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Published at http://www.ijate.net http://dergipark.gov.tr/ijsm **Review Article**

Nutritional and Antinutritional Factors of Some Pulses Seed and Their Effects on Human Health

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Abstract: The Food and Agriculture Organization (FAO) realizes about fifteen pulses (primary and minor) such as dry peas, black beans, chickpeas, roman bean, beans, and lentils etc. cultivated worldwide over a hundred countries. Similarly pulses especially bean, chickpea and lentil are really popular in Turkish Cuisine culture and there are many meals made with the pulses in Turkey. Thus, seed quality of the pulses is too significant for producers to be sold at higher prices. Moreover, it is also important for human health with over nutrition rates and has high levels of minerals as well as folate and other B-vitamins and diminished rate of diseases particularly resulting from obesity due to the high level of fiber and protein rates. But pulses seeds have also antinutritional factors such as some enzyme inhibitors (trypsin and chymotrypsin proteinase inhibitors), phytic acid, flatulence factors, lectins and saponins, and some different allergens. The factors cause some health problem such as mineral (Fe, Zn, Mg etc.) deficiency of human body. So, we prepared the review to show situation of some pulses in Turkey and in the world and to explain some antinutritional factors (secondary metabolites) of pulses seeds besides some nutritional characteristics.

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1. INTRODUCTION

Pulses are identified as one of the earliest domesticated plants by humans and have played critical part of food, especially during the transition period from hunting-gathering times to agriculture. There are some archaeological evidences about cultivation of pea on The Fertile Crescent dating back to 11,000-10,000 years BP in Syria and Turkey [1]. Pulses are unique in comparison to other plant foods owing to higher proportions of protein contain. In fact, the protein content of pulses ranges from 17 to 30 % of dry weight which is typically twice the amount found in cereals [2], but it hasn't got some essential amino acids especially Cysteine and Methionine [3]. Despite in a relatively low number of calories, pulses are providing

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substantial amounts of vitamins and minerals. Because of diverse ecological conditions in Turkey, pulses can be grown throughout the year. They are grown on approximately 63-million-hectare area with annual production of 53 million tons in Turkey [4].

Pulses have shown numerous health benefits via the protection against cardiovascular diseases owing to having dietary fiber content [5] and combined with vitamin C improves iron absorption [6] and promotes bone health [7]. They are rich sources of complex carbohydrates, minerals as well as folate and other B-vitamins, protein [8]. Furthermore, the whole pulses are an abundant source of some key minerals include iron, zinc, selenium, phosphorous and potassium and high-quality oil and folic acid, isoflavones and tocopherol [9]. Therefore, it is said that pulses are identified as natural preservative of obesity and related disorders including coronary heart disease, diabetes, and the metabolic syndrome [10 –11]. There are recommended as part of healthy eating for lower glycemic index by health organizations globally [12].

Nowadays, there are a lot of studies about the nutritional benefits of pulses [13, 14, 80–81] and their suggestions have been that more consumption of pulses (dried seeds from the legume family such as dry peas, black beans, chickpeas, beans, and lentils) because of seeds nutritional quality [82]. Moreover, for most of them, the more legume consumption has been an elixir of the healthier life of the world [83]. But the seeds have also some compounds (antinutritional factors) such as some enzyme inhibitors (trypsin and chymotrypsin proteinase inhibitors), phytic acid, lectins and saponins, and some different allergens etc. besides protein, fiber, vitamins and minerals. The compounds are named as secondary metabolites which synthesize in plants consequence of frequent bioactivities and sometimes may cause some health problems. With this review, we tried to determine agricultural situation of some pulses in Turkey and in the world and some positive and negative effects of pulses on human health.

