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A REVIEW ON PHARMACOGNOSTIC, PHARMACOLOGICAL POTENTIALITIES AND HEALTH BENEFITS OF VIGNA RADIATA

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ABSTRACT

Mung bean also known as Vigna radiata, a rich source of many nutrients with potential health benefits is a commonly used functional food in India. The nutritional composition of Vigna radiata seeds are estimated in terms of carbohydrate, free amino acid, protein, chlorophyll and fat content pre and post germination to assess the biochemical changes in the seeds. They were found to have slightly higher carbohydrate content value i.e. (0.021 mg/g) after germination. The amino acid value (0.239 mg/g) and protein content value (0.207 mg/g) were appreciably increased compared to dry seeds. There was an insignificant difference in the chemical constituents like fat, chlorophyll a and b contents of pre and post germinated seeds. These results suggest that the nutritional content and quality of the seeds of Vigna radiata improves after germination. Here, this paper also explains about the effects of the mung bean on the human being also the yield of the mung bean in various reasons.

KEYWORDS: Mung Bean, polysaccharides, pectin, peptides, yield.

INTRODUCTION

Mungbean also known as Vigna radiata of size (2n = 2x = 22) belongs to the family leguminosae and sub family papilionaceae. It is also one of the most important pulse crops having global economic significance as a dietary ingredient of staple food in tropical and in subtropical region. Mungbean also known as a green gram and is one of the important grain legumes of India. It is grown principally for its protein rich edible seeds that are able to consume as human food, while its herbage is used as the fodder and green variation. It is short growth duration approximately 70-90 days grain legume crop having high nutritive value and protein content approximately 22-24%. India is one of the major producer and consumer of mungbean, which is about 65% of the world acreage and 54% of the world production of this crop. It is one of the third most important pulse crop in India, in the area of 3.44 million hectares with annual production about 1.54 million tons and average productivity of 461 kg ha-1. It has the capacity to fixed the atmospheric nitrogen in symbiotic association with Rhizobium species. The mungbean germplasm is available as wild, cultivated and weedy populations, but are very little is known about population structure, diversity, gene flow, and the introgression. The yield of the mung bean fluctuates due to the suitability of varieties to the different growing environments. A specific genotype does not always exhibit the same phenotypic traits under all the environments and also different genotypes respond differently to specific location. In India, mung bean is grown in the two seasons: during summer and winter. However, it’s large-scale adoption is affected by the low yield potential accompanied with the various biotic and abiotic factors.[1] The sprouted seeds also known as "bean sprouts" in English, and incorrectly called as "germes desoja" or "pousses de soja" in French are relished raw or cooked throughout the world. The immature pods and the young leaves are been eaten as a vegetable. Several mung bean products are useful for the livestock feeding. Mung bean is sometimes grown for the fodders hay, straw or silage. It is particularly valued as an early forage as it outcompetes the other summer growing legumes such as cowpea or velvet bean in their early stages. Mung bean plant makes valuable green manure and it can be used as a cover crop.[2] In the arid and semi-arid regions, water deficit is the main factor that limits the crops performance. Limitation of the water source, irregular annual rainfall during growth season and the lack of sources management causes severe decrement in the crops yield at these regions. Therefore, the drought stress during the growth season is an important problem that need to paid attention. Using crops with the short-term growth is one of the procedures to the drought tolerance in the dry regions.[3] Seed germination begins with the water absorption, followed by significant chemical changes also including the interconversion of some compounds and the synthesis of new compounds. Raw seed sprouts, such as those of broccoli, alfalfa, and beans are been attracting attention as an health foods because they are rich in the various phytonutrients, such as minerals, amino acids, vitamins, proteins, and the phytochemicals. During sprouting, a large portion of the original nutritional value of the mung bean seeds get retained and the amounts of some active substances gets increase significantly.[4] The dry beans are sometimes used for the animal food and mainly poultry, when they are either roasted or boiled while its biomass is used as a fodder. Thus, it has a great value as a food and fodder.[5]

Mung bean also requires relatively high P, particularly for the Adenosine Triphosphate (ATP) formation required to retrieve N from the air. Then, fertilization by the mycorrhizal application with the Plant Growth Promoting Rhizobacter (PGPR) which is very helpful in absorbing P from the soil and also improves the growth and the production of the plant. The applications of N and P in Mung bean and the sufficient P in plants may improve the metabolism, seed filling and seed weigh.[6]

Difference Between Vigna Radiata and Vigna Munga

Vigna radiata and Vigna mungo are important pulse crops and both belongs to the family Fabaceae. These beans have the worldwide productivity and commonly cultivated in Asia. They are the summer pulse crops having short duration and high nutritive value. Among legume, these are more useful because they are the main sources of the amino acid as well as the protein. They are also considered more valuable due to their high digestibility and less flatulence effect. Vigna radiata and Vigna mungo are also highly used for the therapeutic purposes.[7] Vigna mungo also known as Black grams and Vigna radiata also known as green grams are highly valued plants for the human and animal food. They are the most imperative food legumes grown and also consumed by humans. Black gram is a tropical leguminous plant which belongs to the genus Vigna and under the sub genus Ceratotropis. It is the highly prized pulse, very rich in phosphoric acid and is one of the most nutritious from all pulses. Black gram has the protein content almost three times that of the cereals and is one of the richest sources of proteins and the Vitamin B. It also has the good quantities of iron, folic acid, calcium, magnesium and potassium. The rich fiber content also makes them easy to digest and helps to reduce the cholesterol and also improves cardiovascular health. The Vigna radiata known as green gram also forms a very nutritious article of the diet and it is consumed in the form of whole dried seeds and dal prepared by splitting the seeds in the mill. The sprouted bean sare very highly nutritious food and are one of the most wholesome among pulses in the India. Both Vigna mungo and Vigna radiata are among the most important legumes used as a vegetables, pulses and feed for human and animal in developing countries. Because of their great value, there is a huge demand for the large-scale production of these legumes.[8]

