Effects of Processing on Nutritional Composition and Anti-Nutritional Factors of Grass pea (Lathyrus Sativus L): A Review

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Abstract

Grass pea (Lathyrus sativus L.) is one of the most important food legumes that is widely grown and consumed in many developing countries like Bangladesh, India and Ethiopia. They are inexpensive source of protein and good quantities of essential amino acids. Despite their potential in upgrading diets of the poor people of the world, there are certain constraints to optimal utilization of grass peas as food and they are generally underutilized. Processing can improve grass pea sensory appeal, nutritive value and antinutritional factors that affect their utilization. Major constraint in utilization of grass pea is reported to be the presence of the neurotoxin β-ODAP (β-oxalyl- diamino propionic acid) in addition to phytate, tannin and trypsin inhibitor. This review focuses on the effect of different processing methods such as boiling, fermentation, germination, extrusion and autoclaving on nutritional composition and anti-nutritional factors of grass pea and potential health impacts on consumers. Most of the processing methods are effective in improving the nutritional quality and reducing the antinutritional factors of grass pea. To minimize nutrient loss during adverse processing of grass pea, optimization of processing conditions are recommended for investigation.

Keywords: Grass pea, anti-nutritional factors, processing methods, nutritive value

1. INTRODUCTION

Plants are the most important sources of food for human beings. Among these, legumes and legume products are important sources of protein in the diets of millions of people in the world They are sources of low-cost dietary vegetable proteins and minerals when compared with animal products such as meat, fish and egg (Ramakrishna *et al.,* 2006). Among these, grass pea one of the most economically important legume for resource constrained people like Ethiopia. The genus *Lathyrus* in the family *Leguminosae (Fabaceae*) is large with 187 species and subspecies recognized (source). 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 (source). Over the past decade, grass pea has received increased interest 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) also known as "guaya" in Ethiopia and khesari dhal in India is a food, feed and fodder crop that belongs to the family Fabaceae (source). It is produced in India, Pakistan, Bangladesh, Ethiopia, Syria, China and Nepal, giving rise to different names in different regions (source). It is 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*., 2006). The use of grass pea (Lathyrus Sativus) as grain legumes for human and animal consumption dates goes 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 (Ghirma *et al*., 2004).

Currently, grass pea occupies some 9% of the cultivated area and represents almost 8% of the total production of food legumes in Ethiopia and is the cheapest available legume in the market (EARO, 2000). Grass pea is very tasty, nutritious, easily cultivated and hardy crop. It tends to replace the staple cereal- based diet of the people of rural north and central Ethiopia during times of acute food shortage. Because of its drought-tolerant nature, it is extensively cultivated in the highlands of north and central Ethiopia where cases of lathyrism are seen both sporadically and in the form of epidemics (Lambein *et al*., 2007). In Ethiopia, there was a strong epidemiological association between excessive consumption of grass pea and the development of an irreversible crippling disorder of the legs, known as neurolathyrism in humans and animals (Urga and Gebretsadik, 1993).

Grass pea is endowed with many properties that make it an attractive food crop in drought stricken, rain-fed agriculture areas where soil quality is poor and extreme environmental conditions prevail. Despite its tolerance to drought, it is not affected by excessive rainfall and can be grown on areas subjected to floods. It has a very hardy and penetrating root system and therefore can be grown on a wide range of soil types, including very poor soils and heavy clays. This hardiness, together with its ability to fix atmospheric nitrogen, makes the crop one that seems designed to grow under adverse conditions. Compared with other legumes, grass pea is resistant to many pests including storage insects (Campbell, 1997).

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).

The main anti-nutritional factors occurring in grass pea include protease inhibitors (trypsin inhibitors), phytic acid, tannins, and β-ODAP (Sarma and Padmanaban 1969, Lambein *et al*. 1993). The major physiological effect 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 feces (Urga *et al*., 2005). Phytic acid binds trace and macro-elements such as zinc, calcium, magnesium, and iron, in the gastrointestinal tract and making dietary minerals unavailable for absorption and utilization by the body (Jansman *et al*., 1998). 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.

