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Review Article

Review on Pretreatment Techniques of Grass Pea Seeds for Reduction of Antinutritional Factors and β-Diaminopropionic (β-ODAP) Contents from Seeds

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Abstract

Grass peas are one of the most nutritious foods and are widely harvested and consumed in many developing countries. They are an inexpensive source of protein and contain large amounts of essential amino acids. The potential of grass peas to improve food security, nutrition and household income generation remains largely untapped. However, the naturally occurring amino acid β-diaminopropionic acid (β-ODAP) leads to limited neurotoxic activity. Lathyrus sativus β-ODAP exists in two isomers (α and β isomers) in nature. The α isomer accounts for approximately 5% of the total ODAP content and is less toxic, but the β isomer is also more toxic. Decreased β-ODAP levels through food processing such as overnight soaking, cooking bean sprouts, fermentation, and roasting. Most food pretreatment processing methods can effectively improve the nutritional quality of grass bean grains and reduce anti-nutritional factors. Grass peas, a variety of traditionally treated seeds, serve as a staple food for poor farmers in countries such as Ethiopia and are primarily consumed during times of drought and famine. Grass pea seeds are valued as a nutritious staple food and feed plant mainly due to their high protein content.

Keywords

Grass Pea, Roasting, Nutrition, Antinutritional, β-ODAP

1. Introduction

Grass Pea (Lathyrus sativus) belongs to the genus Lathyrus in the Fabaceae family (Fabacea [1] and has common names such as chickpea, butara, kesari, Indian vetch Almorta (Spain), and guaya (Ethiopia) included., Jirban (Sudan), Gesette (France), Picello Bretonne (Italy), and Dar. Grass peas are a member of the legume family that are widely harvested around the world. Because of its tolerance to drought, flooding, salinity, and low soil fertility. It is an important rotational crop for sustainable agricultural systems such as cereals and other legumes in parts of Africa, Europe, and Asia [2]. Grass Pea seeds are a staple food for poor farmers in countries such as India, Bangladesh, China, and Ethiopia, especially during periods of drought or famine [3]. It is an annual legume cultivated primarily for livestock feed and human consumption. Grass peas provide basic food security and income and are a source of nutrition for millions of people [4, 5].

Grass pea is an annual Legume crops [4]. It is widely cultivated in Ethiopia. Ethiopia produced 312.6795 thousand tons of

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grass peas from 145.537-thousand-hectare area during 2019–20. However, production is more common in the northern parts and central of the country. In terms of geographical distribution, its production in the Amhara region (West Gojam (16.3%), and (East Gojam, South Gondar, and south Wollo zone 78%) and Oromia region (West Shewa 58%), East Shewa (12.8%), and northern Shewa as well as South East (12.9 %). Generally, in Ethiopia produces 85% of the total area supply of grass pea, recently time wassie variety the commonly cultivated. Therefore, grass pea seeds produce 8.7% of the total area of crop production and contribute 7.6% of the total production of food legumes in Ethiopia compared with other crops that are used as the staple food for human consumption. The nutritional value of grass pea depends on geographical location [6]. In addition, these seeds have a high level of protein content (particularly rich in lysine) and polyunsaturated fatty acids [7].

Grass pea is low in cost compared to other legumes. It is an important economic resource and provides high yield under adverse environmental conditions and with a great potential for use in marginal low-rainfall areas [8]. In the last fifty years, farm research has only been able to produce Wassie, a single grass pea variety. Grass pea is still underutilized with only around 4% of the total production process for human consumption due to toxic presence in seeds. Traditional processes effectively reduced bioavailability. Also, the neurotoxic compounds of grass pea mostly (ODAP) are water-soluble [9]. Therefore, soaking and other traditional process procedures can be reduced. Generally, pretreatment methods are the maximum reduction in the ODAP content and processing including soaking, roasting, boiling, and preparation of sauce and unleavened bread are used for the consumption of grass peas in the daily diet.

