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Advances in Research on the Bioactive Components and Health Effects of Mung Bean as a Medicinal and Edible Plant

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Abstract Mung bean (*Vigna radiata* L.) is an important medicinal and edible legume crop. It is rich in various functional components, including polyphenols, flavonoids, polysaccharides, bioactive peptides, and phytosterols, which contribute to its high nutritional value and wide range of health-promoting effects. This paper systematically reviews recent advances in the composition, metabolic changes, and health benefits of bioactive compounds in mung bean. The results show that vitexin, isovitexin, polysaccharides, and bioactive peptides are the major substances responsible for its biological activities. These compounds can exert antioxidant, anti-inflammatory, hypoglycemic, hypolipidemic, antihypertensive, hepatoprotective, and immunoregulatory effects by regulating signaling pathways such as Nrf2, PI3K/Akt, NF-κB, and TLR4. A large number of in vitro studies, animal experiments, and limited human clinical studies have demonstrated that mung bean and mung bean sprout products have good potential for improving metabolic syndrome, cardiovascular diseases, gut microbiota imbalance, and oxidative stress-related damage. At the same time, processing technologies such as germination, fermentation, thermal treatment, and ultrasound-assisted treatment can significantly alter the composition of bioactive compounds in mung bean, improve their bioavailability and functional activity, and provide technical support for the development of functional foods and nutraceutical products. Although the medicinal and edible value of mung bean has attracted considerable attention, there are still gaps in understanding the structure-activity relationships of its bioactive compounds, their mechanisms of action, clinical evidence, and the development of standardized products. Future studies should focus on multi-omics analysis, human clinical validation, and precision processing technologies to promote the industrial development and high-value utilization of mung bean-based functional products.
Keywords Mung bean (*Vigna radiata* L.); Medicinal and edible homology; Bioactive compounds; Health effects; Functional foods

1 Introduction

Mung bean (*Vigna radiata* L.) is an important legume crop worldwide, especially in Asia. It is not only a common food in the daily diet but also a traditional medicinal resource with a long history of use. Mung bean is rich in high-quality protein, dietary fiber, vitamins, minerals, and various bioactive compounds, including polyphenols, polysaccharides, and peptides. Because of these nutritional and functional components, it is increasingly recognized as a functional food with both nutritional and health-promoting properties (Singh and Kaur, 2021). In traditional Chinese medical classics such as Compendium of Materia Medica (Ben Cao Gang Mu), mung bean was recorded as a food and medicine used to clear heat, remove toxins, relieve summer heat, and improve gastrointestinal function, reflecting its long-standing role as a medicinal and edible resource. With the development of modern nutrition and functional food science, the potential applications of mung bean and its sprouts in foods, pharmaceuticals, and cosmetics have received increasing attention.

From the perspective of medicinal and edible resources, mung bean seeds and sprouts provide high levels of easily digestible protein, carbohydrates, and dietary fiber. They also contain a wide range of phytochemicals, including flavonoids, phenolic acids, polysaccharides, bioactive peptides, and phytosterols. Flavonoids represented by vitexin and isovitexin are the major polyphenols in mung bean seeds, while small peptides containing hydrophobic amino acids exhibit high biological activity. Together, these compounds provide the material basis for the pharmacological effects of mung bean (Mehta et al., 2021). Germination and other processing methods can also significantly change the metabolite profile of mung bean, generally leading to increased polyphenol content and antioxidant capacity, thereby further improving its health-promoting properties.

Research on the health effects of mung bean bioactive compounds has grown rapidly in recent years. Studies include in vitro experiments, animal models, and a limited number of clinical investigations, with particular attention given to the prevention and management of chronic degenerative diseases. Mung bean and its extracts have shown multiple pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, antihyperlipidemic, antihypertensive, antitumor, immunomodulatory, and hepatoprotective effects. These properties suggest that mung bean has potential as a dietary intervention for the prevention of metabolic syndrome, cardiovascular diseases, and certain types of cancer. Different bioactive fractions, such as mung bean polysaccharides, proteins and peptides, and metabolites from sprouts, have also demonstrated potential in regulating the gut microbiota, improving hepatic lipid metabolism, and reducing stress responses (Karami et al., 2025).

This review summarizes the nutritional value and traditional medicinal uses of mung bean as a medicinal and edible resource. It then focuses on the major bioactive components in mung bean seeds and sprouts, including polyphenols, polysaccharides, proteins, and bioactive peptides, with emphasis on their composition, structural characteristics, and dynamic changes during germination and other processing methods. Based on available evidence from in vitro studies, animal experiments, and limited clinical studies, this review further summarizes the main health benefits of mung bean, including antioxidant, anti-inflammatory, metabolic regulatory, cardiovascular protective, antitumor, and gut microbiota-modulating effects. In addition, it evaluates the potential application of mung bean in the development of functional foods and nutritional supplements. Finally, the current limitations in studies on mechanisms of action, preparation standardization, and safety evaluation are discussed, and future research priorities and directions are proposed.

2 Bioactive Components of Mung Bean

2.1 Polyphenols and phenolic acids

The main polyphenols in mung bean include phenolic acids, flavonoids, and tannins. These compounds are widely distributed in both the cotyledons and seed coat, but they are much more concentrated in the seed coat (Kabré et al., 2022). The phenolic acids identified in mung bean include caffeic acid, syringic acid, p-coumaric acid, ferulic acid, chlorogenic acid, and neochlorogenic acid. These compounds are found in both mung bean seeds and sprouts. Metabolomic studies during germination have also revealed several groups of phenolic compounds, including coumarins and isoflavones.

A significant positive correlation has been observed between total phenolic content and antioxidant capacity among different mung bean genotypes, indicating that phenolic compounds are the major contributors to the free radical scavenging activity of mung bean. Since the seed coat contains much higher levels of polyphenols than other tissues, it exhibits stronger antioxidant activity and is considered a valuable source of functional food ingredients (Wu et al., 2026). Germination, as well as specific treatments such as ultrasound combined with γ-aminobutyric acid (GABA), can significantly increase the polyphenol content and antioxidant activity of mung bean sprouts.

2.2 Flavonoids

Vitexin and isovitexin are the major flavonoids found in mung bean seeds and have been consistently detected in different varieties and geographical origins. They are C-glycosyl derivatives of apigenin and are mainly accumulated in the seed coat, where they account for more than 95% of the total vitexin and isovitexin present in mung bean (Ganesan and Xu, 2018). These two flavonoids have a wide range of biological activities, including antioxidant, anti-inflammatory, antidiabetic, antiviral, anticancer, and hepatoprotective effects. Therefore, they are regarded as two of the most important bioactive compounds in mung bean.

In addition to vitexin and isovitexin, mung bean also contains many other flavonoids, such as rutin, kaempferol 3-O-rutinoside, isoquercitrin, genistein, daidzein, isorhamnetin, as well as several isoflavones and lignans. These compounds contribute to the rich polyphenol profile of mung bean. Yang et al. (2020) further identified several additional flavonoids in different mung bean varieties, demonstrating the remarkable chemical diversity of this crop. These flavonoids play an important role in the antioxidant and antiproliferative activities of mung bean extracts.

