Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6 [8] July 2017: 01-13

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

REVIEW ARTICLE **OPEN ACCESS**

Bioactive Components of *Vigna species*: Current Prospective

Shweta[1] and Meena Kumari[2], Anita Rana[1]
1. Department of Chemistry and Biochemistry, CSKHPKV, Palampur, Himachal Pradesh, India.
2. Department of Environment Science, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, H.P.

India. Email: shwetakhosla14@gmail.com

ABSTRACT
Legumes are excellent sources of proteins than cereal grains. Legumes supply significant amount of energy, minerals and vitamins in addition to protein. The species of genus Vigna comes under family Leguminosae.Vigna species are rich and cheap source of protein and easily grown in extreme environment conditions. Apart from its nutritious value, Vigna species also contain a number of bioactive substances including enzyme inhibitors, phytic acid, oligosaccharides, fiber, saponin and phenolic compounds. These bioactive compounds play a significant role as nutraceuticals, pharmaceuticals, pesticides and industrial products. Phytic acid and phenolic compound exhibit antioxidant activity and protects DNA damage. Saponins have hypocholesterolaemic effect and anti-cancer activity. Oligosaccharides are used as a prebiotics. The pharmacological properties of mainly five Vigna species are discussed in this review i.e. cowpea, mungbean, adzuki bean, blackgram and ricebean.The aim of present review is to explore the phytochemical and pharmacological properties of Vigna genus.
Keyword: *Antioxidant, Health benefits, Legume, Nutraceutical, Phytochemicals.*

Received 10.06.2017 Revised 27.06.2017 Accepted 12.07. 2017

INTRODUCTION

Legumes occupy an important place in the world food and nutrition. They are important constituents in the diets of a large number of people, especially in the developing countries, where animal proteins are scarce and expensive. Legumes belong to the plant family leguminosae. Legumes are richer source of protein than cereal grains. Legumes also supply significant amount of carbohydrate, energy, minerals and vitamins. It also has an ability to fix environment nitrogen by the help of rhizobium bacteria and maintain the nitrogen level in the soil.

Legumes produce many primary and secondary metabolites, which involve for the treatment of various diseases, such as on consumption of legumes are significantly associated with 22% and 11% lower risk of coronary heart disease and cardiovascular disease, respectively [1]. Recently, legumes are gaining interest because they are excellent sources of bioactive compounds, which play a significant role as a nutraceuticals, pharmaceuticals, pesticides and industrial products. The aim of present review is to explore the phytochemical and pharmacological properties of *Vigna* genus.The genus *Vigna* belongs to family Fabaceae and more than 200 species comes under the genus *Vigna* that are of considerable economic importance in many developing countries. Annual worldwide production of the different *Vigna* species are 20 million hectares and major production is contributed by developing countries. These species are grown successfully in extreme environment conditions such as high temperatures, low rain fall and poor soils, with few economic inputs [2]. *Vigna species* contain a number of bioactive substances including enzyme inhibitors, lectins, phytates, oligosaccharides and phenolic compounds that play metabolic roles in human and prevent them from many diseases. Phytic acid protects DNA damage due to its antioxidant activity [3], phenolic compounds present in legumes include anthocyanidin pigments such as delphinidin, cyanidin, pelargonidin, malvidin and petunidin also show antioxidant and other important biological properties [4], saponins exhibit anti-cancer activity and also reduce the cholesterol level [5, 6]. In this review paper, we discussed the pharmacogenetic properties of five different *Vigna* species. So that further research could be carried out on these genus plants.

Mung beans (*Vigna radiata)*

Mungbean [*Vigna radiata* (L.) R. Wilczek] is popular legume in Asian countries. It is short duration and warm seasonal crop. Its worldwide production is 6 million hectares per annum and 3 million hectare in India [7]. It has high nutritive value and rich source of protein, amino acids, carbohydrate and vitamins. It is the grain legume of highest digestibility for direct human consumption. The sprouts of mungbean are also excellent source of nutrients and bioactive components, which promote the health and lower the risk of various diseases [8].

Adzuki bean (*Vigna angularis*)

Adzuki bean or small red beans is traditional pulse crop in East Asia, widely used as a source of protein for human nutrition, especially in developing countries. Adzuki bean is reportedly the sixth largest crop grown in Japan [9]. Rubatzky and Yamaguchi [10] estimated annual adzuki bean cultivation in China, Japan, Korean Peninsula and Taiwan up to 670,000, 120,000, 30,000 and 20,000 ha, respectively. In India, its cultivation is confined to North-eastern and Northern hill zones. Adzuki bean has economic importance such as soil improver, animal food, medicines (folklore-herb) and for human food (pulse, vegetables, beverage base) [11].

Cowpea (*Vigna unguiculata*)

Cowpea [*Vigna unguiculata* (L.)Walp.]is one of the important *Kharif* pulses grown in India. It is one of the important protein rich leguminous food sources in the tropics and subtropics region. The world wide productions of cowpea are 3.6 million tons [12]. In India, its production is 0.5 million hectares and productivity 600-750 kg grain per hectare [13]. The dry mature seeds of the crop are rich source of protein, carbohydrate and also containing minerals and water soluble vitamins like thiamine, riboflavin and niacin.

Ricebean (*Vigna umbellata*)

Rice bean (*Vigna umbellata* L.), known as climbing mountain bean, mambi bean and oriental bean, is native to Southeast Asia. Rice bean(*Vigna umbellata*) is grown in the different parts of the world mainly in the hilly areas. Though little information is available about exact area under this crop in India, but roughly it is estimated to be grown in around 15000 ha with an average yield of 25.57g/plant [14]. The nutritional profile of rice bean is very high, which is mainly attributed to the high content of protein and is essential amino acids such as lysine, tryptophan and methionine as compared to the other traditional pulses [15]. However, they also contained different bioactive component such as phytate, α-galactosides and trypsin inhibitors, which significantly act as antioxidant, anticancer and antidiabetic agents.

Blackgram (*Vigna mungo*)

Black gram (*Vigna mungo L.*) is an important pulse crop occupying unique position in Indian agriculture.Among the pulses, it stands fourth in production and acreage [16]. The cultivation of blackgram in India is 3.25 million hectares and its production is 1.45 million tons [17]. It is very nutritious and is recommended for diabetics. *Vigna mungo* are used as cooling astringent, diet during fever, poultice for abscesses, soap alternative, affections of liver and cough [18].

BIOACTIVE COMPONENTS

Vigna species contain different bioactive components such as protein, minerals and vitamins, fiber, oligosaccharides, saponin, phytates, phenolic compounds, flavonoids, isoflavones, protease inhibitor and amylase inhibitor etc. These bioactive components and their beneficial effects are described in Table 1.

Protein

Protein malnutrition is one of the major nutritional problems in the developing world. The specific maladies like kwashiorkor and marasmus are prevalent in the children due to protein deficiency [19]. *Vigna species* are rich and cheaper source of protein. Besides providing nutrition, there are some proteins, present in *Vigna species*, show antifungal and antiviral activity. Such as *Vigna angularis* have angularin protein (8 K Da), *Vigna unguiculata* have α-antifungal protein (28 K Da), β-antifungal protein (12 K Da) and unguilin (18 K Da), *Vigna umbellata* have delandin (28 K Da) and antifungal peptide (5 K Da) and *Vigna sesquipedalis* (ground bean) have ground bean lectin (60 K Da), which act on Human Immuno Deficiency Virus -1 reverse transcriptase. These proteins bind with reverse transcriptase enzyme non-competitively and causes conformational change in the three dimensional structure of the enzyme, which affect the catalytic activity of the enzyme and inhibit the transcription of the viral RNA. These proteins also inhibit translation in RRLS (rabbit reticulocyte lysate system). So these proteins act as an anti–HIV agent [20- 25].

Out of all these proteins, *Vigna unguiculata*'s α-antifungal protein, β-antifungal protein and unguilin also act on α and β glucosidases enzyme and inhibit the digestion of carbohydrates and act as anti-diabetic agent. Ground bean lectin inhibits the hemagglutinating activity by polygalacturonic acid but not galacturonic acid and simple monosaccharides. It decreases the viability of hepatoma (HepG2), leukaeima

(L1210) and leukaemia (M1) cell and also elected a mitogenic response from mouse splenocytes. These proteins also contribute some antifungal activity toward *Mycosphaerella arachidicola, Botrytis cinerea, Fusarium oxysporum, Rhizoctonia solani* and*Colletotrichumgossypii* [20-25]. Due to presence of all these properties, these proteins act as an excellent drug for the treatment of AIDS patients with no adverse effects as compare to synthetic drugs.