2. MATERIAL and METHODS

2.1. Bean

Beans usually refers to food legumes of the genus *Phaseolus*, family *Leguminosae*, subfamily *Papilionoideae*, tribe *Phaseoleae*, and subtribe *Phaseolinae*. *Phaseolus vulgaris* originated from Central and South America, where it was cultivated as early as 6000 BC in Peru and 5000 BC in Mexico. Then it was introduced to the Old World by the Spaniards and the Portuguese. It is now widespread and cultivated as a major food crop in many tropical, subtropical and temperate areas of the Americas, Europe, Africa and Asia [15]. It grows from sea level up to an altitude of 2200-3000 m where annual rainfall is between 300 and 4300 mm and average temperatures range between 15°C and 23°C. The global harvest today has been estimated approximately 18.7 million tons from nearly 150 countries (27.7 million hectares) [4]. While *P. vulgaris* is by far the most economically important domesticated species of the genus *Phaseolus*, there are four others: *P. dumosus*, *P. coccineus*, *P. acutifolis* and *P. lunatus* [16]. It has slight frost tolerance but growth stops below 10°C and frost hinders yield at various stages of growth [17–15]. Furthermore, yield of beans is also largely dependent on-air temperature of the first flowering date and then. Because the probability of the flowers that firstly opened are more likely to hold the pods than the others [18]. The common bean is a warm season legume under subtropical conditions.

Beans are an important crop in Turkey economically, since their production and export has increased significantly in recent years. Because dry weather during the maturing stage which is prevalent especially Mediterranean climate condition in a large part of Turkey, benefits seed preservation. The common bean grows well on a large variety of soils with pH ranging from 4 to 9. However, it does better on well-drained, sandy loam, silt loam or clay loam soils, rich in organic content [19, 88]. There are some bean varieties such as Akman-98, Doruk,

Karacaşehir-90, Noyanbey-98, Sarıkız, Horoz and Sarnıç suitable for climate and environmental conditions in Turkey. Today, climate change and the varieties adaptation of these is one of the most important issues in our agricultural production [89]. It generally cannot withstand waterlogging though some cultivars do well in standing water. Bean is sensitive to Al, B, Mn and high levels of Na. Deficiencies in minerals may arise in calcareous soils (Zn deficiency) and in sandy acidic soils (Mg and Mo deficiencies) [15].

2.2. Chickpea

Chickpea (*Cicer arietinum* L.) is one of the largest produced food legumes in South Asia and the third largest produced food legume globally, after common bean (*Phaseolus vulgaris* L.). Chickpea is grown in more than 50 countries (89.7% area in Asia, 4.3% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe). India is the largest chickpea producing country accounting for 64% of the global chickpea production. The other major chickpea producing countries include Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. Production area of chickpea is about 11.0 million hectares and production value is 8.8 million tons and average yield is nearly 800 $kg.ha^{-1}$ [4]. Chickpea production is almost half of bean, so it can be identified as the second most important grain legume [91]. Social factors and ecological constraints determine whether bean or chickpea are grown in a particular region [90].

There are two distinct types of chickpea cultivars named desi (microsperma) and kabuli (macrosperma) [20]. The desi type which has brown, yellow, green or black color and thick seed coat account for about 80-85% of the total chickpea area and are mostly grown in Asia and Africa [21]. While the kabuli type which has white or beige color and thin seed coat is grown small part of the world.

2.3. Lentil

Lentil (*Lens culinaris* Medik.) may have been one of the first agricultural crops grown more than 8,500 years ago. Production of the cool season annual crop spread from firstly the Near East to the Mediterranean area, then Asia and Europe and finally the Western Hemisphere. The crop has received little research attention to improve its yield and quality. It grows well in limited rainfall areas of the world [22]. The highest lentil production values of the world are made countries like Canada, Indian, Turkey, USA, Nepal and Australia. Besides most exports of lentil in the world is also done by Canada, Turkey, USA and Australia [23].

