IJPSR (2013), Vol. 4, Issue 4 **(Review Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 21 December, 2012; received in revised form, 23 February, 2013; accepted, 19 March, 2013

NUTRITIONAL AND HEALTH IMPLICATIONS OF LEGUMES

Mebrahtom Gebrelibanos*, Dinka Tesfaye, Y. Raghavendra and Biruk Sintayeyu

Course and Research Unit of Pharmacognosy, Department of Pharmacy, College of Health Sciences, Mekelle University, Mekelle, Ethiopia

Keywords:
Legumes, Nutrition, Anti-Nutritional Factors, Health Benefits

Correspondence to Author:

Mebrahtom Gebrelibanos

Course and Research Unit of Pharmacognosy, Department of Pharmacy, College of Health Sciences, Mekelle University, Mekelle, Ethiopia

E-mail: mebrahtomgs@yahoo.com

ABSTRACT: Legumes are plants in the family Fabaceae characterized by seeds in pods that are often edible though sometimes poisonous. The nutrient content (protein, carbohydrate and micronutrients) of legumes contribute to address under-nutrition, especially protein-calorie malnutrition among children and nursing mothers in developing countries where supplementing cereal-based diets with legumes is suggested as one of the best solutions to protein calorie malnutrition. Anti-nutritional factors, in legumes, may limit their biological value and acceptance as a regular food item, yet they are readily removable and recent research has shown potential health benefits of some of these compounds; and hence, manipulation of processing conditions may be required to remove or reduce only those unwanted components. Moreover, legumes play a role in prevention, improvement and/or treatment of disease conditions such as, diabetes mellitus, cardiovascular diseases, cancer diseases (e.g breast and prostate cancers) and lowers blood cholesterol level. Most of these disease conditions are associated with over-nutrition and obesity and are considered as diseases of the rich. It is, therefore, claimed that including legumes in a health-promoting diet is important in meeting the major dietary recommendations to improve the nutritional status of undernourished as well as over-nourished individuals, and to reduce risk of chronic diseases such as cardiovascular disease, diabetes mellitus and cancer. In this review, some of the scientific viewpoints that attempt to justify the nutritional contributions, anti-nutritional considerations and health implications of legumes are discussed.

INTRODUCTION: A legume is a plant in the family Fabaceae (or Leguminosae), or a fruit of these specific plants, characterized by seeds borne in pods [1] and often edible, though sometimes quite poisonous [2].

QUICK RESPONSE CODE

IJPSR:
ICV (2011)- 5.07

Article can be accessed online on:
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Members of the family are important food sources; and food legumes are those species of the legume family that are consumed by human beings or domestic animals commonly as dry seeds, i.e. the grain legumes [3]. They include peas, beans, lentils, peanuts, and other podded plants that are used as food [4].

Grain legumes are commonly subdivided into pulses and oilseeds [5]. Pulses are distinguished from oil seeds by their low fat content [3]. They are those grain legumes, which, in addition to protein, store high levels of carbohydrate and low amounts of lipid in

their dry seeds, and leguminous oilseeds are those which boast higher lipid, but lower carbohydrate levels than pulses. Soybean (*Glycine max*) and peanut (groundnut, *Arachis hypogaea*) are typically categorized as oilseeds while common beans (*Phaseolus vulgaris*) and cowpea (*Vigna unguiculata*) are considered pulses [5].

The oil seeds are cultivated primarily for their protein and oil content, and the grain legumes as a protein source [6]. The terms "legumes" and "pulses" are used interchangeably because all pulses are considered legumes *but* not all legumes are considered pulses. The term "pulse", as used by the Food and Agriculture Organization (FAO), is exclusively for crops harvested solely for the dry seed of leguminous plants. This excludes oil seeds and also green beans and green peas which are consumed and considered as vegetables [3].

History and ecological importance: Generally, legumes are well known crops with long history of utilization [7], which have been cultivated for thousands of years [4]. Their consumption dated back to as far as 5500 BC and they are thought to be one of the first crops cultivated by man [8]. They have played an important role in the traditional diets of many regions throughout the world [4] and their value has long been appreciated in many countries [9]. In addition to their food value, legumes are important in cropping systems because of their ability to fix atmospheric nitrogen and increase the overall fertility of soil, reducing the need for expensive nitrogenous fertilizers.

