# Antinutritional Factors in Food Grain Legumes

Mustafa Onder
Selcuk University, Agricultural Faculty,
Department of Field Crops, Konya, TURKEY
monder@selcuk.edu.tr

Ali Kahraman
Selcuk University, Agricultural Faculty,
Department of Field Crops, Konya, TURKEY
kahramanali@selcuk.edu.tr

**Abstract:**The use of plants to meet the world's food needs is vital to human survival. On a global basis, over 65 % of food protein and over 80 % of food energy is supplied by plants. In terms of gross tonnage, approximately 98 % of the total world food production is harvested from land sources and only 2 % from the ocean and inland waters. Of the total food harvest, plant products directly contribute about 82 % of the gross tonnage, whereas the other sources (animal and marine products) together contribute only 18 %. The avarage production of plant protein potentially edible by humans was estimated to be 200 million tons, compared to 50 million tones of animal protein.

Their unfavorable balance of amino acid requires that complementary protein be provided for optimal nutrition. In the developed countries of the Western world, animal protein make up a substantial portion of the diet. In the developing countries, however, the animal proteins are either too expensive, so legumes serve as main sources of both protein and calories in many of these tropical and subtropical areas of the world. Dry legumes and legume products are, in fact, the richest source of food protein from plants.

**Keywords:** Antinutritional factors, inhibitory, legume, pulses.

## Introduction

Pulses, whose history of cultivation dates back to earlier times, are essential for human and animal nutrition as well as crop rotation. The fact that their grains contain 18-36 % protein (Çiftçi, 2004), are sufficient in carbohydrates, consist of high amounts of phosphor, iron and calcium and are rich in vitamins (A, B, C, D) further adds to their significance. Since pulses contain high amounts of amino acids, they are consumed in developing countries together with low-protein and high calorie foods that are staple diets of those areas instead of animal proteins, which are both expensive and rare. Rice and bean or bean and bulgur in Turkey, corn and cowpea or rice and cowpea in African countries and corn and bean combinations (mixtures) complement each other in terms of their nutrient contents. However, in addition to increasing consumption of pulses in diets, it is also important to know how sparing amounts of antinutrient substances that are inherent in them will be removed. It has been established that pulses contain various substances, some varieties of which can be toxic (though rare) or may cause indigestion. However, it has been observed that the effects of these factors disappear or decrease when legumes are properly prepared. Among appropriate techniques of preparing legumes are germination, peeling, soaking, cooking, treating with various chemicals, fermenting, adding enzymes, roasting and frying. However, heat treatment applied to remove antinutritious substances should be performed carefully because this can lead to a decrease in essential amino acids. Shimelis and Rakshit (2005) reported that the most important factor that affected the amount of the ingredients in a grain is genetic constitution.
Pulses contain proteins, oils, vitamins, mineral substances, carbohydrates and dietary fibers, which positively affect nutritional value as well as antinutrients that negatively affect diets. The most important of these substances are the following.

## Enzyme inhibitors

Protease (trypsin, chymotrypsin) and Amylase Inhibitors: These protein inhibitors are found in many nutrients. Found in various forms, inhibitors are present in the tissues of animals and plants as well as in microorganisms. By virtue of their innumerable pharmacological properties, they also enjoy medical value. The rate of water-soluble non-glucose proteinase inhibitor in legume seeds is about 0.2-2 % of the total soluble protein (Sgarbieri and Whitaker 1982). These substances reduce protein digestion. They decompose with heat. Therefore, when legumes are eaten raw or without being cooked properly, they upset digestive functions and cause diarrhea or excessive gas. Autoclave treatment or boiling also reduces the quantity of these substances (Khalil, 2001). About 10-20 % of the total active trypsin is found in human pancreatic juice ( Weder and Link 1993). They bind proteases, which are resistant to digestion in the small intestine, and thus ensure their removal through excretion. This is why the availability of amino acids (methionine and cystine) consisting of sulphur in legume grains is low. Sulphur deficiency may occur in a diet that is dependent on legume grains (Ergün et al., 2002). In addition to this information, it is also known that trypsin inhibitors also carry characteristics of an insecticide (Hilder et al. 1990). Amylase inhibitors alter reactions to blood sugar and insulin by slowing down digestion and thus can be used for therapeutic purposes in diabetes (Lajolo et al. 1991).

