

Review Article

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Nutritional and Health Promoting Attribute of Kidney Beans (*Phaseolus vulgaris* L.): A Review

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ABSTRACT

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Shifting towards plant based diet is good approach to tackle nutritional and health issues. In this context, red kidney beans consider to be high in component like protein carbohydrates, dietary fiber, minerals and vitamins. Proteins are normally considered as the prominent macronutrient in red kidney beans. Consumption of red kidney beans has been linked to decreased occurrence of chronic non communicable diseases such diabetes, cancer, obesity and coronary heart diseases. Similarly, red kidney beans contain a variety of phyto-chemicals. These phyto-chemicals like, flavonoids, polyphenols and antioxidants are conforming to offer protective physiological effects in the body against numerous ailments *i.e.* cancer, diabetics, cardiovascular diseases and neurodegenerative. Thus the present aim of this review is to highlight the magnitude of the nutrition on such ailments.

Introduction

Legumes are an important food source and play a significant role in traditional diets all over the world. Legumes are widely grown and consumed in various regions, are excellent sources of proteins, complex carbohydrates and fairly good sources of minerals, vitamins and polyunsaturated fatty acids (Hudson, 1994). Legumes belongs to the

leguminaceae family are produced and consumed widely throughout the world, particularly in tropical and sub-tropical areas of Africa, Asia and Latin America (Barampama and Simard,1995).

The importance of legume seeds as food and functional ingredients has stimulated much attention to their utilization. They have been used by food industries as ingredients and

supplements in food products for many years. For successful use in food applications, they should possess several desirable characteristics, referred to as functional properties (Hudson, 1994). Legumes occupy an important place in human nutrition, especially among the low-income groups of populace in the developing countries. Legumes are a good source of protein, which is 2–3 times that of cereal grains, and are a rich source of dietary fiber, starch minerals and vitamins.

The various types of beans are a staple food and a low-cost source of protein in many countries where protein energy malnutrition is prevalent widely. In recent years, KB has been recognized as potential alternate source of meat products and also as potent antioxidant, with lower glycemic index useful for persons suffering from diabetes, increased satiation, cardiovascular diseases, atherosclerosis and breast cancer (Beninger & Hosfield, 2003; Cardador-Martinez, Loacra-Pina, & Oomah, 2002; Guajardo-Flores, Serna-Saldívar, & Gutiérrez-Urbe, 2013; Heimler, Vignolini, Dini, & Romani, 2005; Madhujith, Naczki, & Shahidi, 2004; Rocha-Guzman *et al.*, 2013; Xu, Yuan, & Chang, 2007).

The inclusion of legumes in the daily diet has many beneficial physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease and colon cancer (Tharanathan & Mahadevamma, 2003). It has been reported that the protective effects of dry beans in disease prevention, such as against cancer, may not be entirely associated to dietary fiber, but to phenolics and other non-nutritive compounds (Oomah, Tiger, Olson, & Balasubramanian, 2006), as polyphenols from dry beans may possibly act as antioxidants, hindering the formation of free radicals (Boateng, Verghese, Walker, & Ogutu, 2008).

In addition, legumes belong to the food group that elicits the lowest blood glucose response. The general consensus on healthy eating habits favors an increase in the proportion of legume-based polymeric plant carbohydrates including starch in the diet. The role of legumes as a therapeutic agent in the diets of persons suffering from metabolic disorders has been reported previously (Shehata, Darwish, Nahr & Razeq, 1988; Simpson *et al.*, 1981).

Nutritional aspects

Phaseolus is the most important food legume for human consumption in the world. Its seeds consist mainly of carbohydrates and are a good source of nitrogen and protein. It also contains calcium, magnesium, potassium, phosphorus, copper, iron, zinc, manganese and sulfur. This legume is rich in bioactive components such as enzyme inhibitors, lectins, phytates, oligosaccharides and phenolics, which exhibit metabolic roles in humans and animals. Among the observed biological activities are the antioxidant capacity, the reduction of cholesterol and reduction of low-density lipoproteins, thus *Phaseolus* has a protective effect against cardiovascular diseases. Also it has shown favorable effects against cancer because of the anti-mutagenic and anti-proliferative properties of their phenolics, lectins and protease inhibitors. Additionally, it has showed effects on obesity and diabetes due to its content of resistant starch and α -amylase inhibitor. Here we present a review of the beneficial properties of beans as a nutraceutical food.

