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Nutritional, antinutritional properties and breeding strategies for quality improvement in pulses

A. Thanga Hemavathy◆, S. Kavitha, V. Dhanushkodi, M. Sakila, N. Premalatha and V. Vijayageetha
Department of Pulses, Tamil Nadu Agricultural University, Coimbatore-641046, Tamilnadu, India

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Abstract

Pulses play a crucial role in diets due to their high protein content and abundance of minerals and vitamins. With a substantial share of the world's geographical area and output, India is the top producer and consumer of pulses worldwide. The actual intake in India is far lower, averaging about 30-35 g per day, compared to recommendations by the Indian Council of Medical Research and the World Health Organization for daily per capita consumption at 80 g and a minimum of 47 g, respectively. Pulses are historically ingested in many forms alongside cereals and are essential for vegetarian diets. Among food crops, they have the highest protein content often twice that of cereal grains. On the other hand, while cereal grain proteins are rich in sulfur containing amino acids but lacking in lysine; pulse proteins are generally deficient in sulfur containing amino acids such as cystine and methionine. A balanced amino acid profile is ensured by combining pulses and grains; pulses provide lysine, while cereals provide amino acids that include sulfur. Pulses are rich in vitamins (folate, thiamine, riboflavin, niacin), minerals (potassium, calcium, magnesium, phosphorus, iron), and a wide range of phytochemicals (phenolics, flavonoids, phytates, lectins, tannins, saponins, oxalates, enzyme inhibitors, phytosterols, and antimicrobial peptides) that may have health benefits. However, several anti-nutritional compounds, such as trypsin inhibitor, phenolic compounds, phytates, cyanogenic compounds, lectins and saponins are also found in the legumes. Most of the antinutritional compounds of the pulses are present in the seed coat. Most of these compounds are sensitive to heat and can be substantially reduced by milling, cooking, germination, fermentation and heat processing. Due to its low cost and high protein content, pulses are sometimes referred to as "poor people's meat." This review looks at their nutritional characteristics, antinutritional elements, breeding goals, strategies, and successes.

1. Introduction

Pulses belong to leguminoseae family and include those species that are consumed by human beings and domestic animals, commonly in the form of dry grains and does not include groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) which are grown mainly for edible oil. The Food and Agriculture Organization of the United Nations has declared 2016 as the International Year of Pulses with aims to enhance public awareness of the nutritional benefits of pulses as part of sustainable food production. This was intended towards global food security and nutrition (Narpinder Singh, 2017).

Malnutrition is a major problem, especially in developing and underdeveloped countries (Chaitieng *et al.,*2006). Proper nutrition can attenuate risk factors (*e.g.*, hyperglycemia, hyperlipidemia, and overweight/obesity). However, a general trend towards poor diets continues to increase rates of chronic disease, causing a myriad of associated negative social and economic impacts. Shockingly, treatment of chronic disease alone cost the United States $1.1 trillion in 2016, equivalent to approximately 6% of gross domestic product (GDP).

India is the world's largest producer and consumer of pulses, accounting for 22 per cent of global production and 33 per cent of the world's total area. The nation uses about 23 million hectares of land for pulse cultivation, producing about 15 million tonnes per year. In a similar vein, traditional medicines made from medicinal plants are generally accepted as safer substitutes and have been shown to be effective in treating a range of illnesses (Geetha *et al.,* 2022).

Due to their high protein content and plenty of vitamins and minerals, pulses are essential to diets. Nonetheless, domestic demand and consumption greatly exceed levels of production, primarily due to the fact that a sizable fraction of the vegetarian population depends heavily on pulses as a source of protein (Indumathy *et al.,* 2023). Furthermore, by means of biological nitrogen fixation, pulse farming produces a substantial quantity of nutrient-rich green fodder and contributes to the restoration of soil fertility. Popular pulses including lentils, bengalgram, greengram, redgram and blackgram are consumed in large quantities in India. Important pulses are also grown, including horsegram, lathyrus, cowpea, and mothbean. The actual consumption of pulses in India is much lower, averaging about 30-35 g per day, despite recommendations from the Indian Council of Medical Research and the World Health Organization for a minimum intake of 47 g per day and 80 g per capita, respectively. Pulses have a crucial function in providing critical nutrients for a balanced diet, making them an essential part of vegetarian diets. Pulses have long been an essential component of human meals, frequently appearing in dishes along with grains. Surprisingly, pulses have more protein