## **Lectins** (Hemagglutinins)

All of them are proteins or glycoproteins. Lectin activity has been determined in more than 800 varieties of the legume family, which consists of 600 genus (Liener et al. 1986). 2-10 % of the total protein legume seeds are lectins. One of their most important characteristics is that they prevent absorption of digestive end products in the small intestine. They enable the coagulation of red blood cells by affecting erythrocytes. Lectins possess some other interesting chemical and biological properties, some of which are as follows: they interact with specific blood groups; they perform various functions in mitotic division, demolish cancerous cells and have toxic effects in some animals. Since they bond with different sugar groups, their bonding with intestinal wall may exhibit variation depending on the type of sugar. If some types of beans are consumed raw, they may cause shock cramps (Saldamlı 1998). Besides these characteristics, lectins can easily disintegrate (El-Adawy- 2002; Mubarak, 2005).

## Oligosaccharides

They are gas generating factors in legumes. Legume seeds, which produce digestive gases in humans and animals, contain oligosaccharides of raffinose, stachyose and verbascose (Aksar 1986). As the duration of cooking increases, a decrease is observed in oligosaccharide content. Moreover, a decrease in oligosaccharide content also occurs when soaking water is poured, seeds are washed a second time or seeds are germinated (Table 1). It is known that flatulent substances, which belong to the indigestible fibers group, reduce the risk of intestinal cancer, fortifies the immune system, increases excretion frequency and weight as well as HDL cholesterol level.

| Duration of cooking (min) | Total Sugar | Verbascose | Stachyose | Raffinose | Percentage |
|---|---|---|---|---|---|
| 0 | 78,5 | 40,3 | 7,8 | - | 0 |
| 10 | 59,3 | 35,7 | 7,6 | - | 8,8 |
| 20 | 56,6 | 34,8 | 7,5 | - | 10,9 |
| 30 | 54,9 | 33,9 | 6,8 | - | 14,3 |
| 40 | 52,6 | 29,6 | 5,8 | - | 25,5 |

Table 1. The Effect of Cooking on Total Sugar and Oligosaccharides Content of Legume Seeds (from Reddy and Salunke (1980))

## Phenol Compounds

They constitute plants' protection mechanisms against external factors. It is known that there is a relationship between flower color and boll color and tannin compositions. They are found in fruit and vegetables and in some cereals. They cause plants to have a pungent taste. They reduce bioavailability of some minerals (especially zinc). Tannins of this group are usually stable when confronted with heat, and they may negatively affect pH mechanism, reduce protein digestion, and cause nitrogen mechanism. They can be discharged with excrement.

## Saponins

They are glycoside derivatives that are found in many plants. Their general characteristics can be cited as follows: they give a bitter taste, foam when they are treated with various solutions and cause hemolysis in red blood cells. Since they reduce the surface tension of blood in cold-blooded animals, they have an extremely toxic effect. On the other hand, due to their cholesterol-reducing effect, legumes are the most important sources of saponins. The fact that saponins can bond with cholesterol and therefore reduce absorption and that legumes contain saponins points to their importance for health (Sidhu and Oakenfull 1986). Studies on medical uses of saponins continue.

## Cyanogens Glycosides (HCN)

Many members of the plant kingdom contain cyanide. The cyanide contents of some legumes have been investigated for long years (Montgomery 1964). Cyanogen compounds of tall plants are of two types: cyanogen glycosides and cyanogen lipids. Both groups contain cyanohydrins and free carbonyl. Since glycosides, which consist of HCN (hydrocyanohydric acid), can come out as a result of hydrolysis, they are potentially toxic. Cyanide can not be disintegrated with heat and since it separates from legumes during cooking or washing, it will be beneficial to pour soaking water (Devos 1988). It is known that broad beans and Lima beans are potential sources of cyanide.

## Vicine and Convicine (Favism factors)

Favism is a hemolytic disease that is found in sensitive individuals with consumption of broad beans. It is more widely found in people living in the Mediterranean countries. It is known to be of genetic source (Liener 1983). The structure of hemoglobin, which is the primary carrier of oxygen, is upset. Dizziness, vomiting, feeling of tiredness and dark orange urine, which is the first symptom of blood transfusion, are symptoms of this disease. The disease disappears soon but incidences of death may be encountered when the disease is prolonged. This disease of hemolytic anemia is caused by favogens. Favism also causes high fever and jaundice.