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 of intermediate to high molecular weight and their name 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).

Grass pea is considered as strategic famine food for the developing countries like Ethiopia where there is harsh weather condition and unreliable rain fall. But, the image of grass pea as a healthy food lags behind other food commodities (legumes) and it is generally underutilized. Under-utilisation of grass pea has been attributed to the presence of rafinose family oligosaccharides (RFO) that interfere with digestion causing gastrointestinal distress and flatulence (Urga *et al*., 2006. Moreover grass pea causes an irreversible paralysis of the legs (neurolathyrism) and the lower limbs (lathyrism) in upon 6% of the consumers (source). This toxicity of grass pea associated with the presence of inherent neurotoxin 3-(-Noxalyl)-L-2, 3-diamino propionic acid (β-ODAP) as reported by Yan *et al*. (2006). Part of this is due to lack of scientific data on the most effective processing methods that can deactivate those inherent components of grass pea which are not friendly for safe human consumption.

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

The processing condition of grass pea should also take in to 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 the 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 of 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 input to propose the optimum processing condition to achieve the intended nutritional quality and elimination of the inherent neurotoxins found in grass pea.

2.1 Overview of status in grass pea production

Grass pea is an annual vine closely resembling field pea (*Pisum sativum L.*) in growth habit, but its leaflets are long and grass shaped, hence its name grass pea. In Ethiopia, grass pea is known by different local names as:

guaya in Amharic, *sebere* in Tigrigna and *gayo*in Afan Oromo. In India, Nepal and Bangladesh grass pea is commonly called *khesari*. Its unique feature of drought tolerance makes it a golden crop for the arid regions of the world. Nevertheless, the presence of a toxic chemical in the seed, which causes paralysis of the limbs when consumed excessively, makes it a threatening crop (Tsegaye *et al*., 2007).

2.2 Production and distribution of grass pea in Ethiopia

Grass pea is widely grown in Ethiopia in the off-season under residual moisture. However, its production is more common in the north-western (58%), the central (16%) and the north-eastern (13%) parts of the country (Tsegaye *et al*., 2007). The northern as well as southern parts of the country account for the remaining 13% of the area under grass pea (Tsegaye *et al*., 2007). In Ethiopia, grass pea is the third most important pulse crop after faba bean and chick pea (CSA, 1998). Its production area increased from 70,400 ha in 1992 to 159,731.5 ha in 2009 (CSA, 2009). The factor underlying this growth is the relatively good performance of grass pea under adverse environmental conditions, such as moisture stress, water logging, insufficient soil fertility, diseases, and pest damage (Tsegaye *et al*., 2007).

2.3 Trends of grass pea Utilization

Grass pea is cultivated in a number of countries for human food, animal feed and fodder (source). It is an important food crop and total consumption is highest in Asia and the Middle East where the whole seed is used in soups and ground to make unleavened bread (Tsegaye *et al*., 2007).The major uses of grass pea include: green fodder, pasture, and seed as feed and as human food. In South Asia, Ethiopia and China the crop has a dual purpose and in other regions, it is mostly used as fodder or feed. There are various trends of grass pea utilization in different parts of the world. In India, the grains are sometimes boiled whole, but are most often processed through a *dhal* mill to obtain split *dhal*. *Dhal* is the most common method of retailing the crop in the India subcontinent. In Canada its uses would be for high protein livestock feed.

In Ethiopia, the grass pea seeds are processed in various forms. The most common method of preparation of grass pea is soaking in water and then boiling until the grains are soft ('*nifro*'). Other traditional methods include sprouting and boiling of sprouted seeds, roasting of soaked seeds (*kollo*) (Urga and Gebretsadik, 1993; Teklehaimanot *et al.,* 1993). When alternative crops are scarce grass pea is used alone or mixed with other cereal flours for making unleavened bread. In time of famine, the diet of the population of grass pea cultivating regions is forced to consist of only grass pea. When harvest is plentiful, grass pea flour is mixed with other legumes to prepare flour for sauce (*shiro wott'*) (Urga and Gebretsadik, 1993).