Minerals and Vitamins

Vigna species are good reservoir of minerals and vitamins, which play important role in human body. Some minerals act as a cofactor for many enzymatic reaction e.g. copper, zinc, magnesium and manganese. Vitamins such as thiamin, riboflavin, pyridoxine and folic acid are also present in legumes in appreciably quantities, which act as coenzyme. In absence of these mineral and vitamins, some enzymes become inactive and affect many metabolic reactions of biological process. Some vitamins like vitamin E, C and K are present in trace amount in legumes. Vitamin E and C are known to play a role as an antioxidant and inhibiting the oxidation of vitamin A in the gastric intestinal tract. Antioxidant properties of these vitamins, maintain the stability of cell membranes by protecting its polyunsaturated fatty acid from oxidative damage [26]. Vitamin E also prevents cancer by inhibiting carcinogens from precursor substances. Whereas, vitamin K play functional role by act as blood clotting factor in liver. The B vitamin folic acid significantly also reduces the risk of neural tube defects (NTDs) like spina bifida in newborn babies. Selenium acts as a cofactor for glutathione peroxidase, which is the key enzyme to protect from oxidative damage. Due to antioxidant property selenium shows protective effect against colorectal, prostrate and lung cancers [27].

Fiber

Legumes are good source of fiber. Dietary fiber comes from the portion of plants that is not digested by enzymes in the intestinal tract. Bacteria present in lower gut may metabolize this and produce short chain fatty acid. The short chain fatty acid includes acetic, proprionic and butyric acids, have many important physiological functions. Proprionate and acetate are metabolized in liver and provide energy, whereas proprionate also act as a natural inhibitor of HMG CoA (3-hydroxy-3-methylglutaryl-coenzyme A) reductase. HMG CoA reductase is the key enzyme for cholesterol synthesis. Fiber also reduce body cholesterol level by binding with cholesterol in human gut [28]. Butyrate provides an important energy source for the cells that line the colon. In fact, butyrate is the preferred source for energy metabolism in the colon. Butyrate has been shown to possess impressive anticancer activity and is being used in treatment of ulcerative colitis and colon cancer.

According to Anderson et al. [29], high fiber foods can improve serum lipoprotein values, lowers blood pressure and improves blood glucose level for diabetic individuals. Insoluble fiber increases the rate of transient time of wastes material from the gastrointestinal tract. Due to this, body may have less exposure to toxic substances produced during digestion. High fiber diets may be useful for weight loss. Fiber itself has no calories, yet provides a “full” feeling because of its water-absorbing ability.

Oligosaccharides

Indigestible substances especially flatulence induced oligosaccharides (α- galactosides) e.g. raffinose, stachyose and verbascose (Fig.1), occur mainly in legume seeds. These galacto-oligosaccharides are low molecular weight, nonreducing and water soluble sugars or constitute 53% of total soluble sugars. Two enzymes are required for the digestion of oligosaccharides i.e. sucrase and α–galactosidase. But these saccharides are not digested in the intestine of monogastric animals due to the absence of endogenous enzymes (α-galactosidase) in the intestinal mucosa. This enzyme is necessary to break α 1-6 linkages. But high concentration of α -galactosides in colon of monogastric animals may have a beneficial effect. Microorganisms lives in large intestine, have enzyme α galactosidase, can digest oligosaccharides [30, 31]. Bacteria favored the intensive anaerobical bacterial fermentation (promote the growth of *Bifidobacteria*) and created considerable quantities of the short chain fatty acids, which are the source of energy for cell of intestinal mucosa, but also producedcarbon dioxide (CO_2)and methane (CH_4), which caused flatulence. They can also shorten transit time and promote the growth of bifido bacteria in man and used as prebiotic agent. Oligosaccharides show wide range of physiological properties like anticarcinogenic effect, anti-diabetic, anti-cardiovascular and higher rate of mineral absorption that are beneficial to human health [32]. Prebiotic such as *Bifidobacteria* prevent colon cancer.

Saponins

Saponins are secondary plant metabolites, containing a carbohydrate moiety (mono/oligosaccharide) linked to a hydrophobic aglycone (sapogenin), which may be steroidal or triterpenoid (Fig. 2) in nature. In pulses, triterpenoid saponin is common, while steroidal saponin is common in plants, which used as herbs. *Vigna* species also contain saponin, which is an antinutritional component. Though saponin acts as an antinutrient and reduces the nutritive value of pulses, but the saponins appear to be beneficial by showing different pharmacological properties including expectorant, antiinflammatory, vasoprotective, hypocholesterolemic, immunomodulatory, hypoglycaemic, molluscicidal, antifungal, antiparasitic and many others [33, 34]. Saponin might also exert an anticancer effect at the intestinal level. Intestinal microorganism metabolized bile acid and to form secondary bile acid, which is also one of the reasons to cause colon cancer. Saponin can reduce the formation of carcinogenic substances in the colon by binding with bile acid and reduce its availability to the microbial population. As they may bind with cholesterol or bile acids, they also increase the faecal cholesterol excretion. So saponin is responsible for lowering the cholesterol level of body and may be important in human nutrition in reducing the risk of heart diseases. Saponin exerts immune stimulant effects because it induces the production of cytokines such as interleukins and interferons [35, 36]. Saponin based adjuvants have the unique ability to stimulate the cell mediated immune system, as well as to enhance antibody production, and have the advantage that only a low dose is needed for adjuvant activity [37].

Phytic Acid

Large amount of phytic acid is present in *Vigna* species as antinutriants. Phytic acid binds with charged proteins, amino acids, starch, enzymes and minerals such as pro-oxidant. The resulting complexes are insoluble and not metabolized properly in gastro- intestinal tract, so these bio-molecules are nutritionally less available for absorption. Phytic acid binds with enzymes of digestive tract and reduces the rate of digestion of starch, and protein. Such undigested starch may reach the colon, where it metabolized into short chain fatty acid, which is beneficial for the treatment of colon cancer. Phytic acid can also chelate with polyvalent cation like iron, zinc and calcium, which is essential for DNA synthesis and cell growth. It also involve in signal transduction, cell signaling cascades and gene expression [38].

Phytic acid (myo-inositol hexaphosphate or InsP6) (Fig. 3) storesin seed in the form of phosphate, which is important part of ATP (energy source) and its salt phytates regulate various cellular functions such as DNA repair, chromatin remodeling, endocytosis, nuclear messenger RNA export and potentially hormone signaling crucial for plant and seed development [39]. Phytate exhibit significant effect in plant metabolism, stress and also provide pathogen resistance against pest or insects. Phytic acid also has ability to inhibit the transcription of the viral genome from HIV-1 [40].

Phytic acids form a complex with iron and reduce the peroxidation of membrane by inhibiting the generation of free radical [41]. The backbone of most inositol phosphates in cells is *myo-inositol. Myo-inositol* and InsP6 have synergistic or additive effects in inhibiting the development of cancer [42]. Phytic acid consumption may also reduce the formation of kidney stone. Renal lithiases, popularly called kidney stones, are small, hard deposits of mineral and acid salts on the inner surfaces of kidneys. Phytate can interfere with formation of crystals of calcium oxalate and phosphate by binding with calcium and phosphate. Phytate may also prevent the formation of cavities, plaque and tartar in the teeth by reducing the solubilities of calcium, fluoride and phosphate, which are the major components of enamel and also protect the teeth from demineralization [43, 44]. Phytic acid may play important role via. reducing level of cholesterol and lipids in serum and thus reduce the risk of heart disease, while both exogenous and endogenous. Phytic acid may have hypoglycemic effects and thus be of consequence in diabetes [38]. Phytate has great nutritional implication in the prevention and management of diabetes mellitus [45]. Phytate maintain the secretion of insulin via regulating the calcium channel activity because it specifically inhibits serine threonine protein phosphatase activity. This, in turn, opens intracellular calcium channels, driving insulin release [46, 47].

