AkiNik

American Journal of Essential Oils and Natural Products

Available online at www.essencejournal.com

A J E O N P American Journal of Essential Oils and Natural Products

ISSN: 2321-9114
https://www.essencejournal.com
AJEONP 2024; 12(1): 74-79

Received: 16-05-2025
Accepted: 18-06-2025

Elina Kolarov
Institute of Plant Biology
Sofia Agricultural College, Sofia, Bulgaria

Ivan Dimitrov
Institute of Plant Biology
Sofia Agricultural College, Sofia, Bulgaria

Kristina Georgieva
Institute of Plant Biology
Sofia Agricultural College, Sofia, Bulgaria

Corresponding Author:
Elina Kolarov
Institute of Plant Biology
Sofia Agricultural College, Sofia, Bulgaria

Extraction and analysis of essential bioactive components from improved mung beans

Elina Kolarov, Ivan Dimitrov and Kristina Georgieva

Abstract
Mung beans (*Vigna radiata*) are a significant legume crop, renowned for their nutritional value and bioactive compounds. Recent advancements in agricultural practices have led to the development of improved mung bean varieties with enhanced yields and nutritional profiles. This paper delves into the extraction methodologies and analytical techniques employed to isolate and characterize the bioactive components of these improved varieties. Emphasis is placed on optimizing extraction processes to maximize yield and bioactivity. Furthermore, the therapeutic potentials of these bioactive compounds, including antioxidant, anti-inflammatory, and anti-diabetic properties, are discussed.

Keywords: Mung beans, *Vigna radiata*, bioactive compounds, improved varieties, extraction techniques, antioxidant activity, therapeutic potential, nutritional analysis

1. Introduction

Mung beans (*Vigna radiata*), commonly known as green gram, are one of the most important pulse crops globally, particularly in Asian countries, where they have been cultivated for over 3,000 years. They are well-known for their nutritional value, providing a rich source of plant-based protein, dietary fiber, vitamins, and essential minerals such as iron, magnesium, and potassium. Mung beans are versatile in culinary applications, commonly used in soups, stews, salads, and as an ingredient in various traditional dishes. Beyond their culinary uses, mung beans have long been recognized for their potential therapeutic effects, owing to the presence of bioactive compounds that exhibit various health benefits.

In recent years, the demand for functional foods and nutraceuticals has spurred extensive research into the health benefits of natural products, particularly plant-based foods like mung beans. These legumes have garnered attention due to their bioactive compounds, such as polyphenols, flavonoids, peptides, and polysaccharides, which have demonstrated antioxidant, anti-inflammatory, anti-diabetic, and immunomodulatory effects. As a result, mung beans are now considered a valuable functional food source with potential applications in the prevention and management of various chronic diseases.

While traditional mung beans have been studied for their bioactive components, recent advances in agricultural biotechnology have led to the development of improved mung bean varieties that possess enhanced nutritional profiles and higher levels of bioactive compounds. These improved varieties are typically bred for greater yield, improved resistance to pests and diseases, and higher concentrations of essential nutrients, making them an even more promising candidate for inclusion in functional food products.

The extraction and analysis of bioactive components from mung beans are crucial for unlocking their full therapeutic potential. However, the challenge lies in efficiently extracting these bioactive compounds without compromising their integrity or therapeutic efficacy. Traditional extraction methods, such as solvent extraction and maceration, have been widely used but often come with limitations such as long extraction times and the use of large volumes of solvents. More recent approaches, such as pressurized liquid extraction, ultrasonic-assisted extraction, and deep eutectic solvent-based extraction, have shown great promise in improving the efficiency and sustainability of the extraction process.

The growing interest in mung beans as a source of bioactive compounds has also led to the development of sophisticated analytical techniques to quantify and characterize these compounds. High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), and Fourier Transform Infrared (FTIR) spectroscopy are among the most widely employed methods for analyzing mung bean extracts. These techniques allow for the precise identification of bioactive components such as flavonoids, phenolic acids, and proteins, and provide valuable insights into their molecular structures and biological activities.

