A Comprehensive Review on the Effect of Food Processing Techniques on the Components of Grass pea (*Lathyrus sativus*)

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Abstract

Grass pea (*Lathyrus sativus*) is one of the most widely grown and consumed food legumes in many developing countries like India, Bangladesh, China and Ethiopia. They are nutritionally inherent with rich amounts of protein, essential amino acids and minerals. Grass pea has immense potential to upgrade the diets of the poor people of the world, especially the poor farmers but also has some constraints for the optimal utilization of grass pea as food, feed and fodder. Processing can improve the nutritive value and prevent the anti-nutritional factors from affecting the optimal utilization of grass pea. The main reported constraint in the utilization of grass pea is the presence of the neurotoxin β-ODAP (β-oxalyl- diamino propionic acid) in addition to the various anti-nutrients present in it. Most of the food processing techniques are effective in uplifting the nutritional quality and eliminating the anti-nutritional factors present in grass pea. This review focuses on the role of various food processing techniques such as boiling, soaking prior to boiling and roasting on the nutritional composition and anti-nutritional factors of grass pea. It also highlights the potential prospects of grass pea.

KEYWORDS: Grass pea, nutritional composition, anti-nutritional factors, β-ODAP, processing methods

INTRODUCTION

Man depends on plants as his major source of food. The legumes form the main source of plant protein wherein all the pulses, beans, peas and some nuts also fall into this class. They are sources of low-cost dietary vegetable proteins and minerals when compared with animal products such as egg, meat, and fish (Ramakrishna *et al.*, 2006). Among the legumes, grass pea is one of the most economically viable pulse for the resource constrained people like the poor farmers. The genus *Lathyrus* in the family *Leguminosae (Fabaceae*) is the largest one with 187 species and subspecies recognized (Biswas & Biswas, 1997). However, only one species *Lathyrus sativus* (grass pea) is widely cultivated as a food crop, while other species are cultivated to a lesser extent for both food and forage. Over the past decade, grass pea has received increased attention as a plant that is adapted to arid conditions and contains high levels of protein, a component that is increasingly becoming hard to acquire in many developing areas (Campbell, 1997).

Grass pea (*Lathyrus sativus*) is known by a wide range of common names, include chickling vetch, Indian vetch, khesari or batura (India) and dhal (Muehlbauer & Tullu, 1997) "guaya" in Ethiopia and khesari dhal in India which is a food, feed and fodder crop that belongs to the family Fabaceae (Biswas & Biswas, 1997). It is produced in India, Pakistan, Bangladesh, Ethiopia, Syria, China and Nepal, with different names in different regions. It is a hardy crop grown under various agro-ecological situations (poor soil and climate conditions, drought and flooding) where other crops fail to grow (Urga *et al*., 2005). Grass pea (*Lathyrus sativus*) is used as grain legumes for human and animal consumption dates back to the Neolithic period (Hanbury *et al*., 2000). It has a high nutritional value containing up to 31% protein and 65% carbohydrate and is a good source of minerals (Girma *et al*., 2004).

Based on triennium ending 2010-11, it is mentioned that the contribution of Lathyrus is 2% of the cultivated area and is grown by 5 States of India representing almost 8% of the total production of food legumes in India (Status Paper on Pulses, GOI). Grass pea is a hardy crop, easily cultivated, very tasty and nutritious. It tends to be the staple food of the peasants during times of acute food shortage like droughts and famines. The intake of grass pea as food and its use as feed and fodder is very common in different States of India like Bihar, East U.P., Jharkhand and some parts of Odisha and Madhya Pradesh. Because of its drought-tolerant nature, it is extensively cultivated in India despite the ban on its cultivation and consumption. Its cultivation is restricted by Government Agencies but the continued production and consumption of kesari dal indicates its acceptability as Indian human diets. In contradiction, the outbreak of lathyrism is not noticed since three decades in spite of its regular consumption, especially by farmers. The reasons for this could be that it is no longer a staple food and that its detoxification with respect to ODAP during domestic cooking processes is well practised.

Nature has very well designed this crop, to sustain and to be the best among all the foodcrops even in the most adverse conditions. Grass pea grows well in all types of soils and also in very poorly nourished soils. But its high grain yielding capacity makes it very different from other legumes. It requires very low or no inputs of irrigation, fertilizers, soil turning, weeding and also requires meager investment of capital, man power and energy (Urga *et al*., 2005). Thus, grass pea can be called as a designer crop.