Corresponding author: Dr. A.Thanga Hemavathy
Associate Professor, Department of Pulses, CPBG, TNAU, Coimbatore-641006,Tamilnadu, India
E-mail: hemavathytnau@gmail.com
Tel.: +91-9976772474

than any other food crop-typically twice as much as cereal grains. These proteins are notably high in lysine but frequently low in amino acids that include sulfur, such as cystine and methionine. Cereal grain proteins, on the other hand, usually contain enough amounts of amino acids that include sulfur but are low in lysine. Cereals and pulses work together to give a balanced range of amino acids; the former supplies lysine, while the latter provides sulfur-containing amino acids like cystine and methionine. Additionally, this combination has drawn notice for its hypocholesterolemic properties, which successfully lower blood cholesterol levels (Warrier, (2021). Therefore, promoting the addition of legumes to cereals has become a smart move in the fight against protein energy malnutrition in poor countries.

2. Nutritional quality in pulses

2.1 Protein

Pulses contain between 17% and 43% protein (Table 1), with the majority of the protein being contained in the cotyledons and embryonic axis and only a little portion in the seed coat. Across all farmed pulse species, there is a significant amount of variation in seed protein, which can be attributed to various factors including cultivars, growing season, soil and climate, and management techniques. Essential amino acids vary widely in pulse proteins, generally considered. They are rich in lysine but frequently deficient in sulfur-containing amino acids like tryptophan and methionine (Bean and Lookhart, 2001). The cultivation environment has an impact on the amino acid composition of pulse crops. Methionine levels can be impacted by elements such as the application of phosphorus, molybdenum, and nitrogen. Pulses have a biological value that ranges from 32% to 78% on average, with considerable variation even found in species variants. Pulses are less valuable biologically because they contain comparatively less sulfur amino acids. Methionine and tryptophan supplements, even in little amounts, greatly increase the protein efficiency ratio (PER) of pulses. Although, the proteins from pulse seeds are usually not very digestible, mungbean is an excellent source of protein that is very digestible. Interestingly, uncooked pulses have poor nutritional value and protein digestion unless they are cooked or otherwise heated.

2.2 Carbohydrates

Pulses consist of between 53.3% and 68.0% of total carbohydrates, which includes starch and other polysaccharides. Still, sugars only make up a small portion of all the carbohydrates. Of these sugars, the majority of pulses contain oligosaccharides belonging to the raffinose family (raffinose, stachyose, verbascose, and ajugose), which account for a sizeable fraction (between 31.0% and 76.0%) of the total soluble sugars (Singh, 2010). It is crucial to remember that oligosaccharides in beans that belong to the raffinose family have been linked to human flatulence. Intestinal flatus can cause pain, cramping, rumbling in the abdomen, diarrhea, and other gastrointestinal problems. Pulses have a varied starch composition, ranging from 31.5% to 53.6%, with a significant amount of this starch fraction being amylose (Tiwari and Singh, 2012). Amylose and amylopectin are essential components of the starch granules' structural arrangement. Pulses that contain cellulose, hemicellulose, lignin, pectic, and cutin materials are said to contain crude fiber. Crude fiber content in pulses is significant and usually ranges from 1.2% to 13.5%. Different pulse species have varying levels of carbohydrate digestibility; nevertheless, some preparation techniques like boiling, roasting, and germination have been shown to improve carbohydrate digestibility.

2.3 Lipids

Pulses usually have a lipid content of 1.0% to 5.0%, depending on a number of variables including cultivar, region, climate, environmental factors, and soil composition. With a few notable exceptions, most pulses have relatively low lipid content. These lipids are divided into multiple classes, such as glycolipids, phospholipids, and neutral lipids. Of these types, neutral lipids are the most common form of lipid, mostly consisting of triacylglycerols. They also have lower concentrations of sterols, sterol esters, free fatty acids, and diacylglycerols and monoacylglycerols. The primary components of neutral lipids, phospholipids, and glycolipids are fatty acids (Roland *et al.,* 2017).The main fatty acids found in pulses vary in relative amounts and include palmitic, oleic, linoleic, and linolenic acids. These fats are very important in terms of nutrition. In instance, unsaturated fatty acids are essential for cholesterol esterification, which lowers blood and hepatic cholesterol levels. Studies using empirical data have shown that mungbean, urdbean, chickpea, and pigeonpea reduce blood, hepatic, and cardiac cholesterol levels (Warsame and Kimani, 2014). Pulses have been found to have higher quantities of polyunsaturated fatty acids, specifically linoleic and linolenic acids, which are responsible for the reported impact.