Phenolic Compounds

Phenols are secondary metabolite present in plants. In legumes, phenolic compounds are present in the form of antinutritional factor, but due to its ability to chelate metals, inhibit lipid peroxidation and scavenge free radicals, phenols act as antioxidant [48]. In legumes major phenolic compounds consist mainly of tannins, phenolic acids and flavonoids. Polyphenolic compounds e.g. flavonoids such as flavonol glycosides, anthocyanins and condensed tannins (proanthocyanidins) contribute the seed color of pulses [49]. The seeds of different varieties, which are dark and highly pigmented, have high content of phenolic compounds such as red kidney beans (*Phaseolus vulgaris*) and black gram (*Vigna mungo*) [50]. Phenolic compounds have been reported to reduce the risk of cancer, heart disease and diabetes, as well as have antibacterial, antiviral, anti-inflammatory and anti-allergenic activities [51].

Tannin

Legumes are good source of tannin. Different amount of tannin account in *Vigna species* such as cowpea have (175- 590 mg/g) , ricebean have (490-860 mg/100g), mungbean have (437- 799 mg/g), blackgram have (540-1197 mg/g) [52] and in adzuki bean have (291mg/g) [53]. The structure of tannic acid is given in Fig. 3. The physiologicalactivity of the tannins also depends on limitingthe permeability of intestine walls. This phenomenon has unfavorable influence on the degree of feed utilization, but on the other hand the limitation of permeability ofintestine walls can be successfully used in casesof intake of some toxic substances by animal. Because of their ability to bind the proteins, tannins can be used as a factor in removing some toxins from the intestine. These complexes(tannin-toxin) are unstable, so removed from the intestine very fast because of the danger of secondary degradation and absorption. Tannin can inhibit the growth of bacteria that cause tooth decay, so tannins can also be useful in keeping hygiene of the mouth. The tannin-protein complexes(e.g. tanalbine) are applied in human andanimal medicine as a prophylactic substance,styptic agent and antidiarrhoeal drug.Tannins were also attributed to have a slight,positive role in limitation of parasitic invasionsand reduction of the pathogens activity [54].

Flavanoid

In *Vigna species*, ricebean and mungbean have flavanoid content 3.38 RE mg/g and 0.95 RE mg/g, respectively [55]. Flavonoids are also secondary metabolites of plants with polyphenolic structure. Common flavonoid groups include aurones, xanthones, and condensed tannins. Flavonoids give the plant a rich taste. It acts as an antioxidant and prevents many diseases such as cancer, inflammation, autoimmune diseases, cataract, arteriosclerosis and aging [56].

Isoflavones

Isoflavones are largely reported from the Fabaceae/Leguminosae family (Rochfort S). Isoflavones consist of daidzin, daidzein, genistin and genistein (Fig. 3). In gastrointestinal tract, daidzin and genistin are metabolized into daidzein and genistein by the help of enzyme β- glucosidase [57]. Isoflavones act as an antioxidant in plants and act as agonist of estrogen in mammals. Isoflavones attributed its bioactivity by reducing osteoporosis, cardiovascular disease and prevention of cancer and also used for the treatment of menopause symptoms [58]. Genistein is potent inhibitor of protein tyrosine kinase enzyme, which can arrest the cell cycle and cause apoptosis of leukemic cells to prevent cancer [57].

Antioxidant Activity

Free radicals are produced by the process of oxidation. These free radicals are very unstable molecules due to unpaired electron and cause oxidation of protein, nucleic acid, lipids and initiate many degenerative diseases. Antioxidant prevent or remove the damaging oxygen molecules from interacting with cellular molecules before they damage and lead to disease.

Vigna species contains different anti-nutrients such as phenols, phytic acid, tannin etc. and some vitamins like vitamin B and ascorbic acid, which act as antioxidant. These antioxidants play important role for the treatment of chronic diseases such as cancer, heart disease, stroke, rheumatoid arthritis and cataracts [59, 60]. Antioxidant activity (DPPH method) shown by ricebean (39.87- 46.40 μM TE/ g), cowpea (37.27 μM TE/ g), mungbean (45.36 μM TE/ g) and adzuki bean (18.08 μM TE/ g) [61, 62]. Whereas, cowpea contain 0.38 mg/g and 1.88 mg/g, alpha and delta tocopherol, respectively [63], which also act as an antioxidant. Lin [64] studied different varaity of soyabean, adzuki bean and mungbean and found that out of all these varities, the dark-coat seeds, such as azuki beans and black soybeans, contained high amounts of phenolic compounds, flavanoid component and contributed to high antioxidative ability. Whereas, Wu et al. [65] have recently shown that a water soluble extract of the adzuki beans could inhibit acetaminophen induced liver damage. Han et al.[66] have reported the protective action of an adzuki extract against acetaminophen induced hepatotoxicity *via* a hepatic γ-glutamylcysteinylglycine (GSH) mediated antioxidation /detoxification system in rat liver after four weeks of feeding.

Enzyme Inhibitors

Enzyme inhibitors present in legumes are involved in the regulation of endogennous proteases, amylases, lipases, glycosidases and phosphatases enzyme but also used as a defense related strategies against seed eating insects and microorganisms. Legumes have inhibitors belong to family, Kunitz (20-24 KDa) and Bowman-Birk (8 KDa) family. In common beans, lima bean, cowpea and lentil, protease inhibitors have been characterized as members of the Bowman-Birk family (BBI) [67, 68]. These inhibitors have double headed configuration, so they can interact with two enzymes simultaneously. These inhibitors show highly stability at wide range of temperature and pH, due to presence of disulfide bond. From the nutritional aspect, the inhibitors of the serine proteases trypsin and chymotrypsin are the most important [67].

i Protease inhibitors

The protease inhibitors can also be used for the prevention of cancer. Content of protease inhibitor in kidney bean and cowpea ranged from 8 - 10.6 g of trypsin and 9.2 g of chymotrypsin inhibited kg^{-1}, respectively [69]. BBI is a double headed inhibitor usually capable of inhibiting both trypsin and chymotrypsin enzyme. According to Clemente et al. [70] the anti-chymotryptic activity is more effective that the antitryptic activity in inhibition of carcinogen induced transformation. BBIs also attribute anti-inflammatory activity, by inhibiting the inflammation mediating protease [71]. Pea, chickpea and mungbean protein hyrolysates have been shown to have angiotensin converting enzyme (ACE) inhibitory activity. Since ACE plays a key role in modulating blood pressure, ACE inhibitors, including those derived from pulses, may improve cardiovascular health [72]. Inverse correlations between pulse consumption and colon cancer mortality and risks of prostrate cancer, gastric cancer and pancreatic cancer have been reported in several epidemiological studies [73].

iiα-amylase inhibitor

Obesity is a complex disease with serious medical consequences. Legumes are rich in protein as compare to carbohydrates and fats. So protein rich food is beneficial for weight lose [74]. However, raw legume seeds contain good amount of α-amylase protein inhibitors, which is used for the prevention and therapy of obesity and diabetes. α-amylase inhibitor binds with porcine pancreas α-amylase enzyme (which act on starch and hydrolyzed into mixture of small oligosaccharides like maltose, maltotriose and oligoglucans) and delay carbohydrate absorption, due to this there is reduction of peak postprandial plasma glucose concentrations in blood. So, α-amylase inhibitor can be used as a nutraceutical molecule [75, 76]. According to Suzuki et al. and Muri et al. 2004] [77, 78], some patents concerning the use of food preparations containing suitable amounts α-amylase inhibitors from various sources for the obesity control and the prevention or treatment of diabetes have recently appeared.

iiiα-glucosidase inhibitor

α-glucosidase enzyme present at the epithelium of the small intestine and required for the digestion of mixture of small oligosaccharides, which is hydrolysed from starch by α-amylase . α -Glucosidase has been recognized as a therapeutic target for modulation of postprandial hyperglycaemia, which is the earliest metabolic abnormality to occur in type 2 diabetes mellitus [79]. *Vigna species* contain α-glucosidase inhibitor, which have great potential for the treatment of diabetic patients.Inhibition of intestinal α -glucosidases delays the digestion and absorption of carbohydrates, thereby suppressing postprandial hyperglycaemia [80]. Ricebean, cowpea, mungbean and adzuki bean show α - glucosidase inhibition, 57.98 %, 51.54 %, 18.62% and 64.33 %, respectively[61].

dTyrosinase inhibitor

Tyrosinase act as a key enzyme for synthesis of melanin pigments. Tyrosinase catalyzes two distinct reactions in melanin synthesis: the hydroxylation of L-tyrosine to L-dopa and the oxidation of L-dopa to dopaquinone, after further series of conversions to the melanin produced [81]. Ricebean, cowpea, mungbean and adzuki bean show Tyrosinase inhibiton, 60.97%, 47.49%,81.24% and 38.92%, respectively [61]. The inhibitors of tyrosinase have been used to treat some dermatological hyperpigmentation illness connected with overproduction of melanin, which also play a significant role in the cosmetic business as a skin whitening agent [82].