Grass pea can serve as a rich food for the nation. Grass pea has high potential in terms of high levels of protein, carbohydrates, and minerals for humans (Getahun, 2005). It has 14.6-15.4% water, 18.2-34.6% protein, 0.6-0.8% fat, 58.2% carbohydrate including 1.5% sucrose and 6.8% pentoses, 3.6% phytin, 1.5% lignin, 6.69% albumin, 1.3% globulin, 1.5% prolamin, 3.8% glutelin, 36.5% fibre and 6.1% ash. The essential amino acids (in grams/16 g of nitrogen) are arginine-7.85, Histidine-2.51, Leucine-6.57, Isoleucine-6.59, Lysine-6.94, Methionine-0.38, Phenylalanine-4.14, Threonine-2.34, Valine-4.68 and Tryptophan-0.4. The vitamins are carotene, thiamine, riboflavin, nicotinic acid, biotin, pantothenic acid, folic acid, pyridoxine, ascorbic acid and dehydroascorbic acid.

The main anti-nutritional factors occurring in grass pea include protease and amylase inhibitors (trypsin and chymotrysin inhibitors), phytic acid, tannins, lectins, saponins, alkaloids, oligosaccharides, lathyrogens and β-ODAP (Sarma and Padmanaban, 1969; Liener, 1989; Lambein *et al*., 1993; Ramachandran and Ray, 2008). ODAP is also an ANF and is almost unique to the Lathyrus genus. There are only few studies on levels and activities of ANFs, other than ODAP, in *L. sativus* (Latif et al., 1975; Deshpande and Campbell, 1992; Aletor et al., 1994; Urga et al., 1995; Srivastava and Khokhar, 1996; Wang et al., 1998)

The major physiological activity of trypsin inhibitor is to inhibit the action of the enzyme trypsin found in the digestive tract of humans and animals and to cause the enlargement of the pancreas and secretion of excessive amounts of pancreatic enzymes much of which is lost to the animal in faeces (Urga *et al*., 2005). Phytic acid binds trace and macro-elements such as zinc, calcium, magnesium, and iron, in the gastrointestinal tract and making these dietary minerals unavailable for absorption and utilization by the body (Jansman *et al*., 1998). Moreover, the phosphorus in phytate has been considered unavailable to the organism because of the limited capacity of monogastric species to hydrolyze phytate in the small intestine.

In addition to phytate, tannins (phenolic compounds) are found in significant quantity causing bitterness and astringency of many legume foods like grass pea and beverages (Ramakrishna *et al*., 2006). Tannins are compounds having intermediate to high molecular weights and their name originated from their tanning ability. They also form insoluble complexes with carbohydrates and proteins, and the precipitation of salivary proteins is responsible for astringency in tannin-rich foods. In addition, tannins often form complexes with the vital minerals thereby reducing intestinal absorption and the subsequent utilisation at cellular level (Salgado *et al*., 2001).

Indigenous legumes like grass pea are an important source of affordable alternative protein to poor people in many tropical countries especially in Africa and Asia where they are mostly consumed (Ojimelukwe, 2009). However, as legumes contain a wide range of toxic components, they go through several preliminary processing operations-hulling (husking), puffing, grinding, splitting and so on before they are used in different food preparations which improve the nutritional quality of a given legume and reduce the deleterious effects of antinutritional factors and other toxic components. During any processing attempt of grass pea, it is important to note that toxic components be reduced to levels that pose no threat to health due to the presence of inherent paralytic neurotoxin.

The processing condition of grass pea should also be taken into consideration the degree of ripeness of grass pea. At different stage of maturity, grass pea contains different concentration of neurotoxin and other antinutritional factors. It is reported that unripe grass pea is most toxic and should be avoided by all means for human consumption. In addition to this, processing parameters are also major determinant factors to what level any given processing method can improve the nutritional quality and reduce natural toxins and antinutritonal factors found in grass pea. This review indicates the literature examines how different processing methods affect the nutritional quality, and level of antinutritional factors in grass pea. The report from different authors can be used as an attempt to propose the optimum processing condition which is to achieve the intended nutritional quality and elimination of the inherent neurotoxins found in grass pea.