The dominant food legumes of any region may vary from country to country or even from region to region, but most of them can be grown under a reasonably wide range of ecological conditions and many legumes can be grown reasonably well on poor soils even without the application of fertilizers [3].

Legumes are well adapted to adverse environmental conditions and highly resistant to disease and pests [10]. They are widely grown in semi-arid regions while cereals require more water and intensive cultivation [11]. Historically, legumes have complemented cereals in both human diets and production systems, especially in efficient use of land and water resources and sustainability of agriculture systems globally [12].

Most legumes that are used for foods are multipurpose plants, serving for animal forage as well as soil improvement due to their ability to fix atmospheric nitrogen [13]. Nowadays, in addition to their nutritional, agricultural and ecological significance, legumes are of great importance because of their numerous health benefits.

Generally, despite numerous advantages (improve soil fertility, serve as food and feed, provide cheaper protein source and health promoting components), legumes have certain limitations such as their deficiency of sulfur amino acids, poor digestibility and the presence of antinutritional factors although these limitations are not far from control as there exist recommended manipulations for their optimization.

Objective: The main objective of this review is to discuss on some of the scientific arguments about the nutritional contributions, anti-nutritional considerations and their suggested options of minimization as well as health implications of legumes.

Nutritional role of Legumes: Legumes constitute a part of the diet of nearly all humans [13] and their nutrient content (protein, carbohydrate and micronutrients) contribute to address under-nutrition [14]. They contain complex carbohydrates (oligo-saccharides, dietary fibers and resistant starch- i.e. starch that escapes digestion in the small intestine and may ferment in the large intestine), protein with a good amino acid profile (high lysine), important vitamins (B vitamins, folates, ascorbic acid and tocopherols), minerals as well as antioxidants, polyphenols and numerous other phytochemicals endowed with useful biological activities [3, 14-17].

They are good sources of water-soluble vitamins, especially thiamine (*Vitamin B_1*), riboflavin (*Vitamin B_2*), niacin (*Vitamin B_3*), pyridoxine (*Vitamin B_6*) and folate, but poor sources of fat-soluble vitamins and vitamin C. They are low in sodium but are excellent sources of other minerals, including calcium, copper, iron, magnesium, phosphorus, potassium and zinc [14, 18, 19]. They have desirable characteristic such as low fat (except oilseeds), high concentration of polyunsaturated fatty acids and a long shelf life [20, 21]. The predominant fatty acid is linoleic acid, although they also contain α-linolenic acid [14].

Thus, legumes contain many nutritionally important and health-promoting components responsible for addressing under-nutrition and promotion of health.

Malnutrition is currently widespread in many areas of the world; and the most serious one is protein-calorie malnutrition (PCM). PCM is a widespread problem throughout the world, especially among children in the developing countries; and has both health and economic consequences. It is a major nutritional syndrome affecting more than 170 million preschool children and nursing mothers in developing Afro-Asian countries where provision of adequate proteins of animal origin is difficult and expensive. Legumes are the major contributors of protein and calories in Afro-Asian diets for economic and cultural reasons [22, 23].

The high cost and limited supply of animal proteins have necessitated contemporary research efforts geared towards the study of food properties and potential utilization of protein from locally available food crops, especially from under-utilized or relatively neglected high protein oilseeds and legumes [23]. As the lower income group of the population is particularly vulnerable, it is suggested that attention must be given to easily available, accessible, cheap but nutritious plant protein sources (especially legumes – because among plants, legumes are considered the major source of dietary proteins) to improve the nutritional status of the low-income groups of the population[22,23].

Legumes (poor man's meat) play an important role in human nutrition since they are rich and economical sources of good quality protein, calories, certain minerals and vitamins, and fibre [14, 22, 24]. They are inexpensive, nutrient dense sources of plant protein that can be substituted for dietary animal protein [25]. However, proteins in legumes are higher in nonessential amino acids compared with proteins from animal foods [26]; and their nutritive value has been known to be low because of their deficiency of sulfur amino acids, poor digestibility and the presence of antinutritional factors [23, 27].