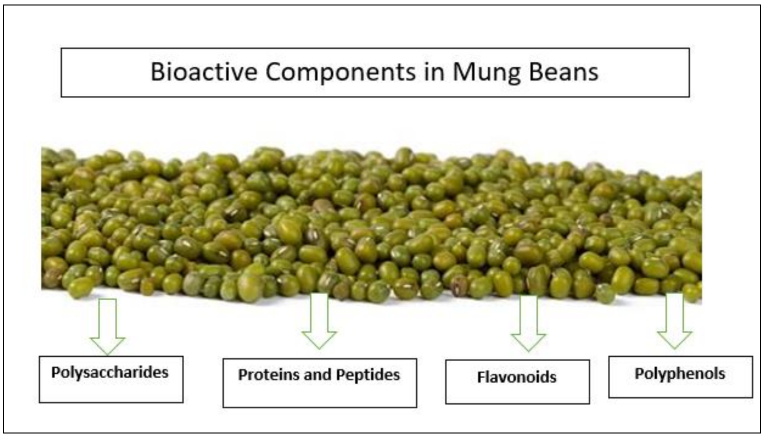
In light of the rising demand for functional foods, mung beans offer significant potential for integration into dietary supplements, functional beverages, and food products aimed at promoting overall health and preventing chronic diseases. Research into the bioactive components of mung beans, particularly those found in improved varieties, is critical for enhancing their therapeutic applications. Furthermore, understanding the optimal extraction techniques and analytical methods for identifying these bioactive components will play a crucial role in the development of mung bean-based products with proven health benefits.

In this paper, we explore the extraction methodologies and analytical techniques used to isolate and identify the bioactive components in improved mung bean varieties. The paper focuses on optimizing extraction processes to maximize the yield and bioactivity of mung bean bioactives. Moreover, we discuss the potential therapeutic benefits of these bioactive components, including their antioxidant, anti-inflammatory, and anti-diabetic properties, and their relevance in the development of functional foods and nutraceuticals.

By shedding light on the advancements in mung bean research and highlighting the methods used to extract and analyze their bioactive components, this paper aims to contribute to the growing body of knowledge on the potential uses of mung beans in health promotion and disease prevention. The findings presented here could pave the way for the development of novel mung bean-based products that provide consumers with natural, plant-based solutions to support their overall well-being.

2. Bioactive Components in Mung Beans

Mung beans (*Vigna radiata*) are an exceptional source of several bioactive compounds that contribute to their numerous health benefits. These compounds play a vital role in the therapeutic and preventive applications of mung beans. The bioactive components found in mung beans are primarily categorized into polyphenols, flavonoids, proteins and peptides, and polysaccharides, each contributing to the bean's antioxidant, anti-inflammatory, anti-diabetic, and immune-boosting properties. Below, we will explore each of these bioactive components in detail, along with examples and their respective health-promoting properties.



2.1 Polyphenols

Polyphenols are a group of naturally occurring compounds that have significant antioxidant properties. In mung beans, polyphenols are concentrated in the seed coat and include compounds such as phenolic acids, flavonoids, and tannins. These polyphenols play a key role in scavenging free radicals and preventing oxidative stress, a major factor in aging and the development of chronic diseases like heart disease, diabetes, and cancer.

A study by Ganesan and Xu (2018) [4] found that the polyphenol content in mung beans, especially in the seed coat, exhibited strong antioxidant properties that could help mitigate the effects of oxidative damage. The specific polyphenolic compounds found in mung beans include chlorogenic acid and caffeic acid, both of which have been linked to reducing inflammation and enhancing the immune system's ability to fight infections. These compounds may also play a role in enhancing the bioavailability of other nutrients by improving their absorption in the gut.

2.2 Flavonoids

Flavonoids are a subclass of polyphenols and are widely recognized for their antioxidant, anti-inflammatory, and anti-cancer properties. Mung beans contain several flavonoids, including vitexin, isovitexin, quercetin, and rutin. Among these, vitexin and isovitexin are the most studied, and they have been shown to exhibit potent antioxidant effects that help reduce oxidative stress and lower the risk of chronic diseases.

For instance, Zhang *et al.* (2020) demonstrated that the flavonoid vitexin found in mung beans helps inhibit the production of pro-inflammatory cytokines, which are responsible for inflammation in the body. Moreover, these flavonoids have shown promise in regulating blood sugar levels, which could aid in the management of type 2 diabetes.

2.3 Proteins and Peptides

Proteins are a critical component of mung beans, comprising a significant portion of the bean's nutritional content. Mung bean proteins are rich in essential amino acids, making them an excellent source of plant-based protein, especially for individuals who follow vegetarian or vegan diets. Upon hydrolysis, mung bean proteins release bioactive peptides, which have been shown to have several health benefits, including antihypertensive, antimicrobial, and antioxidant effects.