2.4 Major nutrients of grass pea

Adequate nutrition via food is a necessity of human life. Among these food groups, legumes play a significant role in their contribution for human consumption in a variety of ways. Legumes have a significant role in providing the bulk of protein requirement for people in different parts of the world and constitute an integral part of the staple diet. Food provides energy and essential macro- and micronutrients required for growth, tissue maintenance and the regulation of metabolism and normal physiological functions. Besides these essential nutrients, foods of plant origin supply various non-nutritive phytochemicals (like tannin and phytate) that promote good health and reduce the incidence of many chronic diseases. Hence, frequent consumption of pulses is now recommended by most health organizations (Leterme, 2002).The World Health Organization (WHO) recognizes the importance of plant foods in the diet, recommending >400 g/day consumption of fruits and vegetables, not including tubers (WHO/FAO, 2003).

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), (Rotter *et al*. (1991). With regards to nutritional composition, there appears to be few studies on the nutritional aspects of grass pea. In general, the cotyledon and embryo make up most of the nutritionally beneficial part of the seed whilst the seed coat contains many of the antinutritional factors (ANFs). As any legume Grass pea is rich in protein (28-32%) and contains good quantities of essential amino acids except the sulfur containing amino acids (Urga *et al*., 2005). Urga *et al*. (2005) reported the protein content of grass pea to range from 27.29% to 31.98% in Ethiopian varieties. 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.

In addition to being important source of protein and calories, grass pea is rich in minerals. The seeds have a higher concentration of magnesium and phosphorus followed by calcium (Urga *et al*., 2005). Grass pea plants obtain minerals from their soil environment and partition 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 (Urga *et al*., 2005). The ash and crude fiber concentration of grass pea is also reported to range from 3.56 and 1.2% to 8.62 and 4.14 %. Fats and carbohydrates concentrations also range from 0.92% to1.47% and 55.05% to 85.17% respectively (Rotter *et al.* (1991). In summary, grass pea is a good source of energy, protein, minerals, vitamins, fibre.

2.5 Anti-nutritional factors and toxic compound in grass pea

Currently, there has been an increased interest regarding nutrition among a wider segment of society. The primary focus of the society is not simply on eating for survival, but to be informed of what we eat to enjoy the best quality of life for longer. 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. 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). 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). The most frequently occurring anti-nutritional substances in grass pea are protease and amylase inhibitors, lectins, tannins, saponins, alkaloids, phytates, and lathyrogens (Ramachandran and Ray, 2008).

2.5.1 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 to the animal in faeces (Aletor *et al.,* 1994).

2.5.2 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). Phytic acid content in grass pea can vary with genotype, climate, type of soil and year. Phytic acid has been considered an antinutrient as it binds with other nutrients and makes them indigestible. Excessive phytic acid in the diet can have a negative effect on 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+} resulting in these ions becoming 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.

2.5.3 Tannins

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)(source). Tannins can also be generally divided into hydrolysable (glucose polyesters of Gallic or hexahydroxydiphenic acids) and condensed tannins (proanthocyanidins) (Bender, 2006).

Theanti-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 (source). Tannins also reduce the absorption of vitamin B12 (source). 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 removed the inhibitory action of tannins on amylase, and interactions between tannins and cyanogenic glycosides reduced the deleterious effects of the latter (Francis *et al*., 2001).

Condensed tannin levels in grass pea lines ranged 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 make 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).

2.5.4 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).

2.6 Health problem of grass pea (Lathyrism)

Chemotaxonomic studies which was established in the early 1960s found the presence of toxic amino acids named as ODAP (β-N-oxalyl-L-α,β- diaminopropionicated) in 1964.This toxic non-protein amino acid molecule caused several lathyritic epidemics in grass pea producing country. Lathyrism, traditionally known in Ethiopia as "Sebre" or "yeguaya beshita" which is irreversible neurodegenerative disease essentially manifested by spastic paraparesis of the lower limbs in man (EIAR, 2007).