γ-Aminobutyric acid (GABA)

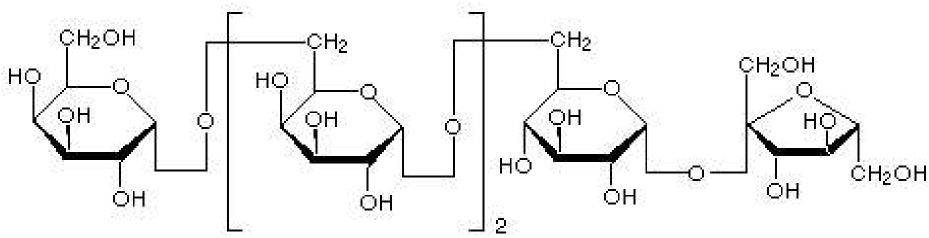
γ-Aminobutyric acid (GABA) (Fig. 3) is a non-protein amino acid and act as a depressive neurotransmitter in the sympathetic nervous system. GABA is used as effective medicine for people who are suffering from hypertension by lowering their blood pressure. It can also be effective for the treatment of sleeplessness, depression, autonomic disorders, chronic alcohol related symptoms and to stimulate immune cells [83]. Seed of adzuki bean had 21.31 mg/100 g of GABA content and its level increases after seedling [84]. Due to presence of GABA, mung bean acts as a hepatoprotective agent. On germination and fermentation of mungbean seed, there areincreases in 7.3 times of GABA content and 8.7 and 13.2 times of amino acid improvement, respectively. Besides this, there are also increase in antioxidant levels, serum markers and NO level, which can promote mungbean extract to reduce the hepatocyte damage [85].

Table I : Different bioactive components present in *Vigna species* and their effect

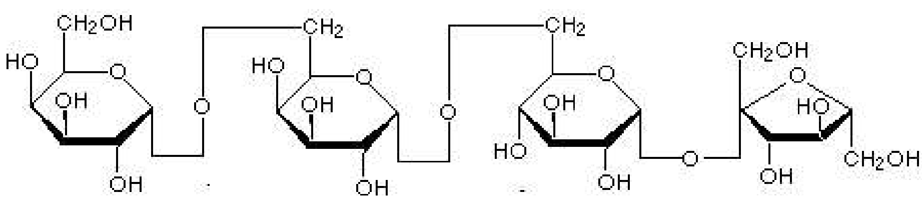
Bioactive components	Beneficial effects
Protein (angularin, delandin and unguilin)	Anti –HIV activity
Minerals and Vitamins	Act as antioxidant
Fiber	Lower cholesterol level and reduce colon cancer
Oligosaccharides	Reduce colon cancer and act as prebiotics
Saponins	Hypocholesterolaemic effect and anticarcinogenic
Lectins	May help in obesity treatment and tumor growth
Phytates	Hypocholesterolaemic effect, anticarcinogenic and also protect DNA damage
Phenolic compounds	Risk factors for menopause, coronary heart disease and anticarcinogenic
Flavonoids, isoflavones (phytoestrogens)	Act as antioxidant and anticarcinogenic
Protease inhibitors	Anticarcinogenic
Amylase inhibitors	Antidiabetic

Table II: *Vigna* species and their main potential positive and beneficial effects

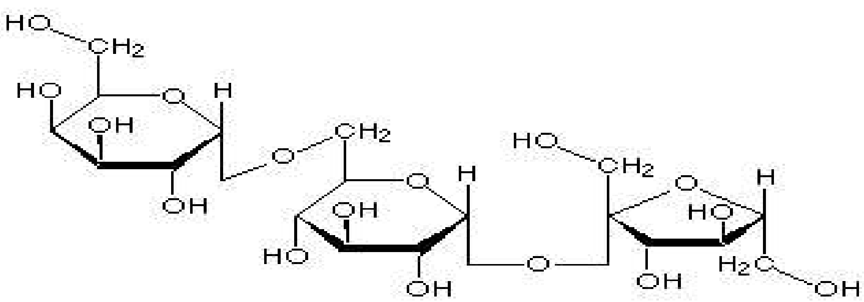
Azuki bean juice	Hypertriglyceridemia	Decreased triglyceride concentrations by inhibited pancreatic lipase activity	[88]
Boiled Azuki bean juice	Aging	To prevent damage associated with the stress of aging, inhibitory effect on malonaldehyde formation, and thereby exert antioxidant activity	[89, 90]
Mung bean	Glucose and lipid Metabolism	Modify glucose and lipid metabolism favorably in rats	[91]
	Liver	By increasing the level of GABA and antioxidants, act as hepatoprotective agent	[85]
Butanol and Hexane extracts of mungbean	Gastric carcinoma cell line	Inhibit cancer cell line	[8]
Aqueous extract of seed of *Vigna mungo* (Blackgram)	Hepatoprotective and nephroprotective	Maintain the level of glutathione pyruvate tranaminase, oxaloacetate transaminase, alkaline phosphatase and total bilirubin, also maintain the level of urea nitrogen, creatinine and uric acid in serum	[92]
Cowpea	Cancer	Trypsin inhibitor cause death of MCF-7 cell and inhibit the growth of tumor	[93]



VERBASCOSE



STACHYOSE



RAFFINOSE

Figure 1: Structure of Oligosaccharides

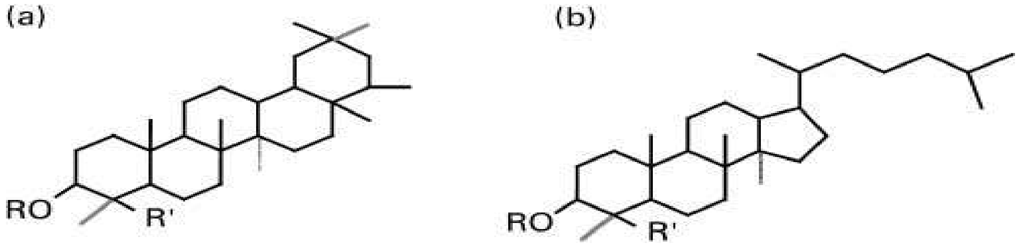
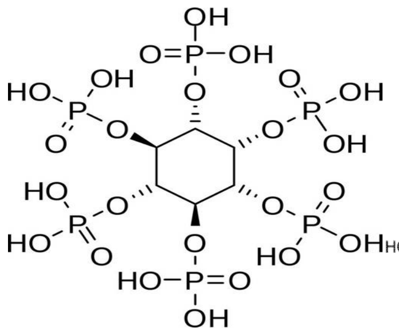
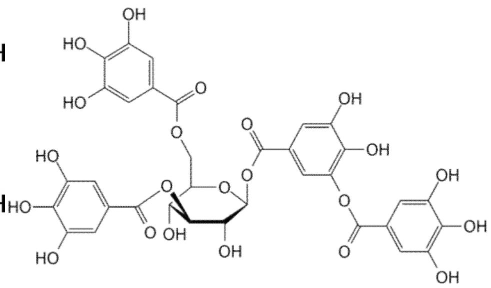


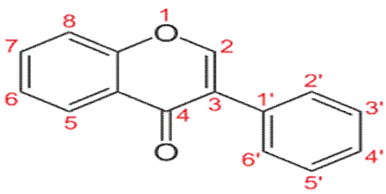
Figure 2: Structure of saponin: (a) triterpenoid (b) steroid.