Cultivation and varities of vigna radiata

Cultivation Soil and Climatic Requirements of Mungbean is a dry season crop and can be grown best in the rotation with rice or corn in an optimum temperature ranging from 20 to 30o C. It needs the plenty of sunlight and daylength of 11.5 to 13.0 hours. In the Philippines, mungbean can be grown during the wet season from May to june, dry season from September to October and late dry season from February to March. High humidity brought about by continuous rains can severely reduce the quality of harvested seeds. It can be profitably grown in the different types of soil with pH ranging from 5.8 to 6.5. It is fairly well adapted to the sandy loam soils and a dry condition, which gives it a competitive advantage and permits it to fit in the various cropping systems as an intercrop, rotation and relay crop. If it is grown during the wet season, the soil should be well-drained. Heavy soils are suitable only for the dry season planting because the mungbean is sensitive to the extended periods of water-logging. Just like other crops, the mungbean production can be affected by the several constraints such as erratic weather, insect pests and diseases, poor management practices, and the use of inferior or low yielding varieties or the cultivars. Cultural Management Practices Land Preparation Prepare the land thoroughly so that the mungbean seeds can be germinated uniformly, establish rapidly and compete well with weeds. For the uplands, prepare the soil thoroughly by plowing alternately with harrowing at weekly interval. For the post-rice culture, zero or minimum tillage can be practiced. Planting Drill the seeds along shallow furrows spaced by 60 centimeters apart. Twenty (20) kgs of the seeds is enough to plant a hectare. If seed inoculant is available, moisten the seeds with the water and then mix the inoculant until all seeds are coated. Keep the newly inoculated seeds under the shade until they are planted. At planting, sufficient soil moisture is necessary so that the seeds can get germinate uniformly. For post-rice culture, flood the paddy for 1-2 days before planting. Then, drain the water before broadcasting the seeds. Water Management Mungbean is relatively tolerant to the drought. However, it needs sufficient amount of the water during its critical stages of growth and the development (germination, vegetative, flowering and podfilling stages). The daily water requirement of the mungbean differs, depending on the intensity of solar radiation and rate of evaporation. In general, the crop requires about 3.5 millimeters of water per day or about 410 millimeters per cropping season. If there is the residual rain and sufficient soil moisture, during the early dry season planting from September to October, supplemental irrigation is not needed. On the other hand, late dry season planting from January to March requires irrigation at its various critical stages of the development. Overhead the sprinkler or furrow irrigation may be used to irrigate the field. Nutrient Management of Mungbean obtains nitrogen through its symbiosis with the N-fixing bacteria in the roots. Excessive nitrates from applied fertilizer will the restrict N fixation. The amount of phosphorous (P) and potassium (K) removed by the crop (when it yields 2 tons per hectare) is the basis for deciding the amount of the fertilizer to be applied to avoid the depletion of these major elements. In P and K deficient soils, about 30-45 kgs per hectare and in each of these elements it should be applied before planting. In commercial production of the mungbean, fertilization rate and type of application depends on the results of soil analysis. However, in the absence of such analysis and during the dry season cropping, basal application of three bags of (150 kgs of complete fertilizer (14-14-14) per hectare is recommended for heavy soils (loam to clay loam) and four bags of (200 kgs) for light soils (sandy to sandy loam). You can also apply the organic fertilizer if you want to produce mungbean organically as well as to improve the soil conditions. It is recommended to inoculate the seeds with the appropriate Rhizobia strain inoculant right before planting. Then apply only the 20 kgs per hectare of nitrogen which can be supplied by 150 kgs of 14-14-14. Do not expose the newly inoculated mungbean seeds to the direct sunlight. For upland planting, apply the fertilizer evenly in furrows and evenly cover with a thin layer of the fine soils before planting the seeds. With a machine applicator, the fertilizer is drilled about 5 centimeters slightly below the side of the seeds at planting. This makes the fertilizer readily available for the roots of the growing young seedlings.[9]

Isolation of Polysaccharide And Protein From Vigna Radiata

Polysaccharide

Polysaccharides are proved to play an important role in the physiological activities. In recent years, bioactive polysaccharides obtained from the mung bean have attracted increasing the attention and some advances have been made to characterize these polysaccharides. Most of the reported polysaccharides are prepared from water extracts which is solvent-free of mung beans, and the exhibited antioxidant and the immunoregulatory activities. However, the ethylenediaminetetraacetic acid and alkali-soluble polysaccharides isolated from the mung bean were also shown to activate the macrophages Ketha et al. investigated the structural properties of an acidic arabinogalactan (AGP-2) which is isolated from the mung bean Hemicellulose-B and which was proved to be the most potent in the immunomodulation. The structural characterization of the AGP-2 indicated it as a Type II arabinogalactan backbone which is composed of a 1, 3, and 1, 3, 6-Galp. The side chains originating at the position 6 of the backbone are composed of 1, 6-Galp and the terminal arabinose residues. There was a close relationship between the structure and activity of the polysaccharides. Thus, the structures of polysaccharides remain to be further determined to elucidate the structure-activity relationship.[10]

Polypeptides = In addition to serving as a dietarynutrients for humans, the proteins of pulses, including the mung bean, also contain the amino acid sequences that, upon digestion, release the peptides, which may exhibit a certain bioactivity. Additional bioactive properties, such as the functioning as angiotensin I-converting enzyme (ACE) inhibitors, antioxidants and an anticancer asiatic acid carrier, can be provided by these peptides which is obtained from the mung bean protein hydrolysate. Current studies on the bioactivity of the peptides mainly focused on the ACE inhibition effect. The un-hydrolyzed mung bean protein isolates shows no inhibitory activity on ACEs. The activity of the mung bean protein peptides was affected by many factors such as types of the hydrolases, enzymatic hydrolysis time and amino acid compositions, sequences and molecular weight. The peptides derived from the alcalase exhibited the highest degree of hydrolysis and a trichloroacetic acid–nitrogen soluble index, as compared to the other enzyme hydrolysates, including neutrase, papain, and protamex. These peptides obtained with the alcalase (20 μL/g enzyme/bean protein) for 2 hour of hydrolysis time at 55 ◦C and pH 8.0 were proved to show the highest ACE inhibitory activity with the IC50 value of 0.64 mg protein/mL. Moreover, it was found that three kinds of the novel ACE inhibitory peptides isolated from the alcalase hydrolysate of the mung bean protein isolate the exerted high ACE inhibitory activity and their amino acid sequences were identified to be Lys-Asp-Tyr-Arg-Leu, Val-Thr-Pro-Ala-Leu-Arg, and Lys-Leu-Pro-Ala-Gly-Thr-Leu-Phe. The structural-activity correlations among the different peptide inhibitors of ACEs indicated that those peptides containing hydrophobic amino acid residues, especially the aromatic amino acids, at each of the three C-terminal positions are appeared to be preferred by ACE as the substrate or competitive inhibitors. The relatively high concentrations of aromatic amino acids i.e. 10.56% in the amino acid composition of the small molecular weight peptide may be another important explanation for its high activity. Thus, more work is needed to establish the molecular weight profile and amino acid sequence of the peptides obtained from mung bean protein hydrolysates, as well as their role in optimizing applications to benefit of human health.[10]

PECTIN

Pectins are the complex polysaccharides found in the primary cell wall of most plants, gluing the adjacent cells together. Structurally the main pectin polysaccharide is primarily a linear polymer of (1,4)-linked α-D-galacturonic acid which may be partially methyl esterified. This backbone is interrupted by the (1,2)-linked a-D-rhamnopyranose which serves as an anchoring points for the attachment of lateral neutral oligosaccharides containing mainly D-galactopyranoses and Larabinofuranoses. Several studies 1,2 have shown that pectic substances play an important role in regulating the firmness of the processed vegetables. The chemical composition of the pectins (i.e., degree of esterification, distribution of rhamnopyranoses and amount of specific neutral sugars) and the interrelation with the other cell wall polysaccharides, determine the firmness of the fresh and processed plant tissue.[11]