2.3 Bioactive peptides

Mung bean protein is an important precursor for the production of bioactive peptides. These peptides are mainly prepared by enzymatic hydrolysis, chemical hydrolysis, or fermentation-assisted hydrolysis of whole seeds or protein isolates. Peptides with relatively low molecular weight and high contents of hydrophobic amino acids generally show stronger biological activities and are therefore preferentially enriched and selected during the preparation process (Shea et al., 2024).

Mung bean protein hydrolysates have shown strong antioxidant activity in both the Oxygen Radical Absorbance Capacity (ORAC) and Trolox Equivalent Antioxidant Capacity (TEAC) assays, indicating an excellent ability to scavenge free radicals. Bioactive peptides from mung bean also exhibit beneficial effects in lowering blood pressure and blood glucose, reducing obesity and cholesterol levels, inhibiting cancer development, and improving mineral bioavailability. As a result, they are considered promising ingredients for functional foods, edible packaging films, and active delivery systems (Hou et al., 2023).

2.4 Polysaccharides

Mung bean polysaccharides include water-soluble polysaccharides and acidic heteropolysaccharides, which differ considerably in monosaccharide composition and molecular weight. Two polysaccharide fractions, MP1 (83 kDa) and MP2 (45 kDa), differ significantly in uronic acid content and sugar residue composition, and these differences are closely associated with their antioxidant properties (Tang et al., 2014).

Mung bean polysaccharides possess various biological activities, including antioxidant, immunomodulatory, hypoglycemic, and antimicrobial effects. They are recognized as one of the major bioactive components responsible for the health-promoting properties of mung bean. Different polysaccharide fractions show complementary free radical scavenging and reducing capacities, suggesting a clear relationship between their structure and biological activity.

2.5 Other functional components

Mung bean seeds contain saponins, and the total saponin content varies significantly among different germplasm resources (Desta et al., 2024). These triterpenoid saponins are considered important compounds that help regulate cholesterol metabolism and provide other health benefits in legumes. Phytosterols and related derivatives, such as sitosterol ferulate, have also been identified among the bioactive compounds of mung bean. These substances may contribute to lowering blood lipid levels and reducing inflammation.

The mung bean seed coat is rich in dietary fiber and contains most of the polyphenols and flavonoids, including vitexin and isovitexin. As a result, it exhibits strong antioxidant and antidiabetic potential (Supasatyankul et al., 2022). Extracts from the seed coat have been shown to improve insulin sensitivity in insulin-resistant cells through antioxidant and anti-inflammatory mechanisms (Pavasutti et al., 2023).

During germination, mung bean sprouts undergo substantial metabolic changes. The contents of total phenolics and total flavonoids increase significantly, and new bioactive compounds such as neochlorogenic acid are formed. The antioxidant activity of mung bean sprouts generally reaches its highest level around the third day of germination (Lim et al., 2022).

3 Antioxidant and Anti-inflammatory Activities of Mung Bean

3.1 Antioxidant mechanisms of major bioactive components

Mung bean polyphenols, especially vitexin, isovitexin, and other bound phenolic compounds derived from the seed coat, show strong free radical scavenging activity. A study combining network pharmacology with the ABTS radical scavenging assay found that β-carotene and vitexin are the key antioxidant components in mung bean. Their ABTS radical scavenging activity was comparable to that of vitamin C, suggesting that they exert antioxidant effects mainly through efficient single-electron transfer or hydrogen atom donation mechanisms (Kong et al., 2022). Bound polyphenols extracted from mung bean seed coat dietary fiber increased DPPH radical scavenging activity, oxygen radical absorbance capacity (ORAC), and ABAP inhibition activity in a dose-dependent manner, indicating that they have both proton-donating ability and peroxyl radical scavenging capacity (Zheng et al., 2020).

Bioactive peptides derived from mung bean proteins are another important group of antioxidant compounds. Protein hydrolysates obtained by membrane separation showed that fractions with molecular weights below 1 kDa and rich in hydrophobic amino acids had the strongest DPPH, superoxide anion, and hydroxyl radical scavenging activities, as well as excellent metal ion chelating ability. These results indicate that peptide size and hydrophobicity are important factors affecting the interaction between peptides and free radicals or metal-binding sites (Sonklin et al., 2018). Further purification identified cysteine-containing peptides, such as HC, CGN, and CSGD, which exhibited strong DPPH, hydroxyl radical, and superoxide anion scavenging activities, together with high ferric reducing power and metal chelating capacity. Sonklin et al. (2021) suggested that the high antioxidant activity of these peptides is mainly related to the reactive sulfhydryl (-SH) groups in their peptide chains.

Lipophilic peptides obtained from mung bean protein hydrolysates were able to inhibit the formation of both primary and secondary lipid oxidation products in emulsion and oil systems. This indicates that these peptides can localize at the oil–water interface, interact with lipid radicals, and delay lipid oxidation (Zheng et al., 2022). Mung bean polysaccharides mainly exert antioxidant activity through free radical scavenging and reducing capacity. Low-molecular-weight polysaccharides extracted from mung bean seed coats by alkaline extraction showed high DPPH, ABTS, and ferric reducing antioxidant power (FRAP). This suggests that polysaccharide degradation exposes more available hydroxyl groups, thereby enhancing electron-donating ability and antioxidant activity (Ding et al., 2025).

3.2 Regulation of oxidative stress-related signaling pathways

In addition to directly scavenging free radicals, several bioactive compounds from mung bean can regulate the endogenous antioxidant defense system. Mung bean antioxidant peptides (MBAPs) protected hydrogen peroxide (H_2O_2)-injured human liver WRL-68 cells by reducing intracellular reactive oxygen species (ROS), restoring mitochondrial membrane potential, and improving cell viability to nearly normal levels. Western blot analysis showed that MBAPs significantly upregulated proteins related to the Keap1/Nrf2 signaling pathway, increased antioxidant enzyme levels by about two-fold, and reduced malondialdehyde (MDA) content by approximately 55%. These findings indicate that MBAPs activate the Keap1-Nrf2-ARE signaling axis and enhance cellular antioxidant capacity (Miao et al., 2023).

Mung bean sprout-derived exosome-like nanoparticles (MELNs) showed significant antioxidant and anti-diabetic effects in high-fat diet/streptozotocin (HFD/STZ)-induced diabetic mice and insulin-resistant liver cells. MELNs reduced hepatic oxidative stress, increased the expression of Nrf2 and GLUT4, and promoted the production of HO-1 and SOD through PI3K/Akt-mediated inactivation of GSK-3β, thereby relieving the inhibitory effect of GSK-3β on Nrf2 (He et al., 2023). Dietary phytochemicals can also protect cells by activating the NRF2/ARE signaling pathway and its downstream antioxidant enzyme system, including GPx, SOD, CAT, and HO-1, with the involvement of kinases such as PI3K/Akt and GSK-3β (Thiruvengadam et al., 2021).