Lathyrism in humans has received more attention than that in animals, due to the social cost. Symptoms in humans are most often initial painful spasms in the muscles of the lower limbs with accompanying weakness, followed by chronic spastic paraplegia of various degrees (Spencer *et al*., 1986), and can lead to total loss of use of the legs. The paralysis is rarely reversible (and then only in early stages of the symptoms; and the consequences for poor communities who depend upon L. sativus as a primary food source at times of food scarcity can be devastating(Hugon *et al*., 2000).

Human lathyrism causes reduced mobility, scissor gait, turning-in of the toes, stiffness and semi-flexion of the knee-joints. Sensory symptoms of pain, numbness and cramps may present but commonly at the onset victims suddenly feels week and heavy in the leg when weight is excreted on them or after falling down or awakening from sleep. There is dragging of leg, increased reflexes and impaired ability to walk (Haileyesus *et al*., 2005).

There are two forms of lathyrism, neurolathyrism and osteolathyrism. Osteolathyrism is characterized by skeletal deformities (bone deformation (osteolathyrogenic) by affecting the cross-linking of collagen during bone and connective tissue formation) and can be caused by consumption of the species L. odoratus (sweet pea), L. hirsutus, L. pusillus and L. roseus (Roy, 1981), however, consumption of L. sativus seedlings and shoots as vegetables has been blamed as the cause of osteolathyritic symptoms found in a small proportion of people with chronic neurolathyrism (Haque *et al*., 1997).

Osteolathyrism has been recorded experimentally in a wide range of animals (Barrow *et al*., 1974). The principal compound responsible was found to be b-aminopropionitrile (BAPN but, BAPN is not found in either L. sativus or L. cicera (Bell, 1964), there is evidence that a BAPN precursor (2-cyanoethyl-isoxazolin-5-one) is present in L. sativus seedlings but not in seed (Lambein *et al*., 1993). Consumption of L. sativus seedlings and shoots as vegetables has been blamed as the cause of osteolathyritic symptoms found in a small proportion of people with chronic neurolathyrism (Haque *et al*., 1997).

Neurolathyrism is the term used to describe the symptoms for weakness of the hind limbs and paralysis or rigidity of the muscles shown after heavy consumption of several different Lathyrus species, probably for 2-3 months. Within the Lathyrus genus, the category of neurolathyrism has been further divided into two subcategories. One is caused by the compound L-2, 4-diaminobutyric acid (DABA), primarily found in the perennial species L. sylvestris (Foster, 1990). The form of neurolathyrism most pertinent and common is the one caused by the non-protein amino acid 3-(-N-oxalyl)-L-2,3-diamino propionic acid (ODAP, which is also named as b-N-oxalylamino-L-alanine or BOAA) recorded in humans and animals those consuming L. sativus, L. cicera, L. ochrus and L.clymenum (Franco,1991).

Lathyrism is the term mostly used to refer to neurolathyrism caused by ODAP. It is one of the oldest diseases known to man and caused by over-consumption of grass pea food during an uninterrupted extended period potentially to the extent of accumulating -ODAP above a threshold level in the body to suddenly develop the crippling disorder overnight. Even if it is not answered the amount taken up in the blood and over what length of time and how much is transported to Central Nervous System are crucial because lathyrism is incurable just like AIDS, except the latter is a fast killer in most cases, while lathyrism remains a life time health problem. According to virulence of the disease and extent of walking difficulty of lathyrism is divided into four stages (Haileyesus *et al*., 2005).

In Ethiopia lathyrism is a neglected disease that attracts little or no attention and appeared neither on the list of the top 10 nor on the top 20 diseases, where AIDS took the first position. There is neither formal nor strict advice given to consumers in periods of drought and high risk of lathyrism, even in areas where more than one crippling patient per family is common or in cases where this poverty linked disease seems inherited. In it's commonly prevalence rate of more 2% of every sever epidemics, the threat of lathyrism never triggered any effort for national prevention campaigns, and the disease is still overlooked by media (EIAR, 2007). So until recently, lathyrism remained neglected and unattended while in Ethiopia alone tens of thousands are estimated paralyzed and several millions of fully exposed consumers are little or totally uninformed of the potential risk and are possible victims of the crippling disorder.