Protein

As mentioned above, the mung bean seeds are particularly rich in protein, containing about 20.97–31.32% protein content. A chemical score of 76% for mung bean amino acids, which was calculated based on the Food and Agriculture Organisation of the United Nations (FAO)/the World Health Organisation (WHO) guidelines. Therefore, due to its high protein content and the digestibility, the consumption of the mung bean seeds in combination with the cereals has been recommended to significantly increase the quality of the protein intake as part of a vegetarian diet. To characterise this nutritional content more specifically, analyse the protein composition of isolates from the mung bean seeds. The total protein content in mung bean protein isolates (MBPI) was about 87.8%, with a total amino acid content of 800.2 mg g^{-1}. Essential the amino acids constituted 43.5% of total amino acids in MBPI, whereas the sulphurcontaining amino acids constituted approximately about 1.6% of total MBPI amino acids. Specifically, the essential amino acids such as leucine, lysine and phenylalanine/tyrosine were predominant followed by the valine, isoleucine and histidine. In addition, the aromatic amino acid content of MBPI was 12.1%, in which the phenylalanine and the tyrosine constitutes 11.3% (90.3 of 800.2 mg g−1). Indeed, the total essential amino acid content of the MBPI exceeds the FAO/WHO recommendations. Conversely, the values for threonine, tryptophan and total sulphur-containing the amino acids (methionine and cysteine) were nutritionally inadequate. The protein content of the mung bean has been reported to be negatively correlated with the content of the lysine and threonine, whereas the latter has been positively correlated with the methionine content. These results suggest that the increase in the methionine content is accompanied by decreased total protein content in the mung bean. Therefore, the reverse scenario of high protein content in mung bean seed probably reflects low methionine content. In addition, the low levels of threonine, tryptophan and sulphur-containing amino acids (methionine and cysteine), compared to the FAO/WHO recommended values, were reported in MBPI. However, reported that the threonine content was about 140.88% of the value provided by the FAO/WHO, as compared to 83.53% reported by. Although the mung bean seeds are rich in protein, the deficiency in the sulphur-containing amino acids (methionine and cysteine) places the nutritional quality of the mung bean seeds on par with other legumes. To address the lack of sulphur-containing amino acids, methionine was successfully introduced into 8Sα globulin, a major mung bean protein, using the protein engineering. Consequently, the nutritional quality of the modified protein containing increased methionine in the terms of the amino acid score improved from 41 to 145%. In a similar vein, reported another protein engineering method that introduced the free sulfhydryl groups and disulphide bonds to generate the cysteine-modified mung bean 8Sα globulin to improve the nutritional quality. Meanwhile, the presence of the hydrophobic amino acids has been reported to contribute greatly to the thermal and/or conformational stability of the globulins to boost yield. Consequently,the hydrophobic amino acid content increased to 53.1% in MBPI after substitution of charged amino acids with the hydrophobic amino acids. Three types of globulins present in the mung bean seed have been characterised and are designated as basic-type (7S), vicilin-type (8S) and legumin-type (11S) globulins (5, 27), comprising 3.4%, 89.0% (5, 27) and 7.6% (w/w) of total mung bean globulin content.[11]

Chemical Constituents of Vigna Radiata

Using gas-liquid chromatography (GC)/ mass spectrometry (MS), it is reported that the Mung Bean and the sprouts contain various nutraceutical including water (90.4g), carbohydrates (hexasaccharide, raffinose, etc.; 5.94g in sprouted), proteins (globulins (63%), albumins (12%), glutelins (21%), prolamins (1%)), amino acids (tryptophan: 0.037g, threonine: 0.078g, isoleucine: 0.132g, leucine: 0.175g, glycine: 0.063g etc.), lipids (SFA (71%), MUFA (18%), PUFA (11%)), vitamins (ascorbic acid: 13.2mg, thiamine: 0.084mg, Vit. B-6: 0.088mg, -A: 21IU, -E: 0.1 mg, -K: 33µg etc.), minerals (Mg, P, Fe, K, Cu, Zn, Ca, Mn, Na, Se etc.), total dietary fibre (1.8g), organic acids (oxalic, malic, citric, fumaric etc.). These compounds are the functional food ingredients having the biological activities like anti -oxidant, - inflammatory, -diabetic, -viral, -bacterial, -fungal, -cancer and -tumour activity, hepatoprotective and the other detoxification activities etc.

Bioactive Compounds like Polyphenols the Mung Bean is a rich source of the Polyphenols. The major the phenolic constituents in the mung bean are phenolic acids (1.81-5.97 mg rutin equivalent/g), the flavonoids (1.49-1.78 mg catechin equivalent/g), and the tannins (1.00-5.75 mg/g) [26- 29]. Flavonoids are the most common secondary metabolites in the mung bean. Five subclasses of the flavonoids are flavones, flavonols, isoflavonoids, flavanols and the anthocyanins found in the mung bean. Polysaccharides In the Mung Bean Polysaccharides like Hemicellulose-A and Hemicellulose-B containing acidic Arabinogalactan (AGP2), terminal Arabinose are responsible for the antioxidant, immunomodulatory activities and also to activate the macrophages.

Peptides: Therefore, the dietary nutrients, protein from pulses like mung bean releases peptides which may exhibit bioactive properties. Un-hydrolysed mung bean peptides have shown Angiotensin I-converting enzyme (ACE) inhibitory effect which is also important for current COVID-19 outbreak, along with the anti -cancer, -oxidant effects. Health Benefits: Based on the high constituents and the efficacy of bioactive compounds mung bean plays an important role in health benefits. The Mung bean seeds, sprouts contain a large amount of macro and micronutrients which exerts antioxidant activities. Specially, the phenolic compounds and the vitamins are the major antioxidants. Both of the compounds can restrain free radical generation by chelating metal ions or inhibiting key enzymes (protein kinase, xanthine oxidase, GSH, lipoxygenase, cyclooxygenase, NADH oxidase and GST). Mungbean sprouts have higher antioxidant potential than the raw seeds. The consumption of mung bean has been also reported as a potential antidiabetic agent. An experiment have shown the effect of fermented and non-fermented mung bean extracts on the normoglycemic, glucose-induced hyperglycemic and the alloxan-induced hyperglycemic effects, caused no hypoglycemic effect and lowered blood sugar levels. Another experimental study also revealed that the mung beansprout (2 g/kg) and seed coat extracts (3 g/kg) possessed antidiabetic effects. Mung bean with dietary fibres induced satiety to reduce the cholesterol level. Its sprouts have the lipid modulatory effect. In a study, rabbits with the hyperlipidemia were fed a 70% mung bean mixed meal and sprout powder to reduce the cholesterol. Additionally, in a recent study, normal mice and rats were fed mung bean extracts for about 7 days, and the total cholesterol level was decreased. In another study has shown that the high doses (600 mg peptide/kg body weight) of the raw sprout extracts, dried sprout extracts and the enzyme digested sprout extracts reduced systolic blood pressure (SBP) in rats after administration for different time intervals. Enzymes, peptides and polyphenols extracted from the mung bean shown the positive antimicrobial (agar diffusion method) as well as antifungal (crescents method) effect. The Mung beans have been consumed in several ways to treat heat stroke connected with thirst, irritation and the high body temperature, detoxification, and these health promoting effects of the mung bean seeds and sprouts are believed for inflammatory response in Asian countries. The Mung bean seed and sprout extracts may reduce the lipopolysaccharidestimulated peritoneal macrophages and inflammation-related parameters (TNF-α, IL-1β, IL-6, nitric oxide synthase, COX-2, and NF-κB) and alleviate the symptoms of obesity, colitis and colon inflammation. The Mung beans extracts are also proved for Anti -tumour and - cancer activities. Nucleases derived from the mung bean are effective against melanoma tumours. The Mung bean extracts are anti-proliferative against DU145, SK-OV-3, MCF-7 and HL-60 cancer cell lines. The aqueous extract from the mung bean coat (MBC) is protective against sepsis in-vitro and -vivo. It was found that the MBC dose-dependently attenuated the LPS-induced release of HMGB1 and several chemokines in the macrophage cultures, helpful for sepsis.[12]