3.3 Anti-inflammatory activity and its molecular mechanisms

Bioactive peptides derived from mung bean proteins have shown stable anti-inflammatory activity in both immune cells and animal models. In lipopolysaccharide (LPS)-stimulated RAW264.7 macrophages, mung bean protein hydrolysate (MBPH) significantly reduced the levels of nitric oxide (NO), inducible nitric oxide synthase (iNOS), interleukin-6 (IL-6), and interleukin-1β (IL-1β), while promoting the secretion of the anti-inflammatory cytokine IL-10 in a dose-dependent manner. In addition, MBPH inhibited the activation of the NF-κB signaling pathway by suppressing IκBα phosphorylation and preventing the nuclear translocation of the p65 subunit, thereby producing anti-inflammatory effects (Diao et al., 2019).

Among the MBPH fractions, the low-molecular-weight components showed the strongest inhibitory effects on LPS-induced inflammatory cytokine production and NF-κB signaling, indicating that peptide molecular weight is one of the key factors determining anti-inflammatory activity.

Mung bean seed coat polysaccharides also exhibit bidirectional immunomodulatory activity. In Caco-2 cells, hot water-extracted mung bean seed coat polysaccharides significantly inhibited the mRNA expression of IL-6 and TNF-α induced by LPS, indicating a direct anti-inflammatory effect on intestinal epithelial cells (Ding et al., 2025).

In RAW264.7 macrophages, mung bean polysaccharides (MBP) enhanced phagocytic activity, promoted cytokine and NO production, and activated the TLR4, MAPK, and NF-κB signaling pathways. After treatment with pathway inhibitors, the levels of NO and TNF-α were significantly reduced, indicating that MBP regulates and shapes immune responses through the TLR4-mediated signaling pathway (Qin et al., 2022).

In vivo studies further demonstrated that mung bean peptides can effectively relieve chronic intestinal inflammation. Mung bean peptides prepared by Neutrase hydrolysis not only showed good antioxidant activity in vitro but also increased survival rate, maintained intestinal structural integrity, and regulated amino acid metabolism and linoleic acid metabolism in a dextran sulfate sodium (DSS)-induced Drosophila intestinal inflammation model (Wang et al., 2025).

In a DSS-induced mouse model of ulcerative colitis, mung bean peptides (MBPs) increased colon length, reduced histological damage and disease activity index (DAI), restored the expression of the tight junction proteins ZO-1 and Claudin-1, regulated gut microbiota composition, and decreased systemic inflammatory cytokine levels. These results indicate that MBPs protect the intestinal barrier while also regulating immune responses (Xu et al., 2025).

3.4 Current experimental evidence

Various bioactive compounds in mung bean, including polyphenols, peptides, and polysaccharides, possess strong free radical scavenging and reducing abilities. The seed coat, which is rich in polyphenols, provides abundant bound phenolic compounds. Its DPPH radical scavenging activity, ORAC value, and ABAP inhibition activity all increased significantly with increasing concentration (Zheng et al., 2020).

A comparative analysis of 24 mung bean varieties showed that higher contents of soluble phenolic compounds, especially vitexin and isovitexin, were associated with stronger DPPH and ABTS radical scavenging activities. This further confirms that phenolic compounds are the main contributors to the antioxidant activity of mung bean seeds (Wang et al., 2021) (Figure 1).

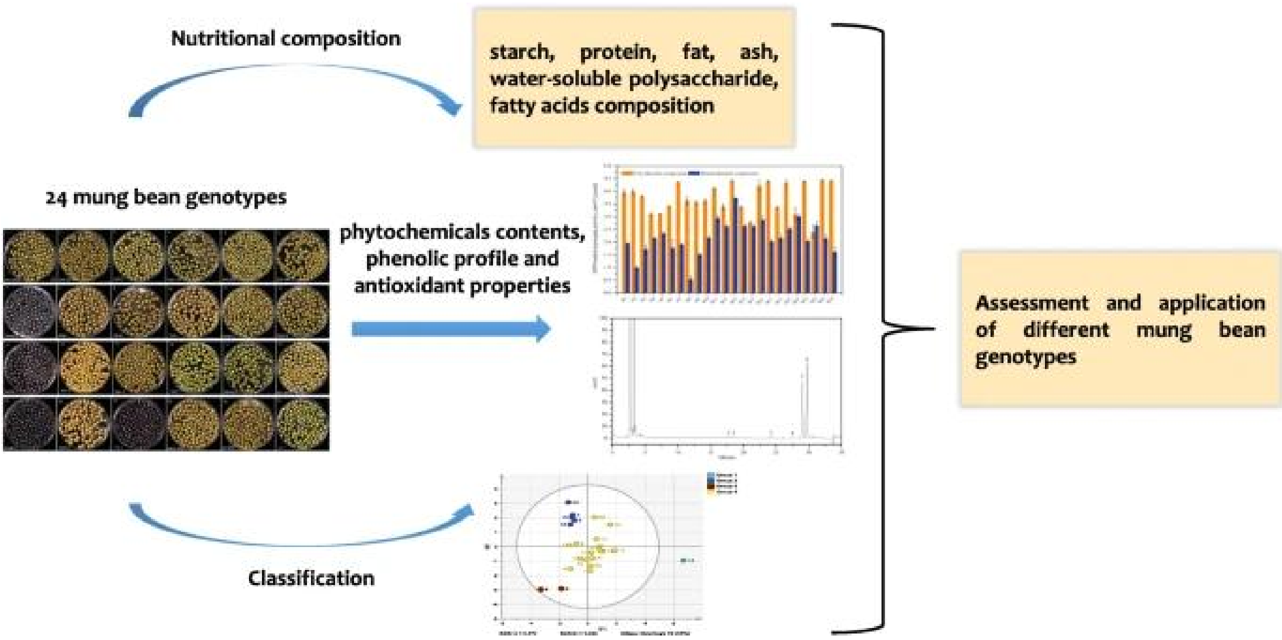

Figure 1 Integrated assessment framework for nutritional composition, phytochemical properties, and application potential of different mung bean genotypes (Adapted from Wang et al., 2021)

Studies on bioactive peptides consistently showed that both membrane-separated protein hydrolysates and purified antioxidant peptides produced similar results. Peptides with lower molecular weight, higher hydrophobicity, and/or higher cysteine content exhibited the strongest DPPH, superoxide anion, and hydroxyl radical scavenging activities, together with excellent metal ion chelating ability (Sonklin et al., 2021).

Studies using different immune cell models, including RAW264.7 cells, Caco-2 cells, and MBP-treated RAW264.7 cells, demonstrated that mung bean peptides and polysaccharides regulate the NF-κB, TLR4, and MAPK signaling pathways, thereby suppressing excessive inflammatory responses or promoting appropriate immune activation (Diao et al., 2022).