Grass pea seeds still remain undervalued and underutilized as a food source in Ethiopia and other countries [4] in spite of their unique nutritional (rich resource of protein (26-33%) and low fat, dietary fibre, and moderate total carbohydrates), starch (40-55%) and health benefits. It is used as pea flour (shiro) for the traditional preparation of Ethiopia with or without mixed with other legume flours and cooked as snack food (roasted with mixed salt). Also, grass pea is used in various ways in our country for human foods such as flatbread, Shiro, Porridge, Nefro, kollo, and local beverage known as “Arake” [4]. Grass pea flour is used in various investigated as replacements for other legume flour in traditional products.

Grass peas contain β-N-oxalyl-L-α, β-diaminopropionic acid (β-ODAP), a natural substance that makes them inedible. Commonly known as Lathyrus sativus, the grass pea is an important source of affordable alternatives for resource-poor populations in many tropical countries, especially Africa and Asia, where protein is consumed primarily [10].

Grass pea seeds are valued as a nutritious staple and forage crop, mainly due to their moderately high protein content of 18–34% in dry weight seeds and 17% in mature leaves, and high lysine content [11]. However, the intake of the naturally occurring amino acid β-N-oxalyl-L-α, β-diaminopropionic acid (β-ODAP) is limited due to its strong neurotoxicity [8]. β-ODAP of Lathyrus sativus naturally exists in two isomeric forms, with the α form accounting for approximately 5% of the total [2, 12]. Although (β-ODAP) is a water-soluble neurotoxin, concentration in proteins can be reduced/removed by isolation by aqueous extraction of the protein followed by precipitation [12]. Additionally, β-ODAP is removed/reduced to safe limits before consumption by food processing such as overnight soaking, cooking, and roasting [3].

1.1. Utilization of Grass Pea Seeds

Grass peas are also widely cultivated in Ethiopia and are an important legume for human consumption, and the straw is used as animal feed. However, grass pea is one of the least utilized legumes [14]. The underutilized grass pea seed is a legume whose potential contribution to the national economy is understudied due to lack of attention paid to its production, consumption, and use. Grass peas are a typical underutilized and orphaned legume crop that plays an important role in many developing countries, providing food and nutritional security to consumers and providing income to resource-poor farmers. Based on this definition, grass pea flour refers to the product from milling grass pea seeds. Grass pea flour has been described as having a light yellow color and flavor [9]. Despite the popularity of its consumption in the form of flour in some areas for the preparation of the traditional dish, porridge, its use for human consumption [1]. In Ethiopia, grass pea is an important food and is processed in various forms of dishes. The most commonly prepared dishes from legumes are, in Ethiopia, spiced soup-like dishes, spiced dishes, shelled and split cotyledons, boiled and salted whole seeds, roasted whole seeds, used as unleavened flatbread, and sourdough bread made by mixing thirds.

Figure 1. *Grass pea seed and fruits [16].*

1.2. Nutritional Composition of Grass Pea Seeds

Grass pea seeds are a rich source of nutrients having higher protein (28-32% g/100 g db.), lower total dietary fibre (7.3g/100g dry basis.), and carbohydrate (58.2%) compared to Anchote flour. Grass pea seeds are also very low in starch (35 to 39.3 %), and 0.38% of essential amino acid, unlike anchote flour in which starch is the major component [17]. It is also containing the most important such as 6.8% pentosans, 1.5% sucrose, 14% albumin, 1.5% lignin, 3.6% phytic, 5% prolamins, 15% glutelin and 66% globulin. The fat content of grass peas ranged from 0.6 g/100 db to 0.8 g/100 g db., depending on species [7]. Grass pea is nutritious, rich in protein (28-32%), and contains good amounts of essential amino acids [18]. Grass pea is comparable to other legume crops, such as field pea based on its nutritional composition, the grass pea is a good source of protein and starch.

Grass pea seeds also contain vitamins such as beta-carotene (52-58%), carotene (39-48%), thiamine (14.2-16.3%), folic acid, riboflavin (24-39%), ascorbic acid (83%), niacin, and thiamine [19] as well as minerals including phosphorus, magnesium, zinc, copper, and calcium [18]. It was also reported that grass pea seeds have high levels of carotenoids compared to those of L. albus and L. luteus [19]. Grass pea contains antioxidants [20] in the form of polyphenolic flavonoids and tannins. Additionally, it is also low in tryptophane and sulphur amino acids, but rich in lysine and threonine [17].