Sprouted seeds of the mungbean contain pure vitamins A, B, C, and E, and minerals such as iron, calcium and phosphorous. On a dry-weight basis the mungbean contains 22 to 28% protein, 1.0 to 1.5% fat, 3.5 to 4.5% fibre, 4.5 to 5.5% ash and 60 to 65% carbohydrate. Mungbean is a good source of amino acids like the aspartic acid, glutamic acid and it's a fairly good source of some essential amino acids like isoleucine, leucine, lysine, phenylalani . The sprouts are of free cholesterol. One cup of the mungbean sprouts contains approximately 80 kcal, 3 g of protein, 6 g carbohydrates, 2 mg of iron and only 0.2 g of fat. The Mungbean sprouts are also a rich source of fibre, easily digestible and containing the high concentration of the enzymes facilitating the digestive process. Mungbean can be complemented with the cereals. Washing and chilling the raw mungbeans will reduce the risk of infection by the harmful bacteria while cooking will destroy bacteria.[13]

Abrinogalactan: Arabinogalactan-proteins (AGPs) are undoubtedly one of the most complex families of the macromolecules found in the plants, perhaps matched only by the polyphenolics (lignins/cutins/suberins) and the pectins. Their complexity arises from the incredible diversity of the glycans decorating the protein backbone, the array of peripheral sugars decorating the large arabinogalactan (AG) chains, the microheterogeneity of the protein backbone glycosylation, and the diversity of protein backbones containing AG glycomodules. It has been postulated that up to the 40% of the Arabidopsis (Arabidopsis thaliana) proteins predicted to be the glycosylphosphatidylinositol anchored have the potential to be substituted with AG chains, whether these are all AGPs remains to be established. This complexity is reminiscent of the mammalian extracellular glycoproteins/proteoglycans that are known to be critically important as both of structural and functional determinants. These parallels have provided the impetus for the plant scientists to establish roles for AGPs in plant growth and the development as biological regulatory molecules, with some tantalizing possibilities emerging. They have also been widely used by society for industrial and the food applications due to their general emulsifying, adhesive, and water-holding properties. Some AGs/AGPs, such as larch AG and the gum arabic, have more recently been investigated as a potential immunomodulators of the human immune system.[14]

Arabinogalactan proteins consist of about 65-98% carbohydrate covalently linked to the Hydroxyproline, Proline, Serine, Threonine and Alanine rich protein backbone. The polysaccharide fraction of the arabinogalactan protein mainly consists of the arabinose and galactose. Arabinogalactan possess various attractive properties such as high solubility in water, biocompatibility, biodegradability, and the ease of drug conjugation in an aqueous medium which makes it a potential protein to backbone. It mainly focused on the overall immuno stimulatory activity of arabinogalactan protein isolated from various plant species.[15]

These allergy-protective effects have been traced back to the different factors, such as the inhalation of cowshed dust extracts (CDE) or single components isolated from the CDE (10–13). One allergy-protective molecule that makes up about 13% of CDE total mass was identified as arabinogalactan (AG). It was shown in a mouse asthma model that the AG isolated from the Alopecurus pratensis can prevent allergic airway inflammation and the sensitization. AGs are polysaccharides that are ubiquitously present in most plants and even in the mycobacteria, but not in the animals. They consist predominantly of the galactose and arabinose. Further sugars, such as rhamnose, fucose and mannose, occur to be a lesser extent. Different AG preparations are already in use in the several traditional and natural medical products worldwide and are subjected to studies due to their immune-modulating properties.[16]

Arabinogalactan (AG), which is a constituent of the pectin, has been studied both in vivo and in vitro as a potential prebiotic in view of stimulating the bifidobacteria in the gut microbiota. However, the enzyme functions for AG degradation in gut bacteria, even though predicted from the genome analysis, are still poorly understood from a functional viewpoint. There are the two structural types of AG, type I and type II.

Type I AG consists of a β-1,3 and 1,4 linked galactan backbone, whereas type II AG has more complex structure consisting of a β-1,3 linked galactan backbone with β-1,6 linked galactan side chains. In addition, the backbone of the type I AG and side chains of type II AG are substituted with α-arabinofuranose and/or, less frequently, β-arabinopyranose at the non-reducing terminus of side chains of both types of AG. Gum arabic (GA) has a similar structure to the type II AG, which includes a β-1,3 linked galactan backbone and the β-1,6 linked galactan side chains with some arabinose substitutions. AG can be utilized by many Bacteroides species, such as the Bacteroides thetaiotaomicron, Bac. uniformis, Bac. cellulosilyticus, Bac. ovatus, and Bac. caccae, while Bac. distasonis, Bac. eggerthii and Bac. fragilis cannot. Bifidobacterium species prefer the fermentation of oligomers of relatively short degree of the polymerization (DP), such as fructooligosaccharides (FOS) and galactooligosaccharides (GOS). Furthermore, bifidobacteria also have the ability to degrade arabinoxylan oligosaccharides [(A)XOS], but this activity is also strain-dependent. Many in vitro studies reported that some gut bacteria cannot be degrade specific polysaccharides by themselves but take the advantage of the metabolic products of other gut bacteria. These products can be carbohydrate fragments and/or fermentation products such as SCFAs.[17]