Animal experiments further extended these findings to the whole-organism level. Both DSS-induced Drosophila and mouse colitis models demonstrated that mung bean peptides maintained intestinal structural integrity, improved survival rate or disease scores, restored the expression of intestinal barrier proteins, remodeled gut microbiota, and reduced inflammatory cytokine levels. In HFD/STZ-induced diabetic mice, MELNs improved blood glucose control, reduced hepatic oxidative stress and inflammatory infiltration, and increased pancreatic β-cell area, linking their antioxidant and anti-inflammatory activities with improved metabolic function (He et al., 2023).

4 Health Effects on Metabolic Diseases

4.1 Hypoglycemic effect and diabetes prevention

Whole mung beans, mung bean seed coats, mung bean sprouts, water extracts, polyphenol extracts, and bioactive peptides can all reduce fasting blood glucose, improve glucose tolerance, and increase insulin sensitivity in diabetes or prediabetes models (Li et al., 2023; Gupta and Verma, 2026). Exosome-like nanoparticles from mung bean sprouts and extracts from mung bean seed coats can lower fasting blood glucose, improve the results of the oral glucose tolerance test (OGTT) and intraperitoneal glucose tolerance test (IPGTT), and restore pancreatic β-cell area or improve pancreatic tissue structure (Li et al., 2022).

Clinical studies have also shown positive results. A purified mung bean protein product (GLUCODIA) can suppress the seasonal increase in fasting plasma glucose and insulin levels in people with prediabetes. It also reduces the homeostasis model assessment of insulin resistance (HOMA-IR), suggesting that it may help prevent the development of insulin resistance (Kohno et al., 2017).

4.2 Lipid-lowering effect and obesity management

Mung bean intake can significantly improve abnormal blood lipid levels. It reduces total cholesterol (TC), triglycerides (TG), and non-high-density lipoprotein cholesterol (non-HDL-C), while increasing high-density lipoprotein (HDL)-related indicators.

In high-fat diet models, mung bean flour and its bioactive peptides reduce body weight gain, fat accumulation, and adipocyte size, thereby helping prevent obesity and obesity-related metabolic syndrome (Hou et al., 2020c). About one-third of the published studies reported clear lipid-lowering and anti-obesity effects (Karami et al., 2025).

In addition, clinical trials using mung bean protein isolate have shown that it can reduce serum triacylglycerol (TAG) levels, improve liver enzyme indicators, and may help prevent visceral fat accumulation (Kohno et al., 2018).

4.3 Regulation of glucose and lipid metabolism

Mung bean affects several steps of glucose metabolism. It promotes glucose uptake in peripheral tissues, increases hepatic hexokinase activity, inhibits gluconeogenesis, and suppresses starch-digesting enzymes, thereby improving glucose utilization. At the same time, mung bean water extracts, polyphenols, and bioactive peptides can reduce the formation of advanced glycation end products (AGEs) and relieve oxidative stress, which indirectly helps maintain glucose homeostasis (Saeting et al., 2021).

For lipid metabolism, mung bean protein and its extracts regulate the expression of genes related to hepatic cholesterol synthesis, bile acid metabolism, and lipid synthesis. As a result, they reduce circulating blood lipid levels and alleviate hepatic steatosis (Hou et al., 2020a).

Whole mung beans and their seed coats can also reshape the gut microbiota. They increase the abundance of beneficial bacteria such as Bifidobacterium, Roseburia, and Akkermansia, and promote the production of short-chain fatty acids (SCFAs). These changes are closely associated with improvements in glucose and lipid metabolism.

4.4 Potential mechanisms of metabolic regulation

Both crude mung bean extracts and purified bioactive peptides can inhibit the activities of intestinal α-amylase and α-glucosidase. This reduces postprandial blood glucose fluctuations and is considered one of the main reasons for the hypoglycemic effect of mung beans.

At the cellular level, mung bean water extracts inhibit protein tyrosine phosphatase 1B (PTP-1B) activity and regulate the expression of key genes such as FOXO1, PEPCK, and GSK-3β, thereby improving insulin signaling in liver cells. Exosome-like nanoparticles and bioactive peptides from mung beans can activate the PI3K/Akt signaling pathway, promote GLUT4 translocation, and regulate signaling pathways such as AMPK and JAK2. These effects enhance glucose utilization in the liver and skeletal muscle (Yoshioka et al., 2023).

For lipid metabolism, mung bean protein inhibits hepatic lipogenesis by downregulating the expression of sterol regulatory element-binding protein 1 (SREBP-1) and fatty acid synthase (FAS). At the same time, it increases the expression of cholesterol 7α-hydroxylase (CYP7A1), promotes fecal sterol excretion, and consequently lowers serum triglyceride and cholesterol levels (Kohno et al., 2018).

5 Cardiovascular Protective Effects

5.1 Blood pressure regulation

Mung bean has a clear antihypertensive effect. This activity is mainly related to angiotensin-converting enzyme (ACE) inhibitory peptides produced during protein hydrolysis or fermentation. Mung bean protein hydrolysates prepared with Alcalase protease significantly reduced systolic blood pressure in spontaneously hypertensive rats (SHR). After a single oral dose of 600 mg/kg, systolic blood pressure decreased by about 30.8 mmHg at 6 h after administration, and the antihypertensive effect lasted for at least 8 h (Hou et al., 2020b).

In vitro studies and research on functional foods further support this mechanism. Protein hydrolysates from Vigna species, including mung bean, showed high ACE-1 inhibitory activity, with inhibition rates ranging from 80% to 93%. Therefore, they are considered promising ingredients for antihypertensive functional foods and nutritional supplements (Yuwanti et al., 2020). Fermented mung bean tempeh extracts showed an ACE inhibitory activity of approximately 75%, indicating that appropriate processing methods can promote the formation of highly active antihypertensive peptides (Muawanah et al., 2022).

Clinical studies have also provided supporting evidence. In a 6-week intervention study involving middle-aged participants, consumption of a mung bean protein beverage improved flow-mediated dilation (FMD). Muchimapura et al. (2024) suggested that ACE inhibition is one of the important mechanisms responsible for the improvement of vascular function (Figure 2).

5.2 Improvement of blood lipid profile

Mung bean consumption can regulate lipid metabolism. In hamsters fed a high-cholesterol diet, mung bean protein dose-dependently reduced total cholesterol (TC), triglycerides (TG), and non-high-density lipoprotein cholesterol (non-HDL cholesterol). These effects may be associated with increased expression of 3-hydroxy-3-methylglutaryl-CoA reductase (HMG-CoA reductase) and cholesterol 7α-hydroxylase (CYP7A1), as well as enhanced bile acid and sterol excretion (Hou et al., 2019).