Major nutrients of grass pea

Food is one of the main needs among the three primary needs of humans. To acquire adequate nutrition from the various food groups, legumes play a vital role as protein rich foods from plant sources. Proteins play a significant role and constitute an integral part of the human diet. Legumes not only provide energy and essential macro- and micronutrients required for growth, tissue maintenance but also the regulation of metabolism and normal physiological functions take place. Besides these essential nutrients, foods of plant origin supply various non-nutritive phytochemicals (like tannin and phytate) that promote good health and reduce the occurence of many chronic diseases. Hence, frequent consumption of pulses is now recommended by most of the health organizations (Leterme, 2002).

There are some studies on the nutritional composition of grass pea. The chemical composition of grass pea may vary according to varieties/ genotype, soil biology, agronomic practices, geographical region of their growing and maturity and environmental factors (soil fertility/nutrition, nitrogen nutrition, temperature, water stress and soil pH, biotic and abiotic factors (Rotter *et al*., 1991). In general, the cotyledon and embryo part of the seed consists of the nutritional components whereas the seed coat contains many of the antinutritional factors (ANFs). Being a legume, especially from the subclass of pulses, grass pea is abundantly rich in protein (28-32%) and contains good quantities of essential amino acids except the sulfur containing amino acids (Urga *et al*., 2005). Protein in the diet is essential in providing the body with amino acids to build new proteins for tissue repair and replacement, and to synthesize enzymes, antibodies and hormones. Concentrations of fats and carbohydrates concentrations also range from 0.92% to 1.47% and 55.05% to 85.17% respectively (Rotter *et al*., 1991).

In addition to being an important source of protein and calories, grass pea is rich in minerals. Grass pea plants obtain minerals from their soil environment and spread these to their seeds. Roots utilize specific and/or selective transport proteins to obtain all the minerals (usually as ions) that are essential for plant growth and development i.e. Ca, Mg, K, P, S, Cl, B, Fe, Mn, Zn, Cu, Ni and Mo. These seeds have a higher concentration of magnesium and phosphorus followed by calcium (Urga *et al*., 2005). The ash and crude fiber concentration in grass pea is also reported to range from 1.2% to 3.56% and from 4.14% to 8.62%. (Rotter *et al*., 1991). The vitamins present in grass pea are carotene, thiamine, riboflavin, nicotinic acid, biotin, pantothenic acid, folic acid, pyridoxine, inositol (part of the vitamin B_2 complex), ascorbic acid and dehydroascorbic acid. Thus, grass pea makes a rich source of energy due to the presence of protein, carbohydrate, minerals, vitamins and fibre.

Anti-nutritional factors and toxic compounds in grass pea

Anti-nutrients have been defined as substances which by themselves, or through their metabolic products arising in living systems, interfere with food utilization and affect the health and production of animals (Francis *et al*., 2001). The contribution of legumes to the nutrition of the consumer is limited principally due to the presence of anti-nutritional factors (Ramakrishna *et al*., 2006). The presence of these anti-nutritional factors may influence the digestibility of various nutrients in the diet and give erroneous results (Lall, 1991). Manifestations of toxicity from the consumption of legumes containing anti-nutritional factors range from severe reduction in food intake and nutrient availability or utilization, to profound neurological effects and even death (Bhat and Raghuram, 1993).

Despite good nutritional composition of legumes for human consumption, they are often associated with a series of compounds known as antinutrients, which generally interfere with the assimilation of some nutrients. In some cases, antinutrients can be toxic or cause undesirable physiological effects (e.g. flatulence). However, recent epidemiological studies have demonstrated that many antinutrients may be beneficial, in small quantities, in the prevention of diseases like cancer and coronary diseases. For this reason they are now often called non-nutritive or bioactive compounds; although they may lack nutritive value, they are not always harmful (Muzquiz, 2000a).

Indigenous legumes like grass pea are an important source of affordable alternative protein to poor people in many tropical countries especially in Africa and Asia where they are predominantly consumed (Ojimelukwe, 2009).