2. Methods

2.1. Pretreatments of Grass Pea Seeds for Reduction Anti-Nutritional Component

2.1.1. Clean and Separation of Solids

Absolutely, the cleaning process is crucial for all grains and legumes as it involves removing contaminants that can range from harmless to potentially harmful. The primary objective of cleaning is to separate these impurities from the raw materials. This separation is achieved by exploiting the physical properties that differentiate the contaminants from the particles. By effectively eliminating impurities through cleaning, the quality and safety of the grains and legumes can be ensured for further processing and consumption. For example, it is used to remove, stones, or metallic particles from grain prior to milling to avoid contamination [21].

2.1.2. Soaking and Dehulling

Soaking is the initial steps in cleaning seriously dirty ingredients, such as root and tubers, crops, legumes, and cereals allowing softening of the soil and partial removal of stones and other contaminants. Soaking of grain legumes is primarily done to soften the exterior matrix for easy removal of the seed coat. Soaking grain depends on soaking time and soaking solution. The main importance of soaking specifically grass pea for the removal of toxic substances and anti-nutritional factors. It is the simple process of removing toxic compounds present in seeds. Also, soaking grain facilitates cooking time and improves the nutritional value [15].

(β-ODAP) is a toxic amino acid present in grass pea. It is a strong epidemiological of permanent disabling syndrome of the legs, known as neurolathyrism. However, the neurotoxin β-ODAP is water-soluble, i.e., it can be removed by washing the seeds several times or soaking the grain for some time in the water. The soaking *Lathyrus sativus* seeds in water, alkaline, salt, rock salt, and wood ash solutions were potentially decrease of β-ODAP content and other anti-nutritional factors. However, soaking for long periods reduces the nutritional content of legumes [22]. The soaking process affects the proximate of seeds such as reduced carbohydrate, protein, fibre, mineral, and vitamins [23]. On another hand, antinutritional factor is reduced when soaking grass pea seeds in water [10].

2.1.3. Drying Heat Treatment Under Roasting Techniques

Drying heat treatment had eliminated tannins and highly phytic acid, ODAP, and trypsin inhibitor activity (64%, 100%, 75%, 87.4%) respectively [23]. The reduction of ODAP content, in grass pea that was roasted (150 ℃ for 60min) and cooked for 60 min was 82%, and 57% respectively [24]. It is clear from the results that the (β-ODAP) of breads was lower than that of the flour, probably due to the baking of bread at a high temperature (181.46 ℃) a decline in (β-ODAP) and also, the flour dilution for dough. This implies that the cooking and heat treatment process successfully reduced the ODAP content to 78 and 77%, respectively [23].

2.1.4. Dehusking

Dehulling is the development of elimination of hulls (seed coats) of legumes to simplify grinding [25] In these the cleaned and graded grains were passed through an emery-coated roller for initial pitting or scratching of the husk. Pitted grains were thoroughly mixed with about 1% oil and spread in a thick layer for sun drying in the drying yards for 2-5 days. Trypsin inhibitor inhibition was important reduced in soaked, dehulled, and germinated seeds as compared to the raw seeds and decreased the phytic acid content of the processed grass pea [22]. The dehulling process helps to remove the seed coats and increased protein and fat contents but decreases ash and fibre contents. The dough is to be prepared, the soaked grain is rubbed by hand to remove the husk, after which it is separated by flotation or wet ground in a stone grinder. The trypsin inhibitor inhibits was significantly reduced in soaked, dehulled, and germinated seeds as compared to the raw seeds and decrease in the phytic acid content of the processed grass pea [22].

2.1.5. Dry Milling

Premilling treatments influence the milling method by loosening the hull, reducing breakage, and improving the value of the split products [25]. Dry milling outcomes in the ground floor from grain legumes, a process that overall is substantially more energy-efficient than any wet milling process. Dry fractionation involves milling and separating the milled flour into a fine, protein-enriched fraction and a course, starch-enriched fraction [26]. Milling quality is mostly affected by the grain shape, size, grain hardness, test weight, thousand kernel weight, and flour color [27]. The native properties are reflected in better solubility, foam stability, digestibility, and lower viscosity related to protein isolates [26].