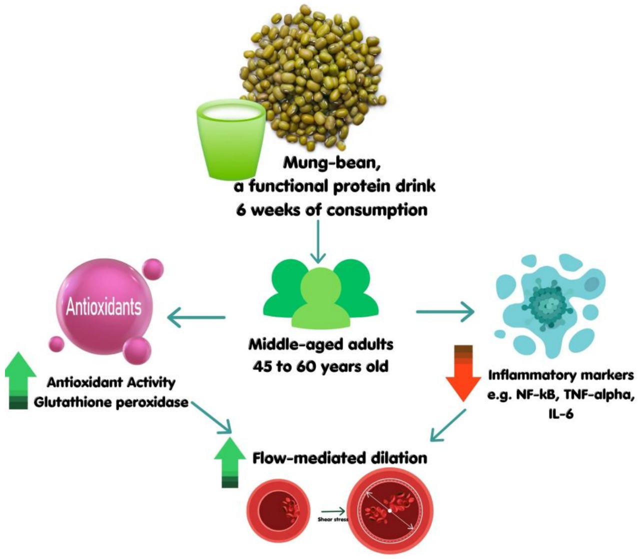

Figure 2 Health benefits of mung bean functional protein drink on antioxidant status, inflammation, and vascular function in middle-aged adults (Adapted from Muchimapura et al., 2024)

In hyperlipidemic rats, hydroalcoholic extracts of mung bean seeds significantly reduced the levels of TC, TG, very low-density lipoprotein (VLDL), and low-density lipoprotein (LDL), while also alleviating pathological changes similar to atherosclerosis (Ganesan and Xu, 2018).

Processed whole mung beans also showed good lipid-lowering effects. In rats fed a high-cholesterol diet, diets containing 30% raw, cooked, or germinated mung beans all reduced serum TG and non-HDL cholesterol levels while increasing high-density lipoprotein (HDL). Although cooking and germination reduced the levels of some phenolic compounds, they enhanced the cholesterol-lowering capacity of mung bean (Liyanage et al., 2018).

Mung bean coat (MBC), which is rich in dietary fiber and polyphenols, also improves blood lipid profiles. In prediabetic mice, supplementation with 3% MBC reduced TC, TG, and low-density lipoprotein cholesterol (LDL-C) by approximately 14%~24% (Hou et al., 2021b). In mice fed a high-fat diet, supplementation with 6% MBC not only reduced serum TG, TC, and LDL-C levels but also alleviated hepatic steatosis. These effects were associated with regulation of hepatic lipid metabolism and lipogenesis-related gene expression through the PPAR signaling pathway (Hou et al., 2021a).

5.3 Protection against vascular oxidative damage

The protective effect of mung bean on the cardiovascular system is closely related to its strong antioxidant activity. Ethanol extracts of mung bean seeds showed strong ABTS radical scavenging activity, DPPH radical scavenging activity, and anti-lipid peroxidation capacity. In rats fed a high-fat diet, consumption of whole mung beans restored antioxidant enzyme activity, increased the expression of antioxidant-related genes, and reduced liver damage caused by oxidative stress associated with hyperlipidemia.

Mung bean also shows protective effects on the myocardium. Flavonoids isolated from mung bean and whole-seed extracts significantly reduced isoproterenol-induced myocardial ischemic injury in rats. After mung bean treatment, serum levels of lactate dehydrogenase (LDH), creatine kinase (CK), and aspartate aminotransferase (AST) were significantly decreased. In addition, the level of malondialdehyde (MDA) in tissues was reduced, while superoxide dismutase (SOD) activity was significantly increased. These results indicate that oxidative damage was effectively inhibited and myocardial tissue was better protected (Bai et al., 2016).

6 Hepatoprotective and Detoxifying Effects

6.1 Protective effects against oxidative liver injury

Water extracts from germinated and fermented mung beans, which are rich in amino acids and γ-aminobutyric acid (GABA), can significantly increase the levels of superoxide dismutase (SOD), ferric reducing antioxidant power (FRAP), and nitric oxide (NO) in the livers of ethanol-treated mice. At the same time, they reduce malondialdehyde (MDA) content and restore the levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), triglycerides (TG), and cholesterol to near-normal values. Liver cell necrosis, inflammatory responses, and ballooning degeneration are also markedly improved.

Antioxidant peptides derived from mung bean protein hydrolysates can protect H_2O_2-injured human liver WRL-68 cells. These peptides restore cell viability, reduce reactive oxygen species (ROS) and MDA levels by about 55%, and improve mitochondrial function by activating the Keap1/Nrf2 signaling pathway, thereby protecting liver cells (Miao et al., 2023).

Mung bean protein hydrolysates can also decrease ROS, lactate dehydrogenase (LDH), and MDA levels in NCTC-1469 liver cells while improving cell survival. Among the hydrolysate fractions, those with molecular weights below 3 kDa and rich in hydrophobic and aromatic amino acids show stronger protective activity (Xie et al., 2019).

6.2 Regulation of hepatic lipid metabolism

In hamsters fed a high-cholesterol diet, both cooked whole mung beans and germinated whole mung beans reduce plasma total cholesterol and non-high-density lipoprotein cholesterol (non-HDL cholesterol), increase fecal cholesterol excretion, lower AST and ALT activities, and reduce lipid accumulation in the liver. Germinated mung beans also show no inflammatory cell infiltration and better liver vascularization than cooked mung beans (Lopes et al., 2018).

In diabetic rats, supplementation with mung bean water extract decreases plasma total cholesterol, very low-density lipoprotein cholesterol plus low-density lipoprotein cholesterol (VLDL-C+LDL-C), and hepatic MDA levels. It also increases the expression of hepatic hexokinase and regulates the activities of other liver metabolic enzymes, indicating that it can improve glucose and lipid metabolism while reducing oxidative stress (Huang et al., 2024).

The seed coat of mung bean, which is rich in dietary fiber and phytochemicals, reduces liver lipid accumulation and insulin resistance in mice fed a high-fat diet (HFD). It also improves hepatic oxidative stress and inflammation. These effects are mainly related to the regulation of the gut microbiota and its metabolites (Hou et al., 2022).

6.3 Anti-inflammatory and detoxification mechanisms

In an alcohol-induced liver injury model, mung bean extracts rich in flavonoids, together with their major active compounds vitexin and isovitexin, significantly reduce ALT, AST, and MDA levels, increase SOD activity, and relieve liver tissue damage. These results indicate that the extracts protect the liver from ethanol toxicity mainly through their antioxidant activity. Water extracts from germinated and fermented mung beans also reverse ethanol-induced increases in ALT, AST, blood lipids, NO, and MDA, and restore liver tissue to a nearly normal condition. These findings support the traditional use of mung beans for relieving alcohol intoxication and removing xenobiotics from the body (Liu et al., 2014).

In a modified NIAAA model of alcoholic liver disease, ethanol extracts of mung bean reduce alcoholic liver injury by improving lipid metabolism disorders, inflammation, oxidative stress, and intestinal barrier damage. The protective effects involve PPARα-mediated regulation of lipid metabolism and activation of the Nrf2 antioxidant system. In addition, the extract increases the abundance of gut microorganisms associated with higher spermidine levels, and spermidine itself can produce similar hepatoprotective effects (Liu et al., 2025).

