mg). The mean of trypsin inhibitor content in mungbean genotypes is 13.08 TIU/mg.

These values are in good agreement with the reported values by earlier workers: 1.83 TIU/mg (Lorenson *et al.,* 1981); 15.8 TIU /mg (Mubarak, 2005); 2.50-2.56 TIU/mg (Kakati *et al.,* 2010); 12.6-24.1 TIU/mg (Dahiya *et al.,* 2018); 1.53 -2.05 TIU/mg (Gaxiola *et al.,* 2018).

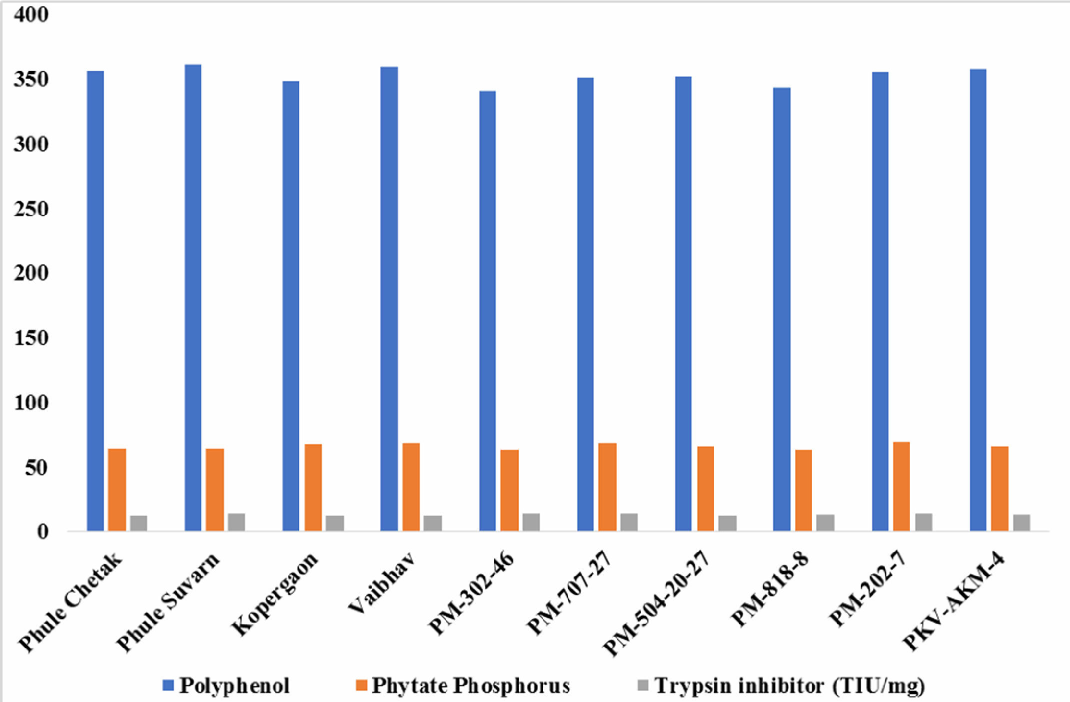

Fig. 6 : Antinutritional content in mungbean genotypes

Correlation study

Seed colour was found to exhibit a significant positive correlation with polyphenols. Seed hardness indicated positive correlation with seed weight (+0.502), seed density (+0.213), crude protein (+0.554) and carbohydrate (+0.191) and negative cor. Crude protein exhibits negative correlation with crude fat and crude fibres. Methionine and tryptophan showed significantly positive correlation with crude protein while showed negative correlation with polyphenols. Carbohydrate found positive correlation with crude protein (+0.091), tryptophan (+0.509) and methionine (+0.514) while it showed significantly negative correlation with antinutritional factors *viz.,* polyphenols (-0.633), phytate phosphorus (-0.609) and trypsin inhibitor (-0.617). Polyphenols and trypsin inhibitor was found negative correlation with crude protein. Phytate phosphorus was found negative correlation with crude protein (-0.136) and minerals like phosphorus (-0.186), calcium (-0.629), magnesium (-0.566) and iron (-0.166).

Table 7 : Correlation coefficient (r) for various chemical constituents in mung bean genotypes

Sr. No	Constituents*	Correlation coefficient (r)
1	Seed hardness to seed weight	+0.502*
2	Seed hardness to seed density	+0.213
3	Seed hardness to crude protein	+0.554**
4	Seed hardness to carbohydrates	+0.191
5	Crude protein to crude fat	-0.177
6	Crude protein to crude fiber	-0.187
7	Methionine to crude protein	+0.514
8	Methionine to polyphenol	-0.098
9	Tryptophan to crude protein	+0.509
10	Tryptophan to polyphenol	-0.102
11	Carbohydrate to crude protein	+0.091
12	Carbohydrates to methionine	+0.514*
13	Carbohydrates to tryptophan	+0.424
14	Carbohydrates to polyphenols	-0.633**
15	Carbohydrates to phytate phosphorus	-0.609**
16	Carbohydrates to trypsin inhibitor	-0.617**
17	Polyphenols to crude protein	-0.227*
18	Trypsin inhibitor to crude protein	-0.297
19	Phytate phosphorus to phosphorus	-0.186
20	Phytate phosphorus to calcium	-0.629**
21	Phytate phosphorus to magnesium	-0.566**
22	Phytate phosphorus to crude protein	-0.136
23	Phytate phosphorus to iron	-0.166

*Significant at the 5% level, **Significant at the 1% level

(Crude protein, crude fiber, crude fat and total carbohydrates were expressed as percent (%), tryptophan and methionine were expressed as g/16 N, Phosphorus, calcium, magnesium, iron, zinc, polyphenol and phytate phosphorus were expressed as mg/100gm, seed weight expressed as gm, seed density was expressed as gm/dm^3, seed hardness was expressed an N (Newton) and trypsin inhibitor was expressed as TIU/mg.)