Yet, it is suggested that sulfur amino acids deficiency can be solved by complementing legume with cereals [5]; and food processing can improve the nutritional quality and increases the bioavailability of nutrients, by inactivating antinutritional factors [11, 28].

Thus, legumes, with the exception of soybeans, are not a complete protein like meat; however, when paired with grains or another complementary food, they provide a complete source of amino acids [19].

In developing countries, legumes complement the lack of proteins from cereals, roots and tubers [21]. Their most vital role is that of supplying most of the protein in regions of high population density and in balancing the deficiencies of cereal protein [13]. Legumes and cereals are considered ideal dietary partners because the amino acids making up their proteins are very good complements [5].

Cereal proteins are deficient in certain essential amino acids, particularly lysine. On the other hand, legumes have been reported to contain adequate amounts of lysine, but are deficient in sulfur-containing amino acids (methionine, cystine and cysteine). Therefore, intentional combination of cereals and legumes at meals offers cheap, compared to meat, plant-based diets with balanced amino acid composition [5, 11, 22].

Accordingly, supplementing cereal-based diets with legumes improves overall nutritional status and is one of the best solutions to protein calorie malnutrition in the developing countries [11].

Anti-nutritional factors: The use of legume seeds in food and feed is usually limited because of their deficiency of sulfur-containing amino acids, low protein digestibility and the presence of several anti-nutritional components. The anti-nutritional factors include flatulence causing raffinose family oligosaccharides (α-galactosides), phytates, phenolics, tannins, cyanogens, enzyme (trypsin, chymotrypsin and α-amylase) inhibitors and lectins (phytohemagglutinins) [5, 21, 23, 24, 27, 29, 30].

Anti-nutritional factors impede the digestion and absorption of some interesting components (e.g. proteins, vitamins), or, in some cases, they are simply toxic or cause undesirable physiological side effects (e.g. flatulence) [24]. Although only a few legumes may contain all these anti nutritive factors, many contain a few of them. Tannins and cyanogens are the two anti-nutritional factors that are present almost in all legumes [30]. The anti-nutritional factors can generally be categorized as proteinaceous and nonproteinaceous compounds [5].

1. **Proteinaceous anti-nutritional factors:** Legume seeds, in addition to nutritional proteins, contain a number of other abundant proteins which may vary in types and amounts among the legume seeds. Some of them are biologically active proteins, which for years have been referred to as anti-nutritional compounds. These groups of proteins include lectins, proteases and amylase inhibitors. The proteinase and α-amylase inhibitors are monomeric seed proteins [31]; and lectins are proteins that bind to carbohydrates or to molecules containing carbohydrates [5].

   Lectins (or phytohemagglutinins), are present, paralleling the distribution of protease inhibitors, in the seed of a number of legume species that are consumed by humans [32, 33]. Protease inhibitors often inhibit the digestive enzyme trypsin, but may act more broadly by inhibiting chymotrypsin and other serine proteases [5]. They can retard growth by interfering with dietary protein digestion; and as a mechanism to adapt to this situation, the secretory activity of the pancreas can be stimulated and its size enlarged leading to an overall physiological effect of impaired growth and enlarged pancreas [33].

   Young humans and other animals are more susceptible to the effects of protease inhibitors than adults and are primary concern as these can impair nutrient utilization and reduce growth rates in the young groups. Lectins differ in the severity of their impact (toxic, only growth inhibitory or essentially nontoxic) [5]. Their antinutritional effects lies in the fact that dietary lectins strongly resist proteolytic degradation in the gut and bind to surface receptors [5, 32] on the cells lining the small intestines and interfere with the absorption of nutrients; the result is a failure in growth and eventual death [33].

   Options for minimization of problems: Fortunately, in many cases, protease inhibitors and lectins are heat labile and rendered innocuous by usual methods of cooking. Both are heat-labile and can be effectively eliminated or inactivated, essentially under the same conditions, by the heat treatment involved in domestic cooking and commercial processing [5, 33].