2.1.6. High Hydrostatic Pressure for Treatment of Antinutritional and Toxic β-ODAP in Grass Pea Seeds

The consumption of whole grains and legumes is important for a nutritious diet, but they often face challenges due to poor edible and cooking qualities, as well as the presence of antinutritional factors and allergens. High hydrostatic pressure (HHP) treatment is a non-thermal processing technology that can address these challenges [2]. HHP treatment improves the edible quality of whole grains and legumes while preserving their natural nutrition and freshness. It achieves this by reducing the concentration of antinutritional elements and sensitizing allergens, while minimally affecting the color and scent of the food components. This review provides an overview of the principles of HHP treatment technology and its effects on the nutritional components, antinutritional factors, and cooking qualities of whole grains and legumes. Additionally, it explores the potential effects of HHP-treated whole grains and legumes on certain diseases. The information presented in this review can serve as a reference for the application of HHP treatment in the context of whole grains and legumes.

High Hydrostatic Pressure (HHP) treatment has been found to effectively reduce phytate content in grass pea. When HHP treatment is combined with soaking, it becomes even more effective in degrading β-ODAP and IP6 (phytate) [1]. As a result, after HHP treatment, most accessions/varieties of grass pea are considered safe for human consumption. Additionally, HHP treatment has been shown to significantly improve the nutritional value of grass pea.

2.1.7. Germinating Reduction Anti Nutrietional Content in Grass Pea Seeds

Germination is another simple and inexpensive treatment to enhance the nutritional value of seeds by affecting synthesis macromolecules, proteolysis, conversion of seed nitrates into ammonium compounds or plant proteins and degradation of antinutrients [3]. Germination is a widely used technique to enhance the nutritional value of seeds, particularly in legumes and cereals, at the household level. It involves the process of sprouting seeds, which affects various aspects such as respiration, subcellular structures, synthesis of macromolecules, proteolysis, conversion of seed nitrates into ammonium compounds or plant proteins, and degradation of antinutrients [4]. Through germination, certain antinutrients like phytate and protease inhibitors can be broken down, leading to increased palatability and improved nutritional qualities of the seeds [5] This simple and inexpensive technique offers a way to enhance the nutritional value of seeds.

Germination of seeds has been found to have several effects on their nutritional composition. It leads to a decrease in dietary fiber and starch content, resulting in an increase in the level of sugars. Additionally, germination has been shown to increase the in vitro digestibility of starch and protein, as well as the availability of calcium (Ca), iron (Fe), and zinc (Zn). This increase in digestibility and availability is attributed to the reduction in antinutrient contents, specifically phytic acid and polyphenols, which occurs after 48 hours of germination [3].

2.1.8. Fermentation of Grass Pea Seeds for Anti-nutritional Contents

Fermentation has vital advantages of retaining nutrients, sensory attributes, and reducing the microbial load of food products [6]. During soaking the seeds absorb water, endogenous enzymes are activated, and the content of antinutritional factors is declining. Long time soaking, however, has been found to reduce the nutritional quality of legumes by leaching of nutrients into the soaking water [5, 7]. The fermentation of grass pea seed meal has been found to be an effective method for reducing the levels of anti-nutritional factors, including tannins, phytic acid, and the neurotoxin β-ODAP (β-oxalyl-diaminopropionic acid). This process has shown significant success in decreasing the concentrations of these compounds [8]. The process of fermentation and extrusion of grass pea has been found to effectively reduce the tannin content. Research has shown that the process of fermentation and extrusion of grass pea can effectively reduce the tannin content. Both bacterial fermentation, specifically lactic acid fermentation, and fungal fermentation, such as tempeh fermentation, have been found to be useful in reducing the ODAP (β-N-Oxalyl-L-α,β-diaminopropionic acid) content [9]. Specifically, the tannin content was reduced by 80.7% through fermentation and extrusion. Autoclaved grass pea seed meal showed a reduction of 75.3% in tannin content, while germinated grass pea seed meal exhibited a reduction of 46.9% in tannin content [7, 9-11].