It produces protein energy malnutrition and lathyrism appears frequently. One of the reasons is due to the presence of anti-nutritional factors, which inhibits the digestibility of food and the bioavailability of essential minerals and trace elements. The other more serious reason is that when the grass pea, if consumed by the people as staple food for 3-4 months it causes lathyrism (Malek et al., 1995). Overconsumption of grass pea for an extended period of time can cause spastic paraparesis of the legs in up to 6% of the population, affecting mainly the young males (Strickland GT, 1988). Since grass pea is deficient in cysteine and methionine, and consumption of cereals richer in these amino acids and condiments rich in antioxidants seem to be protective factors (Getahun, 2005), malnutrition and oxidative stress have to be considered as contributing factors in the etiology of neurolathyrism, together with the ingestion of the neurotoxin. The other more serious reason is that when the grass pea is consumed by the people as staple food for 3-4 months it causes lathyrism (Malek et al., 1995). Moderate daily consumption of grass pea like other legumes has no deleterious effects, and some authors even mention beneficial effects for human health (Rao SLN, 2011).

Trypsin inhibitors

Trypsin inhibitors (TI) have a wide distribution in the plant kingdom and are present in most legume seeds and cereals (Francis *et al*., 2001). In comparison with most edible legumes, trypsin inhibitor activity (TIA) in grass pea is high (Aletor *et al.*, 1994). Trypsin inhibitors inhibit growth by interfering with the digestion of protein in the intestine of animals thereby causing hypertrophy of the pancreas (Oke, 2007). The major physiological effect of trypsin inhibitor is to cause the enlargement of the pancreas and secretion of excessive amounts of pancreatic enzymes much of which is lost through the animal faeces (Aletor *et al.*, 1994).

Phytates (Phytic acid)

Phytic acid, myo-inositol-(1, 2, 3, 4, 5, 6) hexakis-phosphate and its salts are the major sources of phosphorus in legume seeds (Urbano *et al*., 2000). Phytate is storage form of phosphorus and abundant in foods having high fiber content. Human body is unable to digest phytate similar to non-ruminant animals. It doesn't provide phosphorus but it is a chelating agent as it chelates metal ions like iron, zinc, calcium and magnesium, vitamin niacin and makes them unavailable to the body and thus cause mineral deficiency and pellagra (Jansman *et al*., 1998; Ali et al., 2010).

Moreover, the phosphorus in phytate has been considered largely unavailable to the organism because of the limited capacity of monogastric species to hydrolyze phytate in the small intestine. The reason is it can bind enzymes too (e.g. pepsin), blocks absorption of the important minerals and causes starch to be less digestible imposing worse nutrition. It is present in every plant, but highest concentrations in cereals, legumes, nuts and spices. They are heat-stable. On the other hand, they protect against cancer, one of the breakdown products is inositol triphosphate, which enhances natural killer cells activity.

Phytic acid content in grass pea can varies with genotype, climate and type of soil. Phytic acid has been considered as an antinutrient as it binds with other nutrients and makes them indigestible. Excessive phytic acid in the diet will have a negative effect on the mineral balance by forming a complex with mono, di- and trivalent mineral ions such as Na^+, K^+,Ca^{2+}, Mg^{2+}, Zn^{2+}, Cu^{3+} and Fe^{3+} thereby these ions are unavailable for body utilization or causes poor mineral bioavailability (Urbano *et al*., 2000). Phytic acid is also able to make phytate–protein complexes, decreasing protein solubility, thus reducing the availability of dietary protein (Francis *et al*., 2001). The ability of phytic acid to bind with minerals, proteins or starch, directly or indirectly, may alter solubility, functionality, digestibility and absorption of these nutrients.

Tannins

In addition to phytate, tannins (phenolic compounds) are found in significant quantity causing bitterness and astringency of many legume foods like grass pea and beverages (Ramakrishna *et al*., 2006). Tannins are compounds with intermediate to high molecular weights and their name is originated from their tanning ability. They are also able to form insoluble complexes with carbohydrates and proteins, and the precipitation of salivary proteins is responsible for astringency in tannin-rich foods. In addition, tannins often form complexes with the vital minerals, reducing intestinal absorption and the subsequent utilisation at cellular level (Salgado *et al*., 2001).