2.4 Minerals

Pulses are known for having a high mineral content, which includes vital components like calcium, phosphorus, iron, copper, zinc, potassium, and magnesium. One important component of pulses is potassium, which makes about 25-30% of the total mineral content. This may be advantageous for people who use diuretics to treat hypertension or who have excessive potassium excretion (Heng *et al.,* 2006). Pulses have higher calcium content than grains. In addition, pulses are reasonably considerable sources of iron, containing 5 to 9 mg/100 g of seeds on average. Pulses are also a good source of phosphorus, mostly as phytic acid. Among pulse varieties, chickpeas and sprouted mungbeans stand out as notable providers of iron.

2.5 Vitamins

Pulses are a prominent provider of important B vitamins, such as niacin, thiamin, and riboflavin. Although, the majority of pulses have relatively low quantities of carotene, they make up for it with high levels of thiamine roughly on par with or somewhat higher than cereals (Mukherjee *et al.,* 2017). Furthermore, pulses are known to be excellent providers of folic acid, which improves their nutritional profile even more.

Table 1: Nutritional content of different pulse crops

Crop	Energy (kcals.)	Moisture (g)	Protein (g)	CHO (g)	Fat (g)	Minerals (g)	Fibre (g)	Ca (mg)	P (mg)	Fe (mg)
Pigeonpea	335	13	22	58	2	3	1	73	304	2
Pigeonpea	116	65	10	17	1	1	6	57	164	1
Mungbean	334	10	24	57	1	3	4	124	326	4
Mungbean	348	10	24	60	1	3	1	75	405	4
Urdbean	347	11	24	60	1	3	1	154	385	4
Cowpea	323	13	24	54	1	3	3	77	414	9
Soybean	432	8	43	21	20	5	4	240	690	10
Horsegram	321	12	22	57	0	3	5	287	311	7
Chickpea	360	10	17	61	5	3	4	202	312	5
Chickpea	372	10	21	60	6	3	1	56	331	5
Chickpea	369	11	22	58	5	2	1	58	340	9
Lentil	343	12	25	59	1	2	1	69	293	7
Mothbean	330	11	24	56	1	3	4	202	230	9
Peas	93	73	17	16	0	1	4	20	139	1
Peas	315	16	20	56	1	2	4	75	298	7
Peas	340	10	23	57	1	2	4	81	345	6
Rajmah	346	12	23	61	1	3	5	260	410	5
Kesari Dhal	345	10	28	57	1	2	5	287	311	7

Source: Gopalan. C, Rama Sastri B.V. and Balasubramanian, S.C., 2004, Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad.

3. Antinutritional factors in pulses

Besides having lots of health's benefits, pulses are also have antinutritional factors such as phytate, enzyme inhibitors (trypsin inhibitors, chymotrypsin inhibitors, and amylase inhibitors), polyphenolics (including tannins), lectins, and saponins. These antinutrients impart hindrance in many biochemical pathways. Pulses were reported to have low digestibility owing to the presence of antinutrients which inhibit enzymes involved in digestion and reduces bioavailability of nutrients. Among antinutritional factors, phenolic compounds interfere with the digestibility of the proteins in human body (Carbonaro *et al.,* 1996). Since several antinutritional factors are known to affect digestibility, a great deal of research has been done on their concentrations across genotypes, heredity, and what happens to them when they undergo primary or secondary food processing. Notably, among legumes, *Phaseolus vulgaris*, or dry beans, showed the strongest trypsin inhibitor activity, according to research conducted by Pak and Bajra. Two further antinutritional factors that are heat-sensitive are lectins and hemagglutinins. Since most edible legumes are boiled or steamed before being eaten, these compounds are unlikely to represent a major hazard to the overall nutritional content of legumes.With the exception of some species of Phaseolus, these materials are usually removed from pulse crops after 20 min of autoclaving. Notably**,** chickpeas have stronger gasigenic activity than other pulses (Husain, 2021). These compounds frequently continue to exist after cooking and may even become more active when food is being prepared; this is probably because they are released during the cooking process. Digestive enzymes have been found to be inhibited by polyphenols or tannins. It has been shown that removing the seed coat or testa, which contains the majority of these chemicals, improves biological parameters and net protein utilization.