6.4 Evidence from animal and cell studies

In a non-alcoholic fatty liver disease model, germinated mung beans reduce serum transaminase activity, lipid peroxidation, and nitrite/nitrate levels. They also restore glutathione levels and the expression of antioxidant enzyme-related genes, decrease mitochondrial ROS production, and prevent the progression of simple steatosis to steatohepatitis in rats (Alshammari et al., 2018).

Studies using high-fat diet models have shown that whole mung beans or diets supplemented with mung beans reduce liver lesions, increase the activities of antioxidant enzymes including glutathione peroxidase (GSH-Px), catalase (CAT), total antioxidant capacity (T-AOC), and SOD, and decrease MDA levels. These findings indicate that mung beans can protect the liver from oxidative damage associated with hyperlipidemia (Yousef, 2022).

In oleic acid-induced HepG2 cells, ethanol extracts of mung bean restore intracellular lipid levels, reduce MDA content, and increase antioxidant enzyme activity. In insulin-resistant liver cell models, exosome-like nanoparticles derived from mung bean sprouts improve cell viability, reduce oxidative stress, promote Nrf2 nuclear translocation, and activate the PI3K/Akt/GLUT4/GSK-3β signaling pathway, thereby enhancing antioxidant enzyme activity (Liu et al., 2019).

7 Gut Health and Immune Regulation

7.1 Regulation of gut microbiota composition

Polyphenols, polysaccharides, proteins, and their fermentation products from mung bean can continuously regulate the composition of the gut microbiota. During in vitro human fecal fermentation, polyphenol-rich mung bean seed coat extracts significantly increased the total production of short-chain fatty acids (SCFAs). They also selectively promoted the growth of beneficial bacteria, including Enterococcus, Ruminococcus, Blautia, Bacteroides, Bifidobacterium, Lactobacillus, Faecalibacterium prausnitzii, and Prevotella, while inhibiting the growth of Escherichia–Shigella (Charoensiddhi et al., 2022).

In mice fed a high-fat diet, supplementation with cooked whole mung beans or whole mung bean flour effectively prevented gut microbiota imbalance. It reduced the abundance of obesity-related bacteria, such as Ruminiclostridium_9, Mucispirillum, Bilophila, Blautia, and Odoribacter, while increasing the abundance of Muribaculaceae, Akkermansia, and Bifidobacterium. These changes in the gut microbiota were significantly associated with obesity-related metabolic indicators (Hou et al., 2020c).

In prediabetic mice, supplementation with mung bean seed coat promoted the growth of Roseburia and Bifidobacterium and increased SCFA production. Mung bean peptides also reversed gut microbiota imbalance caused by a high-fat diet, improved microbial diversity, and regulated the abundance of several key bacterial genera, including Akkermansia, Roseburia, and Ruminiclostridium. These microbial changes were closely related to host metabolism and redox metabolites (Li et al., 2022).

In addition, products prepared from mung bean protein also promoted the growth of Parabacteroides, Bifidobacterium, and Lactobacillus during in vitro fecal fermentation. At the same time, they inhibited the growth of Escherichia–Shigella, Dorea, and Klebsiella, accompanied by increased production of SCFAs and branched-chain fatty acids (Tampanna et al., 2024).

7.2 Prebiotic effects of mung bean polysaccharides

A water-soluble polysaccharide (MBP-02) isolated from mung bean seed coat showed clear prebiotic activity in mice. MBP-02 increased colon length, enhanced SCFA production, and improved the α-diversity indices (Chao1 and ACE). It also changed the gut microbiota structure by increasing the abundance of Firmicutes, Bacteroidetes, and Clostridium, while reducing the abundance of TM7. These changes are considered beneficial for maintaining gut health. Dietary fibers from plant polysaccharides can be degraded by intestinal microorganisms and therefore have "potential prebiotic activity." They improve gut health by reshaping the gut microbial community and promoting SCFA production, further supporting the potential application of mung bean polysaccharides as prebiotic candidates (Wang et al., 2024).

Fermented mung bean starch liquid (MBSFL), which is rich in polysaccharides and organic acids, relieved antibiotic-induced constipation in mice. It improved intestinal motility, restored gut microbial diversity, and promoted the enrichment of SCFA-producing bacteria such as Lactobacillus and Bifidobacterium. Tao et al. (2025) described it as a "diet-derived prebiotic candidate."

In cyclophosphamide-treated mice, mung bean ethanol extract restored the balance between Firmicutes and Bacteroidetes, reduced the abundance of potential pathogenic bacteria, and increased the abundance of

Lactobacillus reuteri. This effect may be achieved by regulating bacterial quorum sensing, indicating a significant prebiotic effect (Liu et al., 2026).

7.3 Enhancement of intestinal barrier function

Several bioactive compounds from mung bean can strengthen the intestinal mechanical barrier. In a dextran sulfate sodium (DSS)-induced colitis model, mung bean peptides significantly increased colon length, reduced histological damage and disease activity index, and restored intestinal barrier function by increasing the expression of the tight junction proteins ZO-1 and Claudin-1 in colon tissue.

A compound prebiotic extract containing mung bean components improved barrier integrity in lipopolysaccharide (LPS)-stimulated HT-29 cells. The mechanism involved reducing the mRNA expression of TNF-α, IL-1β, and NF-κB, while increasing the expression of the tight junction markers CLDN1 and OCLN. In DSS-induced colitis mice, this extract also increased colon length, reduced intestinal permeability, and decreased the release of inflammatory mediators (Lee et al., 2025).

In a chemotherapy-induced intestinal injury model, mung bean ethanol extract effectively reduced intestinal mucosal damage by increasing the expression of key tight junction proteins. This strengthened intestinal barrier integrity and corrected gut microbiota imbalance at the same time (Liu et al., 2026).

Studies on dietary polysaccharides have shown that these compounds promote the production of tight junction proteins (Occludin-1 and ZO-1), mucins, beneficial bacteria, and SCFAs. Together, these factors support the mechanical, chemical, immune, and biological functions of the intestinal mucosal barrier. These mechanisms are highly consistent with the effects observed for mung bean polysaccharides and related products (Yan et al., 2024).

7.4 Immunomodulatory activity and mechanisms

Mung bean shows complex immunomodulatory effects on both innate and adaptive immunity. Polysaccharides extracted from mung bean seed coat enhanced the phagocytic activity of RAW264.7 macrophages and increased the production of reactive oxygen species (ROS), nitric oxide (NO), and cytokines. RNA sequencing and Western blot analysis showed that these polysaccharides activated the TLR4, MAPK, and NF-κB signaling pathways. Inhibitors of these pathways significantly reduced the production of NO and TNF-α, indicating that mung bean seed coat polysaccharides moderately activated macrophages through TLR4-mediated signaling (Qin et al., 2022).

In contrast, mung bean protein hydrolysates showed clear anti-inflammatory activity in LPS-stimulated RAW264.7 cells. They reduced the levels of NO, iNOS, IL-6, and IL-1β by about 50% and significantly increased the expression of the anti-inflammatory cytokine IL-10. The main mechanism involved inhibition of IκBα phosphorylation and suppression of NF-κB p65 nuclear translocation (Diao et al., 2019).