Conclusion

Based on the data obtained on proximate composition Kopergaon, PM-302-46, PM-707-27, PKV-AKM-4 genotypes of mungbean were found to be superior over other genotypes. As far limiting as amino acids are concerned, all genotypes were found deficient in these amino acids. However, within these Vaibhav, PM-302-46 and PM-202-7 are found promising for methionine and tryptophan content when compared with FAO values.As per the mineral composition all the genotypes are good source of minerals like phosphorus, calcium and magnesium and poor source of Iron and zinc respectively. Antinutritional principles viz., polyphenols, phytate phosphorus lowest in pale olive green-coloured genotypes viz., Vaibhav and PM-818-8 and lowest trypsin inhibitor are found in Phule Chetak, Kopergaon and Vaibhav genotypes of mungbean. Based on above results it can be concluded that genotypes Phule Chetak, Kopergaon, Vaibhav, PM-707-27 and PM-818-8 were found to be promising for nutritional composition, limiting amino acids, minerals and antinutritional constituents.

Future Prospects

Current study helps in identifying genotypes with optimal balance of physical, nutritional, and minimal antinutritional factors. This could lead to the development of high-yielding, nutritious mungbean varieties that are better suited for human consumption and animal feed. The information obtained beforehand can be utilized by the Pulse Breeders in their breeding strategies, and varietal improvement projects of mungbean for higher proximate principles, minerals, limiting amino acid composition and low level of antinutritional factors for contributing to global food security and sustainable agriculture.

References

Abdel-Rahman, E. S. A., El-Fishawy, F. A., El-Geddawy, M. A., Kurz, T. and El-Rify, M. N. 2007). The changes in the lipid composition of mung bean seeds as affected by processing methods. *Int. J. Food Eng*. **3**:1–10.

Abdullah, A and Baldwin, R. E. (1984). Mineral and vitamin contents of seeds and sprouts of newly available small seeded soybeans and market samples of mungbean. *J. Food Sci.* **49**:656-657.

Abeykoon, A. M. C. N., Herath, H. M. T. and Jayasinghe, M. A. (2021). In-vitro analysis of trypsin and alpha-amylase inhibitory activities in selected legume varieties in Sri Lanka. *Asian Food Science Journal*, **20**(1), 1-9.

Adhikari, S., Schop, M., de Boer, I. J. and Huppertz, T. (2022). Protein quality in perspective: a review of protein quality metrics and their applications. *Nutrients*, **14**(5), 947.

Adsule, R. N., Kadam, S. S. and Salunkhe, D. K. (1986). Chemistry and technology of green gram [*Vigna radiata* (L.) Wilczek] *CRC Crit. Rev. Food Sci. Nutr.* **25**: 73-105.

Aguilera, Y., Estrella, I., Benitez, V., Esteban, R. M. and Martín-Cabrejas, M. A. (2011). Bioactive phenolic compounds and functional properties of dehydrated bean flours. *Food Research International*, **44**(3), 774-780.

Amarowicz R, Estrella I, Hernández T, Troszyńka A (2008). Antioxidant activity of extract of adzuki bean and its fractions. *J. Food Lipids*, **15**: 119–136.

Amarowicz R, Weidner S. (2009). Biological activity of grapevine phenolic compounds. In K. A. Roubelakis Angelakis pp. 389–405).

Anwar F, Latif S, Przybylski R, Sultana B, Ashraf (2007). Chemical composition and antioxidant activity of seed of different cultivars of Mungbean. *Journal of food science*.; **72** (7).

AOAC. (2000). Official methods of Analysis, Association of Official Analytical Chemist. Washington, D.C.

Arora, S. K. and Y. P. Luthra (1971). Relationship between sulphur in the leaf with methionine, cysteine, and cystine contents in the seeds of *Phaseolus aureus* as affected by sulphur, phosphorus, and nitrogen application. *Plant Soil.* **34**: 91-95

Aulenbach, B. B., Yeatman, J. N and Worthington, J. T. (1972). *Quality sorting of Red Delicious apples by light transmission* (No. 936). US Department of Agriculture, Agricultural Research Service.

Baker, B.E., Papaconstantiou, J.A., Tross, C.K and Kham, N.A. (1961). Protein and lipid composition of some Pakistani pulses, New York, pp. 2470.

Barroga, C. F., Laurena, A. C. and Mendoza, E. M. T. (1985). Polyphenols in mung bean (*Vigna radiata* (L.) Wilczek) – Determination and removal. *J. Agric. Food Chem.* **33**:1006–1009.

Bhatia, C.R. (1983). Possibilities of seed protein improvement in tropical and sub-tropical legumes. In Seed proteins (Goltschalk, W. and Muller, H.P., eds.), Martinus Nijhoff/ Dr. W. Junk, The Hague, The Netherlands, pp. 451-452.