Although comprehensive survey have never been done, in Asia and Africa there may be several hundred thousand people affected by this disease that crippling not only their legs but also their livelihoods grounding their socio-economic functioning in the already poor communities of farmers surviving in a hand to mouth economy(EIAR., 2007). Lathyrism still occurs, with a 1997 outbreak during food shortages in Ethiopia crippling 2000 people (Getahun *et al*., 1999). Lathyrism is endemic to the areas of the world which have significant areas of L. sativus cultivation such as India, Bangladesh, Ethiopia and Nepal. However, in the 20th century outbreaks were also reported in Afghanistan, Algeria, China, France, Germany, Italy, Pakistan, Romania, Russia, Spain and Syria (Hugon *et al*., 2000).

2.7 Effects of processing methods on nutritional composition of grass pea

There are many procedures that food raw materials go through before they are finally available as edible food products. 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 (source). Food processing involves techniques of converting raw materials into semi-finished and finished products that can be consumed or stored (Hayma, 2003). Food can be processed at different levels including home-based food processing and at industrial level. The processing of grass pea into the 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.

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. Children are most exposed as they eat the green seeds as snack during field stay with the herd or walking. Despite any grass pea food processing attributes to decrease the toxin level by certain amount, pre-processing like long soaking (>18hrs) and fermentation have significance role (source). 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 insignificant levels. Mixing grass pea food preparation with condiments such as onion, 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).

2.7.1 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 reduced 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 some minutes. It tenderizes the seeds through water absorption. Traditionally, cooking of beans can be 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 reduced 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 depended 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). Boiling has been found to reduce ODAP levels in several cases. Padmajaprasad *et al*. (1997) reported that boiling grain and discarding the water reduced ODAP levels by up to 90%.

Cooking for 10, 20 and 30 minutes had variable effects. Cooking for 20 minutes resulted 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 days of age (Tadelle *et al*., 2003).

2.7.2 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).

2.7.3 Fermenting

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.

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 grass-pea has been removed by 80% on average for the high-toxin variety and by 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).

2.7.4 Germinating

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 form of sprouts and are better than ungerminated 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.

2.7.5 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). 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.

2.7.6 Autoclaving

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

3. CONCLUSIONS AND RECOMMENDATIONS

This review demonstrated that different processing method; soaking and boiling, roasting, fermentation, germination, extrusion and autoclaving affect the nutritional composition, the sensory appeal and antinutritional factors of grass pea. 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. Processing can foster wider utilization of grass pea in food diversification to improve the nutrient intake of resource constrained community in developing countries like Ethiopia.

Major nutrients of grass pea, such as protein, carbohydrate, lipid, minerals, vitamins and fibre have been reported to be influenced by various processing methods. In most cases, processing methods upgrade the nutritional quality of grass pea while nutritional deterioration due to processing is reported in few investigations. The protein content of grass pea surpass all other nutrients and it is also confirmed that the quality is improved upon processing with regards to biological value, true protein digestibility, net protein utilization(NPU). Overall, it is important to note that grass peas should be processed prior to consumption to improve the digestibility of carbohydrates and proteins and also reduce antinutritional factors.

The major constraint in consumption of grass pea is the presence of natural neurotoxin; β-ODAP in higher concentration in the raw seeds of grass pea. This can cause irreversible paralysis and it is highly emphasized that processing is also very important for public health concern apart from the nutritional quality improvement. In addition to β-ODAP, grass pea contains other antinutritional factors such as tannins, phytic acid, trypsin inhibitors, saponins and oligosaccharides. Oligosaccharides cannot be easily digested and hence can cause abdominal discomfort and flatulence. The deletriuos effect of all antinutritional factors can be minimized through applying appropriate processing methods.

In order to maximize wider consumption of grass pea, the future line of research effort should focus on awareness creation among the general public on the dangers of consuming raw grass pea. In addition to this promotional work, optimization of processing parameters should be investigated to come up with optimum point in both nutritional quality improvement and reduction of antinutritional factors in which the finding can help to minimize adverse changes in nutritional loss and quality deterioration as a result high thermal processing.

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