2. **Non-proteinaceous anti-nutritional factors:** Non-proteinaceous compounds include phytic acid, α-galactosides, phenolics and tannins, cyanogens and toxic amino acids [5, 21, 30, 32, 33].

a. **Raffinose family oligosaccharides (RFOs):** RFOs of legumes are synthesized by sequential addition of galactose units to sucrose [34] and are α-galactosyl derivates of sucrose [29]. These α-galactosides or oligosaccharides are a common carbohydrate present in the seed of grain legumes [32]. Raffinose is the first member of the series. Verbascose, stachyose and ajugose are the next higher RFOs [34]. RFOs of legumes produce flatulence**.** Humans do not have the enzyme α-galactosidase to cleave the α-galactosyl linkage and the intact oligosaccharide is not absorbed by the digestive tract. These oligosaccharides accumulate in the large intestine where the α-galactosidase containing intestinal bacteria degrade them and subsequent anaerobic fermentation results in production of H_2, CO_2 and traces of CH_4. These gases cause abdominal discomfort due to a flatus effect and sometimes result in diarrhea [29].

   Options for minimization of problems: Traditional methods of processing grain legumes prior to their consumption significantly reduced the level of oligosaccharides [32]; and the flatulence side effect of legume oligosaccharides can be minimized in different ways such as processing, plant breeding, incorporation of microbial or plant α-galactosidase, or by changing the water in which beans are boiled one or more times [14, 29].

b. **Tannins:** Many plant species contain tannins. However, the seed of a number of legume species contain appreciable quantities of tannins [32, 33]. Tannins are present in almost all legumes predominantly. They are complex group of phenolic compounds which are astringent in taste that precipitate proteins. They have major impact on both human and animal nutrition because of their ability to form complexes with molecules like carbohydrates, proteins, poly-saccharides, enzymes involved in protein and carbohydrate digestion [30]. The anti-nutritional impact of tannins on digestion and metabolism is not fully understood, but the major effect is to interfere with the digestibility of dietary protein

[5, 33]. This may be due to the binding of the tannins to the protein to form substrates that are resistant to digestive enzymes (indigestible complexes) or to a direct binding to these enzymes themselves [32, 33]. They can irritate the gut lining and stimulate the secretion of mucus. This increases endogenous protein secretion and therefore increases protein demand. They also form complexes with divalent metals and reduce mineral absorption. A common feature of diets high in tannin is weight loss [32].

Options for minimization of problems: Since tannins are located primarily in the seed coat of dry seeds, the physical removal of the seed coat by dehulling or milling markedly reduces the tannin content with a resultant improvement in the nutritional quality of the protein. Soaking in water or salt solution prior to household cooking also causes a significant reduction in tannin, provided the cooking broth is discarded [32,33]. Soaking may help leach out some tannins, but heat treatment will not reduce the impact of that remaining in the seeds [5].

c. **Cyanogens:** Relatively high level can be found in grain legumes (pluses). Cyanide in trace amounts is fairly wide spread in the form of glycosides (cyanogens). These glycosides are non-toxic in the intact tissue but when later are damaged or begin to decay, a hydrolytic enzyme is released liberating hydrogen cyanide. The hydrogen cyanide is rapidly detoxified in the liver by conversion to thiocyanate. Excess cyanide ion can quickly produce anoxia of the central nervous system through inactivating the cytochrome oxidase system and death can result in few seconds [30].

Options for minimization of problems: One method of reducing the problem is via plant breeding [32]. A further reduction in toxicity is achieved by the application of heat (boiling, roasting, or sun drying), which serves to inactivate hydrolytic enzyme and to volatilize any hydrogen cyanide that may have been produced [33].

d. **Phytate:** Phytic acid or its salt, phytate, is inositol combined with six phosphate groups and is a common constituent of most plants and legumes. Its antinutritional effect lies in the fact that it forms a chelate with metal ions such as calcium, magnesium, zinc, and iron to form poorly soluble compounds that are not readily absorbed from the intestine, thus interfering with the bioavailability of these essential minerals.