Bhatty, N., Gilani, A. H. and Ahmad Nagra, S. (2000). Nutritional value of mung bean (*Vigna radiata*) as effected by cooking and supplementation. *Archivos Latinoamericanos de Nutricion*, **50**(4), 374-379.

Bhatty, R. S. (1982). Albumin proteins of eight edible grain legume species. Electrophoretic patterns and amino acid composition. *J. Agric. food chem.* **30**(3), 620-622.

Bindu, B. M., Ashwini, M., Vijaykumar, A. G. and Kasturiba, B. (2017). Nutrition composition and antinutritional factors of green gram varieties. *Environ. Ecol*. **35** (3), 1699-1703.

Bliss, F.A. and, T.C. (1977). Food legumes – Compositional and nutritional changes induced by breeding. *Cereal Food World* **22**: 106-113.

Bouchard, J., Malalgoda, M., Storsley, J., Malunga, L., Netticadan, T. and Thandapilly, S. J. (2022). Health benefits of cereal grain-and pulse-derived proteins. *Molecules*, **27**(12), 3746.

Bressani, R. and Elias, L. G. (1980). Nutritive value of legume crops. In: Advances in legume sciences (Summerfield, R. J. and Bunting, A. H., ed.), HMSO, Royal Botanic Gardens, Kew, p.139.

Butt M.S., Batool R (2010). Nutritional and Functional Properties of Some Promising Legumes Protein Isolates. *Pak. J. Nutr*. **9**(4): 373-379.

Chandrasekhar, S. and Harvey, A. K. (1989). Induction of interleukin-1 receptors on chondrocytes by fibroblast growth factor: a possible mechanism for modulation of interleukin-1 activity. *Journal of cellular physiology*, **138**(2), 236-246.

Chatterjee, S. R. and Abrol, Y. P, (1975). Amino acid composition of new varieties of cereals and pulses and nutritional potential of cereal pulse combinations. *J. Food Sci. Technol*. **12**:221- 227.

Chavan, J. K. and Duggal, S. K. (1978). Synergistic effect of different pulses on the protein quality of rice. *J. Sci. Food. Agric*. **29**(3), 230-233.

Cheng, C., Tsou, S. C. S. and Wang, H. (1988). Utilization patterns of mung bean in the Chinesediet. In: Proceedings of the Second International Mung bean Symposium, pp. 498–507. Bangkok, Thailand, November 16–20.

Chopra, S. L and Kanwar, J. S. Analytical Agricultural Chemistry, Kalyani Publisher, Ludhiana, New Delhi. 1978, 344.

Chrispeels, M. J. and Baumgartner, B. (1978). Trypsin inhibitor in mung bean cotyledons: purification, characteristics, subcellular localization, and metabolism. *Plant Physiology*, **61**(4), 617-623.

Dahiya, P. K., Linnemann, A. R., Nout, M. J. R., Van Boekel, M. A. J. S. and Grewal, R. B. (2013). Nutrient composition of selected newly bred and established mung bean varieties. *LWT-Food Science and Technology*, **54**(1), 249-256.

Dahiya, P. K., Linnemann, A. R., Van Boekel, M. A. J. S., Khetarpaul, N., Grewal, R. B. and Nout. (2010).

Dai, F., Han, Z., Zhang, F., Zhao, W., Gao, A. and Li, X. (2015). Research Article Determination Testing of Seed Hardness of Staple Breeding Wheat Seed in Gansu Province of China. *Advance J. Food Sci.Tech.* **7**(4), 260-265.

Daniel, J. B., Van Laar, H., Dijkstra, J and Sauvant, D. (2018). Nutrient composition of selected newly bred and established mung bean varieties. *J. Food Sci. Tech.* **54**(1), 249-256.

Debasmita Chakraborty (2018); Medicinal Role of mung bean Sprouts (*Vigna radiata*) Department of Biotechnology, University of Engineering and Management (UEM), Newtown, Kolkata, West Bengal 700160, IndiaEmaildebasmitac9[at]gmail.com. *International Journal of Science and Research* (IJSR) ISSN: 2319-7064.

Deshpande, S. S. and Cheryan, M. (1984). Effects of phytic acid, divalent cations, and their interactions on α-amylase activity. *J. food sci*. **49**(2), 516-519.

Deshpande, S. S., Sathe, S. K., Salunkhe, D. K. and Cornforth, D. P. (1982). Effects of dehulling on phytic acid, polyphenols, and enzyme inhibitors of dry beans (*Phaseolus vulgaris* L.) *J. Food Sci*. **47**(6), 1846-1850.

Dhage, A.R., Patil, N.D. and Kadam, S.S. (1984). Effect of N and P fertilization on yield and chemical composition of black gram (*Vigna mungo* (L.) Hepper). *Plant Soil*. **81**: 441-444.

Dhole, V. J and Reddy, K. S. (2015). Genetic variation for phytic acid content in mungbean (*Vigna radiata* L. Wilczek). *The Crop Journal*, **3**(2), 157-162.

Duke, J. A. (1981). Handbook of Legumes of World Economic Importance, Plenum Press, New York, pp. 293-302.

Eggum, B. O. and Beames, R. M. (1998). The nutritive value of seed proteins. In Seed proteins: biochemistry, genetics, nutritive value (pp. 499-531)m.

El-Adawy, T. A., Rahma, E. H., El-Bedawey, A. A., and El-Beltagy, A. E. (1996). Nutritional potential and functional properties of germinated mung bean, pea and lentil seeds. *Plant Foods for Human Nutrition.* **58**: 1-13.