Antioxidant profile

Antioxidants are the compounds that prevent the human, animal and animal cells from harmful effects of free radicals (Kukic *et al.*, 2006). Phenolic acids and flavonoids are the

natural source of antioxidants which are produced from plants. They are considerable sources of antioxidants and more efficient than Vitamin C, E and carotenoids (Dai and Mumper, 2010). The antioxidant characteristics of phenolic and flavonoid compounds are driven from their capability to regulate the antioxidant defense, scavenging the radical species (Cotelle, 2001). The reduction property of phenolic compounds rely on the number of free hydroxyl groups present in molecular structure (Ghasemzadeh and Ghasemzadeh, 2011), whereas flavonoids capability as antioxidants depends on position of hydroxyl groups and some other features in chemical structure (Saxena *et al.*, 2012).

Kidney beans are a good source of the trace mineral manganese which is an essential cofactor in a number of enzymes important in energy production and antioxidant defenses. For example, the key oxidative enzyme superoxide dismutase, which disarms free radicals produced within the mitochondria (the energy production factories within our cells), requires manganese. (Bazzano 2003)

Amino acids profile

Red kidney beans show excellent amino acid profile mainly rich in lysine, leucine, aspartic acid, glutamic acid and arginine. Beans provide optimum amount of essential amino acids when utilized with cereals and other sulfur containing products (Boye *et al.*, 2010a). The glutamic and aspartic acids are mainly acidic in nature and present in raw as well as processed beans. Except for cysteine, methionine and tryptophan, the raw and processed red kidney beans replenish the FAO/WHO amino acid needs for teenagers. Red kidney beans provide 10.2g glutamic acid, 9.5g aspartic acid, 1.2g cysteine, 1.7g methionine, 3g histidine, 4.4g alanine, 5.2g glycine, 3.4g threonine, 3.3g proline, 3.7g isoleucine, 3.1g tyrosine, 4.6g phenylalanine,

4.1g valine, 3.1g serine, 6.9g arginine, 7g lysine and 7.2g leucine per 100g (Audu and Aremu, 2011). Cowpea is methionine and threonine rich legume. It also contains glutamic acid & aspartic acid which are non-essential amino acids. Cowpea has essential amino acids in higher quantity whilst lentil is rich in non-essential amino acid (Iqbal *et al.*, 2006). Broad bean has methionine/cystine as the limiting amino acids. However, mostly all other EAAs fulfill the people needs though the quantity in contrast to egg is lower (Mortuza *et al.*, 2009).

Dietary fiber

Dietary fiber can be classified as insoluble or soluble (Zhang *et al.*, 2011) and each class have different physiological effects (Ajila and Rao, 2013). The ratio between two classes of dietary fiber is important for nutritional and functional properties (Jaime *et al.*, 2002). The soluble dietary fiber faces bacterial fermentation in the GIT and affects the carbohydrates and fat metabolism. Whereas insoluble fraction lower the incidence of constipation by reducing the gastrointestinal transit time and also hinder the development of rectal cancer (Bingham *et al.*, 2003).

Dietetic fiber can be defined as a heterogeneous group of non-digestible compounds, including fiber (soluble and insoluble), resistant starch and oligosaccharides, such as raffinose, estachyose and mullein, among others. The common bean (*Phaseolus vulgaris* L.) mostly consumed in Latin America has a high fiber content (Cruz-Bravo *et al.*, 2011). Levels of Cholesterol 7- α -hydroxylase on rats fed with a pancreatin resistant fraction prepared from kintoki beans (*Phaseolus vulgaris*) were significantly higher compared to those of rats on a cellulose diet. It also increased intestinal content viscosity and decreased bile acid absorption in the small intestine (Han *et al.*,

2004). It has been shown that long-term feeding with beans decreases cholesterol and low-density lipoprotein (LDL) serum levels in humans, so it seems likely that it can offer protection against cardiovascular diseases (Marzolo *et al.*, 1993). The fibre isolated from *Phaseolus mungo* showed a neutral detergent residue (NDR). It has significant cholesterol lowering activity and increased bile acid excretion in faeces (Thomas, Leelamma, & Kurup, 1983).

Gluten-free

People with celiac disease should consume a diet that is free of gluten, a protein found in many grain products. They must eliminate these products from their diet, which increases the risk for deficiencies in several B-vitamins and other nutrients that typically are found in grains (Niewinski *et al.*, 2008). Beans are a naturally gluten-free food, and they provide many of the same vitamins and minerals often found in enriched grain products, including thiamin, riboflavin, folate, iron and fiber. Bean flour may be particularly beneficial to those following gluten-free diets because bean flours can be combined with other gluten-free flours (such as rice or tapioca flour).