In recent years, lentil production in Turkey has increased substantially. Red lentils are grown intensely in southeastern Anatolia region [24]. Not only local varieties, but also culture varieties such as Fırat-87 (Komando), Seyran-96 and Çağıl are grown in the region. Red lentils are divided into 2 classifications as crusted lentils and red inner lentils [92]. Both groups are also divided into 2 classifications named first class and second class with some characteristics such as humidity, total foreign matter presence, % inorganic matter presence, total defective grain presence, presence of insect damaged grain, broken-shell peeled grain existence etc. [25]. Lentil growth rates are slow during early stages of vegetative growth and weeds can quickly overgrow on the crop if not adequately controlled [26]. Weeds compete with the crop for nutrients, water, and light, reducing crop yields and grain quality. Yield losses in lentil of 40-80%, as a result of weeds, have been reported [27–28].

3. DISCUSSION

3.1. Antinutritional factors of pulses and its some effects of human health

Pulses have importance both nutritional and worldwide commercial because, they are easy to store and are rich in protein and fiber [29]. However, their nutritional value is limited

by the presence of antinutritional factors such as some enzyme inhibitors (trypsin and chymotrypsin proteinase inhibitors), phytic acid, flatulence factors, lectins and saponins etc. [30]. It is noted that a significant correlation between nutritional factors (protein – starch or protein – oil) but found no correlation between antinutritional factors (phytic acid - flatulence factors or lectins – saponins) [31]. It is explained below that some of the most important antinutritional factors of pulses and their effects on the feed rate.

3.1.1. Trypsin and chymotrypsin proteinase inhibitors

Protease inhibitors are found everywhere in nature. There are a lot of studies observed various important biological functions of the inhibitors like digestion of proteins, control of blood clotting in human, signaling receptors interaction in animals and defense against insect attack in plant [31, 93 – 94]. They are present in significant amounts in plants and belong to two major groups, namely Bowman-Birk type and Kunitz type protease inhibitors. Kunitz type protease inhibitors include at least nine trypsin and chymotrypsin inhibitors [32].

Proteinase inhibitors of plants are small molecular weight proteins that are natural, defense-related proteins often present in seeds and induced in certain tissues by herbivory or wounding. Most storage organs such as seeds (*Leguminosae* and *Graminae*) contain about 1 to 10% of their total protein, which inhibit different types of enzymes [33]. Thus, their main function is thought to be in plant defense, the regulation of endogenous proteinases in addition to the prevention of unwanted proteolysis [34]. There are a number of reports in the literature related to proteinase inhibitors in various legume species. Studies discussed the role of trypsin and chymotrypsin inhibitors which decrease protein digestibility if not properly inactivated during processing [35, 36–95]. Moreover, some study showed that trypsin inhibitors play also a protective role against attack by insects [37, 99–100].

For example, 30-40% of cysteine in bean protein is found in protease inhibitor structure [38]. Protease inhibitors are resistant to small intestinal digestion. They are increase the activity of feces by binding proteases [39]. Therefore, the availability of sulfur-containing amino acids in leguminous grains is low.

3.1.2. Phytic acid

The trace elements copper, manganese, iron and zinc special attention when evaluating the nutritional adequacy of vegetarian or vegan diets. Moreover, the elements are also vital for children from the age of development and pregnant or lactating women [40]. The world population, particularly in Latin America, Sub-Saharan Africa, the Caribbean and Southeast Asia, is at risk for micronutrient intake [41]. Recent reports indicate that Fe deficiency is the most prevalent micronutrient problem in the world, affecting over 2 billion people globally [42]. An estimated 49% of the world population is at risk for low Zn intake [43]. Zn deficiency of children are common in the world [44–45]. Calcium content in rural diets in developing countries is not adequate [46] and dietary Ca deficiency has been linked to several chronic diseases, including osteoporosis [47].