Tannins are secondary metabolites of various chemical structures widely occurring in plant kingdom (Francis *et al*., 2001). They are defined as high-molecular-weight polyphenolic compounds that have the ability to bind with protein and preserve animal hides. However, the term “tannin” is commonly used to refer polyphenolic secondary metabolites of higher plants, which fall into four specific groups depending on their basic chemical structure: (i) gallotannins, (ii) ellagitannins, (iii) complex tannins, and (iv) condensed tannins (also known as proanthocyanidins) (Bender, 2006; Maxson and Rooney, 1972).

Tannins are polyphenolic compounds having astringent and bitter taste that can be felt after eating unripened fruit. They are known to bind protein and alkaloids and make the meal difficult to digest. Consumption of tannin in large doses may cause bowel irritation, damage the liver and stomach, kidney irritation, gastrointestinal pain, chelate minerals and makes them unavailable to the body. Its prolong consumption may lead to iron deficiency that causes anaemia. However tannins reduce the bioavailability of only plant sources of iron i.e. non-haem iron by making complexes (McGee and Harold, 2004; Karamac, 2009).

Many factors such as soil composition, water stress, temperature and humidity will affect levels of phenolics present in plants (Kouki and Manetas, 2002). Tannin content alters during the development of the plant and also as a response to the environmental changes (Hatano et al., 1986; Santos et al., 2002; Salminen et al., 2001).

The anti-nutritional effects of tannin include interference with the digestive processes either by binding the enzymes or by binding to food components like proteins or minerals. Tannins also reduce the absorption of vitamin B_{12}. Contrary to condensed tannins, the hydrolysable tannins are easily degraded in biological systems, forming smaller compounds that can enter the blood stream and over a period of time causing toxicity to the organs (e.g., liver and kidney). Tannins are also known to interact with other anti-nutrients. For example, interaction between tannins and lectins removes the inhibitory action of tannins on amylase, and interactions between tannins and cyanogenic glycosides reduce the deleterious effects of the latter (Francis *et al*., 2001).

Condensed tannin levels in grass pea lines ranges from zero to 4.38 g/kg (Urga *et al*., 2005). Tannins are strongly astringent (owing to their protein-binding properties), a depression of feed intake which lowers animal productivity would be expected. Although astringency seems to be the major cause of lower feed intakes, several other factors may contribute to the lower feed efficiency ratios of tannin-containing diets. These include the formation of tannin/protein complexes that makes the protein unavailable, inhibition of the digestive enzymes, increased synthesis of digestive enzymes due to inadequate enzyme digestion, and increased loss of endogenous proteins such as the mucoproteins of the gastrointestinal tract (Campbell, 1997).

Tannin levels were found to generally vary with the intensity of pigmentation, with the darker seed coats generally giving higher levels of tannins consistent with the work of Deshpande and Campbell., 1992. These workers also observed that the color of flower in *Lathyrus sativus* is highly correlated with the seed color, the blue pink or red colored flowers usually produce speckled, colored seeds, whereas the white flowers are associated with white to creamy yellow seeds. The blue flowered varieties are concentrated in south-west Asia and Ethiopia whereas grass pea types with white or cream seeds are rarely found in accessions from Ethiopia or from the Indian subcontinent. Blue flowered varieties are also reported to exhibit tolerance to abiotic factors such as drought, water-logging, heavy soils, high and low pH, poor soil, and biotic factors (Duke JA., 1981).

Lathyrogens

Lathyrogens are toxic compounds found in certain *Lathyrus* plant species, including the flatpodded vetch *(L, cicera)*, Spanish vetch *(L, clymenum)*, and the *L. sativus*. Lathyrogens include β-amino propionitrile and the neurotoxic amino acid β-N-oxalyl-L-α, β- diaminopropionic acid. Consumption of lathyrogens in humans causes a disease called lathyrism. The toxicity symptoms including skeletal lesions, retarded sexual development and paralysis (Tacon, 1995).

Effects of food processing methods on the nutritional and antinutritional components of grass pea

Food preparation is also an important factor. Food processing involves techniques of converting raw materials into semi-finished and finished products that can be consumed or stored (Hayma, 2003). In food processing, these procedures are commonly referred to as unit operations. They include: cleaning, coating, concentrating, heating and cooling (heat exchange), drying, disintegrating, mixing, pumping and separating. One major way of utilizing legumes is through food processing. Food can be processed at different levels including home-based food processing and at industrial level. The processing of grass pea into many food and feed products can cause changes in their nutritive value. However, despite the changes in nutritive value, the changes that are known to occur during normal thermal processing may not in any measurable way adversely affect the nutritive value of grass pea.

