

ANTINUTRITIONAL FACTORS AND THEIR DETOXIFICATION IN PULSES- A REVIEW

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ABSTRACT

Pulses are relatively a cheaper source of protein than milk, cheese, cashew, almond, meat and fish etc., hence valuable for developing countries. The seeds of pulses are most commonly eaten can be economically stored well for future use. The food values of seeds of pulses is high, have about the same calorific value per unit weight as cereals and are fair sources of some vitamins and minerals. Their protein contents are generally about double that of most cereals. Consumption of pulses is highest in India as compared to other pulses growing countries due to low purchasing power and religious restrictions on non-vegetarian diet. Pulses contain about 18.0 to 32.0 % protein and about 1 to 5% fat. Pulses are considerably richer in calcium than most cereals and contain about 100 to 200 mg of calcium per 100 g of grain. They are also considerably rich in iron, thiamine, riboflavin and nicotinic acid as compared to cereals. Young sprouts of pulses like mungbean, mothbean and chickpea are popular foods in some places. Pulses contain several anti-nutritional factors, such as trypsin and chymotrypsin inhibitors, lectins, polyphenols, flatulence factors, lathyragens, saponins, antihistamines and allergens. The protease inhibitors, lectins and other antinutrients cause toxicity. Heat treatment has been well established to destroy proteinaceous antinutrients, such as protease inhibitors and lectins, but heat treatment destroys some of the amino acids and vitamins as well. For maintaining the nutritional value of food, it is necessary that heating temperature and length of processing do not exceed the optimum temperature required to eliminate the effect of inhibitors. Proteins in pulses are known to interact with lipids, tannins, phytates, flavor compounds and pigments. These interactions occur when pulses are processed and converted into products. It decreases the bioavailability of proteins. Similarly, tannins and phytates interact with minerals and vitamins resulting in a decrease in their bioavailability. Thus, bioavailability of nutrients depends not only on their content in the seed, but also on the interaction of nutrients under various processing conditions. The pulses are subjected to various processing techniques like milling, dehulling, soaking, germination, fermentation and cooking. These processing techniques not only save time, energy and fuel but have several nutritional advantages and produce edible products having a higher nutritional value and lower toxic compound. The degrees of elimination of toxic compound depend on type of pulses and the processing technique.

India is the largest producer of pulses in the world. The common pulses grown are chickpea, pigeonpea, mungbean, urdbean, lentil, field pea, moth bean, horse gram and lathyrus, containing small amount of fat, and offers a relatively cheaper source of protein. Consumption of pulses is highest in India where majority of the population is

vegetarian. Pulses contain 18 to 32 % protein and 1 to 5 % fat (Srivastava and Ali, 2004). They are also rich in iron, thiamin, riboflavin and niacin and dietary fiber (Table 1). The crude fiber, protein and lipid components of pulses have shown to have a hypocholesterolemic effect. Vegetable soybeans are rich in high quality protein and contains high

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Table 1: Nutrients Contents of vegetable soybean and green pea

Nutrient Contents	Vegetable Soybean	Green pea
Energy (K cal)	139.0	94.0
Moisture (%)	68.2	75.6
Protein (%)	13.0	6.2
Fat (%)	5.7	0.4
Total Carbohydrates (%)	11.4	16.9
Crude fiber (%)	1.9	2.4
Ash (%)	1.7	0.9
P (mg/100g)	158.0	102.0
Ca (mg/100g)	78.0	32.0
Fe (mg/100g)	3.8	1.2
Vit. A (mg/100g)	360.0	405.0
Vit. B ₁ (mg/100g)	0.4	0.3
Vit B ₂ (mg/100g)	0.2	0.1
Vit. C (mg/100g)	27.0	27.0

Source: FAO 1972

quality oil and folic acid, isoflavons and tocopherol.

The nutritional value of pulses may be adversely affected by the presence of anti physiological or toxic substances such as trypsin and chemotrypsin inhibitors, phytates, lectins, polyphenols, flatulence causing agents, cyanogenic compounds, lathyrogens, esterogens, goiterogens, saponins, anti-vitamins and allergens. These substances reduce the nutritive value of foods by inhibiting digestibility and utilization of proteins. It is therefore necessary to eliminate these substances by processing by genetic manipulation. Processing plays an important role in improving nutritive value of pulses and by decreasing antinutritional factors up to a tolerable limit.