Phytic acid in foods of plant origin forms a complex with dietary minerals such as calcium, zinc, iron, and magnesium and makes them biologically unavailable for absorption. Phytic acid is also widely distributed in legume seeds and it accounts for about 78% of the total phosphorus in pulses [48]. Phytic acid has also been linked to the inhibition of digestive enzymes such as protease and alpha amylases [49]. Phytic acid binds trace elements and macro-elements such as zinc, calcium, magnesium and iron, in the gastrointestinal tract are making dietary minerals unavailable for absorption and utilization by the body [50–51]. It can also form complexes with proteins, proteases and amylases of the intestinal tract, thus inhibiting proteolysis [52]. Moreover, the phosphorus in phytate has been considered to be largely

unavailable to the organism because of the limited capacity of monogastric species to hydrolyze phytate in the small intestine. Phytic acid is the major determinant of Zn absorption, especially for diets with a low animal protein content [53]. It strongly binds Zn in the gastrointestinal tract and reduces its availability for absorption and reabsorption [54]. Similarly, there is some evidence that phytic acid has also an inhibitory effect on the absorption of Fe in human [55 – 56]. Phytic acid decreases Ca absorption [57] and phytic acid breakdown improves Ca availability [79–58]. On the other hand, in spite of the presence of phytic acid, it is difficult to ascribe a negative effect to whole products on Mg absorption [101]. Effective reduction of phytic acid can be obtained via the action of exogenous phytic acid degrading enzymes [59].

3.1.3. Saponins and lectins

Saponins are secondary plant metabolites present in pulses, containing a carbohydrate moiety (mono/oligosaccharide) attached to an aglycone, which may be steroidal or triterpenoid in structure [102]. They are generally characterized by their bitter taste (those in liquorice are an exception, being sweet), their ability to foam in aqueous solutions, and their ability to hemolyse red blood cells, these latter properties being a consequence of their amphiphilic properties [85]. Ingestion of foods with saponin have been both deleterious and beneficial effects. On the one hand, saponins have unfavorable effects such as low weight in animals and hypocholesterolemia in humans [103]. On the other hand, they reduce the risk of heart diseases in humans with a diet rich in food legumes containing saponins [104]. Following oral administration, saponins are only poorly absorbed and are either excreted unchanged or metabolized in the gut. Detailed information on the fate of saponins in the animal gut is lacking, but enteric bacteria, intestinal enzymes, and gastric juices most likely cause breakdown within the gastrointestinal tract [105].

Lectins (hemagglutinins or phytohemagglutinins) are a group of proteins of nonimmune origin in nature. They are found in nature as share the property of specifically and reversibly binding to carbohydrates either in free form or as part of more complex structures. There were first described in 1888 by Stillmark working with castor bean extracts [84]. Moreover, many members of the lectinic protein family agglutinate (clump together) red blood cells. Some of the species of pulses seeds such as lentil, bean and pea also contain phytohemagglutinins (lectins) [61]. These are proteins which possess a specific affinity for certain sugar molecules. Most of the lectins contain 4 to 10% carbohydrates [62]. High levels of lectins (specialized proteins) may be found in grains (also known as cereals or pulses), legumes, dairy and plants in the nightshade family. Many other foods contain lectins but are less well studied and the amounts of lectins present are not thought to be as high or as potentially toxic [96]. The human digestive system was created to handle a variety of plant and animal proteins through the process of digestion and elimination. Some plant and animal proteins or lectins are severely toxic to humans and cannot be eaten without causing death like those in Castor beans and some mushrooms [63]. The major antinutritional toxic factor limiting the use of pulses. Although, in general, lectins are more resistant to heat-denaturation than other plant proteins, prolonged cooking can inactivate legume lectins [87]. However, as heat-processing is expensive and potentially damaging, it is usually kept to a minimum even with legumes, particularly when the product is to be used in animal nutrition [64].

Although pulses seeds also contain previously mentioned anti-nutritional factors such as enzyme inhibitors, lectins, flatulence factors, polyphenols, tannins, phytic acid and saponins. Most of them can be reduced or eliminated to some degree by different cooking techniques such as pressure cooking or any other else [65, 97–98].