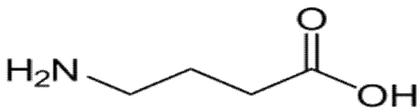
Phytic acid



Tannic acid



Isoflavones



GABA

Figure 3: Stucture of Phytic Acid, Tannic Acid, Isoflavones and GABA

IMPACT OF *VIGNA SPECIES* ON HUMAN HEALTH

Vigna species are cheaper source of protein. By taking legume diet the problem of protein malnutrition could be solved. *Vigna species* are low glycemic index (GI) foods with GI values ranging from 28 - 52 [86]. The low GI in *Vigna species* is due to abundance of non-starch polysaccharides, resistant starch and oligosaccharides, which reduce the glucose, level [87] and reduce the risk of diabetes. The beneficial role of bioactive components of *Vigna* species are given in Table 2.

Cancer

Various legumes are involved for the treatment of different types of cancer like breast, stomach and prostate cancer. *Vigna species* contain many nutrients and bioactive components, which show anti-carcinogenic activity. Fiber, oligosaccharides, phenolic compounds and antioxidants act as an anticancer agent. Mung bean shows preventions to lung cancer and liver cancer induced by morphine and sodium nitrite. Lectins exist in legumes are capable of inhibiting the proliferation of *Escherichia coli* in the rat's intestine [94, 95, 96].

Itoh et al. [97] reported that the 40% (w/v) ethanol fraction of the hot water extract from adzuki beans suppresses not only proliferation of human stomach cancer cells in culture but also benzo(α) pyrene-induced tumorigenesis in the mouse fore stomach. Anti cancer agent stimulate the immune responses, which may prevent cancer.Kazuyasu et al. [98] revealed that some edible beans containe components with biological activity similar to that ofpolyphenyl propanoid polysaccharide complex. They found that adzuki bean (*Vigna angularis*) has differentiation/maturation inducing activity for dendritic cells (DCs) and apoptosis inducing activity for human leukemia U937 cells. Extracts of adzuki bean contains two components; one which was elutes in 100% methanol, induce differentiation from bone marrow cell to immature DCs, while the apoptosis-inducing activity for leukemia U937 cells was eluted with 50% methanol. On engulfment of apoptosis cancer cells can stimulate DCs. So adzuki beans and adzuki extract may be promising immunopotentiating foods, dietary supplements and adjuvant for cancer prevention and immunotherapy.

Cardiovascular disease

Cardiovascular disease is major cause of death in many countries. The main risk factor of this disease is increased level of cholesterol. Legumes act as cholesterol lowering agent.Legumes consumption is significantly associated with 22% and 11% lower risk of coronary heart disease and cardiovascular disease, respectively [1]. So legumes could be considered as heart healthy food. Different bioactive components present in *Vigna species* such as fiber, oligosaccharides, angiotensin converting enzyme, resistant starch, vitamins and minerals, protects from cardiovascular disease. Black gram have high amount of fiber. Indira and Kurup [99] examined that on administration of 30% neutral detergent fiber of blackgram as a diet, reduce cholesterol level as compared to cellulose by binding with bile acids. It can also reduce the hyperlipidemia induced by ethanol. Neutral Detergent Fiber of blackgram have different binding affinities for different bile acids such as maximum for chenodeoxy cholic acid and minimum in case of deoxycholic acid. Nishimura et al. [100] examined that dietary fiber of sprouted mungbean reduce the cholesterol level in rats. A significant reduction in total plasma cholesterol levels was observed by giving fiber enriched diet for 21 days, accompanied by an increase in total caecal short chain fatty acids. This is beneficial for both, cardiovascular disease and cancer. Salunkhe and Kadam [101] examined the potential effect of saturated fatty acids (FA) on atherosclerosis, coronary heart disease, and myocardial infarction. Legume lipids and dietary fibers are being suggested for dietary reduction of blood cholesterol because legumes contain substantial amounts of desirable polyunsaturated fatty acids (PUFA) and fiber. In case of adzuki bean, fatty acids (FA) of triacylglycerols (TAG) and phospholipids (PL) were present in range of 20.6–21.9 wt % and 72.2–73.4 wt %, respectively. These components also reduce the risk of cardiovascular diseases.

Diabetes

Diabetes occurs due to high glucose level in blood, this disease also associates with other diseases like heart disease, blindness, kidney disease and nerve damage [102]. *Vigna species* play an important role for the treatment of diabetes because it have high amount of fiber and oligosaccharides, which can maintain the glycemic level in blood. Mung bean have low glycemic index, so it can reduce the lipid level, insulin and epidilymal adipocyte volume from plasma. So mung bean can be used as an anti-diabetic agent. Yeap et al. [103] compared fermented and nonfermented mung bean extracts to reduce the glucose level on rats. Fermented mung bean extracts did not induce hypoglycemic effect on normal mice but reduced glucose level and cholesterol triglyceride in blood.

Inflammation

There are many bacteria and fungi, which are the causative agent of inflammation. Many drugs are available in market for their prevention and treatment. But these drugs have many side effects and many microorganism developed resistance against them. So, now researcher giving more attention to utilize those drugs, which are cheap, effective and obtain from natural sources. *Vigna radiata* and sprouts of mungbean have antimicrobial and antifungal activity. Sprouts have more bioactive components as compared to seed. Flavonoid is the substance, which is produced by the plants against bacteria. Mungbean sprout (MBS) crude extract yielded a very promising antimicrobial activity against 11 bacteria. *T. harzianum* is a rare opportunistic pathogen and recently isolated from blood serum, skin lesions, sputum and throat of a pediatric patient with neutropenia. *T. rubrum* is the most common dermatophyte species and the most frequent cause of fungal skin infections in humans worldwide. They are resistant to commonly available drugs. MBS show remarkable antifungal activity against *T. harzianum* and *T. rubrum* [104]*.Vigna vexillata* also have anti-inflammatory bioactivity. In chloroform fraction of *Vigna vexillata* having three compounds such asdaidzein, abscisic acid and quercetin, which show anti-inflammatory potentials compared with the Phosphatidylinositol-3-kinase (PI3K) inhibitor and a NADPH oxidase inhibitor. Phosphatidylinositol-3-kinase (PI3K)/protein kinase B pathway plays an important role in neutrophil activation, whereas NADPH oxidase is also important in the inflammatory mechanism. So *Vigna vexillata* can use as an anti inflammatory drug via. inhibitingPI3K or NADPH oxidase [105]. Lee et al. [106] found that methanolic extract and solvent fraction of *Vigna sinensis* (cowpea) seeds have anti-inflammatory activity.

Heat Stress

Many Asian countries use mungbean soup for the treatment of heat stress.Twocomponents, Vitexin and isovitexin , which are the major antioxidant components in mungbean and reduce the risk of many diseases. Cao et al. [107] found that when rats fed on mungbean coat extracts then the levels of malonaldehyde, activities of lactate dehydrogenase and nitric oxide synthase are remarkably reduced and the levels of total antioxidant capacity or glutathione are significantly enhanced in the plasma of rats before or after exposure to heat stress.

Hepatotoxicity

Vigna species are healthy food for liver. *Vigna mungo* show hepatoprotective effect against Acetaminophen and carbon tetrachloride induced hepatotoxicity in rats and also inhibit the microsomal enzymes [108]. GABA presents in mungbean and adzuki bean also effective hepatoprotective agent.

CONCLUSION

Vigna species are valuable source of protein, carbohydrate, mineral and vitamins, besides these important nutrients, *Vigna* species also contain biologically active components including phenols, phytic acid, saponin, oligosaccharides, fiber etc. Due to presence of these components, *Vigna* species show antioxidant, anticarcinogenic, anti mutagenic and anti hyperglycemic effect. Though *Vigna* species has various medicinal applications and it can be used as a nutraceuticals.Further studies should be conducted to develop genetically engineered plants to control the amounts of specific bioactive compounds.