Elango, D., Rajendran, K., Van der Laan, L., Sebastiar, S., Raigne, J., Thaiparambil, N. A., and Singh, A. K. (2022). Raffinose family oligosaccharides: friend or foe for human and plant health. *Frontiers in Plant Science*, **13,** 829118.

Fan, T. Y. and Sosulski, F. W. (1974). Dispersibility and isolation of proteins from legume flours. *J. Food Sci. Tech*. **7**(4), 256-259.

FAO. 1970. Amino-acid Content of Foods and Biological Data on Proteins. Food and Aericulture Oreanization of the United Nations. Rome, Italy.

FAO/WHO Ad Hoc Expert Committee (1973). Energy and protein requirements. FAO Nutritional Meeting Report Series, no. 52; WHO Technical Report Series, no. 522. Geneva: WHO, 1973.

Felicito, M. R., and Evelyn Mae, T. M. (1990). Physicochemical basis for seed hardness in mung bean (*Vigna radiata* (L.) Wilczek). *J. Agric. Food Chem*. **38**: 29-32.

Fordham, J. R., Wells, C. E. and Chen, L. H. 1975 Sprouting of seeds and nutrient composition of seeds and sprouts. *J. Food Sci*. **40**: 552-556.

Ganai, F. A. (2003). *idas ter of tjtloiafop p* (Doctoral dissertation, Aligarh Muslim University Aligarh (India).

Ganesan, K. and Xu, B. (2018). A critical review on phytochemical profile and health promoting effects of mung bean (*Vigna radiata*). *Food Science and Human Wellness,* **7**(1), 11-33.

Gaxiola, S., Chuck-Hernández, C. and Serna Saldivar, S. O. (2018). Inactivation methods of trypsin inhibitor in legumes: A review. *J. Food Sci*. **83** (1), 17-29. [doi:10.1111/1750-3841.13985].

Gaxiola, S., Chuck-Hernández, C., del Refugio Rocha-Pizaña, M., García-Lara, S., López-Castillo, L. M. and Serna-Saldívar, S. O. (2018). Effect of thermal processing and reducing agents on trypsin inhibitor activity and functional properties of geengram and chickpea protein concentrates. *Lwt*, **98**, 629-634.

Geervani, P. and Theophilus, F. (1980). Effect of home processing on the protein quality of selected legumes. *J. Food Sci.* **45**(3), 707-710.

Gopalan C. The Changing nutrition scenario. *Indian J. Medical Research*. 2013; **138**:392- 397.

Gopalan, C, Sastri, B. V. R. and Balasubramanian, S. C. 1982. In: Nutritive Value of Indian Foods, National Institute of Nutrition, Hyderabad, pp. 62-64.

Griffiths, A. G. and Savage, G. P. (1991). Reviews (Series A). *Nutrition*, **61**(4).

Gupta, Y. P and Das, N. B. (1955). Amino-acid content of pure strains of Indian pulses. 1. Methionine, cystine and tryptophane. *Annals of Biochemistry and Experimental Medicine*, **15**, 75-78.

Gupta, Y. P. (1982). Nutritive value of food legumes. In. Chemistry and Biochemistry of Legumes (Arora, S. K., ed), Oxford and IBH publishing, Co., New Delhi, India, pp. 287-327.

Habibullah, S and Abbas, M. (2007). Proximate and mineral composition of mung bean. *Sarhad J. Agric.* (Pakistan), **23**(2).

Hanumantha Rao, K. and Subramanian, N. (1970). Essential amino acid composition of commonly used Indian pulses by paper chromatography. *J. Food Sci. Tech*. **7**(1), 31-34.

Hou, D., Yousaf, L., Xue, Y., Hu, J., Wu, J., Hu, X., Feng, N. and Shen, Q. (2019). Mung bean: Bioactive polyphenols, polysaccharides, peptides and health benefits. *Nutr*. **11** (6). [doi:10.3390/nu11061238].

Huang, S. C., Cheng, T. C. and Hwang, D. F. (2013). Effect of mung-bean fibre on acidification in culture broths using selected intestinal microflora. *African J. Agri*. **8**(26), 3362-3367.

Humphry, M. E., Lambrides, C. J., Chapman, S. C., Aitken, E. A. B., Imrie, B. C., Lawn, R. J., McIntyre, C. L. and Liu, C. J. (2005). Relationships between hard seededness and seed weight in mung bean (*Vigna radiata*) assessed by QTL analysis. *Plant Breeding*. **124**:292–298.

Jadhav, S., and Gawande, V. (2015). Genetics of traits associated with pod borer resistance and seed yield in chickpea (*Cicer arietinum* L.). *Iranian Journal of Genetics and Plant Breeding*, **4**(1), 9-16.

Johnson, S. E., Lauren, J. G., Welch, R. M. and Duxbury, J. M. (2005). A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. *Experimental Agriculture*, **41**(4), 427-448.

Kakade, M. L., Rackis, J. J., McGhee, J. E. and Puski, G. (1974). Determination of trypsin inhibitor activity of soy products: a collaborative analysis of an improved procedure.

Kakati, P., Deka, S. C., Kotoki, D. and Saikia, S. (2010). Effect of traditional methods of processing on the nutrient contents and some antinutritional factors in newly developed cultivars of green gram [*Vigna radiata* (L.) Wilezek] and black gram [*Vigna mungo* (L.) Hepper] of Assam, India. *International Food Research Journal*, **17**(2), 377-384.