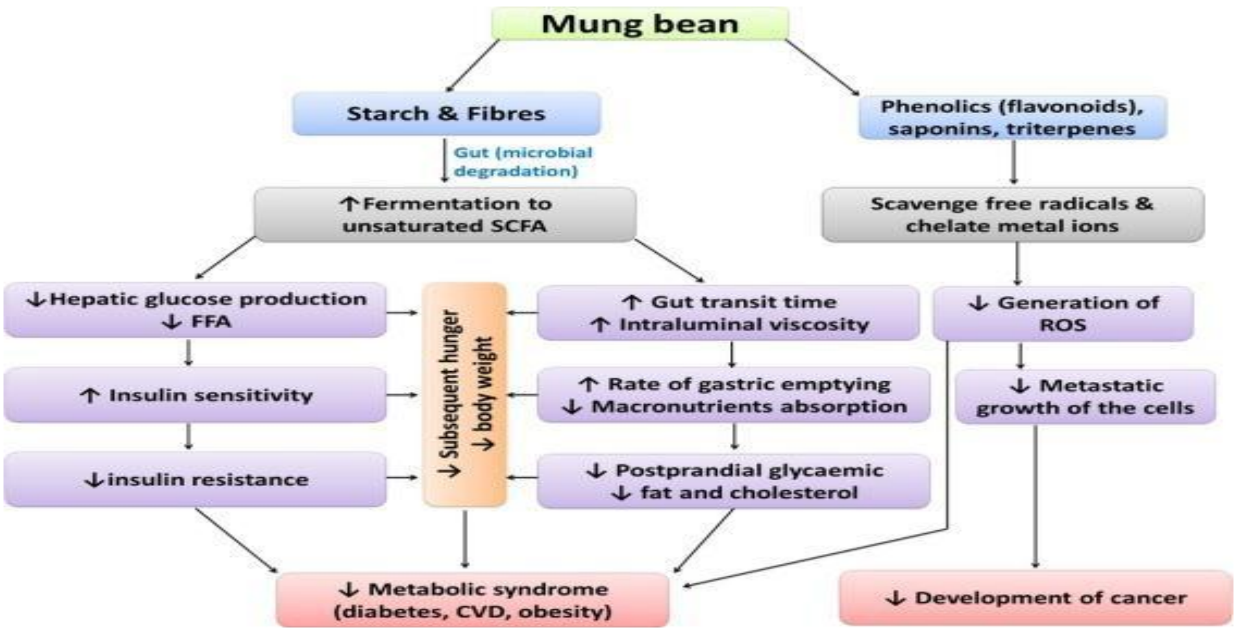
Applications Of Vigna Radiata

Anti-Oxidant Properties Of Vigna Radiata

It has been well established that antioxidant potential of the plant extract is mainly attributed to the concentration of phenolic compounds. Phenolic compounds may exhibit their antioxidant activity due to their redox property. A moderate correlation value i.e. (r = 0.671) was examined between phenolic concentration and the result of measurement of reducing power assay. Relationship between the phenolic contents and the results of bleaching of β-carotene assay exhibited r = 0.673. However, the poor correlation (r = −0.136) was observed between the phenolic contents and the results of inhibition of peroxidation, indicating that there are also many other compounds like (vitamins, carotenoids, and so on) that possess antioxidant potential, that is, exhibiting their antioxidant activity not only by donating hydrogen but also by the other mechanisms like scavenging oxygen. A high correlation (r = 0.999) between the results of reducing power and the bleaching of β-carotene assay was also observed, however, the relationship of the results of the inhibition of peroxidation assay with the reducing power and bleaching of β-carotene assay was not so appreciable, i.e., r = 0.478 and r = 0.381, respectively. The results of the different antioxidant assays exhibited varying degree of the correlation, thus, showing that not a single method is sufficient for the evaluation of the antioxidant activity of the plant extracts.[18]

➢ **Antidiabetic activity**

The consumption of the mung bean has been reported as a potential antidiabetic agent. An experimental animal study showed that the effect of fermented and the non-fermented mung bean extracts on normoglycemic, glucose-induced hyperglycemic and the alloxan-induced hyperglycemic effects, caused no significant hypoglycemic effect and it significantly lowered the bloog sugar level in glucose and the alloxan-induced hyperglycemic mice. Another experimental study also revealed that the mung bean sprout (2 g/kg) and seed coat extracts (3 g/kg) possessed teh potent antidiabetic effects and significantly lowered blood glucose, plasma C-peptide, glucagon, TC, TG, and BUN levels. Epidemiological studies have also demonstrated that the use of the whole-grain foods and the beans reduce the menace of type II diabetes by 25%–30% when compared with low consumption of it.



This one fourth reduction effect may be caused due to the decrease digestibility of the bean's carbohydrates, more amylose, and resistant starch composition, high dense dietary fibers and the generation of SCFAs in the gut, which inhibit the high blood sugar levels and prevent the high glycemic and insulinemic effects. Effects of possible mechanisms of the mung bean consumption on diabetes are given below.[19]

Anti Hypertensive Properties

The ACE inhibitor is one of the main drugs that plays the important role in regulating the blood pressure. ACE inhibitory peptides derived from the food proteins could be safer and milder without the side effects than synthetic ACE inhibitor drugs. The peptides obtained from the alcalase hydrolysate of the mung bean protein isolates and exhibited high ACE inhibitory activity in vitro. For the purpose of the exerting an antihypertensive effect in vivo, the ACE inhibitory peptides must be absorbed in their intact form from the intestine and further resist the degradation by the plasma peptidases to reach their target sites after oral administration. Thus, the in vitro ACE inhibitory activity of these peptides is not always the consistent with their antihypertensive activity in vivo. The mean the systolic blood pressure of 2, 4, 6, and 8 h in spontaneously hypertensive rats (187.9 ± 8.7 mmHg) significantly decreased after the single oral administration of the mung bean protein hydrolysate (prepared with alcalase at 2 h hydrolysis time) at a dose of 600 mg/kg of body weight. The systolic blood pressure was decreased by about 30.8 mmHg at 6 h after administration, and the antihypertensive effect lasted for at least 8 h.

As it is known, a large number of the peptides and other metabolites were produced during germination. Sprouts, or their bioactive components, such as peptides, may have the beneficial properties and may be useful for hypertension management. Highdose aqueous extracts of the raw, dried, and enzyme-digested mung bean sprouts (600 mg peptide/kg body weight) significantly reduced the 6–9, 3–6, and 3–9 h of systolic blood pressure in spontaneously hypertensive rats after a single intragastric administration. A long-term intervention test was also carried out in the same study. The results showed that, after intragastric administration of the 30 mL/day of reconstituted raw and the dried aqueous extracts (600 mg peptide/mL) for 4 weeks, the systolic blood pressure of the rats was significantly reduced from week 1–4 and week 2–4, respectively. The freeze-dried powder of the sprouts (or approximately 488 mg peptide/day) showed no significant effects on the systolic blood pressure of the treated rats after 4 weeks of the intragastric administration. This might be due to the higher concentration of the peptides in water extraction, which was more contributed to the reduction of blood pressure. This result was also strongly influenced by the intragastric dosage. Accurate research is needed to be confirm these speculations. These results indicated that the protein hydrolysates of the mung bean and its sprouts might be utilized for the physiologically functional foods in the prevention and management of hypertension.[20]