REFERENCES

1. Flight, I. and Clifton, P. [2006]. Cereal grains and legumes in the prevention of coronary heart disease and stroke: A review of the literature. European Journal of Clinical Nutrition, 60:1145-1159.
2. Fery, F.L. [2002]. New opportunities in *Vigna.* In: (J Janick and A Whipkey, eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA, p 354
3. Phillippy, B.Q. [2003]. Inositol phosphates in food. Advances in Food and Nutrition Research,45:1-60.
4. Yeh, C.T. and Yen, G.C. [2003]. Effects of phenolic acids on human phenol sulfo-transferases in relation to their antioxidant activity. Journal of Agricultural and Food Chemistry,51:1474-1479.
5. Shi, J., Arunasalam, K., Yeung, D., Kakuda, Y., Mittal, G. and Jiang, Y. [2004]. Saponins from edible legumes: Chemistry, Processing, and Health Benefits. Journal of Medicinal Food,7: 67-78.
6. Mazza, G. and Miniati, E. [1993]. Anthocyanins in Fruits, Vegetables, and Grains. CRC Press, Boca Raton, FL, pp. 2-10.
7. Nair, R.M., Schafleitner, R., Kenyon, L., Srinivasan, R., Easdown, W., Ebert, A.W. and Hanson, P. [2012]. Genetic improvement of mungbean. SABRAO Journal of Breeding and Genetics,44: 177-190.
8. Kim, D.K., Jeong, S.C., Gorinstein, S. and Chon, S.U. [2012]. Total polyphenols, antioxidant and antiproliferative activities of different extracts in mungbean seeds and sprouts. Plant Foods of Human Nutrition, 67: 71–75.
9. Sacks, F.M. [1977]. A Litreature Review Phaseolus angularis, The adzuki bean. Economic Botany,31: 9-15.
10. Rubatzky, V.E. and Yamaguchi, M. [1997]. World vegetables: Principles, production and nutritive values. Chapman & Hall, New York, 2nd ed., p. 572
11. Sato, S., Hori, Y., Yamate, J., Saito, T., Kurasaki, M. and Hatai, A. [2005]. Protective effect of dietary adzuki bean (Vigna angularis) seed coats against renal interstitial fibrosis of rats induced by cisplatin. Nutrition,21: 504-11.
12. Mbene, F., N'Draye, M. and Lowemberg-DeBoer, J. [2000]. Identifying cowpea characteristics which command price premium in Senegalese Market. Presentation at the world cowpea conference Ibadan, Nigeria
13. Ahlawat, I.P.S. and Shivakumar, B.G. [2005]. Kharif pulses: In Textbook of Field Crops Production. Dr. R. Prasad (Ed.) Indian Council of Agricultural Research, New Delhi, India
14. Raiger, H.L., Bhandari, B.C. and Phogat, B.S. [2010]. Annual report of All India Coordinated Research Network on under-utilized crops.NBPGR, New Delhi, p 408
15. Sharma, B.K., Das, A. and Banjarbarnah, K.M. [2003]. Underutilized life support crop species: Production and research in north eastern hill region of India. NATP Household Food and National Security-Programme-1, India
16. Deepalakshmi, A.J. and Anandakumar, C.R. [2004]. Creation of genetic variatiability for different polygenic traits in black gram (Vigna mungo L. Hepper) through induced mutagenesis. Legume Research, 27: 188-192.
17. Pawar, S.E. [2001]. Impact of mutant varieties of black gram in releasing important productivity. Mutagenic Breeding of Newsletters, 45: 7-9.
18. Duke, J.A. [1981]. Handbook of legumes of world economic importance. Plenum press, New York, London
19. Black, R.E., Caulfield, L., Bhutta, Z.A. and Cesar, G. [2008]. Malnutrition kills directly, not indirectly. Victora, 371:1749-1750.
20. Ye, X.Y. and Ng, T.B. [2002c]. Purification of angularin, a novel antifungal peptide from adzuki beans. Journal of Peptide Science, 8: 101–106.
21. Ye, X.Y. and Ng, T.B. [2002d]. Delandin, a chitinase-like protein with antifungal, HIV-1 reverse transcriptase inhibitory and mitogenic activities from the rice bean Delandia umbellata. Protein Expression and Purification, 24: 524–529.
22. Ye, X.Y. and Ng, T.B. [2002 b]. A new antifungal peptide from rice beans. Journal of Peptide Research 60: 81–87
23. Ye, X.Y. and Ng, T.B. [2001 a]. Isolation of unguilin, a cyclophilin like protein with anti-mitogenic, antiviral, and antifungal activities, from black-eyed pea. Journal of Protein Chemistry,20: 353–359.
24. Ye, X.Y., Wang, H.X. and Ng, T.B. [2000]. Structurally dissimilar proteins with antiviral and antifungal potency from cowpea (Vigna unguiculata) seeds. Life Science,67: 3199–3207.
25. Wong, J.H. and Ng, T.B. [2003]. Purification of a trypsin-stable lectin with antiproliferative and HIV-1 reverse transcriptase inhibitory activity. Biochemical and Biophysical Research Communications, 301: 545–550.
26. Davies, S. and Stewart, A. [1987]. Nutritional Medicine. Richard clay Ltd., Bungay, Suffolk
27. Patterson BM and Levander OA. 1997. Naturally occur- ring selenium compounds in cancer preventive trials. A workshop summary. Cancer Epidemiology, Biomarkers and Prevention,6: 63-69.

28. Burkitt, D.P. and Trowell, H.C. [1985]. Refined carbohydrates in foods and disease. Some implications of dietary fiber.Academic Press New York
29. Anderson, J.W., Baird, P., Davis, Jr. R.H., Ferreri, S., Knudtson, M., Koraym, A., Waters, V.and Williams, C.L. [2009]. Health benefits of dietary fiber. Nutrition Reviews,67: 188–205.
30. Cristofaro, E., Mattu, G. and Wuhrmann, J.J. [1974]. Sugars in Nutrition. Academic Press, New York, p 313
31. Rackis, J.J. [1975]. Physiological effects of food carbohydrates. Eds Jeanes A. and Hodge J., American Chemical Society, DC, Washington, pp 207-222
32. Masao, H. [2002]. Noval physiological functions of oligosaccharides. Pure Appllied Chemistry,74: 1271-1279.
33. Sparg, S.G., Light, M.E. and Van, Staden, J. [2004]. Biological activities and distribution of plant saponins. Journal of Ethnopharmacology, 94: 219–243.
34. Sahu, N.P., Banerjee, S., Mondal, N.B. and Mandal, D. [2008]. Steroidal saponins. In: Fortschritte der Chemie Organischer Naturstoffe/progress in the chemistry of organic natural products, fortschritte der chemie organischer naturstoffe/ progress in the chemistry of organic natural products. Springer, Vienna, 89: 45–141.
35. Jie, Y.H., Cammisuli, S. and Baggiolini, M. [1984]. Immunomodulatory effects of Panax ginseung C. A. MEYER in the mouse. Agents and Actions, 15: 386–391.
36. Kensil, C.R. [1996]. Saponins as vaccine adjuvants. Critical Reviews in Therapeutic Drug Carrier Systems, 13: 1–55.
37. Oda, K., Matsuda, H., Murakami, T., Katayama, S., Ohgitani, T. and Yoshikawa, M. [2000]. Adjuvant and haemolytic activities of 47 saponins derived from medicinal and food plants. Biological Chemistry, 381: 67–74.
38. Jenab, M. and Thompson, L.U. [2002]. Role of phytic acid in cancer and other disease. In R. Reddy and S. K. Sathe (Eds.). Food Phytates, London, pp. 232
39. Zhou, R.J. and Erdman, J.W. [1995]. Phytic acid in health and disease. Critical Reviews in Food Science and Nutrition,35: 495-508.
40. Filikov, A.V. and James, T.L. [1998]. Structure based design of ligands for protein basic domains: Application to the HIV-1 Tat protein. Journal of Computer-Aided MolecularDesign, 12: 229-240.
41. Coelho, C.M.M., Santos, J.C.P., Tsai, S.M. and Vitorello, V.A. [2002]. Seed phytate content and phosphorous uptake and distribution in dry bean genotype. Brazilian Journal of Plant, 14: 623-628.
42. Estensen, R.D. and Wattenberg, L.W. [1993]. Studies of chemopreventive effects of myo-inositol on benzo[a]pyrene-induced neoplasia of the lung and fore stomach of female A/J mice. Carcinogenesis,14: 1975-1977.
43. Grases, F., Prieto, R.M., Simonet, B.M. and March, J.G. [2000a]. Phytate prevents tissue calcifications in female rats. BioFactors, 11: 171–177.
44. Grases, F., Simonet, B.M., Vucenik, I., Prieto, R.M., Costa-Bauza, A., March, J.G. et al. [2001]. Absorption and excretion of orally administered inositol hexaphosphate (IP6 or phytate) in humans. BioFactors, 15: 53–61
45. Yoon, J.H., Thompson, L.U. and Jenkins, D.J.A. [1983]. The effect of phytic acid on in vitro rate of starch digestibility and blood glucose response. American Journal of Clinical Nutrition, 38: 835–842.
46. Barker, C.J. and Berggren, P. [1999]. Inositol hexakisphosphate and beta-cell stimulus secretion coupling. Anticancer Research, 19: 3737–3742.
47. Larsson, O., Barker, C.J., Sjoholm, A., Carlqvist, H., Michell, R.H., Bertorello, A. et al. [1997]. Inhibition of phosphatases and increased Ca^{2+} channel activity by inositol hexaphosphate Science, 278: 471–474.
48. Cheung, L.M., Cheung, P.C.K. and Ooi, V.E.C. [2003]. Antioxidant activity and total phenolics of edible mushroom extracts. Food Chemistry,80: 249- 255.
49. Duenas, M., Sun, B., Hernandez, T., Estrella, I. and Spranger, M.I. [2003]. Proanthocyanidin composition in the seed coat of lentils (Lens culinaris L.). Journal Agriculture Food Chemistry,51: 7999-8004.
50. South, P.K. and Miller, D.D. [1998]. Iron binding by tannic acid; Effects of selected ligands. Food Chemistry,63: 167-172.
51. Randhir, R. and Shetty, K. [2007]. Mungbeans processed by solid-state bioconversion improves phenolic content and functionality relevant for diabetes and ulcer management. Innovative Food Science and Emerging Technology, 8: 197–204.
52. Jain, A.K., Kumar, S. and Panwar, J.D.S. [2009]. Antinutritional factors and their detoxification in pulses. Agriculture Review, 30: 64-70.
53. Troszynska, A., Lamparski, G., Kamita- Glazewska, H. and Pikielna, N.B. [2003]. Sensory and chemical aspects of astringency of polyphenolic compounds from legume seeds. Polish Journal of Food and Nutrition Science,12153: 87-99.
54. Wang, S.Y., Wu, J.H., Ng, T.B., Ye, X.Y. and Rao, P.F. [2004]. A non-specific lipid transfer protein with antifungal and antibacterial activities from the mung bean. Peptides, 25: 1235–1242.
55. Ren, S.C., Liu, Z.L. and Wang, P. [2012]. Proximate composition and flavonoids content and in vitro antioxidant activity of ten varieties of legume seeds grown in China. Journal of Medicinal Plants Research,6: 301-308.
56. Ghasemzadeh, A. and Ghasemzadeh, N. [2011]. Flavonoids and phenolic acids: Role and biochemical activity in plants and human. Journal of Medicinal Plants Research, 5: 6697-6703.
57. Yamaguchi, M. [2002]. Isoflavon and bone metabolism: its cellular mechanism and prevention role in bone loss. Journal of health science, 48: 209-222.
58. Cassidy, A., Albertazzi, P., Lise, Nielsen, I., Hall, W., Williamson, G., Tetens, I. et al. [2006]. Critical review of health effects of soyabean phyto-oestrogens in post-menopausal women. The Proceedings of the Nutrition Society,65: 76-92.