Kapoor AC and Gupta YP (1977). Chemical evaluation and electrophoretic pattern of soya protein. *J. Fd. Sci. Agric*. **42**: 1558-1561.

Karamać M, Amarowicz R, Weidner S, Shahidi F, (2004). Antioxidant activity of phenolic fractions of white bean (*Phaseolus vulgaris* L.). *J. Food Lipids*, **11**:165–177.

Kataria, A., Chauhan, B. M., and Punia, D. (1989). Anti-nutrients in Amphidiploids (Black Gram X Mung Bean) - Varietal Differences and Effect of Domestic Processing and Cooking. *Plant Foods for Human Nutrition*. **39**: 257-266.

Katiyar, P. K., Chandra, S., Singh, B. B., Dixit, G. P. and Hasmat, A. (2007). Characterization of mung bean varieties released in India. *Acta Horticul*. **752**:271–273.

Khan, M. A., Jacobsen, I., and Eggum, B. O. (1979). Nutritive value of some improved varieties of legumes. *J. Sci. Food and Agric*. **30**: 395-400.

Khattab, R. Y. and Arntfield, S. D. (2009). Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional factors. *LWT-Food Sci. and Technol*. **42**(6), 1113-1118.

Knuckles, B. E., Kuzmicky, D. D. and Betschart, A. A. (1985). Effect of phytate and partially hydrolyzed phytate on in vitro protein digestibility. *J. Food Sci.* **50**(4), 1080-1082.

Kochar, A. and Hira, C. K. (1997). Nutritional and cooking evaluation of green gram [*Vigna radiata* (L.) Wilezek] cultivars. *Food Sci. and Technol. India*. **34**: 328-330.

Krishnamurthy, K. S., & Rama Rao, G. (1976). Studies on the proteins of green gram. *Indian Food Packer*, **30**(1), 28-33.

Kumar, S., Bhanjana, G., Sharma, A., Sidhu, M.C., Dilbaghi, N. (2014). Synthesis, characterization and on field evaluation of pesticide loaded sodium alginate nanoparticles. *Carbohydr. Polym* **101**, 1061–1067.

Kuppuswamy. S. Srinivasan. M. and Subrahmanyan, V. (1958). "Proteins in Foods." Indian Council of Medical Research, New Delhi. Liener, I.E. (1962). Toxic factors in legumes and their elimination. *Am. J. Clin. Nutr*. **11**: 281.

Kylen, A.M. and McCready, R.M. (1975). Nutrients in seeds and sprouts of alfalfa, lentils, mung beans and soybeans. *J. Food Sci.* **40**: 1008.

Li W, Shu C, Yan S, Shen Q. (2010). Characteristics of sixteen mungbean cultivar and their protein isolated. *International J. food Sci. Tch*. **45**(6):1205- 1211.

Liener, I. E.; Kakade, M. L. (1980) In Toxic Constituents of plant Foodstuffs (Liener, I., Ed.), Academic Press, New York, pp. 7-68.

Lorensen, E., Prevosto, R., & Wilson, K. A. (1981). The appearance of new active forms of trypsin inhibitor in germinating mung bean (*Vigna radiata*) seeds. *Plant Physiology*, **68**(1), 88-92.

Lorenz, K. (1983). Tannins and phytate content in proso millets (*Panicum miliaceum*) M. J. R. (2015). Mung bean: Technological and nutritional potential. *Critical reviews in food science and nutrition*, **55**(5), 670-688.

Mackower, R. U (1970): Changes in phytic acid and acid-soluble phosphorus in maturing pinto beans. *J. Sci. Fd. Agric*. **20**, 82–84.

Macrae, J. C., Baintner, K., Farningham, D. A. H., Bruce, L. A and Pusztai, A. (1993). Fate of the antinutritive proteins of soyabean in the ovine gut. **40**(1-10), 427-431.

McCarthy, T. E. and Paille, S. M. M. (1959). A rapid determination of methionine in crude proteins. *Biochemical and Biophysical Research Communications*, **1**(1), 29-32.

Mclaren, C. A. and Crawford, M. S. (1950). Soil Science. *Society America Journal*. **37**:309.

Mehandi, S., Quatadah, S., Mishra, S. P., Singh, I., Praveen, N. and Dwivedi, N. (2019). Mungbean (*Vigna radiata* L. wilczek): retrospect and prospects. In Legume crops-characterization and breeding for improved food security (pp. 49-66). London: Intech Open.

Mendoza, E. M. T., Barroga, C. F., Rodriguez, F. M., Revilleza, M. J. R. and Laurena, A. C. (1988). Factors affecting the nutritional quality and acceptability of mung bean (*Vigna radiata* (L.) Wilzeck). *Trans. Nat. Acad. Sci. Technol. (Philippines)* **10**:305–322.

Mohapatra, D. and Bal, S. (2012). Physical properties of indica rice in relation to some novel mechanical properties indicating grain characteristics. *Food and Bioprocess Technology*, **5**: 2111-2119.

Molina, M. R., De La Fuente, G. and Bressani, R. (1974). Interrelationships between soaking time, cooking time, nutritive value and other characteristics of beans (*Phaseolus vulgaris*). *Journal of Food Science*. **24**: 469-483.