Anti Cancer Properties

Mung beans proteins (48 kDa) have been isolated and exert anticancer properties through the various underlying mechanisms. The novel anticancer and the immunomodulatory effects of methanolic extracts of the mung bean sprout were evaluated in cervix adenocarcinoma (HeLa) and hepatocellular carcinoma (HepG2) cell lines by testing anticancer cytokines (TNF- and IFN-), immunological cytokines (IL-4, IFN-, and IL-10), cell cycle regulatory genes (cyclin D, E, and A), apoptotic gene expression (Bax, BCL-2, caspases 7–9), the tumor suppressor genes (p27, p21, and p53) and the percentage of apoptotic cells. These results strongly recommend that mung bean sprout is a potent anticancer and the immunomodulatory agent granting new prospects of anticancer therapy. In vitro studies have also reported that the mung bean exerted dose-dependent antiproliferative effects against the various cancer cell lines such as digestive system, ovary and breast. Similarly, the study evaluated the effects of the trypsin inhibitors from the mung beans possess anticancer activities on the metastasis and the proliferation of human colon cancer cells SW480 cells. Microbial flora facilitates fermentation of the dietary fibers and the resistant starch in the gut results in the production of SCFA (butyrate), which has the potential effects on colon cancer. Butyrate has known to be the microbial metabolites inducing apoptosis, inhibit cell proliferation in colon cancer. These microbial metabolites serve as a messengers to the host by acting through selective receptors in the host colon and help the host in energy and the nutritional homeostasis, development and maturation of the mucosal immune system and protection against the inflammation and carcinogenesis. Beans contain the phenolic compounds and the flavonoids, which has a potential properties of the antimutagenic, anticarcinogenic and antioxidant activities. These compounds have the ability to prevent the muta- genic agents (viz., nitrosamines, hydrocarbons, mycotoxins and polycyclic aromatic hydrocarbons) and anticarcinogenic by inhibiting the activation of enzymes, scavenging free radicals and inducing detoxification.[21]

Anti-Inlammatory and Antinociceptive Properties

Inflammation is a host's defence mechanism against the infection, foreign stimulus, and the tissue damage by activating the cellular immune responses that increase stimulation of pro inflammatory mediators such as nitric oxide (NO) and various cytokines. However, excessive production of the inflammatory mediators will lead to the chronic diseases such as rheumatoid arthritis and autoimmune diseases with hallmarks such as redness, swelling, pain, and loss of function. On the other hand, the nociceptive is a sensitization of pain transmitted by the nerves centrally or peripherally. Both of the processes are interconnected where in the event of inflammatory response, the mediators will also stimulate pain sensory. Multiple drugs have been developed for the treatment of the inflammation and nociceptive symptoms. Two typical examples are as follows: (a) nonsteroidal anti-inflammatory drug such as aspirin and dexamethasone and (b) prescribed drugs such as opioids and morphine. However, these types of the drugs are commonly associated with undesired adverse effects. Due to Evidence-Based Complementary and the Alternative Medicine ease of availability and less side effects, the plant-derived compounds are of common interest in the search for alternative substitutes. To the best of our knowledge, the only single study has been conducted on the anti-inflammatory and the antinociceptive properties of the mung bean even though mung bean has been traditionally consumed as nutritional foods. The mung bean coat, which is rich in flavonoids that have positive anti-inflammatory effect against the systemic inflammatory response. Although many plant-derived products studies been conducted on their anti-inflammatory and antinociceptive properties, however, the limited study was done to evaluate and compare the effects from the mung bean (MB) whole seed, germinated mung bean (GMB), and fermented mung bean (FMB) aqueous extract. Hence, the objectives of this study were to evaluate and compare the in vitro and in vivo anti-inflammatory and the antinociceptive properties of MB, GMB, and FMB aqueous extracts.[22]

Antisepsis activity

The aqueous extract from the mung bean coat (MBC) is protective against sepsis in-vitro and -vivo. It was found that the MBC dose-dependently attenuated the LPS-induced release of HMGB1 and the several chemokines in macrophage cultures, helpful for sepsis.[23]

Beans with Benefits -The Role of Vigna radiata in a Changing Environment

A multi-country analysis revealed that the 71% of households worldwide experienced food insecurity and climate shocks in the last five years. The periods of the food insecurity ranged from less than one month in India to more than six months in Ethiopia. This indicates that the climate change has become a major challenge for the food security. The pressure on a natural resource is likely to rise and make both people and ecosystems more vulnerable, particularly where the agriculture plays a major role in the country's economy. However, the agricultural production has to increase by 70% in 2050 to feed a still growing world population and to achieve the United Nations' first sustainable development goal, a world without hunger. In addition, the demand for the freshwater is expected to exceed the renewable water supply by 40% in 2030, while the world will need more than one-third more of energy by 2035.

Environmental stress, pests and the diseases are limiting productivity and the cultivation of a range of crops. Mungbean is adapted to the tropical and subtropical low-lands and relatively tolerant to the abiotic stresses, like drought and heat, but the soil salinity affects the mungbean more heavily than other crops. Salt stress interferes not only with the plant, but also with the symbiotic microorganisms such as Rhizobium sp. essential for biological N fixation (BNF), resulting in the growth retardation and reduced yields. Salt tolerant Vigna species found on ocean beaches under strongly saline conditions, such as V. marina, cannot be crossed with the mungbean, and thus are not available for the breeding salt tolerant varieties. Some degree of the salt tolerance has been found in the mungbean germplasm, but the tolerance at germination and at the seedling stage may appear in the different accessions. Combining these traits by breeding is complex, as many genes are implicated with the tolerance.[24,25]

Economic Analysis of Green Vigna Radiata in Selected Area, Myanmar and Bangladesh

In Myanmar, pulses started grown under the British Rule (1885-1948) brought from the India. Starting from these days, a significant proportion pulses exported to India and is continued today. One of the major reasons of the increased productions of pulses is that pulses can be planted at the leftover moisture of the monsoons after the monsoon rice with not much requiring irrigation facilities in the absence of rain. This makes their cultivation undemanding and the cost effective with no additional allocation of resources required. Furthermore, the shorter the growing period from plantation to harvest and a ready market with the steady demand coming from neighboring India pushed the beans and the pulses production further. Pulses followed second place of total crop sown area. Beans and pulses in Myanmar are normally grown immediately after the monsoon rice in the delta region like (lower parts of Myanmar) and are grown as a monsoon crop in the central plain areas and Shan State like (East part of country). About 70 percent of the beans and pulses are grown during the winter season, with the average yields ranging about 1.0-1.3 MT/hectare. There are about eighteen varieties of the pulses being cultivated commonly in Myanmar, the most significant pulses are the black gram (matpe), green gram (mung bean), pigeon pea (Toor whole), soy bean, chick pea and cow pea. Of these, black gram, green gram and pigeon pea, are the most important, accounting for over about 80% of the total export value and 70- 75%of total bean and the pulse production.[26,27]

Pulse crop is an important protein source for the majority of the people of Bangladesh. It contains the protein about twice as much as cereals. It also contains the amino acid lysine, which is generally deficit in food grains. Pulse bran is also used as a quality feed for animals. Apart from these, the ability to fix the nitrogen and the addition of organic matter to the soil are important factors in maintaining soil fertility. In the existing cropping systems, pulses fit well due to its short duration, low input, minimum care required and the drought tolerant nature. Among the food legumes grown, the lathyrus, lentil, chickpea, blackgram, and mungbean are the major and they contribute more than 95% to the total pulses production in the country.[28,29]

Mungbean also known as Vigna radiata is widely grown in Bangladesh. Mungbean grain contains about 19.5% to 28.5% protein. Major area of the mungbean is replaced by cereals. Now a days, it is being cultivated after harvesting of the Rabi crops (wheat, mustard, lentil, etc.). As mungbean is the short duration crop, it can fit in as a cash crop between the major cropping seasons. It is grown three times in a year covering about 43,680 ha with an average yield of 0.78 t/ha. It is known that area, production and yield were fluctuating since 1995/96 to 2005/06. Area decreased but yield gets increased, thereby the production remained more or less same with wide fluctuation. It provides the grain for human consumption and as well as the plant fix nitrogen to the soil. It supplies the substantial amount of nitrogen to the succeeding non-legume crops (i.e., rice) grown in rotation. Six varieties of the mungbean have been developed by the Pulses Research Centre, BARI and disseminated with the package of the management technologies to the farmers for cultivation. Therefore, the mungbean cultivation is gaining the popularity day by day among the farmers.[30,31]

Phytochemical Changes in (Vigna radiata) under Cobalt Stress.