- Ion exchange chromatography can be used to evaluate individual amino acids, whereas near infrared reflectance (NIR) spectroscopy can be used to determine the amount of protein present (Gopalan *et al.,* 2004). More specifically, quicker determination of methionine levels and also suggested that NIR spectroscopy can also be used to determine amino acids.
- Early generation screening can utilize small seed quantities, reserving resource-intensive tests for advanced generations when line numbers are reduced. Such tests may encompass determining protein efficiency ratio, relative protein value or other protein quality assessments involving animal studies.
- The evaluation of quality stability should initiate at the third stage of screening, involving the cultivation of approximately 80-100 remaining lines from a program in at least two separate locations. During this stage, assessments of cooking time can be conducted in conjunction with evaluations of antinutritional factors. This process facilitates the identification of ideal and unsuitable lines specific to each location, while also yielding crucial insights into the heritability of these traits.
- Retailers are provided with several kilograms of seed and asked to rate the product's acceptability for primary processing in

order to determine commercial acceptance on highly sophisticated materials. Retailers also give information about how satisfied their clients are as final consumers, which helps with business viability decisions.

- Pulses include a wide range of chemicals that have been shown to have antinutritional properties. Protease inhibitors, polyphenols, phytates, saponins, allergens, lathyrogens, and estrogens are some examples of these.

3.1 Protease inhibitors

Pulses contain a variety of compounds that can prevent some enzymes from acting as proteolytic enzymes. Trypsin inhibitors are important members of a larger class of proteins called protease inhibitors, which also includes other proteins that inhibit proteolytic enzymes including chymotrypsin and trypsin. Trypsin inhibitors usually become more active as seed maturation advances. The majority of plant protease inhibitors are destroyed after heat treatment, such as cooking, which is frequently used on pulses. This increases the nutritional value of protein. Furthermore, germination affects the way that trypsin inhibitors function.

3.2 Lectins

Lectins are poisonous, proteinaceous substances that are frequently found in some varieties of beans. Moreover, phytohemagglutinins are present in the seeds of various edible species of pulses, including peas and lentils. 4-10% of lectins are composed of carbs. While lectins derived from rice and pigeonpea seeds that are still immature can be poisonous, lectins from mung beans are not. Soaking is necessary for the complete removal of lectins before autoclaving or cooking.

3.3 Polyphenols

Under certain pH circumstances, polyphenols-tannins in particular have the capacity to form complexes with proteins. These tannin-protein complexes have been linked to increased amounts of fecal nitrogen, decreased amino acid availability, and decreased protein digestibility. Notably, the pulses with the highest tannin content in their seeds include pea, urdbean, and pigeonpea. The color of the testa, or seed coat, affects the amount of tannin in pulses; darker-colored seeds usually have higher quantities of tannin than lighter-colored ones. Beans tend to have less tannin as the seeds get older. Mostly found in the testa or seed coat, tannins can be reduced by physical removal using methods such as grinding or dehulling, which will improve the nutritional value of pulses. Long-term soaking in distilled water increases the amount of tannins leached, and germination has been shown to reduce the amount of polyphenols in seeds.

Table 2: Antinutritional and toxic substances present in pulses

Antinutritional substances	Crop affected	Effects of antinutritional substances	Remarks
Protease inhibitors	Fieldpea, Beans, Fababean, Peas, Lentil and Chickpea.	Trypsin inhibitor activity reduces availability of protein and affects the digestibility andutilization of protein and amino acids.	Soaking the seed in Nacl and $NaHCO_3$ solution and heating and boiling destroys the trypsin inhibitor activity.
Lectins	Beans, Fababeans Chickpea, Urdbean.	Causes the breakdown of red blood.	Haemogglutinings are highly sensitive to heat thus destroyed on cooking.
Cyanogens	Limabean has the highest concentration. Chickpea in traces.	In the form of glycosides from which HCN is released by hydrolysis. Effects protein digestibility and net protein utilization.	Most of HCN is lost on cooking.
Flatus	French bean, chickpea, Urdbean and Fababean.	Certain galactose containing oligo saccharides, sucrose, verbacose, raffinose and stachyose.	Gas producing substances in the grain. Cooked chickpea grain has gas, whereas germinated and immature grains produce less gas.
Lathyrism	Lathyrus (Kesari Dal)	B-Oxalyamino-alanine (BOAA) is neurotoxin causes lathyrism paralysis of lower limbs.	Proper cooking reduces toxic effects: Lines are available with zero BOAA content.
Phytate	Fababeans, French beans, Chickpea.	It is a form of phytic acid. It effectively binds its protein which leads poor digestibility and net protein utilization.	Proper cooking may reduce availability in grains.
Tannins (Polyphenols)	Beans, Chickpea and Fababean.	Protein absorption by tannins is believed to be responsible for depressed growth of rats and chickpea.	Dehulled seeds contains very low concentration of tannins.