Morris, Eugene R., Rex Ellis, Priscilla Steele, and Phylis B. Moser (1986). "Mineral balance of adult men consuming whole or dephytinized wheat bran." *Nutrition Research* 8, no. **5**: 445-458.

Mubarak, A. E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (*Phaseolus* *aureus*) as affected by some home traditional processes. *Food chemistry*, **89**(4), 489-495.

Muhammed, T., Manohar, S. and Junna, L. (2010). Polyphenols of mung bean (*Phaseolus aureus* L.) cultivars differing in seed coat colour: Effect of dehulling. *J. New Seeds*. **4**:369–379.

Nagpal, M. L. and Bhatia, I. S. (1971). Tryptophan content of some Indian foods and feeds. *Indian J. Nutrition and Dietetics*, **8**(4), 183-185.

Nagrale, S. C., Patil, A. N., Tayade, N., Jadhav, P. V. and Wakode, Y. S. (2018). Proximate composition and estimation of mineral content from different mungbean (*Vigna radiata* (L). Wliczek) genotypes. *Journal of Pharmacognosy and Phytochemistry*, **7**(4), 3434-3436.

Nair, R. M., Yang, R. Y., Easdown, W. J., Thavarajah, D., Thavarajah, P., Hughes, J. D. A. and Keatinge, J. D. H. (2013). Biofortification of mungbean (*Vigna radiata*) as a whole food to enhance human health. *J. Sci. Food Agric.* **93**(8), 1805-1813.

Nimkar, P. M. and Chattopadhyay, P. K. (2001). Some physical properties of green gram. *J. Agric*. *Eng. Res*. **80**:183–189.

Noor, M. I., Bressani, R. and Elias, L.G. (1980). Changes in chemical and selected biochemical components, protein quality and digestibility of mungbean (*Vigna radiata*) during germination and cooking. *Plant Foods Human Nutr*. **29**:135–144.

Nwokolo, E. and Smartt, J. (Eds.). (1996). *Food and feed from legumes and oilseeds* (pp. 144-158). London: Chapman and Hall.

Oburuoga, A. C. and Anyika, J. U. (2012). Nutrient and antinutrient composition of mungbean, and crayfish. *Pak. J. Nutr*. **11** (9), 814-844.

Olufelo, J. O. and Eze, C. N. (2023). Comparative study of suitable drying methods for storing pigeon pea (*Cajanus cajan*) and mung bean (*Vigna radiata* (l.) r. Wilezek) under humid tropical conditions. *Global Research in Environment and Sustainability*, **1**(3), 28-36.

Onwuka, G. I and Akaerue, B. I. (2010). Evaluation of the yield, protein content and functional properties of mungbean [*Vigna radiata* (L.) Wilczek] protein isolates as affected by processing. *Pakistan Journal of Nutrition*, **9**(8), 728-735.

Onwuka, G. I. (2010). Evaluation of the yield, protein content and functional properties of mungbean [*Vigna radiata* (L.) Wilczek] protein isolates as affected by processing. *Pakistan J. Nutrition*, **9**(8), 728-735.

Onwurafor, E. U., Onweluzo, J. C. and Ezeoke, A. M. (2014). Effect of fermentation methods on chemical and microbial properties of mung bean (*Vigna radiata*) flour. *Nig. Food J*. **32** (1), 89-96.

Orak, H. H., Karamać, M., Amarowicz, R., Orak, A. and Penkacik, K. (2016). Genotype-related differences in the phenolic compound profile and antioxidant activity of extracts from olive (*Olea europaea* L.) leaves. Molecules, **24**(6), 1130.

Pandey, N., Singh, N.B. and Ojha, C.B. (2000). Correlation and path studies for quality characters in field pea. *Indian J. Pulses Res*. **13**: 14-16.

Pandiselvam, R., Thirupathi, V., Kothakota, A. and Kamalapreetha, B. (2017). Important engineering properties of green gram (*Vigna radiate*). *Agricultural Engineering Today*, **41**(4), 30-36.

Paroda, R. S. and Thomas, T. A. (1988). Genetic resources of mungbean (*Vigna radiata* (L.) Wilczek) in India. In: Proceedings of the Second International Symposium, pp. 19–28. Taipei, Taiwan.

Paul, T., Mozumder, N. H. M. R., Sayed, M. A. and Akhtaruzzaman, M. (2011). Proximate composition, mineral contents and determination of protease activity from green gram. Bangladesh. *Res.Pubs. J*.**5**: 207-213.

Peñas, E., Gómez, R., Frías, J. and Vidal-Valverde, C. (2010). Effects of combined treatments of high pressure, temperature and antimicrobial products on germination of mung bean seeds and microbial quality of sprouts. *Food control*, **21**(1), 82-88.

Pokharel, U. (2021). Effect of processing methods on antinutritional factors present in green gram [mung bean] (Doctoral dissertation, Department of Food Technology Central Campus of Technology, Dharan Institute of Science and Technology Tribhuvan University, Nepal August, 2017).

Pokharel, U. (2021). Effect of processing methods on antinutritional factors present in green gram [mung bean] (Doctoral dissertation, Department of Food Technology Central Campus of Technology, Dharan Institute of Science and Technology Tribhuvan University, Nepal August, 2017).