2.2. The Treatment of β-ODAP Contents of Grass Pea Seeds

The (β-ODAP) content of the products could be described by [28], who reported that the soaking of grass pea for 8 hr in distilled water during the process preparation of grass pea flour (GPF). The mean values for the result of soaking (GP) in tap water as processing treatments of the β-ODAP contents in grass pea flour there was a significant ($p<0.05$) reduction in the β-ODAP toxic. The results showed that grass pea flour contained 439.4 mg/100g of β-ODAP, which in the range the results of reported by [23], (111-476.3mg/100g), [3] (20-700mg/100g), [28] (549-825mg/100g), [29] (618.29-1001.49mg/100g), [30] (360 to 589mg/100g), [31] (94.8mg/100g), [24] (922mg /100g).

The review reported show that of β-ODAP content in raw grass pea from many countries (mg/100 g) as 40 to 760 (Australia), 160 to 250 (Spain), 450 to 1400 (Bangladesh), 280 to 1500 (India), 70 to 750 (Syria), 180 to 520 (Chile), and 80 to 990 (China) [8, 32]. The variability in β -ODAP content can be attributed to the different germplasm collection of grass pea and might be influenced by growing conditions, the environment and locality [33].

Most of the (β-ODAP) was a water-soluble amino acid that can be leached from seed by soaking in water [34]. Steeping grass pea in a large volume of cold water for 3 min leached out approximately 30% of β-ODAP [35]. Similarly, report that soaking dehusked grain seed in boiled water for several hours removed 70-80% of the neurotoxin β-ODAP found in the grass pea seed [36]. This might be the leaching result of soaking likewise degradation of the toxic compound and mineral content in grass pea seeds [28].

2.3. Human Health-Related Benefits of Treatments Grass Pea Seeds

Legume seeds, such as beans, lentils, and chickpeas, not only serve as dietary protein sources but also possess health-related properties. These properties have been attributed to mechanisms such as inhibition of cancer cell migration, matrix metallopeptidase 9 protease activity, and modulation of protein digestibility during in vitro digestion. It is important to note that the health-related properties of legume seeds can be influenced by various processing methods.

In a randomized controlled trial, it was found that cooked grass pea seeds, the decrease in β-ODAP (β-N-Oxalyl-L-α,β-diaminopropionic acid) levels observed with the addition of zinc may be attributed to the chelating effect of zinc on β-ODAP, reducing its mobility within the grain [9]. This suggests that adequate zinc nutrition, either from the soil or through fertilizer application, may partially reduce β-ODAP levels in grass pea, making it safer for human consumption.

However, it is worth noting that the widespread use of Lathyrus sativus (grass pea) as a dietary protein source is limited due to the presence of the potent neurotoxin β-ODAP. The levels of β-ODAP can vary significantly depending on the area of cultivation.

3. Conclusion

Combining traditional food processing and preparation practices can have a positive impact on the nutritional profile of grass pea seeds. These practices can increase the bioavailability of protein and micronutrients, which is important because the antinutritional factors (ANFs) present in the legume can inhibit protein and iron absorption even at low concentrations. Simple and cost-effective methods such as soaking, dehulling, and germination can be employed to improve the nutritional profile of Grass pea flour and foods made with it.

In a published study, it was found that grass peas, an underutilized and orphaned legume crop, play a significant role in providing food and nutritional security in many developing countries. They also contribute to the income of resource-poor farmers. Various pretreatment methods, including washing, soaking, roasting, fermentation, germination, and drying, were used to reduce the antinutritional factor β-ODAP. Overall, these pretreatment methods resulted in a reduction of β-ODAP and contributed to an improved nutritional value of the grass pea crop.

Declarations

Author contribution statement: Bekele kuma: Analyzed and interpreted the data; Contributed materials, analysis tools or data; Wrote the paper. Ashanafi Shiferaw: Analyzed and interpreted the data; Wrote the paper.

Additional Information

No additional information is available for this paper.

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Data Availability Statement

The authors have not taken permission to share data.

Conflicts of Interest

The authors declare no conflict of interests.

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