3.4 Saponins

Secondary metabolites called saponins are found in pulses and consist of an aglycone-linked carbohydrate moiety (mono or oligosaccharide). The saponin content of common pulses like chickpea, mungbean, lentil, and pigeonpea ranges from 0.05% to 0.23%. These substances show promise for improving health, particularly in decreasing cholesterol (Idrissi, 2020). Research investigations have demonstrated that saponins have the potential to function as anti-carcinogens due to their inhibitory effects on colon cancer.

3.5 Lathyrogen toxin

The lathyrogen toxin, naturally occurring in lathyrus seeds, can induce lathyrism upon prolonged excessive consumption. Lathyrism, characterized by paralysis of the legs in vulnerable individuals, is associated with the toxic amino acids beta-N-oxalyl amino alanine (BOAA) or beta-N-oxalyl L-alpha, beta-diamino propionic acid (ODAP).

Though, pulses contain high levels of nutritional compounds, some of the defects noticed with pulse seeds are:

i. The nutritive value and protein digestibility of raw seeds are significantly inadequate from a scientific perspective.

ii. Carbohydrate digestibility is poor in pulses-flatulence in humans and animals.

iii. In uncooked pulses, most of the minerals are not in available form.

iv. Presence of high amount of antinutritional compounds.

However, the following treatments/processing may remove most of the defects and make the pulses highly human friendly;

i. Milling, dehiscing and splitting

ii. Soaking with water and leaching

iii. Heat treatment-cooking

iv. Germination

v. Fermentation

4. Breeding objectives related to for quality improvement in pulses

1. High protein content.
2. High methionine and tryptophan content which increases protein efficiency ratio (PER).
3. Low level of raffinose family of oligosaccharides especially in chickpea.
4. High concentration of linoleic and linolenic acids, which are polyunsaturated fatty acids.
5. High level of calcium, potassium and iron.
6. High level of carotene and ascorbic acid which are low in pulses.
7. Minimal concentration of antinutritional substances, like:

i. Inhibitors of trypsin and chymotrypsin

ii. Lectins content especially in pigeonpea and rice bean

iii. Tannins content - light coloured seeds

iv. High level of saponins

v. Lathyrogen toxin in lathyrus

5. Constraints in breeding for quality improvement

i. Developing countries mostly concentrate on genetic improvement for quantity.

ii. In developed countries, genetic improvement in pulses is very much limited.

iii. The quality characters in pulses are quantitative in inheritance - slow progress in breeding.

iv. The quality characters are highly influenced by variety of environmental factors. Hence, heritability is very low.

v. The availability of genetic variation for quality parameters is very limited.

vi. The estimation of quality parameters is very much cumbersome.

vii. Laboratory analysis of quality parameters is very complicated and costly.

viii. Involvement of multidisciplinary scientists like biochemists, physiologists, post harvest technologists, food technologists, *etc.*, complicates the breeding programme.

6. Breeding strategies for quality improvement in pulses

6.1 Conventional approaches

i. Screening the available genetic resources (at least core collections) for variability of quality characters.

ii. Screening the related wild species of different pulse crops for quality parameters.

iii. Recombination breeding using donors for specific traits with locally adopted high yielding genotypes.

iv. Back cross and back cross inbred method have special place in transfer of quantitative and quality traits.

v. Wide hybridization: Interspecific crosses to increase the farmed germplasm's genetic base and add desirable traits.

Example: There are two ways that pigeonpea seed nutrition has improved.

- The positive aspect of improving the protein content and quality.
- The negative aspect of reducing or eliminating the toxic and other undesirable substances.