Processing can detoxify grass pea seeds. Any processing attempt on grass pea food contributes to toxicity reduction even if one mechanism is more effective than the other. Raw grass pea is the most toxic causing and consumption should be avoided by all means. Despite any grass pea food processing which attributes to decrease the toxin level by certain amount, pre-processing like long soaking (>18hrs) and fermentation have significant role. When legumes are properly soaked and germinated, their nutritive value increases greatly and the anti-nutritional factors such as enzyme inhibitors, toxic amino acids and other anti-nutrients are greatly decreased to significant levels. Mixing grass pea food preparation with condiments such as onion and ginger as in gravy and gravy sauce or keep in proportion below 1/3 in cereal mix, richer in essential amino acids, are among outweighing principles to use the crop safely (Haileyesus *et al*.,2005).

Soaking and Boiling

Different seeds are soaked in water for different periods of time. Soaking in water allows the seeds to absorb water, to decrease and eliminate anti-nutritional factors in legumes. However, soaking for long periods of time has been found to reduce nutritional quality of legumes through leaching of nutrients into the soaked water (Taiwo, 1998).

Shiwani Srivastava *et al*. (1999) reported that soaking of *lathyrus sativus* seeds in various media reduces the contents of β-ODAP to a varying and significant extent; losses of β-ODAP were higher after soaking in boiled water, alkaline and tamarind solutions but less after soaking in drinking water. The highest losses in boiled water (65–70%) were observed for β-ODAP, followed by trypsin inhibitors (42–48%) and polyphenols (30–37%). Also ordinary cooking and pressure cooking of pre-soaked seeds were found to be most effective in reducing the levels of all the natural toxicants examined, while fermentation and germination were more effective in destroying both of the enzyme inhibitors (amylase inhibitors by 69–71%; trypsin inhibitors by 65– 66%) than either phytates or polyphenols.

Boiling improves the appeal and sensory properties of legume. Boiling is usually at 100^0C for few minutes. It tenderizes the seeds through water absorption. Traditionally, cooking of beans is being done using firewood. Pressure cooking pots allows legumes to be cooked under pressure and it reduces cooking time. This process eliminates heat labile antinutritional factors such as trypsin inhibitors (Bishoi and Khetarpaul, 1993). Haileyesus *et al*. (2005) reported that soaking grass pea in water before cooking roughly halved the risk of neurolathyrism but cooking in clay utensils more than quadrupled it. Also, they concluded that consumption of grass pea in the green unripe and boiled forms increased the risk 10 times or more. However, mixing the food with gravy that contains condiments with antioxidant activity reduces it by a factor of 4 and consumption of grass pea mixed with cereals rich in sulphur amino acids was also highly protective, but the magnitude of the effect depends on the grass pea preparation consumed.

A reduced risk of paralysis was associated with soaking L.sativus seeds in water before preparation, fermentation, mixing the seeds with gravy that contains condiments with antioxidant activity or mixing with cereals rich in sulphur amino acids is shown to be protective (Akalu *et al*., 1998). Toxic amino acids are readily soluble in water and can be leached. Moist heat (boiling, steaming) denatures protease inhibitors which otherwise add to the toxic effect of raw grass pea through depletion of protective sulfur amino acids. Steeping as well as discarding the water and then boiling decreases ODAP levels by 90% (Padmajaprasad et al., 1997). Cooking for 10, 20 and 30 minutes had variable effects. Cooking for 20 minutes results in clearly better reduction in ODAP content compared to the shorter duration of 10 minutes or the longer period of 30 minutes for all temperature intensities. There was also a trend of increasing reduction in ODAP content with increasing temperature (Tadelle *et al*., 2003).

Roasting

Legumes are roasted on the open frying pan in the presence or absence of salts or ash. Roasting improves the taste and edibility of legumes. It is important also in reducing and eliminating anti-nutritional factors. Roasted legumes are characterized by unique flavours which can increase their sensory appeal. Roasting resulted in only marginal reduction of ODAP content (20.61%) (Tadelle *et al.*, 2003).