One of the key peptides derived from mung bean proteins is known as lunasin. Lunasin has been extensively studied for its ability to reduce blood pressure by inhibiting the angiotensin-converting enzyme (ACE), a key regulator of blood pressure. Additionally, mung bean-derived peptides have been found to possess antimicrobial activity, providing protection against harmful pathogens that may cause infections. These peptides also have the potential to aid in digestive health by supporting the growth of beneficial gut bacteria.

2.4 Polysaccharides

Mung bean polysaccharides, mainly found in the seed coat, play a significant role in maintaining gut health and modulating immune responses. These polysaccharides are non-digestible fibers that contribute to the prebiotic properties of mung beans. Prebiotics are compounds that stimulate the growth of beneficial bacteria in the gut, thus improving digestion and enhancing overall gut health.

Research by Li *et al*. (2019) found that the polysaccharides in mung beans could help modulate the immune system by enhancing the activity of immune cells such as macrophages and lymphocytes. In addition to their immune-boosting effects, these polysaccharides also exhibit antioxidant activity, contributing to the overall health benefits of mung beans.

Mung bean polysaccharides have also shown promise in managing blood sugar levels. These polysaccharides, when consumed, help slow down the absorption of glucose in the bloodstream, making them beneficial for individuals with diabetes or those at risk of developing the condition. They also help in managing cholesterol levels by reducing the absorption of fat in the digestive tract.

3. Extraction Techniques

The extraction of bioactive compounds from mung beans is crucial for unlocking their full therapeutic potential. Various extraction techniques are employed to isolate bioactive compounds such as polyphenols, flavonoids, proteins, peptides, and polysaccharides. The choice of extraction method plays a vital role in the yield, efficiency, and quality of the extracted compounds. In this section, we explore traditional and advanced extraction techniques used to extract bioactive components from mung beans, each with its own advantages and limitations.

3.1 Conventional Extraction Methods

Conventional extraction methods have long been the standard in the extraction of bioactive compounds from plant materials, including mung beans. These methods are relatively simple and well-established but often require large amounts of solvents, extended extraction times, and high energy inputs. Despite these limitations, they are still widely used due to their effectiveness in extracting a wide range of compounds.

3.1.1 Soxhlet Extraction

Soxhlet extraction is one of the most widely used methods for extracting bioactive compounds from plant materials. It works on the principle of continuous solvent extraction. The sample is placed in a thimble, and the solvent is continuously cycled through the sample. The solvent vaporizes, condenses, and extracts the bioactive compounds from the plant material, which are then collected in a flask. Soxhlet extraction is commonly used for extracting lipophilic compounds, such as flavonoids and polyphenols.

While Soxhlet extraction is effective, it has several drawbacks. It requires large volumes of solvents, long extraction times (usually several hours), and is energy-intensive. Additionally, the prolonged exposure to high temperatures may lead to the degradation of some heat-sensitive compounds. To address these drawbacks, modifications to the Soxhlet extraction process, such as using greener solvents or reducing extraction time, have been explored.

3.1.2 Maceration Extraction

Maceration is another traditional method in which plant material is soaked in a solvent (usually water or ethanol) for an extended period. The solvent extracts the bioactive compounds from the plant cells, and after soaking, the solution is filtered to separate the solvent and the extract. This method is commonly used for extracting water-soluble compounds like proteins and polysaccharides.

Maceration is simple and inexpensive, but it has limitations similar to Soxhlet extraction, including the use of large quantities of solvent and extended extraction times. The process can also result in the loss of volatile compounds due to the long soaking period, making it less effective for certain bioactives.

3.2 Advanced Extraction Techniques

Over the years, advanced extraction methods have been developed to improve the efficiency of bioactive compound extraction from mung beans while reducing the environmental impact. These methods often involve the use of new technologies, such as high pressure, ultrasound, or microwaves, to enhance the solubility and extraction yield of bioactive compounds. These techniques offer several advantages over traditional methods, such as shorter extraction times, reduced solvent usage, and increased extraction efficiency.

3.2.1 Pressurized Liquid Extraction (PLE)

Pressurized Liquid Extraction (PLE) is a modern and efficient technique for extracting bioactive compounds from plant materials. This method utilizes solvents under high pressure and temperature to enhance the extraction of compounds. The elevated pressure and temperature increase the solubility of bioactive compounds, allowing for faster extraction and reduced solvent usage.