Lectins:

Lectins are proteinaceous in nature and commonly found in some of the beans. Seeds of some of the edible species of pulses such as lentil and pea also contain phytohemagglutinins. It was observed that extracts from many edible crude bean seeds agglutinated red cells, but no toxic action was detected in these seeds. These are proteins which possess a specific affinity for certain sugar molecules. Most of the lectins contain 4 to 10% carbohydrates. The lectins from mungbean are non toxic, whereas the lectins obtained from immature seeds of pigeon pea and ricebean are

harmful (De-Muelenaere, 1965, Ikegwuonu and Bassir, 1977, Manage *et al.*, 1972). Lectins reduce the bioavailability of nutrients, which is due to direct action of lectin on digestive enzymes (Jindel *et al.*, 1982, Rea *et al.*, 1985). Preliminary soaking prior to autoclaving or cooking is required for complete elimination of the toxicity of lectins (Liener, 1976, Kute *et al.*, 1984).

Tannins:

Tannin (Polyphenol) is known to form complexes with proteins under certain pH conditions. Tannins-protein complexes are reported to be responsible for low protein digestibility, decreased amino acid availability and increased fecal nitrogen. These complexes may not be dissociated and may thus be excreted with the feces. Among pulses, pigeonpea, urdbean and pea have highest tannins in seeds. It appears that tannins content in pulses varies with colour of the seed coat. Lower amount of tannins, in general are observed in light coloured seeds than brown dark coloured pulses. White seeded varieties of *Phaseolus vulgaris* are contain almost negligible tannins, while coloured varieties contain large quantities of tannins (Deshpande *et al.*, 1982, Deshpande and Cheryan, 1983). The tannins content in beans changes during seed maturation (Kadam *et al.*, 1982). Tannin content of some of the pulses is given in Table 2 (Reddy *et al.*, 1985).

Table 2: Tannin content of common pulses

Food	Tannin Content(mg/g)	
	Whole Seed	Cotyledon
Cowpea	175-590	28
Chickpea	175-590	28
Pigeonpea	380-1710	22-43
Mung bean	437-799	21-39
Pea	500-1050	460-560
Urdbean	540-1197	16-33

Tannins form complexes with proteins, carbohydrates and other biomolecules in foods as well as with certain ions such as iron. The greater tendency of tannins to form complexes with proteins rather than carbohydrates and other food polymers is attributed due to hydrogen bonding affinity of the carboxyl oxygen of the peptide group. One tannin molecules binds two or more carboxyl oxygen of the peptide group with possible formation of cross links between the protein chains (Reddy *et al.*, (1985). Tannins are mainly located in seed coat of pulses, hence physical removal of seed coat by either dehulling or milling and separating hulls decreases the tannin content of pulses and improves their nutritional quality. Dehulling eliminates about 68 to 99% of tannins in seed. Soaking of seeds before cooking is a common household practice and, used to soften the texture and hasten the process of cooking. Leaching of tannins increases with the time of soaking in distilled water. Raising the period of soaking from 6 to 12 and 18 hrs further reduces tannin content of seed (Jood *et al.*, 1988, Kataria and Chauhan, 1988). Cooking and discarding the cooking water results in about 37.5 to 77% decrease in tannin content of seeds (Reddy *et al.*, (1985). Overnight soaking in water and subsequent germination for 48 hrs removes more than 50% of the tannins in pigeonpea, chickpea, mungbean and urdbean (Jood *et al.*, 1987, Kataria *et al.*, 1989, Khokar and Chauhan, 1986, Rao and Deosthale (1982), Sharma and Sehgal, 1992). Loss of tannins during germination may be attributed to presence of polyphenol oxidase and enzymatic hydrolysis (Rao and Deosthale (1982).

Germination significantly increased the protein and moisture content, whereas roasting and autoclaving decreased their contents. Crude lipid content was significantly reduced by various processing. Ash content varied significantly between raw and processed samples. The antinutritional factors levels of bean have been studied by many authors. Trypsin inhibitors activity level ranged from 11.8to 29.0 TIA /gm sample (Ahmed and Nour, 1990; Dekaand Sarkar, 1990; Devaraj and Manjunath, 1995). Tannin content of untreated lablab bean has been reported to be high, (Deka and Sarkar, 1990; Shastry and John, 1991). In order to utilize bean effectively as human food, it is essential to inactivate or remove these antinutritional. Generally, adequate heat processing inactivates the trypsin and chymotrypsin (DiPitero and Liener, 1989, Osman *et al.*, 2002). Heat stable compounds in cereal and legumes such tannins and hydrates are easily removed after germination (Reddy *et al.*, 1985) and fermentation (Osman, 2004). The trypsin inhibitor activity and phytic acid content significantly decreased by different process methods, while the amounts of tannins significantly decreased. The cooking of presoaked seed appeared to be the most effective method for reducing trypsin inhibitor activity (Osman, 2007). A better understanding of the effect different traditional processing methods on nutritive value, may lead to wider use of this legume in food industry.