59. Chikane, M.R., Parwate, D.V., Ingle, V.N., Chhajjed, S. and Haldar, A.G. [2011]. In vitro, antioxidant effect of seed coats extracts of Vigna mungo. Journal of Pharmacy Research, 4: 656-657.
60. Oboh, G. [2006]. Antioxidant properties of some commonly consumed and underutilized tropical legumes. Europian Food Research Technology, 224: 61–65.
61. Yao, Y., Cheng, X., Wang, L., Wang, S. and Ren, G. [2011]. Biological potential of sixteen legumes in China. International Journal of Molecular Science,12: 7048-7058.
62. Yao, Y., Cheng, X.Z., Wang, L.X., Wang, S.H. and Ren, G. [2012]. Major phenolic compounds, antioxidant capacity and antidiabetic potential of rice bean (Vigna umbellata L.) in China. International Journal of Molecular Science, 13: 2707-2716.
63. Carvalho, A.F.U., de Sousa, N.M., Farias, D.F., da Rocha-Bezerra, L.C.B., da Silva, R.M.P., Viana, M.P., Gouveia, S.T., Sampaio, S.S., de Sousa, M.B., de Lima, G.P.G., de Morais, S.M., Barros, C.C. and Filho, F.R.F. [2012]. Nutritional ranking of 30 Brazilian genotypes of cowpeas including determination of antioxidant capacity and vitamins. Journal of Food Composition and Analysis,26: 81–88.
64. Lin, P.Y. and Lai, H.M. [2006]. Bioactive compounds in legumes and their germinated products. Journal of Agricultural Food Chemistry, 54: 3807-3814.
65. Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E. and Prior, R.L. [2004]. Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. Journal of Agricultural Food Chemistry,52: 4026-4037.
66. Han, K.H., Fukushima, M., Oba, K., Shimada, K., Sekikawa, M., Chiji, H., Lee, C.H. and Nakano, M. [2004]. Hepatoprotective effects of the water extract from Adzuki bean hulls on acetoaminophen induced damage in rat liver. Journal of Nutritional Science and Vitaminology, 50: 380-383.
67. Belitz, H.D. and Weder, J.K.D. [1990]. Protein inhibitors of hydrolases in plants foodstuffs. Food Reviews International,6: 151-211.
68. Lajolo, F.M., FinardiFilho, F.and Menezes, E.W. [1991]. Amylase Inhibitors in Phaseolus vulgaris Beans. Food Technology,45: 119-121.
69. Grant, G., Dorward, P.M., Buchan, W.C., Armour, J.C. and Pusztai, A. [1995]. Consumption of diets containing soya beans (Glycine max), kidney beans (Phaseolus vulgaris), cowpeas (Vigna unguiculata) or lupin seeds (Lupinus augustifolius) by rats for up to 700 days: Effects on body composition and organ weights. British Journal of Nutrition,73: 17-29.
70. Clemente, A., McKenzie, D.A., Johnson, I.T. and Domoney, C. [2004]. Investigation of legume seed protease inhibitors as potential anti-carcinogenic proteins. Legumes for the benefit of agriculture, nutrition and the environment. Proceeding of 5th Europian Conference Grain Legume Dijon. AEP; p. 51
71. Ware, J.H., Wan, X.S., Newberne, P. and Kennedy, A.R. [1999]. Bowman-Birk inhibitor concentrate reduces colon inflammation in mice with dextran sulfate sodium induced ulcerative colitis. Digestive Diseases and Sciences, 44: 986.
72. Pedrosche, J., Yust, M.M., Giron-Callon, J., Alaiz, M. and Milan, F. [2002]. Utilization of chickpea protein hydrolyzates for production of peptides with angiotension I converting enzyme (ACE) inhibitory activity. Journal of Science Food and Agriculture,82: 960-965.
73. Jain, M.G., Hislop, G.T., Howe, G.R. and Ghadirian, P. [1999]. Plant foods, antioxidants and prostrate cancer risk: finding from case control studies in Canada. Nutrition and Cancer, 34: 173-184.
74. Kontessis, P., Jones, S.L., Dodds, R., Trevisan, R., Nosadini, R., Fioretto, P. et al. [1990]. Metabolic and hormonal responses to ingestion of animal and vegetable proteins. Kidney International, 38:136.
75. Oneda, H., Lee, S. and Inouye, K. [2004]. Inhibitory effect of 19 alpha-amylase inhibitor from wheat kernel on the activity of porcine pancreas alpha-amylase and its stability. Journal of Biochemistry, 135: 421-427.
76. Lankisch, M., Layer, P., Rizza, R.A. and DiMagno, E.P. [1998]. Acute postprandial gastrointestinal and metabolic effects of wheat amylase inhibitor (WAI) in normal, obese, and diabetic humans.Pancreas, 17: 176-181.
77. Suzuki, H., Sakane, I., Hosoyama, H., Sugimoto, A., Nagata, K., Tsunoda, T. [2003]. Patent number: JP2003095941
78. Muri, M.A., Luffs, J.B. and Lo-Sometz, H. [2004]. Patent number: CN1498659
79. Lebovitz, H.E.[1998]. Postprandial hyperglycemic state: Importance and consequences. Diabetes Research and Clinical Practice,40: S27–S28.
80. Puls, W., Keup, U., Krause, H.P., Thomas, G., Hofmeister, F. [1977]. Glucosidase inhibition: A new approach to the treatment of diabetes, obesity, and hyperlipoproteinaemia. Naturwissenschaften. 64: 536–537.
81. Shiino, M., Watanabe, Y. and Umezawa, K. [2001]. Synthesis of N-substituted N nitrosohydroxylamines as inhibitors of mushroom tyrosinase. Bioorganic Medical Chemistry,9: 1233–1240.
82. Huang, Z.L., Wang, B.W., Eaves, D.H., Shikany, J.M. and Pace, R.D.[2007]. Phenolic compound profile of selected vegetables frequently consumed by African Americans in the southeast United States. Food Chemistry,103: 1395–1402.
83. Oh, S.H., Soh, J.R. and Cha, Y.S. [2003]. Germinated brown rice extract shows a nutraceutical effect in the recovery of chronic alcohol related symptoms. Journal of Medicinal Food,6: 115-121.
84. Li, L., Liu, B. and Zheng, X. [2011]. Bioactive ingredients in adzuki bean sprouts. Journal of Medicinal Plants Research,5: 5894-5898.
85. Ali, N.M., Yusof, H.M., Long, K., Yeap, S.K., Ho, W.Y., Beh, B.K., Koh, S.P., Abdullah, M.P. and Alitheen, N.B.[2013]. Antioxidant and hepatoprotective effect of aqueous extract of germinated and fermented mungbean on ethanol-mediated liver damage. BioMed Research International, Article ID 693613: 9
86. Atkinson, F.S., Foster, Powell, K. and Brand Miller, J.C. [2008]. International tables of glycemic index and glycemic load values. Diabetes Care,31: 2281-2283.