Protein content and grain yield are found to be negatively correlated. Therefore, improvement of protein content should be tried without reduction in yield. This is possible by evaluation and screening of the available germplasm and selection. Wild species such as *Cajanus platycarpus* and *Rhynchosia* spp. were found to have high protein content. But, these species are not like cultivars with respect to other agronomic characters. Hence, interspecific hybridization followed by backcrossing with the desirable recurrent parent may give better results (Singh and Satyanarayana, 1997).

- Mutation Breeding : Employed to generate new/addition variability for quality characters with a wide array of physical and chemical mutagens

6.2 Biotechnological approaches

(i) Embryo rescue technique

Plants have been grown from immature embryos derived from interspecific hybrids of several pulse crops (Dhanju *et al.,* 1985).

(ii) Gene transfer technology

Most of the pulse crops can be infected by agrobacterium and produce tumors. There are reports on the use of biolistics. However, the transformation frequency is usually low with biolistics compared to agrobacterium mediated system. The particle bombardment may be preferred for gene introduction into large seeded pulses circumventing the host specificity of many pulse crops to infection by agrobacterium (Chaitieng *et al.,* 2006).

Pulses are a difficult genetic transformation target because of the difficulties in rooted transgenic shoots and the resulting stunted growth of the shoots. Overcoming these challenges is essential to the advancement of high-throughput systems, especially in the field of genomics research. The advancement of non-tissue culture transformation techniques has great potential to further this field's success. Adapting the floral dip method-which was originally designed for Arabidopsisto pulse crops is one such tactic (Shivkumar *et al.,* 2020).

(iii) Marker assisted selection

The identification of the genes controlling different quality characteristics is made possible using marker technology. The investigation of genetic diversity and the mapping and tagging of genes or quantitative trait loci (QTLs) associated with desired qualities have been made easier with the development of molecular markers. Furthermore, positional cloning of genes and marker-assisted selection (MAS) have become possible (Masood Ali and Shivkumar, (2005). Two genetic linkage maps of mungbean were recorded by Lambrides *et al.* (2000), while the first linkage map of urdbean was published by Chaitieng *et al.* (2006).

7. Speed breeding in pulses

In recent years, a system called speed breeding was developed in different crops. The speed breeding concept was inspired by NASA's efforts to grow crops in space, using an enclosed chamber and an extended photoperiod. In recognising the opportunity to produce adult wheat (*Triticum aestivum* L.), and barley (*Hordeum vulgare* L.) plants more rapidly and allow faster selection and population development, speed breeding became the norm in cereal research activities at the University of Queensland, Australia (Hickey *et al*., 2019). The technique uses optimal light quality, light intensity, daylength and temperature control to increase the rate of photosynthesis, to induce early flowering and accelerate plant growth, coupled with annual seed harvesting to shorten the generation time. The highlight of the speed breeding process is that it can reduce the generation time and shorten the breeding cycle, enabling rapid development of advanced stable lines and mapping populations, rapid screening to identify donor sources for trait (s), and faster development of improved cultivars in crops (Watson *et al.,* 2018).

Speed breeding is suitable for diverse germplasm and does not require specific equipment for *in vitro* culturing, unlike doubled haploid technology, in which haploid embryos are produced to yield completely homozygous lines. Plants grown under speed breeding conditions typically progress to anthesis in about half the time of those grown in a regular glasshouse. Speed breeding protocols can improve genetic gain in crop improvement programs by increasing the number of plant generations cycled within a within a year, there by shortening the breeding cycle.

8. Achievements

i. The average protein content of pigeonpea is 20.9%. However, AL 201 has got 21.49% protein.

ii. Integration of genes governing high methionine content (Muntz*et al*., 1988) in pigeonpea has been reported.

iii. The wild species of pigeonpea*viz.,C. acutifolius, C. cajanifolius, C. confertiflorus, C. latisepalus*and *C. mollis* were identified as having high protein content.

iv. Varieties with high protein content of mungbean (ML 5-26.0%) against the normal protein content of 22.9% were evolved.

v. *Vigna mungo* and *Vigna silvestris* (TC 2208, TC 2209, TC 2210 and TC 2211) have been found with high levels of methionine and crossing these with mungbean, selection of mungbean with high free methionine (Lamda - glutamyl - methionine content) than in mungbean have been made at AVRDC.