Germination

Germination enhances desired qualities such as improved digestibility, reduced antinutrients like trypsin inhibitors (Ahmed F *et al*., 1995). It improves nutritional quality of the proteins by hydrolyzing them into absorbable polypeptides and essential amino acids. Germinated or malted legumes are eaten in the form of sprouts and are better than non-germinated ones. Sprouting improves the availability of vitamins B and C. It also reduces polyphenols content. Chicken pea and broad beans are commonly germinated before eating, cooking or use in salad dressing.

Fermentation

The process increases the digestibility of plant proteins and also reduces the anti-nutritional factors. Fermentation enhances flavour, colour and texture of legumes. Changes in these attributes are major stimuli in development of legume fermented products. It reduces heat stable anti-nutritional factors such as phytate. Bacterial (lactic acid) and fungal (tempeh) fermentation is useful to reduce ODAP content.

Solid state fungal fermentation on pure grass-pea using the fungal strains *Rhizopus oligosporous* and *Aspergillus oryzae* in succession has shown that the neurotoxin β-*N*-oxalyl-α,β-diaminopropionic acid (β-ODAP) in grasspea has been removed by 80% on average for the high-toxin variety and up to 97% for the low-toxin variety (Yirgalem Yigzaw *et al*., 2004). Solid state fermentation of several low-toxin varieties of grass pea (*Lathyrus sativus* L) seeds with *Aspergillus oryzae* and *Rhizopus microsporus* var *chinensis* removed the neurotoxin β-ODAP (3-*N*-oxalyl-L-2,3- diaminopropanoic acid) to a considerable degree from the seed meal (Fernand *et al*., 2000).

Autoclaving

According to study found by Girma *et al*. (1998), roasting and autoclaving of the milled grass pea causes significant reduction in the content of β-ODAP up to 30% and 50%, respectively, compared to that of raw whole seeds.

Extrusion

Extrusion cooking is a high-temperature, short-time process in which moistened, expansive, starchy and/or proteinacious food materials are plasticized and cooked in a tube by a combination of moisture, pressure, temperature and mechanical shear, resulting in molecular transformation and chemical reactions (Castells *et al*., 2005). Parallel to the increased applications, interest has grown in the physico-chemical, functional and nutritionally relevant effects of extrusion processing. It also significantly reduces antinutrients present in legumes (Abd El Hady and Habiba 2003). Extrusion reduces ODAP levels in grass pea by 46% (Ramachandran et al., 2004).

Nutritional concern about extrusion cooking is reached at its highest level when extrusion is used specifically to produce nutritionally balanced or enriched foods, like weaning foods, dietetic foods, and meat replacers (Plahar *et al*., 2003). Also, extrusion technology causes substential viscosity reduction in cereal gruels and enhances its nutrient densities (De Muelenaere, 1989). Thus, extrusion technique allows broadening the product range, and increasing the consumption of leguminous seeds product matrix.

CONCLUSION

This review illustrates how various processing techniques such as soaking, boiling, roasting, germination, fermentation, autoclaving and extrusion will affect not only the nutritional and antinutritional components but also the sensory appeal of grass pea making it fit for human consumption. Among the different processing methods, soaking in boiled water, and roasting are the most appropriate methods in improving the digestibility of protein and carbohydrate and reduce anti-nutritional factors. These types of processing can be carried out at household as well as industrial levels.

The main nutritional components of grass pea such as protein, carbohydrate, fat, vitamins, minerals and fibre have been reported to be influenced by various processing methods. In most cases, processing methods upgrade the nutritional quality of grass pea. The protein content of grass pea surpasses all other nutrients. It is also onfirmed that the protein quality is improved upon processing with regards to biological value, true protein digestibility, net protein utilization (NPU). Thus, grass pea forms a cheap source of protein-rich food especially for growing children. It is also important to note that grass pea should be processed prior to consumption to improve the digestibility of carbohydrates and proteins and also reduce and sometimes, eliminate antinutritional properties present in it. The deleterious effect of all antinutritional properties can be minimized by applying appropriate processing methods.

Hence, the efficient use of food processing techniques by manipulating the processing time effectively improves the optimal use of the legume- grass pea for safe human consumption.

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