Options for minimization of problems: The ability of phytate to bind metal ions is lost when the phosphate groups are removed by hydrolysis through the action of phytase. Heat alone is relatively ineffective in reducing the phytate content of plant materials, but the phytate content can be reduced by taking advantage of the endogenous phytase that accompanies the phytate in separate compartments of the plant tissue. Traditional fermented dishes have reduced levels of phytate, presumably due to the action of phytase produced by various molds, bacteria or yeasts involved in the fermentation. The germination of mature seeds of various legumes results in a great increase in phytase activity with a concomitant reduction in phytate [33].

e. **Toxic Amino Acids:** In the legume family, there are two toxic non-protein amino acids that have a major negative effect on animals or humans that consume them: mimosine and 3-*N*-oxalyl-L-2, 3-diaminopropanoic acid (ODPA) [32, 33, 5]. Non-protein amino acids are common within the legume family, which are often highly toxic, and are responsible for several serious human toxicoses, among the best known of which is lathyrism, a nonprogressive motor neuron disease associated with high consumption of grass peas (*Lathyrus sativus*).

Consumption of large amounts of *Lathyrus* seed in the diet often occurs at times of food shortages as a result of drought. Grass peas, which are ideally suited to arid regions such as Ethiopia and the Indian subcontinent, contain high levels of ODPA in their seeds, and this compound is responsible for the neurological symptoms and also for deleterious effects on bone formation, particularly in children. There is also some evidence that the response to *Lathyrus* consumption may be sex linked, as it seems to have a major effect on young Males [32, 35]. The tropical legume tree, *Leucaena leucocephala*, contains the amino acid mimosine.

The full chemical name of mimosine is β-[1-(3-hydroxy-4-pyridone)]-α-amino propionic acid. *L. leucephela* is used primarily as a forage crop for feeding livestock, but its use is limited by the fact that it contains mimosine. *Leucaena* seed is usually only used to a limited extent in human diets. One of major effects of mimosine is to stop hair growth; and it has an adverse effect on the growth of ruminants because bacteria can convert mimosine to 3, 4- dihydroxypyridine which acts as a goitrogenic agent [32, 33].

Options for minimization of problems: As with many other legume species that contain antinutritional factors, the toxic amino acids can be removed by traditional processing methods such as soaking, boiling, and fermentation [32]. Over 90% of the ODPA toxin can be eliminated by the simple expedient of soaking the seeds overnight in an excess of water followed by steaming, roasting, or sun drying [33]. Although low-ODPA lines of grass pea have been developed through traditional breeding and selection that appear suitable as supplementary material for animal feeds, removal of the neurotoxin from the seed by transgenic approaches is yet to be reported [35].

3. **Summary points on anti-nutritional factors:** Generally, anti-nutritional factors can decrease palatability, diminish protein digestibility and mineral bioavailability [21]; and thereby limit the biological value and acceptance of legumes or pulses as a regular food item [29]. Thus, they have to be appropriately treated prior consumption [21]. It is suggested that legumes are not eaten raw, but processed in a way that inactivates the anti-nutritional factors. Traditional food preparation techniques result in reduction or elimination of metabolic impediments by anti-nutritional factors [5]; and food processing not only improves flavor and palatability of foods but also increases the bioavailability of nutrients, by inactivating antinutritional factors [28].

4. **Health Implications of Legumes:** The health benefits of legumes have been known for millennia [14]. The observation that diets low in meat and high in cereals and legumes are beneficial for health has recently become a topic of scientific interest, but was noted at least as far back as the Old Testament [36]. People have grown and used legumes as a dietary staple since early biblical times, long before modern nutrition researchers endorsed their significant health virtues. Nowadays, it is claimed that including legumes in a health-promoting diet is important in meeting the major dietary recommendations to improve the nutritional status of undernourished as well as over nourished individuals, and to reduce risk for chronic diseases such as cardiovascular disease, diabetes mellitus and cancer [14].