vi. The variety DPU 88-31 of urdbean was evolved with 24.6% protein as against an average content of 22.0%.

vii. The average protein content of chickpea is 21.5%. However, varieties with high amount of protein (GL 769 - 25.44, GPF 2- 24.97 and Pusa 362- 24.57) were developed.

viii. The average protein content of pea is 19.7%. Varieties with high protein content (JP 885 - 23% and KFP 103 -22.5%) have been evolved.

ix. Theneurotoxin β-ODAP (3-*N*-oxalyl-L-2, 3-diaminopropanoic acid) content of less than 0.1% in Lathyrus has been found safer from neurotoxicity point of view. Newly developed varieties like Bio L 212 (Ratan), BioL 208 and BioR202 have less than 0.1%, (0.05 - 0.06) ODAP.

9. Conclusion

Food legumes, especially pulses, have a significant role in ensuring food and nutritional security of human and animal population. India is the largest producer of pulses in the world, accounting for 28% of the global pulses production. High protein-producing pulses complement the proteins obtained from cereals and animal sources for the growing human population worldwide. The United Nations and FAO jointly declared 2016 as the 'International Year of Pulses (IYP)' and described pulse seeds as 'nutritious seeds for a sustainable future'. Pulses are rich in protein, dietary fibre, and various micronutrients and biologically active substances. Therefore, the

Indian Pulse and Grain Association has described pulses as a future major source for nutritional and health benefits. For the human and environmental health, there should be highly essential towards prioritization of nutrient-dense, sustainable foods. Pulses have higher level of fiber and key nutrients (*e.g.*, potassium and folate) and lower fat intake when compared to nonconsumers. Pulses also have so many important properties supporting health; we call on the nations of the world to take back their beans, empowering people to take back their health. In Western countries, let us boldly embrace the cultural diversity pulses as an important source of fiber, vitamins, minerals, and plant-based proteins the stuff of life itself. However, several antinutritional compounds, such as trypsin inhibitor, phenolic compounds, phytates, cyanogenic compounds, lectins and saponins are also found in the legumes. Most of the antinutritional compounds of the pulses are present in the seed coat. Most of these compounds are sensitive to heat and can be substantially reduced by milling, cooking, germination, fermentation and heat processing finally can provide adequate minerals required to fulfill nutritional requirement.The breeding cycle of recombination followed by selection requires resources, time, and experience to deliver improved varieties with appropriate phenology, efficient plant type, higher yield, and better nutritional quality. In a breeding context, rapid generation advance to homozygosity following crossing will facilitate genetic gain for key traits and allow more rapid production of improved cultivars by breeding programs. The opportunity to integrate speed breeding with other modern plant breeding technologies will revolutionise plant breeding and lead to more efficient development of future crops.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

Aritra Kumar, M.; Anandkumar, N.; Shiva Kumar,U. and Gyanendra, K. (2017). Nutritional value of pulses and their importance in human life. Innovative Farming, **2**(1):57-62.

Bean, S.R. and Lookhart, G.L. (2001). Recent developments in highperformance capillary electrophoresis of cereal proteins. Electrophoresis, **22**:1503-1509.

Carbonaro, M.; Virgili, F. and Carnovale, E. (1996). Evidence for protein–tannin interaction in legumes: Implications in the antioxidant properties of Faba bean tannins. LWT Food Sci. Technol., **29**:743-750.

Chaitieng, B.; Kaga, A.; Tomooka, N.; Isemura,T.; Kuroda, Y. and Vanghan, D.A. (2006). Development of a blackgram (*Vitgna mungo* L.) Hepper linkage map and its comparison with an azukibean (*Vigna angularis* (Willd.) Ohwi and Ohashi linkage map. Theoretical and Applied Genetics **113**:1261-1269.

Dhanju, M.S.; Gill, B.S. and Sidhu, P.S. (1985). *In vitro* development of *Cajanus* x *Atylosia* hybrids. Current Science, **54**:1284-1286.

Geetha, A.; Nagaraju, K.; Pandravada, S.R.; Suhail Khan, M.; Rajasekhar, M.; Sivraj, N. Saidaiah Pidigam and Vishnukiran, T. (2022). Breeding approaches for the development of nutraceutical vegetables: A review. Ann. Phytomed., **11**(2):65-74.

Gopalan, C. ; Rama Sastri, B.V. and Balasubramanian, S.C. (2004). Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad.