PLE has been shown to be highly effective in extracting polyphenols and flavonoids from mung beans. Studies have demonstrated that PLE can extract a higher yield of these compounds in less time compared to traditional methods. Moreover, PLE is considered a greener method as it requires smaller volumes of solvents and operates at lower temperatures, thereby preserving the integrity of heat-sensitive compounds.

PLE can be further optimized by adjusting parameters such as solvent type, temperature, pressure, and extraction time. The ability to fine-tune these parameters allows for the selective extraction of specific bioactive compounds, making PLE a versatile and sustainable extraction method.

3.2.2 Ultrasonic-Assisted Extraction (UAE)

Ultrasonic-Assisted Extraction (UAE) is an advanced technique that uses high-frequency sound waves to generate cavitation bubbles in the solvent. These bubbles create microscopic bubbles that implode, producing intense energy that disrupts plant cell walls and facilitates the release of bioactive compounds into the solvent. This process accelerates the extraction of bioactive compounds while reducing the need for prolonged extraction times and high solvent volumes.

UAE has been widely used for extracting polysaccharides, proteins, and peptides from mung beans. Studies have shown that UAE can significantly improve the yield of polysaccharides and proteins from mung beans compared to conventional extraction methods. UAE also allows for better

extraction efficiency by reducing the need for high temperatures, which can degrade some bioactive compounds.
UAE is also considered an environmentally friendly extraction method, as it uses less energy and solvent than traditional techniques, making it more sustainable.

3.2.3 Microwave-Assisted Extraction (MAE)
Microwave-Assisted Extraction (MAE) is another advanced technique that uses microwave energy to heat solvents in contact with plant material. The microwaves cause rapid heating, which increases the solubility of bioactive compounds and facilitates their extraction from plant cells. This method is highly efficient and reduces extraction time significantly compared to traditional methods.
MAE has been shown to be particularly effective in extracting polyphenols and flavonoids from mung beans. The microwave energy helps release bioactive compounds more quickly and with higher yields. MAE also minimizes the degradation of heat-sensitive compounds by reducing the exposure time to high temperatures. Additionally, the technique uses minimal solvent, making it an environmentally friendly alternative to conventional extraction methods.
Research has shown that MAE can extract a wide range of bioactive compounds from mung beans in a short amount of time. This makes it an attractive option for large-scale production of mung bean extracts used in the food and nutraceutical industries.

3.2.4 Supercritical Fluid Extraction (SFE)
Supercritical Fluid Extraction (SFE) utilizes supercritical fluids, such as carbon dioxide, as solvents to extract bioactive compounds from plant materials. Supercritical fluids possess properties of both liquids and gases, which allow them to penetrate plant material more easily, facilitating efficient extraction. SFE offers several advantages, including high extraction efficiency, minimal solvent usage, and the ability to extract a wide range of compounds, including both lipophilic and hydrophilic substances.
SFE is particularly effective in extracting lipophilic compounds such as flavonoids, oils, and fatty acids from mung beans. However, the high equipment cost and the need for specialized technology make SFE less accessible for small-scale operations. Despite these challenges, SFE remains an attractive method for large-scale extraction of high-value bioactive compounds from mung beans and other plant materials.

3.3 Comparison of Extraction Techniques
The table below summarizes the key features of traditional and advanced extraction methods, comparing their efficiency, environmental impact, and suitability for extracting specific bioactive compounds from mung beans.

Extraction Method	Efficiency	Environmental Impact	Suitable Compounds	Time/Cost
Soxhlet Extraction	High	High solvent usage, energy-intensive	Lipophilic compounds (flavonoids, polyphenols)	Long extraction time, high solvent consumption
Maceration Extraction	Moderate	High solvent usage, energy-intensive	Water-soluble compounds (proteins, polysaccharides)	Long extraction time
Pressurized Liquid Extraction (PLE)	Very High	Low solvent usage, efficient	Polyphenols, flavonoids	Short extraction time, moderate cost
Ultrasonic-Assisted Extraction (UAE)	High	Low energy consumption, efficient	Polysaccharides, proteins, peptides	Short extraction time, low cost
Microwave-Assisted Extraction (MAE)	Very High	Low solvent usage, efficient	Polyphenols, flavonoids	Very short extraction time, moderate cost
Supercritical Fluid Extraction (SFE)	High	Low solvent usage, efficient	Lipophilic compounds (flavonoids, oils)	High equipment cost, short extraction time