Health benefits of kidney beans

Kidney beans and cancer

Cancer is referred to as a multi-step disease. Factors such as environmental, physical, chemical, metabolic and genetic factors have a direct or indirect role in the development of cancer (Fimognari *et al.*, 2005). Cancer is attributed to independent DNA replication and cellular division of abnormal cells which leads to induction of cancerous tumors and causes the destruction of adjacent tissue or lymphatic system. It has been reported that phenolic acids present in red kidney beans

have anticancer characteristic (Nyau, 2014; Duranti, 2006). They can act as an inhibiting agent and hinder the development of tumors from initiated stages. They can also suppress cell multiplication *in vitro* (Scalbert *et al.*, 2005).

Epidemiological and preclinical studies evaluating colon and prostate cancer have provided additional evidence about an inverse relationship between bean consumption and cancer development (Monroe *et al.*, 2003; Thompson *et al.*, 2012). Colorectal cancer is the second principal cause of death related to cancer in developed countries. Studies for its detection have not diminished the incidence or the mortality of this disease, so the interest has focused on preventive strategies focused on life style interventions (Derry, Raina, Agarwal, & Agarwal, 2013). Epidemiological evidence suggests a protective effect of dietary fibre against colorectal cancer. It has been reported that rats with induced colon cancer and fed with pinto, black and white beans developed four times fewer tumours compared to rats not fed with beans (Reynoso-Camacho *et al.*, 2007).

Kidney beans and diabetes mellitus

The regulation of blood glucose level is the main objective in diabetes management. The glycaemic control has a great importance in management of type 2 diabetes. The soluble fiber fraction can control the glycemic by slowing down and decreasing the absorption of glucose from intestine (Brown *et al.*, 1999). Several studies related to diabetics have shown that diets contain higher fiber contents and low GI rating lead to better glycated proteins levels which are helpful in controlling the glycaemic index (Kendall *et al.*, 2006). They can reduce the incidence of diabetes type 2 (Eshak *et al.*, 2010) by lowering the digestion and absorption of macronutrients and reducing the contact time

between intestinal lumen and carcinogens (Raninen *et al.*, 2011). The water soluble fibers enter in small intestine where they thicken the content of small intestine and modulate the digestive process by reducing the nutrients diffusion for absorption and interaction time of food and digestive enzymes.

Hyperglycemia in type 2 diabetes mellitus (DM2) correlates with endothelial dysfunction and an increase in the intima-media thickness, as well as with a greater prevalence of atherosclerotic plaques. This is related to an increase in oxidative stress with platelet activation, thrombin production and low-density lipoprotein oxidation which increase the risk of cardiovascular diseases related to DM2 (Barrett and Udani, 2011). The oral administration of a *Phaseolus vulgaris* ethanolic extract (200 mg/kg of body weight) for 45 days to streptozotocin-induced diabetic rats significantly decreased tiobarbituric acid and hydroperoxide reactive substances. The extract caused a significant increase in reduced glutathione, superoxide dismutase, catalase, glutathione peroxidase, and glutathione-S-transferase in the liver and kidneys. The extract was more effective than glibenclamide in diminishing glucose levels (Venkateswaran and Pari, 2002).

Starch in beans is slowly digested and attenuates postprandial response to insulin (Feregrino-Pérez *et al.*, 2008; Hangen and Bennink, 2002). The α -amylase inhibitor isoform 1 (α -AI1) has been extracted and used in diverse commercial products against obesity and diabetes in humans (Barrett and Udani, 2011; Celleno, Tolaini, D'Amore, Perricone, and Preuss, 2007; Obiro, Zhang, and Jiang, 2008). Epidemiological studies have linked bean consumption with a lowered risk of being overweight or obese. In US adults, bean consumers presented 23% lower risk of obesity, and lower systolic blood

pressure. Studies of Brazilian adults indicate that a regular diet including beans correlates with a lower risk of being overweight and obese, both in men (-13%) and women (-14%) (Nilsson, Johansson, Ekström and Björck, 2013). In addition, there is evidence that a bean extract used by humans lowers body weight, percentage of fat and waist and hip circumference (Preuss, 2009).