Hickey, L.T.; Hafeez, A.N.; Robinson, H.; Jackson, S.A.; Leal, M.; Gao, C.; (2019). Breeding crops to feed 10 billion. Nature Biotechnology, **37**:744-75.

Heng, L.; Vincken, J.P.; Van. G.A.; Legger, L.; Roozen, J.P.; Gruppen, H. and Voragen A.G.J. (2006). Bitterness of saponins and their contents in peas. J. Sci. Food Agric., **86**:1225-1231.

Idrissi, O. (2020). Application of extended photoperiod in lentil: Towards accelerated genetic gain in breeding for rapid improved variety development. Moroccan Journal of Agricultural Sciences, **1**:14-19.

Indumathy, P.; Pavan Kalyan, N.; Vishnu, K.M.; Arun Kumar, R.; Yogeshwaran, R. and Afroz Patan (2023). A review on quinazoline containing compounds: Molecular docking and pharmacological activites. Ann. Phytomed., **12**(1):220-229.

Li, H.; Rasheed, A.; Hickey, L.T. and He, Z. (2018). Fast-forwarding genetic gain. Trends in Plant Science **23**:184-186.

Lambrides, C.J.; Lawn, R.J.; Godwin, I.D.; Manners, J. and Imrie, B.C. (2000). Two genetic linkage maps of mungbean using RFLP and RAPD markers. Australian Journal of Agricultural Sciences, **51**:415-425.

Masood Ali and Shivkumar (2005). Advances in Mungbean and Urdbean (Edited). Indian Institute of Pulses Research, Kanpur. India. pp:356

Mohd Kashif Husain (2021). Herbs that heal: Relevance of traditional natural remedies in promotion of health. Ann. Phytomed., **10**(2):4-21.

Moss, J.P.; Singh, A.K.; Sastri, D.C. and Dundas, I.S. (1988). Wide hybridization legumes at ICRISAT, pp:87-95. Proceedings of the International Workshop on Biotechnology in Tropical Crop Improvement, 12-15 January 1987, International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Patancheru, India.

Muntz, K.; Christav,V.; Sallbach, G.; Sallbach, I.; Waddel, D.; Pickardt, T.; Schieder, O. and Wustenhagen, O. (1988). Genetic engineering for high methionine grain legumes. Nahrung Food, **42**:125-127. Edited by Masood Ali and Shivkumar, IIPR, Kanpur.

Narpinder Singh (2017). Pulses: An overview. J. Food Sci. Technol., **54**(4):853-857.

Roland, W.S.U.; Pouvreau, L. and Curran, J. (2017). Flavor aspects of pulse ingredients. Cereal. Chem., **94**:58-65

Singh, N. (2010). Physicochemical and functional properties of pulse starch. In: Tiwari B, Gowen A, McKenna B (eds) Pulse foods: Quality, technology, and nutraceutical application. 22. Elsevier, Amsterdam

Singh, D.P. and Satyanarayana, A. (1997). Creating higher genetic yield potential in urdbean. Pages:157-172. In : Recent Advances in Pulses Research. (AN Asthana and Masood Ali, eds). Kanpur, India : Indian Society of Pulses Research and Development.

Shivkumar; Priyanka Gupta and Hasnae Chouki. (2020). Efficient breeding of pulse crops. Accelerated Plant Breeding, 3:978-0-030-47305-1

Tiwari, B.K. and Singh, N. (2012). Pulse chemistry and technology. Royal Society of Chemistry, Cambridge

Warrier, R. R. (2021). Authentication of herbal products to attract global markets. Ann. Phytomed., **10**(2):421-431.

Warsame, A.O. and Kimani, P.M. (2014). Canning quality of new drought-tolerant dry bean (*Phaseolus vulgaris* L) lines. J. Food. Tech., **9**(6):311-317.

Watson, A.; Ghosh, S.; Williams, M.J.; Cuddy, W.S.; Simmonds, J. and Rey, M.D.(2018). Speed breeding is a powerful tool to accelerate crop research and breeding. Nature Plants, **4**:23-29.

Yogesh Kumar; Santanu Basu; Deepika Goswami; Mridula Devi; Uma Shanker Shivhare and Rajesh Kumar Vishwakarma (2021). Antinutritional compounds in pulses: Implications and alleviation methods. Legume Science: 4:111.

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