4. Analytical Techniques
Once the bioactive components are extracted from mung beans, it is crucial to employ analytical techniques to identify, quantify, and characterize these compounds. Analytical methods play a key role in determining the chemical composition of the extracts, assessing the purity of bioactive compounds, and evaluating their potential health benefits. A variety of advanced analytical techniques are used to analyze mung bean extracts, including chromatography, spectroscopy, and mass spectrometry. These techniques allow researchers to gain detailed insights into the molecular structure, functional groups, and biological activities of the bioactive components present in mung beans.
In this section, we will discuss the most commonly employed analytical techniques for the characterization of bioactive compounds in mung beans, including High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), Fourier Transform Infrared Spectroscopy (FTIR), and Nuclear Magnetic Resonance (NMR) Spectroscopy. Each of these methods has unique strengths, making them suitable for different types of bioactive compound analysis.

4.1 High-Performance Liquid Chromatography (HPLC)
High-Performance Liquid Chromatography (HPLC) is one of the most widely used techniques for separating and quantifying bioactive compounds in plant extracts. HPLC involves passing a liquid sample through a column packed with a stationary phase (typically a solid or liquid). As the sample flows through the column, the different components in the sample interact with the stationary phase in different ways, causing them to separate. A detector at the end of the column measures the concentration of each separated component, providing information about the identity and quantity of the compounds.
HPLC is highly effective for analyzing polyphenols, flavonoids, and phenolic acids in mung beans. It can also be used to quantify individual bioactive compounds, such as vitexin, isovitexin, and rutin, which are known to exhibit antioxidant and anti-inflammatory properties. The method offers high sensitivity, precision, and accuracy, making it suitable for both qualitative and quantitative analysis of bioactive compounds.
For example, Zhang *et al.* (2020) used HPLC to identify and quantify the flavonoids present in mung beans, particularly focusing on vitexin and isovitexin, which are key bioactive

compounds contributing to the antioxidant properties of mung beans.

Applications of HPLC in Mung Bean Analysis

- **Quantification of Polyphenols and Flavonoids:** HPLC is used to measure the concentration of polyphenolic compounds such as chlorogenic acid and flavonoids like vitexin and isovitexin.
- **Separation of Bioactive Compounds:** HPLC separates individual compounds from complex mixtures, providing detailed profiles of the bioactive components in mung bean extracts.

4.2 Gas Chromatography-Mass Spectrometry (GC-MS)

Gas Chromatography-Mass Spectrometry (GC-MS) is a powerful analytical technique used to identify and quantify volatile compounds in plant extracts. In GC-MS, the sample is first vaporized and then passed through a chromatographic column. The compounds in the sample are separated based on their volatility and affinity for the stationary phase in the column. Once separated, the compounds are ionized and detected by a mass spectrometer, which provides information about their molecular weight and structure.

GC-MS is particularly useful for identifying volatile compounds such as essential oils, fatty acids, and aromatic compounds in mung beans. While this technique is not typically used for polar bioactive compounds such as polyphenols or flavonoids, it is ideal for analyzing the volatile fraction of mung bean extracts, which may include compounds contributing to the aroma and flavor of the beans.

Applications of GC-MS in Mung Bean Analysis

- **Identification of Volatile Compounds:** GC-MS can identify essential oils and other volatile compounds present in mung beans, which may have antimicrobial or antioxidant properties.
- **Analysis of Fatty Acids:** GC-MS is often used to profile fatty acids in plant extracts, which can have beneficial effects on human health, particularly for cardiovascular health.

4.3 Fourier Transform Infrared (FTIR) Spectroscopy

Fourier Transform Infrared (FTIR) Spectroscopy is a technique used to identify functional groups and molecular structures of bioactive compounds in plant extracts. FTIR works by passing infrared light through a sample and measuring the absorption of light at various wavelengths. The resulting spectrum provides information about the functional groups present in the compounds, such as alcohols, phenols, amines, and carboxylic acids.

FTIR is useful for characterizing the molecular structure of bioactive compounds such as polyphenols, flavonoids, and polysaccharides in mung bean extracts. It can also be used to study the interactions between bioactive compounds and other components in the extract, such as proteins and lipids. FTIR is a non-destructive method that requires minimal sample preparation and is often used in combination with other techniques, such as HPLC, to obtain a comprehensive profile of the bioactive compounds.