As noted above, owing to their rich nutrient content, supplementing cereal-based diets with legumes is suggested as one of the best solutions to protein calorie malnutrition in the developing countries [11, 22-24], which reflect the role of legumes to improve the nutritional status of undernourished individuals. On the other hand, over-nutrition and obesity are associated with increased risk of non-communicable diseases such as diabetes, ischaemic heart disease, stroke, and hypertension [37, 38]; and legumes play a role in prevention, improvement and/or treatment of such disease conditions [21, 28, 36, 39]. Hence, once regarded in Western countries as food for poor people, legumes continue to gain recognition for their importance in health and have now become a 'health food' for affluent people [14].

Obesity, cardiovascular disease, diabetes, and cancer have recently become major threats to human health in many nations at least in part due to changes in eating and drinking habits. Although the etiology is multi-factorial, diet has been identified as the most important environmental risk factor for development of these diseases [15].

Experimental, epidemiological and clinical studies show correlations between the consumption of food legumes and decreasing incidence of several chronic disease conditions such as type 2 diabetes mellitus, cardiovascular disease, cancer diseases (e.g breast and prostate cancers), overweight & obesity, osteoporosis, hypertension, gastrointestinal disorders; and results in lowering of low density lipoprotein cholesterol and elevated high density lipoprotein cholesterol levels. Legumes play a role in prevention, improvement and/or treatment of these disease conditions [17, 21, 28, 36, 39].

Below are some of the scientific arguments that attempt to explain the role of legumes in managing certain diseases.

a. **Type 2 Diabetes Millitus:** Legumes may offer benefits in the prevention of diabetes and in the clinical management of established diabetes. They reduce the risk of developing diabetes because of their high-fibre, low-fat content and low glycaemic indices. They are slowly digested and produce uniformly low blood glucose response that result in low glycaemic and insulin responses [3, 9, 14, 21]. Glycemic index is a measure of the potential for carbohydrates in different foods to raise blood glucose levels. Generally, foods with high glycemic index (such as white rice or potatoes) cause rapid rise in blood glucose levels, which result in greater insulin secretion by the pancreas.

Chronically elevated blood glucose levels and excessive insulin secretion are thought to play important roles in the development of type 2 diabetes. Several large prospective studies have shown the associated of low-glycemic index diets like legumes with reduced risk of developing type 2 diabetes. Obesity is another important risk factor for type 2 diabetes; and it is claimed that low-glycemic diets result in significantly more weight or fat loss than high-glycemic diets. Numerous clinical trials have shown that the consumption of foods with low-glycemic index delays the return of hunger, decreases subsequent food intake, and increases the sensation of fullness compared to high-glycemic index foods.

Thus, diets rich in legumes may decrease the risk of diabetes by improving blood glucose control, decreasing insulin secretion, and delaying the return of hunger after a meal [25]. Legumes contain anthocyanins [40] which may lower blood glucose by improving insulin resistance, protecting β cells, increasing secretion of insulin and reducing digestion of sugars in the small intestine [41]. It is reported that clinical use of inhibitors of intraluminal α-amylase inhibitors has importance because controlled reduction of starch digestion theoretically could influence carbohydrate uptake in diabetes mellitus and obesity [42].

General claim on biological activity of legume α-amylase inhibitors in weight control, obesity and diabetes is reported [31, 43].

b. **Cardiovascular Diseases:** Currently, great efforts are focused on reducing the risk of coronary heart disease (CHD) and cardiovascular disease (CVD) through dietary interventions [44]. Dietary interventions to reduce the risk of CVD include attention to the consumption of types of fatty acids, dietary fibre, isoflavones and antioxidants. Legume foods contribute to all these areas [14]; and legumes phytochemicals such as carotenoids and tocopherols may prevent the risk of CVD [16]. The promising link between the intake of leguminous foods and reduced risk of CVD and CHD has been reported in several prospective cohort studies.

Presumably, antioxidant properties of natural antioxidants present in legumes may attribute in part to lower incidence of degenerative CVD. The antioxidant effect may counteract oxidative stress-induced endothelial dysfunction and platelet aggregation, which are two key causes of CVD [45]. Other major risk factor of CVD that can be modulated by dietary intervention is blood cholesterol [46]. A number of dietary agents, including soluble fibres and plant sterols lower cholesterol levels in serum. Plant sterols inhibit cholesterol absorption and viscous fibers increase bile acid excretion [44]. Legumes are loaded with fiber and provide a good mix of water soluble and insoluble fibers. The soluble-fiber is known to have a cholesterol-lowering effect and thereby can decrease risk of cardiovascular diseases [4, 19, 25, 46].