87. Messina, M.J. 1999. Legumes and soyabeans: overview of their nutritional profiles and health effects. American Journal of Clinical Nutrition,70: 439S-450S.
88. Maruyama, C., Araki, R., Kawamura, M., Kondo, N., Kigawa, M., Kawai, Y. et al. [2008].Azuki bean juice lowers serum triglyceride concentrations in healthyyoung women. Journal of Clinical Biochemistry and Nutrition, 43:19–25.
89. Lee, S. and Lee, K.G. [2005]. Inhibitory effects of volatile antioxidants found in various beans on malonaldehyde formation in horse blood plasma. Food and Chemical Toxicology, 43: 515–520.
90. Lee, K., Shibamoto, T., Takeoka, G.R., Lee, S.E., Kim, J.H. and Park, B.S. [2003]. Inhibitory effects of plant-derived flavonoids and phenolic acids on malonaldehyde formation from ethyl arachidonate. Journal of Agricultural Chemistry, 51: 7203–7207.
91. Lerer-Metzger, M., Rizkalla, S. and Luo, J. 1996. Effects of long-term low-glycemic index starchy food on plasma glucose and lipid concentrations and adipose tissue cellularity in normal and diabetic rats. British Journal of Nutrition, 75: 723–732.
92. Nitin, M., Ifthekar, S.Q. and Mumtaz, M. [2012]. Evaluation of hepatoprotective and nephroprotective activity of aqueous extract of Vigna mungo (Linn.) Hepper on rifampicin- induced toxicity in albino rats. International Journal of Health and Allied Sciences, 1: 85-91.
93. Joanitti, G.A., Azevedo, R.B. and Freitas, S.M. [2010]. Apoptosis and lysosome membrane permeabilization induction on breast cancer cells by an anticarcinogenic Bowman- Birk protease inhibitor from Vigna unguiculata seeds. Cancer Letters,293: 73-81.
94. Biernat, M. [2002]. The factors affecting growth and maturity of both the structure and functions of small intestine in piglets in postnatal period. Thesis, Inst.Fizjol.iyw. Zwierz_t PAN, Jabonna (in Polish)
95. Kruszewska, D., Kiela, P., Ljungh, A., Erlwanger, K.H., Westrom, B.P., Linderoth, A. and Pierzynowski, S.G. [2003]. Enteral crude red kidney bean (Phaseolus vulgaris) lectin – phytohemagglutynin induces maturational changes in the enterocyte membrane proteins of suckling rats. Biology of Neonate, 84: 152-158.
96. Czerwiski, J. [2004]. Evaluation of in vitro activity of lectins derived from legume seeds and their effect in gastrointestinal tract, Thesis, SGGW, Warszawa (in Polish)
97. Itoh, T., Itoh, Y., Mizutani, M., Fujishiro, K., Furuichi, Y., Komiya, T. and Hibasam, H.A.[2002]. Hot water extract of adzuki (Vigna angularis) induces apotosis in cultured human stomach cancer cells. Nippon Shokuhin Kagaku Kogaku Kaishi, 49: 339-344.
98. Kazuyasu, N., Yuri, N., Takashi, I., Wei, W.A. [2012]. Stimulation of Dendritic Cell Maturation and Induction of Apoptosis in Leukemia Cells by a Heat-stable Extract from Azuki bean (Vigna angularis), a Promising Immunopotentiating Food and Dietary Supplement for Cancer Prevention**.** Asian Pacific Journal of Cancer Prevention, 13: 607- 611.
99. Indira, M. and Kurup, P.A. [2003]. Black gram (Vigna mungo)- A hypolipidemic pulse. Natural Product Radiance, 2: 240-242.
100. Nishimura, N., Taniguchi, Y. and Kiriyama, S. [2000]. Plasma cholesterol- lowering effect on rats of dietary fiber extracted from immature plants. Bioscience, Biotechnology and Biochemistry, 64: 2543–2551.
101. Salunkhe, D.K. and Kadam, S.S. [1989]. Legumes in human nutrition: future prospects. In CRC Handbook of World Food Legumes: Nutritional Chemistry, Processing Technology, and Utilization, Salunkhe, D.K., Kadam, S.S., Eds.; CRC Press: Boca Raton, FL, USA, Vol. III. pp. 311
102. Rizkalla, S.W., Bellisle, F. and Slam, G. [2002]. Health benefits of low glycaemic index foods, such as pulses, in diabetic patients and healthy individuals. British Journal of Nutrition,88: S255-S262.
103. Yeap, S.K., Ali, N.M., Yusof, H.M., Alitheen, N.B., Beh, B.K., Ho, W.Y., Koh, S.P. and Long, K. [2012]. Antihyperglycemic effects of fermented and nonfermented mung bean extracts on alloxan-induced diabetic mice. Journal of Biomedicine and Biotechnology,2012: 1-7.
104. Hafidh, R.R., Abdulamir, A.S., Vern, L.S., Bakar, F.A., Abas, F., Jahanshiri, F. and Sekawi, Z. [2011]. Novel in-vitro antimicrobial activity of Vigna radiata (L.) R. Wilczek against highly resistant bacterial and fungal pathogens. Journal of Medical Plant Research, 5: 3606-3618.
105. Leu, Y.L., Hwang, T.L., Kuo, P.C., Liou, K.P., Huang, B.S. and Chen, G.F. [2012]. Constituents from Vigna vexillata and their anti-inflammatory activity. International Journal of Molecular Science,13: 9754-9768.
106. Lee, S.M., Lee, T.H., Cui, E.J., Baek, N.I., Hong, S.G., Chung, I.S. and Kim, J. [2011]. Anti-inflammatory effects of cowpea (Vigna sinensis K.) seed extracts and its bioactive compounds. Journal of Korean Social Appllied Biology and Chemistry, 54: l710-717.
107. Cao, D., Li, H., Yi, J., Zhang, J., Che, H. et al. [2011]. Antioxidant properties of the mungbean flavonoids on alleviating heat stress. PLoS ONE, 6: e21071.
108. Solanki, Y.B. and Jain, S.M. [2011]. Hepatoprotective Effects of Clitoria ternatea and Vigna mungo against Acetaminophen and Carbon tetrachloride-induced Hepatotoxicity in Rats. Journal of Pharmacology and Toxicology,6: 30-48.

CITATION OF THIS ARTICLE

Shweta and Meena Kumari, Anita Rana· Bioactive Components of *Vigna species*: Current Prospective. Bull. Env. Pharmacol. Life Sci., Vol 6 [8] July 2017:01-13