## Phytic acid and Phytoids

Phytoid phosphor accounts for almost 80 % of the total phosphor in many legume seeds (Lolas and Markakis 1975). Most of them are found on the outer layer of the aleurone or endosperm (Desphande et al. 1984). Phytic acid causes the bioavailability of essential minerals to decrease and turn into insoluble compounds whose absorption and digestion is less in the small intestine (Desphande and Cheryan 1984). Pulses are sources of dietary phytoid (Ergün et al., 2002). When phytoid phosphor is not made use of, it is discharged with excretion. A way of preventing this is through the hydrolysis of phytoid phosphor; for this purpose, besides methods such as soaking, germinating, using food rich in vegetable endogen phytosis enzyme and storing, methods like cooking and performing autoclave where phytoid phosphor is demolished in the presence of heat can also be used. The studies that have been conducted demonstrated that phytoids reduce cholesterol level and protect against intestinal cancer of iron origin. Besides, phytoids exhibit characteristics of natural antioxidants thanks to their benefits such as reducing lipid peroxidation (Zhou and Erdman 1995). Moreover, pulses are important sources of calcium, copper, iron, magnesium, phosphor, potassium and zinc (Geil and Anderson 1994). The content of these minerals and their bio-availability depend, to a large extent, on the degree of the processing (cooking) process and their absorption is affected by the phytoid level found in the plant (Liener 1994). 50-80 % of the endogen phytoids in broad beans can be discharged through soaking and cooking.

## Allergens

They are substances that are generally found in nutrients. They cause allergic reactions that are specific to certain individuals. The level of harm done depends on the sensitivity level of individual's body rather than the quantity of the substances taken with the food. Diarrhea and vomiting are symptoms of allergy. It is also argued that proteins with high molecular weight cause allergies (Perlman 1980). Histamine and compounds of histamine derivatives act as antigens against allergens.

## Toxic Amino acids

There are certain amino acids in legume plants that are not of protein nature and reduce nutritious value and cause toxic effects. These substances are commonly found in Lathyrus and broad beans. Dihydroxyphenyl alanine (DOPA) is the most common toxic amino acid found in legumes. Although these amino acids do not display a direct toxic effect, the plant firstly takes on a black color due to these substances, and then withers. Moreover, the nutritional value of plants that contain such amino acids (broad beans, Lathyrus) decreases substantially.

Toxic amino acids are believed to combine causes of metabolic favism. Despite all these, these substances can not do any kind of harm because they need to be in large quantities in the plant to pose a risk.

In addition to this group of toxic substances, some legumes may contain sparing amounts of antivitamin substances and estrogen factors. Substances of this kind may be activated with heat and cause serious harm. Extensive studies are reported in the relevant literature on the elimination of these substances in order to reduce their harmful effects on plants (Desphande 1984). When it is taken into account that pulses are sources of the highest quality vegetable proteins, the importance of studies on the toxicity mechanisms of toxic amino acids that have an unfavorable effect on the quality of this protein and the degree of their potential harm become obvious.

## Goitrogens

Soybean, a kind of oil seed, contain glycosides called goitrogens. Consisting of sulphur, these glycosides cause the thyroid gland to grow by inhibiting the iodine intake of the thyroid gland. This toxic effect can be reduced with the addition of iodine to the diet.

## Conclusion

In addition to being perfect sources of vegetable protein, pulses contain nutrients with high-fiber content and reduce blood cholesterol levels thereby contributing favorably to human health (Eastwood and Hamilton 1968; Önder and Akçin 1996). Increased legume consumption is recommended on cold days when energy need rises (Pekşen and Artık, 2005). Nergiz and Gökgöz (2007) stated that soaking before cooking is the most traditional, economic and appropriate method. Although cooking causes a reduction in soluble quality substances, especially vitamins and minerals in legumes, they should not be consumed raw by humans because they eliminate antinutrient substances or reduce them substantially. Also called the meat and bread of the poor and having dry grains whose chemical composition resembles that of peanut and soybean, pulses are recommended to be consumed frequently as they are highly suitable for dieting.

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