Generally, among the mechanisms that have been proposed to explain the cholesterol-lowering effect of legume seeds, the most commons are the physiological action of legume components such as phytic acid, dietary fiber, saponins, phytosterols, proteins, peptides, and their amino acid profiles [47]. Legumes contain high levels of antioxidants, vitamin B6, folic acid [19] and they are fairly good sources of thiamin and niacin [48]. High levels of homo-cystine damage the walls of the arteries; and vitamin B6 and folic acid aid in lowering the levels of homocystine, which in turn can reduce

the risk of stroke, heart attack or vascular disease. Folic acid is also important in preventing birth defects [19, 25] and in reducing the risk of neural tube defects [4]. Moreover, legumes are generally, low in sodium and rich in minerals such as potassium, calcium, copper, and magnesium.

Low dietary intake of sodium and high dietary intake of potassium, calcium, and magnesium have been associated with a reduced risk of cardiovascular disease, by helping to lower blood pressure, in epidemiologic studies [19, 25, 49]. The low glycemic index values of legumes means that they are less likely to raise blood glucose and insulin levels, which may also decrease cardiovascular disease risk [25].

c. **Cancer:** Legumes have anti-carcinogenic properties [50] and many studies have firmly established that polyphenols present in legumes and various plant sources exert beneficial health effects and anticancer properties. Legumes, beside their high nutritive value, contain significant quantities, hence good source, of polyphenolic compounds such as tannins, flavonoids (e.g., kaempherol, quercetin, anthocyanins), isoflavones (e.g., genistein and daidzein), phenolic acids (e.g., p-hydroxybenzoic acid, vanillic acid, p-coumaric acid, and ferulic acid), and lignans.

Legume polyphenolic compounds act as cancer chemopreventive agents, especially by their antioxidant properties [40] as legumes can serve as an excellent dietary source of natural antioxidants for health promotion and cancer [51]. Legume phytochemicals, claimed to demonstrate anticarcinogenic activity, include natural antioxidants, γ-tocopherol, ascorbic acid, soy isoflavones, phytosterols, phytates (inositol hexaphosphate), saponins, fibers, protease inhibitors, lectins, and a variety of polyphenols and phenolic acids. These phytochemicals, if consumed in sufficient quantities, may help to reduce tumour risk and could potentially account for a protective effect. Ascorbic acid, phenolic acids and polyphenols have been associated with reduced cancer risk [14, 16, 21, 43, 50, 52]. Phytate has proven anti-cancer action [19]; antioxidant effects, and may lower the risk of colon and breast cancer.

Fermentable fibers, in legumes, are precursors of luminal butyrate, with well-known anti-inflammatory and antineoplastic properties [14, 53]. Anticancer biological activity of protease inhibitor and lectins is reported [43]. Proteases are considered key factors in cancer progression. Therefore, the control of their activity by protease inhibitors appears to be related to the capacity of preventing or blocking tumoral pathologies [31]. Evidence exist to suggest that consumption of food containing trypsin inhibitors, as are legumes, may have a role in combating breast cancer in humans; and have anticarcinogenic activity in various tissues in animal models [14, 32].

Some legumes may influence estrogen metabolism and thereby decrease the risk of hormone-dependent cancers [36]. Although limited, there is some evidence from observational studies that legume intake is inversely related to the risk of prostate cancer [25]. Genistein which is one of several known isoflavones that are found in legumes has been shown to inhibit the growth of both estrogen-dependent and estrogen-independent breast cancer cells and prostate cancer cells in vitro [4, 54]. A diet with a relatively high glycemic index will increase cancer risk by amplifying cancer promotion via insulin-like growth factor-1 (IGF-I) [55]. Thus, low glycemic index of legumes can mean reducing cancer risk.

d. **Osteoporosis:** Osteoporosis is a decline in the mass of bone. Recognizing and managing the factors that contribute to osteoporosis will help to prevent it or modulate its severity. These include the following: adequate exposure to sunlight, consumption of adequate amounts of calcium in the diet and avoiding excessive intake of calcium-excreting products such as phosphates in some sodas [56].