Protease inhibitors:

Several substances which have ability to inhibit the proteolytic activity of certain enzymes are found

in pulses. Trypsin inhibitors belong to a broad class of proteins (protease inhibitors) that inhibit proteolytic enzymes. Trypsin inhibitor activity increases as seed maturation progresses (Kute *et al.*, 1984). Most of the plant protease inhibitors are destroyed by heat resulting in enhancement of nutritive value of protein (Liener, 1962). The partial size, moisture content, time, temperature and pressure are the major factors that influence cooking rates, inactivation of the trypsin inhibitor, and subsequent increase in nutritive value. Moist heat has been shown to be effective in destroying trypsin inhibitor activity in pulses (Rackis, 1981). Germination also influences the trypsin inhibitors activity (Hobday *et al.*, 1973, Kadam *et al.*, 1986). The application of dry heat to the seeds and meal is not effective in inactivating the trypsin inhibitor and chymotrypsin inhibitory activity of pigeon pea, but soaking for 24 hrs followed by cooking for 20 min is effective in destroying trypsin activity (Mulimani and Paramjyothi, 1994). Autoclaving for 15-20 min at 120°C, extrusion cooking at 150°C or microwave radiation at 107 °C for 30 min are equally effective in destroying most of the trypsin inhibitor activity of pulses (Marquardt *et al.*, 1977).

Phytic acid:

Phytic acid level varied from 100.0 to 313.4mg/100gm (Deka and Sarkar, 1990; Al Othman, 1999). Roasting caused autoclaving of *Dolichos lablab* seeds reduced tannins greater reduction (60.69%) on Phytic acid followed by content by 70% and 60% respectively. The phytic acid content showed the effect of different processing samples varied from 237.95 mg/100gm (roasted) to 471.07 mg/100gm (soaked), whereas control had 605.39 mg/100gm phytic acid. Similar reduction pattern in phytic acid content during soaking, cooking or germination has been reported by many investigators, (Chau and Cheung, 1997, Alonso *et al.*, 1998, Alonso *et al.*, 2000, Desphande and Sheryan, 1983; Vdal-Valaerde *et al.*, 1994, Sievwright and Shipe, 1986) for Chinas legumes, pea, faba pea, dry bean, lentil and black bean respectively. The decrease of phytic acid content by soaking, cooking of presoaked bean or germination maybe due to leaching out of this

compound in water. Similarly, roasting and autoclaving has been reported to decrease phytic acid in dry bean (Tabekhia and Luh, 1980), chickpea and black gram (Duhan *et al.*, 1989), cowpea (Akinyele, 1989), and black bean (Siewwrightand and Shipe, 1986). Phytates is thought to be responsible in mineral bioavailability. In contrast to trypsin inhibitory activity and phytic acid level, the tannins content was significantly increased due to different treatments. Germination and cooking of presoaked beans showed the highest increase whereas; soaking, autoclaving and roasting showed moderate increase. Similar trend had been reported by some authors, (Vijayakumari *et al.*, 1995) reported 55%increase of tannin of *Dolichos lablab*, after soaking. (De Lumen and Salamamat, 1980) reported that cooking creased assayable winged bean tannins by 89-100 % (Al-Jasser, 2005) and (Ahamed *et al.*, 1996), independently showed an increase in tannins in sorghum due to soaking and germination. This increase may be due to the hydrolysis of high molecular weight insoluble polymer in to small molecular weight soluble treatments on protein *in-vitro* digestibility. Phytic acid content significantly decreased by different process methods as soaking, cooking roasting and autoclaving, while the amounts of tannins significantly decreased and the reduction in content of phytic acid was found to be somewhat greater roasted sample compared to others (Osman, 2007).