Cobalt at 50 mg kg soil level increased the reducing, material non-reducing, total sugar and the starch contents of the green leaves.[32]

Salinity Tolerance of Some Vigna Radiata Varieties

Germination is the growth of a plant contained within the seed, it results in the formation of the seedling, it is also the process of the reactivation of the metabolic machinery of the seed resulting into the emergence of the radicle and plumule. The seed of a vascular plant is a small package produced in the fruit or cone after the union of the male and female reproductive cells. All fully developed seeds contain an embryo and in the most plant species some store of food is reserved, wrapped in a seed coat. Some plants produce the varying numbers of seeds that lack embryos, these are called as empty seeds. Dormant seeds are the ripe seeds that do not germinate because they are subject to the external environmental conditions that prevent the initiation of metabolic process and cell growth. Under proper conditions, the seed begins to germinate and the embryonic tissues resumes the growth, developing towards a seedling.

High salinity is a common abiotic stress factor that seriously affects the crop production like mung beanin some parts of the world, particularly in arid and semi-arid regions. Germination is one of the most critical periods for a plant subjected to the salinity. Salt stress has been shown to decrease the germination percentage and the germination rate of some plants. Soil salinity may influence the germination of the seeds either by creating the osmotic potential external to the seed preventing water uptake or the toxic effects of Na+ and the Clions on germinating seed. Salt and osmotic stresses are responsible for both inhibition or delayed seed germination and the seedling establishment. Seed germination, seedling emergence and the early survival are particularly sensitive to substrate salinity. Salt stress affects the germination percentage, germination rate and the seedling growth in different ways depending on plant species. Germination and the seedling growth are reduced in saline soils with varying responses for the species and cultivars. Mung bean was determined to be moderately salt sensitive relative to the other species. Against these stresses, plants adapt themselves by the different mechanisms including the change in morphological and developmental pattern as well as the physiological and biochemical responses.[33,34,35]

Effect of accelerated aging on Vigna Radiata

Seed vigour test is aimed to provide the information about the planting value in a wide range of environments and/or the storage potential of the particular seed lot. Accelerated aging was initially developed as a test to estimate the longevity of the seed in storage and have been evaluated as the aseed vigour indicator in a wide range of the crops. The accelerated aging stress test exposes seeds for short periods to high temperature and the high relative humidity (≈95 %). During the test, the seeds absorb the moisture from the humid environment and the raised seed moisture content, along with the high temperature, causes the rapid seed aging. High vigour seed lots will withstand these extreme stress conditions and age more slowly than low the vigour seed lots. Thus, after the aging treatment, high vigour lots retain the high germination while the low vigour lots significantly decline in the capacity to germinate. Seeds progressively gain the germination ability and the capacity on their mother plants during the seed development. Seed vigour gradually increases and reaches the maximum level at the physiological maturity. Beyond that, seeds start to age and seed vigour begins to decrease with the time. During seed deterioration, a series of the deleterious events such as cellular membrane degradation, lipid peroxidation, and the DNA degradation will occur in the seed. As seed vigour decreases, the seed longevity decreases. Ultimately, the seed losses its viability and fail to germinate. The rate and the extent of seed aging and deterioration mainly depend on the initial vigour of the particular seed lot. Seed vigour not only affects the crop growth and yield, but also the seed storage potential.[29]

Mungbean is one of the important sources of the dietary protein, thus it is of utmost importance to understand the effect of the aging on mungbean seed vigour. This could enhance the seeds storability, increase the productivity, benefit farmers and the national economies. Accelerated aging is a very responsive test in identifying the seed quality and vigour. Regarding the relation between vigour and the seed quality, this study was initiated with the objective to evaluate the effectiveness of accelerated aging test as a vigour test for mungbean seeds.[36,37]

CONCLUSION

In this article it has been described about the Vigna Radiata which is also known as Mung Bean. The difference between the Vigna Radiata and Vigna Munga is been described clearly. Cultivation and varities of Vigna radiata. It's chemical constituents, applications like anti-diabetic, anti-Hypertensive, anti- Sepsis, anti-cancer and anti-Inflammatory effect have been described. Phytochemical Changes in (Vigna radiata) under Cobalt Stress and Salinity Tolerance of Some Vigna radiata Varieties is been described. Effect of accelerated aging on Vigna radiata is been given. There are economic values of vigna radiata (Myanmar and Bangladesh) is elaborated.