Applications of FTIR in Mung Bean Analysis

- **Characterization of Polyphenolic Compounds:** FTIR can be used to identify key functional groups in polyphenols and flavonoids present in mung bean extracts.
- **Structural Analysis of Polysaccharides:** FTIR is helpful in analyzing the polysaccharides found in mung beans, particularly those with immunomodulatory and antioxidant properties.

4.4 Nuclear Magnetic Resonance (NMR) Spectroscopy

Nuclear Magnetic Resonance (NMR) Spectroscopy is a powerful analytical tool used to elucidate the detailed molecular structure of bioactive compounds. In NMR, the sample is exposed to a strong magnetic field, causing the nuclei of certain atoms (such as hydrogen or carbon) to resonate at specific frequencies. The resulting spectrum provides information about the chemical environment of these nuclei, allowing researchers to determine the structure of the compound.

NMR is particularly useful for identifying complex bioactive compounds, such as peptides and polysaccharides, which may be difficult to analyze using other methods. NMR can provide detailed information about the molecular structure, including the arrangement of atoms and the connectivity between different functional groups. This makes NMR an essential tool for the structural elucidation of novel bioactive compounds derived from mung beans.

Applications of NMR in Mung Bean Analysis

- **Structural Elucidation of Bioactive Peptides:** NMR is used to determine the amino acid sequence and three-dimensional structure of bioactive peptides derived from mung beans.
- **Characterization of Polysaccharides:** NMR provides detailed information about the sugar composition and structure of polysaccharides found in mung beans, which are responsible for their immunomodulatory and antioxidant properties.

5. Therapeutic Potentials

The bioactive components extracted from improved mung bean varieties exhibit various therapeutic potentials:

- **Antioxidant Activity:** Phenolic compounds and flavonoids in mung beans possess strong antioxidant properties, which help in scavenging free radicals and reducing oxidative stress. This activity is crucial in preventing chronic diseases such as cardiovascular diseases and cancer.
- **Anti-Inflammatory Effects:** Mung bean extracts have demonstrated the ability to modulate inflammatory pathways, thereby reducing inflammation. This property is beneficial in managing conditions like arthritis and inflammatory bowel diseases.
- **Anti-Diabetic Properties:** Certain compounds in mung beans can inhibit enzymes like α-glucosidase, leading to reduced postprandial blood glucose levels. This makes mung beans a potential functional food for diabetes management.
- **Cardio protective Effects:** Studies have shown that mung bean polyphenol extracts can protect against cardiotoxicity induced by agents like aluminum, possibly through the modulation of oxidative stress and inflammatory pathways.

6. Conclusion

Improved mung bean varieties offer a rich source of bioactive components with significant therapeutic potentials.

Advancements in extraction and analytical techniques have enhanced the ability to isolate and characterize these bioactives efficiently. The therapeutic properties of mung bean bioactive compounds, including antioxidant, anti-inflammatory, and anti-diabetic effects, underscore their potential as functional foods and nutraceuticals. Further research and development are essential to fully harness the benefits of these bioactive components in health promotion and disease prevention.

References

1. Hou D, *et al*. Mung bean (*Vigna radiata* L.): Bioactive polyphenols, polysaccharides, peptides, and health benefits. Front Plant Sci. 2019;10:1046. https://doi.org/10.3389/fpls.2019.01046
2. Supasatyankul B, *et al*. Extraction of phenolic and flavonoid compounds from mung bean (*Vigna radiata* L.) seed coat by pressurized liquid extraction. Molecules. 2022;27(7):2085. https://doi.org/10.3390/molecules27072085
3. Kebede ZY. Case study report on improved mung bean technology demonstration under North-West Ethiopia. Int J Agric Food Sci. 2022;4(1):35-37.
4. Ganesan K, Xu B. A critical review on phytochemical profile and health promoting effects of mung bean (*Vigna radiata*). Food Sci Hum Wellness. 2018;7(1):11-22. https://doi.org/10.1016/j.fshw.2017.11.002
5. Yi-Shen Z, *et al*. Mung bean proteins and peptides: Nutritional, functional and bioactive properties. Food Nutr Res. 2018;62:1290. https://doi.org/10.29219/fnr.v62.1290
6. Du H, *et al*. Extraction technology of flavonoids from mung bean hull. CAB International. 2020. https://doi.org/10.5555/20219973087