Kidney beans and cardiovascular disease

Maintaining healthy blood pressure levels promotes heart health and reduces risk of cardiovascular disease and stroke. The D.A.S.H. (Dietary Approaches to Stop Hypertension) study found that a diet lower in sodium and rich in fruits, vegetables, legumes, fat-free and low-fat dairy, whole grains foods, fish, poultry, seeds, and unsalted nuts reduced blood pressure compared to the control diet, which was modeled after the typical American diet. (Moore *et al.*, 1999) Many of the food groups included in the D.A.S.H. eating plan are natural sources of potassium, including beans.

Bazzano *et al.*, (2001) reported that individuals consuming legumes at least four times per week had a 22% lower risk of heart disease than individuals consuming legumes less than once per week. In the epidemiological studies where legumes are consumed as part of a healthier diet plan, consistent reductions in heart disease risk have also been observed. In the Health Professionals Follow-up Study, men who adhered to a more "prudent" diet that included greater consumption of whole grains, legumes, fish, and poultry had a 30% lower risk of heart disease. Conversely, individuals following a more "Western" diet, characterized by increased consumption of red meat, refined grains, sweets, French fries, and high fat desserts had a higher risk of heart disease. (Hu, 2000) Similar trends were seen in the Nurses' Health Study. Those who

consistently ate the “prudent” diet had half the risk of developing heart disease compared to those that most often ate the “Western” diet. (Fung, 2001) Epidemiologic studies support the cardio protective effects of legumes as part of a healthy diet. In particular, one study examined the relationship between bean consumption and occurrence of cardiovascular disease (CVD) and reported that one serving (1/2 cup) per day of beans was associated with a 38% lower risk of myocardial infarction (Kabagambe, 2005). A second study reported that individuals consuming legumes at least four times per week had a 22% lower risk of heart disease than individuals consuming legumes less than once per week. (Bazzano, 2001)

Kidney beans and degenerative diseases

Polyphenols are plant metabolites with potent anti-oxidant properties, which help to reduce the effects of oxidative stress-induced dreaded diseases. The evidence demonstrated that dietary polyphenols are of emerging increasing scientific interest due to their role in the prevention of degenerative diseases in humans. Possible health beneficial effects of polyphenols are based on the human consumption and their bioavailability. Common beans (*Phaseolus vulgaris* L.) are a greater source of polyphenolic compounds with numerous health promoting properties.

Polyphenol-rich dry common beans have potential effects on human health, and possess anti-oxidant, anti-diabetic, anti-obesity, anti-inflammatory and anti-mutagenic and anti-carcinogenic properties. Based on the studies, the current comprehensive review aims to provide up-to-date information on the nutritional compositions and health-promoting effect of polyphenol-rich common beans, which help to explore their therapeutic values for future clinical studies (Kumar Ganesan and Baojun Xu 2017).

Kidney beans and heart health

Kidney beans are a very good source of cholesterol-lowering fiber, as are most other beans. In addition to lowering cholesterol, kidney beans' high fiber content prevents blood sugar levels from rising too rapidly after a meal, making these beans an especially good choice for individuals with diabetes, insulin resistance or hypoglycemia. When combined with whole grains such as rice, kidney beans provide virtually fat-free high quality protein.

But this is far from all kidney beans have to offer. Kidney beans are an excellent source of the trace mineral, molybdenum, an integral component of the enzyme sulfite oxidase, which is responsible for detoxifying sulfites. Sulfites are a type of preservative commonly added to prepared foods like delicatessen salads and salad bars.

Persons who are sensitive to sulfites in these foods may experience rapid heartbeat, headache or disorientation if sulfites are unwittingly consumed. If you have ever reacted to sulfites, it may be because your molybdenum stores are insufficient to detoxify them (Bazzano *et al.*, 2003).

Modern life-styles induce people to change eating habits by increasing high caloric density food intake. High glycemic index and high fat foods, mainly from processed and simple sugar derived products, increase risks of chronic diseases. Intake of pulses, particularly beans, has been diminishing during the last few years. Scientific evidence shows that this vegetal food group is not only important due its nutritional contribution, but also because its consumption is related to a lower risk of developing important chronic non-transmissible diseases. *Phaseolus* has several beneficial biological activities in humans, as an antioxidant source, cholesterol-

and low-density lipoprotein-lowering properties, anti-mutagenic and anticancer effects as well as effects on cardiovascular disease, diabetes and obesity. It is important to make efforts to increase consumption of beans and take advantage of the benefits.

On the other hand, beans could be a good source of nutraceuticals for human supplementation, mainly compounds that disappear with cooking conditions but exhibit important biological activity.

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