Animal studies further showed that mung bean peptides alleviated DSS-induced colitis by reducing serum inflammatory cytokines, reshaping the gut microbiota, and regulating immune-related signaling pathways.

In a Caenorhabditis elegans model infected with Pseudomonas, mung bean seed coat extract increased host survival and reduced ROS levels. Transcriptomic analysis showed that the extract upregulated the expression of antimicrobial peptides and mitochondria-related genes and regulated signaling pathways including MAPK, daf-2, aak-2, sir-2.1, and skn-1 (Tao et al., 2024).

Proteomic analysis of RAW264.7 cells treated with mung bean seed coat extract showed that the extract regulated antiviral enzymes and antigen-processing proteins and activated the major histocompatibility complex (MHC) pathway. These findings suggest that mung bean seed coat extract may promote Th2-type antigen-specific immune responses (Hashiguchi et al., 2017).

8 Effects of Processing on Bioactive Components and Functional Properties

8.1 Germination and sprouting

Germination is a simple and low-cost biological treatment that can greatly improve the functional value of mung bean. During germination, the extraction yield, total phenolic content, flavonoid content, vitamin C content, and in vitro antioxidant activity all increase. The variety of polyphenolic compounds also becomes richer, and the extracts show stronger protective effects in human cell lines. In general, germination for 3-5 days results in the highest levels of bioactive compounds and antioxidant activity. Phenolics and flavonoids contribute most of the free radical scavenging capacity (Xue et al., 2016).

Germination can also reduce the content of antinutritional factors, improve the bioavailability of proteins and minerals, and increase the accumulation of health-related metabolites, thereby enhancing the value of mung bean as a functional food. After 24~48 h of germination, the protein content increases, the total phenolic content rises significantly, and the phytic acid content decreases, resulting in improved nutritional quality (Kabré et al., 2025).

8.2 Fermentation

Fermentation can further increase the levels of bioactive compounds in mung bean, especially phenolic compounds and γ-aminobutyric acid (γ-aminobutyric acid, GABA). Fermented mung bean is an excellent source of GABA, with its content increasing by about 7.6 times compared with untreated seeds (Hou et al., 2019).

Solid-state fermentation with Aspergillus niger can significantly increase total phenolics, flavonoids, and antioxidant activity. Metabolomic analysis has shown that dozens of phenolic metabolites are upregulated during fermentation, and their changes are closely related to antioxidant activity (Lang et al., 2025). Both germination and solid-state bioconversion can increase the phenolic content and improve the functional properties of mung bean, leading to stronger antioxidant, antidiabetic, and anti-ulcer activities. Therefore, fermentation is considered an effective way to modify the phenolic profile of mung bean. It not only improves antioxidant capacity but also produces new bioactive metabolites and GABA, which may contribute to neuroprotection and metabolic regulation.

8.3 Thermal processing and cooking

Traditional cooking and heat treatment have important effects on the nutritional quality and color of mung bean. A study on mung bean varieties from Burkina Faso found that boiling, roasting, and cooking increased protein content and water absorption capacity, reduced phytic acid levels, and in some cases increased the total polyphenol content. Although the contents of iron and zinc decreased, their bioavailability was higher than that in raw seeds (Kabré et al., 2025).

A comparative study of blanching, germination, and ultrasound treatment showed that short-time blanching was the most effective method for reducing phytic acid, while germination produced the greatest increases in total phenolics, flavonoids, and antioxidant activity. These results indicate that there is a balance between removing antinutritional factors and enriching bioactive compounds (Idris et al., 2026).

Heat treatment also causes changes in pigments and phenolic compounds that affect the appearance and functional properties of mung bean. Prolonged heating of whole seeds leads to chlorophyll degradation in the seed coat and the formation of pheophytin, which increases yellowness and darkens the cooking water. Interestingly, the total flavonoid content in the seed coat increases significantly as the heating time becomes longer. This may be related to condensation reactions between flavonoids and other polyphenols, resulting in the formation of brown polymeric compounds (Huang et al., 2022).

8.4 Emerging processing technologies and functional enhancement

In recent years, various emerging physical processing technologies have been widely used to regulate bioactive compounds in mung bean. Among them, high-intensity ultrasound, either alone or combined with heat treatment as thermosonication, can modify protein structure and improve its biological activity.

Thermosonication pretreatment of mung bean protein increases the proportion of low-molecular-weight peptides in the hydrolysates and significantly enhances the inhibition of cholesterol micelle solubility as well as antioxidant activity. These results suggest its potential as a cholesterol-lowering functional ingredient (Ashraf et al., 2020). Ultrasound treatment of mung bean protein hydrolysates also changes the secondary structure, reduces particle size and surface hydrophobicity, and significantly improves free radical scavenging activity and metal ion chelating ability (Liu et al., 2022).

During germination, combining ultrasound with exogenous GABA or calcium ions (Ca^{2+}) is an effective strategy to further enrich phenolic metabolites. Studies have shown that ultrasound combined with GABA treatment or ultrasound-Ca^{2+} pretreatment significantly increases the contents of free polyphenols and flavonoids and provides stronger antioxidant activity than germination alone (Wang et al., 2023). These treatments activate several flavonoid, isoflavonoid, and phenylpropanoid metabolic pathways, thereby promoting the accumulation of functional compounds.

Studies on the application of high-intensity ultrasound in legume proteins have shown that cavitation can unfold protein structures, improving their solubility, emulsifying properties, and gel-forming ability. This provides an important technical basis for developing mung bean functional foods with both good processing performance and health-promoting properties (Yu et al., 2024).

9 Development and Application of Functional Mung Bean Products

9.1 Functional foods and nutritional health products

Mung bean is widely recognized as a functional food because it contains high-quality protein, dietary fiber, minerals, vitamins, and abundant bioactive compounds such as polyphenols, polysaccharides, and bioactive peptides. These compounds give mung bean many physiological benefits, including lowering blood glucose, blood lipids, and blood pressure, protecting the liver, preventing cancer, and regulating the immune system (Shahrajabian et al., 2019). Among these components, mung bean proteins and their derived peptides are considered promising ingredients for nutritional and health products. These bioactive peptides show antioxidant, anti-obesity, cholesterol-lowering, antihypertensive, hypoglycemic, and anticancer activities. They can be used in functional foods, edible packaging films, and active carrier materials (Gupta, 2024).

Traditional mung bean products include mung bean flour, mung bean cake, mung bean paste, mung bean soup, mung bean porridge, and mung bean noodles. In recent years, modern functional products have gradually developed toward high-protein, low-sugar, and convenient foods. These products include mung bean protein powder, plant-based mung bean protein drinks, mung bean dietary fiber powder, meal replacement powder, nutrition bars, and mung bean protein beverages (Figure 3). In China, companies such as VIVI Group, Dali Foods, Wahaha, and Yinlu Food have launched mung bean beverages and cereal drinks. Among them, Yinlu's "Haozhoudao" mung bean porridge and Wahaha mung bean drinks have achieved good market performance during the summer season. Traditional food companies such as Beijing Daoxiangcun, Shenda Cheng, and Zhiweiguan have also produced mung bean cakes and mung bean ice cakes for many years.