Purohit, P., Rawat, H., Verma, N., Mishra, S., Nautiyal, A., Bhatt, S. and Gupta, A. K. (2023). Analytical approach to assess anti-nutritional factors of grains and oilseeds: A comprehensive review. *J. Agric. Food Research*, 100877.

Ramachandran, M., and Patwardhan, V. N. (1960). Nutritive value of vegetable proteins. 3. Biosynthesis of vitamin B12 and its utilisation in rats on vegetable protein diets. *Indian J. Medical Research*, **48**:243-249.

Randhir, R. and Shetty, K. (2007). Mung beans processed by solid-state bioconversion improves phenolic content and functionality relevant for diabetes and ulcer management. *Innovative Food Science & Emerging Technologies*, **8**(2), 197-204.

Rao, D. S. and Deosthale, Y. G. (1981). Mineral composition of four Indian food legumes. *J. Food Sci*. **46**. 1962-1963.

Ravindran V and M. R., Sayed (1976): Nutritional and anti-nutritional characteristics of Mungbean seeds. *J. Sci. Food Agric*. **46**, 71–79.

Reddy, N. R. and Pierson, M. D. Sathe. SK, and Salunkhe, D. K. (1984). *Chemical, nutritional and physiological aspects of dry bean carbohydrates-A review. Food Chem*, **13**, 25.

Reddy, N. R., Balakrishnan, C. V. and Salunkhe, D. K. (1978). Phytate phosphorus and mineral changes during germination and cooking of black gram (*Phaseolus mungo*) seeds. *Journal of Food Science*, **43**(2), 540-543.

Reddy, N. R., Pierson, M. D., Sathe, S. K. and Salunkhe, D. K. (1989). *Phytates in cereals and legumes*. CRC Press.

Salunkhe D K, Kadam S S and Chavan J K, (1986). *CRC Postharvest Biotechnology of Food Legumes*, 41-43. CRC Press, Florida.

Salunkhe, D. K., Jadhav, S. J., Kadam, S. S. and Chavan, J. K. (1982). Chemical, biochemical, and biological significance of polyphenols in cereals and legumes. *Crit. Rev. Food Sci. Nutr*. **17**:277–305.

Selle, P. H., Ravindran, V., Caldwell, A. and Bryden, W. L. (2000). Phytate and phytase: consequences for protein utilisation. *Nutrition Research Reviews*, **13**(2), 255-278.

Sharma, A. K, Bakshi, A. K. and Verma, M. M. (1991). Proximate comparison and nutritional quality of some improved varieties of mungbean. *Legume Res*. **14**: 197-200.

Shobhana, P. S, Sangawan, H. S, Nanawate, H. S. and Lai, B. M. (1976). Chemical composition of some improved varieties of pulses. *J. Food Sci. Tech*. **13**: 49-59.

Singh, A.B., Ganguly, T.K., Raverkar, K.P., Tripathi, A.K. and Acharya, C.L. (2002). Effect of sulphate and molybdate application on yield and biochemical constituents of soybean (*Glycine max* L. Merr.). *Legume Res*. **25**: 170-174.

Singh, J. (2001). Studies on the morphological, thermal and rheological properties of starch separated from some mungbean cultivars. *Food chemistry*, **75**(1), 67-77.

Singh, K., Dsouza, M. R. and Yogitha, R. (2015). Nutrient content and in vivo reduction of anti-nutrients of mung bean (*Vigna radiata*) under various processing methods. *J. Chem. Biol. Phy. Sci*. **5** (2), 1627-1638.

Singh, S. and Singh, J. P. (1992). Proximate composition, mineral contents and determination of protease activity from green gram. Bangladesh. *Res. Pubs. J* **23**: 207-213.

Singh, T.P., Soni, G.L. and Singh, R. (1977). Biochemical evaluation of the common pulses of the Punjab State. PAU. *J. Res*. **14**: 318-322.

Singh, U. (1993). Methods for dehulling of pulses: A critical appraisal. *J. Food Sci. Tech*. **32**(2), 81-93.

Singh, U., and Eggum, B.O. (1968). Factors affecting the protein quality of mungbean (*Vigna radiata*). *Qualitas Plantarum Plant Foods for Human Nutrition* **34**:273-283.

Skylas, D. J., Molloy, M. P., Willows, R. D., Salman, H., Blanchard, C. L. and Quail, K. J. (2018). Effect of processing on mungbean (*Vigna radiata*) flour nutritional properties and protein composition. *J. Agric. Sci*. **10** (11), 16-28. [doi:10.5539/jas. v10n11p16].

Sompong, U., Somta, P., Raboy, V. and Srinives, P. (2009). Mapping of quantitative trait loci for phytic acid and phosphorus contents in seed and seedling of mungbean (*Vigna radiata* (L.) Wilczek). *Breeding science*, **62**(1), 87-92.

Soni, G.L., George, M. and Singh, R. (1982). Role of common Indian pulses a hypocholesterolaemic agents. *Indian J. Nutrition and Diateics.* **9**: 184 - 190.

Sood M, Malhotra SR, Sood BC (2002) Effect of processing and cooking on proximate composition of chickpea (*Cicer arietinum*) varieties. *J Food Sci Tech.* **39**:69–71.

Sood, D. R., Wagle, D. S. and Dhindsa, K. S. (1982). Studies on the nutritional quality of some varieties of mung bean (*Vigna radiata*). *J. Food Sci. Technol*. **19**:123–125.