3.2. Some positive effects of pulses on human health

Bean quality criteria can be listed as seed weight, wet seed weight, water uptake capacity, water uptake index, swelling capacity, cooking time etc. [66]. It can grow under higher temperatures (35°C) but this may hamper seed production. Due to their high concentrations of protein, fiber, and complex carbohydrates, beans are today one of the most important legumes in the world [67]. Moreover, bean seed is nutrient-dense, fiber-rich, and are high-quality sources of protein. The consumption of dry bean has been greatly connected with many physiological and health promoting effects such as prevention of many types of diseases [68]. Fiber has emerged as a leading dietary factor in the prevention and treatment of chronic diseases [86]. More studies show that dry bean intake has the potential to decrease serum cholesterol concentrations, improve many aspects of the diabetic state, and provide metabolic benefits that aid in weight control [70, 71–72]. Therefore, it could be said that more beans consumption is the best way for reducing the risk of some chronic diseases [69].

Chickpeas are generally considered to be a low glycemic index food [73] and it is a good source of carbohydrates and protein, and protein quality is considered to be better than the others. Furthermore, chickpea has significant amounts of all the essential amino acids except for Cysteine and Methionine which have an S-bond amino acid. In addition, it can be complemented by adding cereals to the healthy diet [74]. Starch is the major storage carbohydrate followed by dietary fiber, oligosaccharides and simple sugars such as glucose and sucrose. Although lipids are present in low amounts, chickpea is rich in nutritionally important unsaturated fatty acids such as linoleic and oleic acids. β-Sitosterol, campesterol and stigmasterol are important sterols present in chickpea oil. Ca, Mg, P and, especially, K are also present in chickpea seeds. Chickpea is a good source of important vitamins such as riboflavin, niacin, thiamin, folate and the vitamin A precursor β-carotene [75].

Lentil is defined as relatively a cheaper source of protein, rich vitamins and minerals. Moreover, the seeds can be defined as rich fiber source [60]. High fiber intakes are associated with lower serum cholesterol concentrations, lower risk of coronary heart disease, reduced blood pressure, enhanced weight control, better glycemic control, reduced risk of certain forms of cancer, and improved gastrointestinal function [78]. So, more health organizations are recommended that people need to increase the consumption of lentil both part of healthy diets for reduce of nutritional deficiencies and against some diseases such as diabetes, heart disease, cancer and cardiovascular disease.

Pulses are annually grown leguminous crops are often promoted in diet owing to their low cost and many beneficial nutritional effects [76]. It was detected significant negative correlations between some nutrients (protein-carbohydrate and protein-fat) [77]. Furthermore, it should be noted that numerous studies are available on the interactions between environmental and genetic factors on seed quality and nutritive value of different legumes [68].

4. CONCLUSIONS

Pulses seeds contain significant amount of proteins, carbohydrates, polyphenols, phytosterols, resistant starch, oligosaccharides and dietary fiber [13, 14, 80–81]. Therefore, nowadays, pulses have been defined as a full advocate against some diseases such as diabetes, heart disease, cancer and cardiovascular disease [82, 83]. Moreover, pulses are also important part of human diet against overweight with low fat content of seeds in many countries of the world. Pulses have a low glycemic index and are rich source of antioxidants, so regular intake of pulses can improve heart health and lowers blood cholesterol [10, 11, 12–102]. In spite of providing many nutritional factors of pulses seeds, there are also providing many antinutritional factors such as phytic acid, saponins, lectins, polyphenols, lathyrogens, protease inhibitors etc.

These factors can cause many illnesses such as some trace elements deficiency, unbalanced or malnutrition [40, 41, 42–46]. So, it should be noted that intense pulses intake in the daily diet over a long time may occur some negative results for human health especially for pregnant or lactating women, children of growth age and vegetarians. Furthermore, it should be kept in mind that just some cooking techniques can reduce these negativities to some degree [65,97,98].

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