9.2 Mung bean sprouts and health-promoting products

Germination can greatly improve the functional value of mung bean. During sprouting, the contents of total phenolics, flavonoids, free radical scavenging activity, and polyphenol diversity all increase, resulting in stronger antioxidant activity and better cellular protection. Germinated mung bean products also show stronger cytoprotective effects and antiproliferative activity in colon cell models (Kapravelou et al., 2020).

During germination, the combined use of ultrasonic treatment and exogenous γ-aminobutyric acid (GABA) can further increase the contents of free polyphenols and flavonoids, improve antioxidant activity in vitro, and produce a richer profile of phenolic metabolites. Mung bean sprout powder obtained after 48 h of germination can continuously release polyphenols during simulated digestion. Germination not only reduces antinutritional factors but also improves nutritional quality. Therefore, mung bean sprouts are widely recommended as important raw materials for dietary supplements and products related to "global medicine" (Nurbaety and Jumriani, 2025).

Many mung bean sprout products are now available on the market, including fresh sprouts, cleaned and packaged sprouts, ready-to-eat seasoned sprouts, frozen sprouts, freeze-dried sprout powder, and mung bean sprout nutrition powder. In China, food processing companies such as Zuming Food, VIVI Food, as well as many central kitchen and fresh vegetable processing companies, have introduced packaged mung bean sprout products that are widely supplied to supermarkets, fresh food e-commerce platforms, and catering supply chains. Some companies have also developed GABA-enriched mung bean sprout powder for use in sports nutrition products and healthy instant beverages.

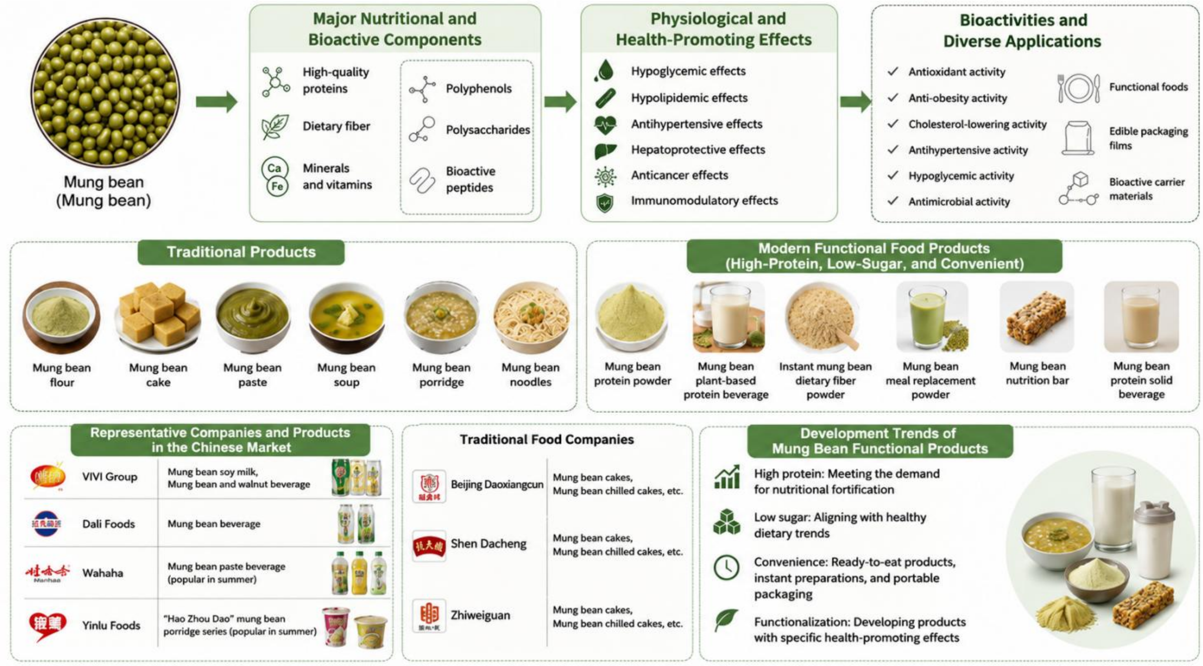

Figure 3 Development of functional foods and nutritional products from mung bean

9.3 Extraction and utilization of bioactive components

To meet the needs of the food and pharmaceutical industries, Zhu et al. (2018) developed several methods for extracting bioactive compounds from mung bean. Albumins and globulins can be obtained by alkaline extraction or salt extraction combined with fractionation. Enzymatic hydrolysis is then used to produce bioactive peptides with angiotensin-converting enzyme (ACE) inhibitory, antifungal, and antioxidant activities. At the same time, mung bean protein has good emulsifying, foaming, gel-forming, and binding properties, together with beneficial biological functions. Therefore, it is considered an important structural ingredient in plant-based meat, dairy alternatives, and egg substitute products (Tarahi, 2024).

Water extraction and organic solvent extraction are commonly used for the isolation of mung bean polyphenols and polysaccharides. Review studies have identified flavonoids such as Vitexin, Isovitexin, and Quercetin, phenolic acids, and polysaccharides as the major functional compounds in mung bean. These compounds have broad application prospects in agriculture, health foods, cosmetics, and medicine. Feng et al. (2023) further separated mung bean polyphenols and identified Vitexin, Orientin, and Caffeic acid as important bioactive molecules involved in heat stress regulation. Their results indicate that targeted extraction technologies can produce functional ingredients for specific antioxidant and stress-resistance applications.

In the food industry, mung bean protein isolate has been used in plant-based protein beverages, plant-based meat, plant-based yogurt, and high-protein baked products. Mung bean polyphenol and flavonoid extracts are also added to functional beverages, nutrition bars, and health foods as natural antioxidants. In the cosmetics industry, mung bean extracts are used in facial masks, facial cleansers, moisturizing lotions, and repair serums because of their antioxidant, soothing, and anti-inflammatory properties. Some Chinese botanical cosmetic brands and Korean functional skincare brands have also launched product lines containing mung bean extracts.

Mung bean starch has become an important industrial raw material and is widely used in the production of vermicelli, starch sheets, jelly products, transparent food packaging films, and biodegradable biomaterials. Companies such as Shandong Longda Food and Hebei Jinshahe have established large-scale production of mung bean vermicelli and starch sheet products. Longkou vermicelli, a protected geographical indication product of China, is partly produced with mung bean starch as the main raw material and is exported to Europe, North America, Japan, and Southeast Asian countries.

Author Contributions

The author conducted this study, including literature review, data analysis, and the drafting and revision of the manuscript. The author has read and approved the final version of the manuscript.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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