Lathyrigen:

Lathyrigen toxin is one of the natural toxins found in the seeds of lathyrus, commonly known as khesari or teora, which is known to cause lathyrism. If consumed in excess quantity for long time, it causes paralysis in the legs in susceptible individuals and is believed to be caused by a toxic amino acid known as N-Oxalyl amino alanine (BOAA). The BOAA content of seed of lathyrus varies from 0.05 to 0.4% (Srivastava *et al.*, (2000). Less than 0.2% BOAA is considered safer from health point of view (Siddiqu, 1995). The concentration of BOAA is maximum in the germ portion of the seed of lathyrus; therefore the degerming of the seed cotyledons greatly reduces

the neurotoxin content of lathyrus seed (Prakash *et al.*, 1977). Processing techniques like soaking, parboiling, roasting and degerming eliminates neurotoxin to a large extent. Pre-cooking soaking of pulse removes 30-40% of toxin (Srivastava and Srivastava, 2002). Roasting of seeds for about 15-20 min at 140 °C removes most of the toxin of lathyrus (Rao *et al.*, 1969). Preboiling of lathyrus seeds removes more than 80% of the toxin and produces minimum change in nutritive value (Nagrajan *et al.*, 1965).

Saponins:

Saponins are secondary plant metabolites present in pulses, containing a carbohydrate moiety (mono/oligosaccharide) attached to an aglycone, which may be steroidal or triterpenoid in structure. The chickpea, mungbean and pigeonpea contain saponins ranging from 0.05 to 0.23%. Though saponin reduces the nutritive value of pulses, but the saponins appear to be beneficial as they are responsible for lowering the cholesterol in body and may be important in human nutrition in reducing the risk of heart diseases and also inhibited colon cancer. Processing techniques like soaking, germination and cooking helps in reducing the saponin contents of pulses. Soaking of pulses reduces 5 to 20% saponin in pulses (Jood *et al.*, 1988, Kataria and Chauhan, 1988, Kataria *et al.*, 1989). Raising the period of soaking further reduces saponin of pulses. The decrease in the level of saponin in the seeds of pulses during soaking may be attributed to their leaching out into soaking media (Kataria and Chauhan, 1988). Germination reduces saponin content of various pulses. Forty eight hours sprouting results in 22% reduction of saponin in urdbean (Jood *et al.*, 1988, Kataria and Chauhan, 1988). The loss of saponin increases with increase in the germination period. Cooking also reduces saponin content of seed/grain in chickpea, mungbean and urdbean (Jood *et al.*, 1987, Kataria *et al.*, 1989, Sharma and Sehgal, 1992), and losses of saponin are more in pressure cooking than in ordinary cooking (Kataria *et al.*, 1989).

Oligosaccharides:

Ingestion of large quantities of pulses is known to cause flatulence in human beings.

Accumulation of flatus in the intestinal tract results in discomfort, abdominal rumblings, cramps, pain, diarrhoea etc. The oligosaccharides of the raffinose family sugars viz., raffinose, stachyose and verbascose from pulses are causative agent of flatulence in humans (Rao, and Belvady, 1978). Raffinose is not digested by man because the intestinal mucosa lacks the hydrolytic enzyme α -1, 6-galactosidase (Cristotaro and Wuhrmann, 1974). Microflora in the lower intestinal tract metabolise these oligosaccharides and produce large amount of carbon dioxide, hydrogen and small quantity of methane, which causes flatus production (Rackis, 1974). Various approaches are suggested in order to decrease the flatulence causing factors of pulses. Varieties with low raffinose sugars can be developed and also be used for reducing the oligosaccharides, which are removed as a result of soaking (Iyenger and Kulkarni, 1977). Discarding cooking water also reduces the raffinose contents in beans (Reddy and Salunkhe, 1980). Raffinose sugars can also be removed from pulses by germination (Gupta and Wagle, 1980, Rao and Belvady, 1978).

Pulses are generally subjected to various processing before their consumption. These include dehulling, milling, soaking, germination, fermentation and cooking. Such processing has several nutritional advantages. Heat treatment has been well established to destroy proteinous antinutrients, such as protease inhibitor and lectins, but this treatment may also destroy some of the amino acids and vitamins. For maintaining the nutritional value of food, it is necessary to ensure the heating temperature required to eliminate the effect of inhibitors. Proteins in pulses are known to interact with lipids, tannins, phytates, flavour compounds and pigments. These interactions occur when pulses are processed and converted into various products and decrease the bioavailability of proteins. Similarly, tannins and phytates interact with minerals and vitamins resulting in low bioavailability of minerals and vitamins. Thus, bioavailability of nutrients depends not only on content of the seed, but also on the interaction of nutrients under various processing conditions and these processes produce

edible product having a reduced level of anti and toxic compounds. Therefore, soaking, cooking of presoaked beans and germinating hold a good potential for improving the nutritional value of lablab bean by reduction in antinutritional factors such trypsin inhibitors and phytic acid and there

by enhancing its utilization. Elimination of antinutrients or toxic compounds depends on type of pulses and the processing technique. Research efforts should be made in the direction to reduce these antinutrients and success can be expected in future.

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