REFERENCES

1. Singh N, Mishra N, Chaurasia S. Antioxidant Activities of Water Soluble Polysaccharides Extracted From Raw and Sprouted Mung Beans. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 2014; 5(3): 1045-1056.
2. Kalaria R. K. Physiological and Biochemical Responses in Mungbean (Vigna radiata L. WILZEK) for Various Abiotic Factors. Research Journal of Chemical and Environmental Sciences, 2017; 5(2): 1-16.
3. Shi Z, Yao Y, Zhu Y, Ren G. Nutritional composition and antioxidant activity of twenty mung bean cultivars in China. The crop journal, 2016; 4: 398-406.
4. Singh A k, Singh P K, Kumar M, Bardoloi L J, Jha A k. Nutrient Management for Improving Mungbean [Vigna radiata (L.) Wilczek] Productivity in Acidic Soil of Northeast India. Indian Journal of Hill Farming, 2014; 27(1): 37-41.
5. Jadhav M, Taur N, Sapkal S, Tathe S, Quadri F. Study on Effect of Caffeine on Growth of Vigna radiata L. International Journal of Advanced Research, 2016; 4(3): 596-602.
6. Allahmoradi P, Ghobadi M, Taherabadi S, Taherabadi S. Physiological Aspects of Mungbean (Vigna radiata L.) in Response to Drought Stress. International Conference on Food Engineering and Biotechnology, 2011; 9: 272-275.
7. Li L, Dong Y, Ren H, Xue Y, Meng H, Li M. Increased antioxidant activity and polyphenol metabolites in methyl jasmonate treated mung bean (Vigna radiata) sprouts. Food Science and Technology, 2017; 37(3): 411-417.
8. Sadeghipour O, Monem R, Tajali A A. Production of mung bean (Vigna Radiata L.) as affected by nitrogen and phosphorous fertilizer application. Journal of applied sciences, 2010; 10(10): 843-847.
9. Tang D, Dong Y, Ren H, Li L, He C. A review of phytochemistry, metabolite changes, and medicinal uses of the common food mung bean and its sprouts (Vigna radiata). Chemistry Central Journal, 2014; 8(4): 1-9.
10. Nasution F M, Hasanah Y, Mariati. Production response of mung bean (Vigna radiata L.) on the application of phosphorus fertilizer and oil palm bunch ash. Indonesian Journal of Agricultural Research, 2020; 03(01): 48-55.
11. Manikandaselvi S, David R C, Aravind S, Ravikumar R, Thinagarbabu R, Nandhini S. Anti-anemic activity of sprouts of Vigna radiata L. in male albino rats. International Journal of Pharmacy and Pharmaceutical Sciences, 2015; 7(11): 263-267.
12. Waniale A, Wanyera N, Talwana H. Morphology and agronomic traits variations for mungbean variety selection and improvement in Uganda. African crop science journal, 2014; 22(2): 123-136.
13. Xue Z, Wang C, Zhai L, Yu W, Chang H, Kou X, Zhou F. Bioactive Compounds and Antioxidant Activity of Mung Bean (Vigna radiata L.), Soybean (Glycine max L.) and Black Bean (Phaseolus vulgaris L.) during the Germination Process. Food Technology and Economy, Engineering and Physical Properties, 2016; 34(1): 68-78.
14. Ullah R, Ullah Z, Al-Deyab S. S, Adnan M, Tariq A. Nutritional Assessment and Antioxidant Activities of Different Varieties of Vigna radiata. The Scientific World Journal, 2014; 5: 1-5.
15. Hou D, Yousaf Y, Xue Y, Hu J, Wu J, Hu X, Feng N, Shen Q. Mung Bean (Vigna radiata L.): Bioactive Polyphenols, Polysaccharides, Peptides, and Health Benefits. Nutrients, 2019; 1238(11): 1-28.
16. Chauhan Y. S, Williams R. Physiological and Agronomic Strategies to Increase Mungbean Yield in Climatically Variable Environments of Northern Australia. Agronomy, 2018; 83(8): 1-20.
17. Abragam D. A, Jeyaseelan S, Selson P. D. To Evaluate the Efficacy of Vermicompost on Green Gram– (Vigna radiata.L). International Journal of Science and Research, 2016; 7(9): 229-234.
18. Kumar S, Jakhar D S, Singh R. Growth and Yield Response of Mung Bean (*Vigna radiata* L.) in Different Levels of Potassium, 2018; 2(6): 23-25.
19. Anwar F, Latif S, Przybylski R, Ashraf M. Chemical Composition and Antioxidant Activity of Seeds of Different Cultivars of Mungbean. Journal of food science, 2007; 72(7): 503-510.
20. Pandiyan M, Karthikeyan A, Senthil N, Sudha M, Sivakumar C, Krishnaveni A, Arunkumar V, Paramasivam V, Vaithiyalingan M. Development of Mungbean yellow mosaic virus Resistant Genotypes in Mungbean through Interspecific Crosses of Wild Vigna Species. HSOA Journal of Plant Science Current Research, 2020; 4(11): 1-8.
21. Kumar R, Singh Y. V, Singh S, Latare A. M, Mishra P. K, Supriya. Effect of phosphorus and sulphur nutrition on yield attributes, yield of mungbean (Vigna radiata L. Wilczek). Journal of Chemical and Pharmaceutical Research, 2012; 4(5): 2571-2573.
22. Belay F, Meresa H, Syum S, Gebresilasie A. Evaluation of improved mung bean (Vigna radiata

L.) varieties for yield in the moisture stress conditions of Abergelle Areas, Northern Ethiopia. Journal of Agricultural Science and Practice, 2019; 4(4): 139-143.
23. Laxmi P B, Rao P J M, Murthy K G K, Kiran P K, Yamini K N, Srividhya A. Genetic Divesity and Molecular Characterization of Mungbean Genotypes (Vigna Radiata (L.) Wilczek). Arch Biochem Mol Biol, 2019; 1(1): 007-020.
24. Unal H, Isik E, Izli N, Tekin Y. Geometric and mechanical properties of mung bean (Vigna Radiata L.) Grain: Effect of moisture. International Journal of Food Properties, 2008; 11: 585-599.
25. Md. Karim A, Fukamachi H, Komori S, Ogawa K, Hidaka T. Growth, Yield and Photosynthetic Activity of Vigna radiata L. Grown at Different Temperature and Light Levels. Plant Production Science, 2003; 6(1): 43-49.
26. Srivastava A C, Pal M, Das M, Sengupta U K. Growth, CO_2 exchange rate and dry matter partitioning in mungbean (Vigna radiata L.) Grown under elevated CO_2. Indian journal of experimental biology, 2001; 39(6): 572-577.
27. Nihayati E, Roviq M, Lintang C W. Improvement of mungbean (Vigna radiata L) Yield through supplementing the plant growth-promoting rhizobacter (PGPR) and mycorriza. Eurasia journal of biosciences, 2019; 13: 2065-2070.
28. Madar I. H, Asangani A. H, Srinivasan S, Tayubi I. A, Ogu G. I. Nutritional and Biochemical Alterations in Vigna Radiata (Mung Bean) Seeds by Germination. International Journal of Current Microbiology and Applied Sciences, 2017; 6(9): 3307-3313.
29. Bahri S, Sharma S, Moitra B S, Sharma N, Bhatt R, Borthakur N S, Agarwal R, Jain D. Influence of silver nanoparticles on seedlings of Vigna radiata (L.) R.Wilczek. DU Journal of Undergraduate Research and Innovation, 2016; 2(1): 142-148.
30. Johnson J, Collins T, Power K, Chandra S, Skylas D, Portman D, Panozzo J, Blanchard C, Naiker M. Antioxidative properties and macrochemical composition of five commercial mungbean varieties in Australia. Legume Science, 2020; 2(27): 1-11.
31. Nasriyanti M N, Noor Aziah A A, Ahmad R. Comparison of properties of mung bean (Vigna radiata) protein isolate films at different Ph. Journal of Tropical Agriculture and Food Science, 2009; 37(2): 179–185.
32. Hou D, Yousaf L, Xue Y, Hu J, Wu J, Hu X, Feng N, Shen Q. Mung Bean (Vigna radiata L.): Bioactive Polyphenols, Polysaccharides, Peptides, and Health Benefits. Nutrients, 2019; (11): 1-29.
33. Kaysha K, Shanka D, Bibiso M. Performance of mung bean (Vigna radiata L.) varieties at different NPS rates and row spacing at Kindo Koysha district, Southern Ethiopia. Cogent Food & Agriculture, 2020; 6: 1-13.
34. Khattak G S S, Saeed I, Shah S A. Breeding high yield and disease resistant mungbean (Vigna radiata (L.) wilczek) genotypes. Pak. Journal bot, 2008; 40(4): 1411-1417.
35. Canci H, Toker C. Yield components in mung bean [Vigna radiata (L.) Wilczek]. Turkish journal of field crops, 2014; 19(2): 258-261.
36. Kaur R, Toor A K, Bassi G, Bains T S. Characterization of Mungbean (Vigna radiata L. Wilczek) Varieties using Morphological and Molecular Descriptors. International Journal of Current Microbiology and Applied Sciences, 2017; 6(6): 1609-1618.