The skeletal system serves as one of the main buffering systems in the body; as a result, hydrogen ions produced from the metabolism of sulphur amino acids cause demineralisation of bone and excretion of calcium in the urine. Substituting vegetable and legumes for animal protein may reduce urinary calcium excretion and reduce the risk of osteoporosis [14].

Sufficient dietary calcium and protein are necessary for bone health during growth as well as in the elderly [57] and legumes are rich source of these two. Soyfoods and isoflavones have received considerable attention for their potential role in preventing and treating cancer and osteoporosis [4, 58]. Lignans from some fruits, vegetables and legumes (Soybean, beans) are reported for their potential health benefits in prevention of cardiovascular disease, cancer, and osteoporosis [59].

e. **Digestive tract diseases:** Dietary fiber is thought to provide important protection against some gastrointestinal diseases and to reduce the risk of other chronic diseases as well [60]. Studies about fiber and colon cancer provide modest support for an association between dietary patterns involving higher fiber intake and reduced risk of colon cancer. Dietary fiber may affect risk of large bowel cancers through mechanisms such as altering bile acid metabolism, increasing fecal bulk, or decreasing gut transit time [36].

Legumes soluble fiber and oligosaccharides are recognized as a source of prebiotics, which have been described as 'colonic foods' that selectively stimulate the growth of beneficial intestinal microflora [9, 14]. Fibers in legumes keep human intestinal system healthy. They keep the bowels healthy and move regularly, improve constipation, and combat against colon cancer and intestinal disorders [19].

SUMMARY: Legumes constitute a part of the diet of nearly all humans and greatly contribute to alleviate malnutrition and sustain good health. The nutrient content (protein, carbohydrate and micronutrients) of legumes contribute to address undernutrition and protein-calorie malnutrition, especially among children and nursing mothers in the developing countries. Legumes are ideally suited to meet two major dietary recommendations for good health-intake of starches and decreased consumption of fat. They are also good sources of quality protein and can be substituted for animal protein sources when complemented with cereals. Thus, supplementing cereal-based diets with legumes is suggested as one of the best solutions to protein calorie malnutrition in the developing countries.

The presence of certain anti-nutritional factors, in legumes, can decrease palatability, diminish protein digestibility and mineral bioavailability; and thereby limit the biological value and acceptance of legumes or pulses as a regular food item. Despite this, recent research has shown potential health benefits of some of these compounds. Therefore, manipulation of processing conditions may be required to remove or reduce only those unwanted components. Fortunately, most of the anti-nutritional factors are reduced or inactivated by traditional cooking and food processing, which not only improves flavor and palatability but also increases the bioavailability of nutrients, by inactivating antinutritional factors.

Owing to their appreciable amount of health-promoting components, legumes play a role in prevention, improvement and/or treatment of disease conditions such as, diabetes mellitus, cardiovascular diseases, cancer diseases (e.g breast and prostate cancers) and lowers blood cholesterol level. Most of these disease conditions are associated with over-nutrition and obesity and are considered as diseases of the rich. Hence, once regarded in Western countries as food for poor people, legumes continue to gain recognition for their importance in health and have now become a 'health food' for affluent people.

Legumes have significant role in optimizing the nutritional status of the poor and the health status of the rich, which make them be suitable food items for all types of population in both developed and developing countries. It is, therefore, claimed that including legumes in a health-promoting diet is important in meeting the major dietary recommendations to improve the nutritional status of undernourished as well as over-nourished individuals, and to reduce risk for chronic diseases such as cardiovascular disease, diabetes mellitus and cancer.

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How to cite this article:
Gebrelibanos M, Tesfaye D, Raghavendra Y and Sintayeyu B: Nutritional and Health Implications of Legumes. *Int J Pharm Sci Res* 2013; 4(4); 1269-1279.