Spice, J.T. and Chamber, D.C. (1949). Chemical determination of tryptophan in protein. Analytical Chemistry, **21** (3): 1249.

Srinivasan, T., Duriaraj, C. and Senguttuvan, S. (2007). Role of phytic acid in the resistance of green gram (Vigna radiata (L.) Wilczek) seeds to *Callosobruchus maculatus* Fabricius (Bruchidae: Coleoptera). *Pest Manage. Econ. Zool*. **15**:63–69.

Swaminathan, M.S. and H.K. Jain. (1972). Food Legumes in Indian Agriculture. Nutritional Improvement of food legumes by Breeding Milnered. pp. 69-82.

Swan, J. and Hills, W. E. (1959). Quantitative analysis of phenolic constituents. *J. Sci. Food. Agric*., **10**, 63-67.

Tajuddin, S. N and Aluwi, M. F. (2013). Exploring the potential of biologically active phenolic acids from marine natural products as anticancer agents targeting the epidermal growth factor receptor. *J. Biomolecular Structure and Dynamics*, 1-24.

Tapash NH, Rubel Mozumder, Sayed MA, Akhtaruzzama (2011). Proximate Composition, Mineral contents and Determination of protease activity from green gram. *Bangladesh Research Publication Journal*; **5**(3):207-213.

Thomson, J. and Dolt, H. (1976). Seed Protein Improvement in Cereals and Grain Legumes, Vol. 1. IAEA, Vienna, 109.

Thonta, R. (2023). Analysis of genetic variability, heritability and genetic advance for growth and yield attributes in green gram (*Vigna radiata* L. Wilczek). MH, 934, 20.

Tomooka, N., Lairungreang, C., Nakeeraks, P., Egawa, Y. and Thavarasook, C. (1991). Development of Bruchid-Resistant Mungbean Line Using Wild Mungbean Germplasm in Thailand. *Plant Breeding*, **109**(1), 60-66.

Tsou, C. S., Hsu, M. S., Tan, S. T. and Park, H. G. (1979). The protein quality of mungbean and its improvement. *Acta Hortic*. **93**:279–287.

Unal, H., Isik, E., Izli, N. and Tekin, Y. (2008). Geometric and mechanical properties of mung bean (*Vigna radiata* L.) grain: Effect of moisture. *Int. J. Food Properties*. **11**:585–599.

Urbano, G., Lopez-Jurado, M., Aranda, P., Vidal-Valverde, C., Tenorio, E. and Porres, J. (2000). The role of phytic acid in legumes: antinutrient or beneficial function? *J. physiology and biochemistry*, **56**(3), 283-294.

Vanderven, C., Matser, A. M. and Vandenberg, R. W. (2005). Inactivation of soybean trypsin inhibitors and lipoxygenase by high-pressure processing. *J. Agric. Food Chem*. **53**(4), 1087-1092.

Wang S H, Yang Z M, Yang H, Lu B, Li S Q and Lu Y P (2004), Copper-induced stress and antioxidative responses in roots of *Brassica juncea* L.; *Bot Bull Acad Sin.* **45**: 203–212.

Wang, F., Huang, L., Yuan, X., Zhang, X., Guo, L., Xue, C. and Chen, X. (2021). Nutritional, phytochemical and antioxidant properties of 24 mung bean (*Vigna radiate* L.) genotypes. *Food Production, Processing and Nutrition*. **3**, 1-12.

Wang, N. and Daun, J. K. (2006). Effects of variety and crude protein content on nutrients and anti-nutrients in lentils (*Lens culinaris*). *Food chem*, **95**(3), 493-502.

Werker, E., Marbach, I. and Mayer, A. M. (1979). Relation between the anatomy of the testa, water permeability and the presence of phenolics in the genus Pisum. *Annals of Botany*. **43**: 765-771.

Williams, P.C., Nakoun, H. and Singh, K.B. (1983). Relationship between cooking time and same physical characteristics in chickpea. *Food Agric.* **34**: 492-496.

Worthington R. E., R. O. Hammons. and A. J. R. llison. (1972). Varietal differences and seasonal effects on fatty acid composition and stability of oil from 82. Peanut Genotypes. *J. Agric. Food Chem.* **20**: 727.

Yildiz, U. M. (2005). Some physical properties of mash bean seeds cultivated in Turkey. *S. U. Ziraat Fakultesi Dergisi*. **35**:41–45.

Yohe, J. M. and Poehlman, J. M. (1972). Genetic variability in the mungbean, *Vigna radiata* (L.) Wilczek. *Crop Science*, **12**(4), 461-464.

Yoon, J. H., Thompson, L. U. and Jenkins, D. J. (1983). The effect of phytic acid on in vitro rate of starch digestibility and blood glucose response. *American J. Clinical Nutrition*, **38**(6), 835-842.

Yousif, A. M., Kato, J. and Deeth, H. C. (2003). Effect of storage time and conditions on the seed coat colour of Australian adzuki beans. *Food Aust*. **55**:479–484.

Zafar, S. H., Umair, M. and Akhtar, M. (2023). Nutritional evaluation, proximate and chemical composition of mungbean varieties/cultivars pertaining to food quality characterization. *Food Chemistry Advances*. **2**, 100160.

Zhao, J., Wu, X., Song, X., Lin, H., Yin, J., Nie, S. and Xie, M. (2023). Nutrients, extractable bound phenolic compositions and their antioxidant properties in different varieties of mung beans.