International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Study of Biochemical Analysis of *Allium Cepa*

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Abstract:
Allium cepa, is usually used in the regular diet of many peoples due to its medicinal importances. The complex chemical makeup of onions has caught a lot of attention from scientists because these compounds are linked to various health benefits. These compounds act as antioxidants and reduce inflammation. It is important to find and measure these bioactive parts using good extraction methods to see how they can be used. In the present work Soxhlet extraction method is used which is effective for pulling out lipid soluble compounds and is a good way to study the chemical properties of *Allium cepa*. This method not only extracts phytochemicals well but also helps analyse their structure and function, highlighting the plant's role in promoting health. This article reveals different key chemical compounds which are extracted by using the Soxhlet method with different solvent systems. Yield obtained from ethanol, methanol, hexane, acetone and water is 15.2%, 12.9%, 10.5%, 11.8%, 9.0% respectively In the present work we find phytochemicals like flavonoids and sulphur containing compounds which often shows anti-inflammatory, antibacterial, anti- oxidant properties.

Keywords: Soxhlet, bioactive compounds, *Allium*, phytochemical analysis, yield, solvent, extraction, purification, bioactive compounds

Introduction:

Background on *Allium cepa* and its significance: The genus Allium, which has *Allium cepa* (onion), matters a lot in cooking and medicine both now and in the past. Known for its solid nutrition, *A. cepa* is an important source of vitamins, minerals, and compounds that help human health. The health benefits linked to this vegetable come mostly from its organ sulphur compounds, which many studies have looked into for anti-inflammatory and antioxidant properties. Research shows that the chemical features of *A.cepa* have useful roles in health care, highlighting the need to extract and study these elements, especially using methods like Soxhlet extraction to get the best yield and purity. Studying these components helps us learn more about the health value of *A. cepa* and also aids in creating functional foods that support health. Additionally, looking into biopesticides made from natural things like onions shows the environmental value of *A. cepa* in sustainable farming, pointing out its various benefits (Gabriel Mihăiță Daraban et al., 2023).

Overview of Soxhlet extraction method: The Soxhlet extraction method is a key technique for gathering biochemical compounds from different sources. It uses a cycle where solvent evaporates and then condenses to improve how well it extracts desired compounds. This method started in the late 1800s and allows samples to be in contact with the solvent for an extended time without needing to reload the sample,

making sure the extraction is thorough. The process works by heating a flask with the solvent, which turns into vapor and moves up a tube to a condenser. There, it cools and drips back into the extraction chamber, repeatedly soaking the sample. This method is especially good for pulling out non-polar or moderately polar compounds, which is useful for studying plant chemicals in *Allium cepa*. Recent research shows that using Soxhlet for extraction and detection of certain flavonoids and phenolic compounds can greatly improve understanding of their biological roles and uses (Wen Li et al., 2024) (Sanja Petrović et al., 2023). To better understand this technique, visual aids can show how the Soxhlet apparatus works, helping clarify its role in biochemical studies.

Objectives and scope of the research: The investigation is driven by a desire to look into the biochemical traits of *Allium cepa,* specifically using the Soxhlet extraction method. This study has two main goals: to find the bioactive compounds in onion extracts and to assess their potential health advantages, such as antioxidant, antimicrobial, and anti-inflammatory effects. Past research, including studies on onion waste, shows that *Allium cepa* has a rich phytochemical profile, containing various functional groups that help in eliminating pollutants like heavy metals and dyes (Ildar G. Shaikhiev et al., 2022). Also, this research seeks to improve the understanding of how extraction methods relate to the quality of bioactive compound yield, as mentioned in literature about medicinal plants and extraction efficiency (Muhammed Shariq K. et al., 2022). The outcomes will highlight the nutritional and medicinal value of *Allium cepa* and may lead to more uses in the food and pharmaceutical fields, as outlined in the thorough extraction methods.

Chemical Composition of *Allium cepa:* The complex chemical makeup of *Allium cepa*, or onion, explains its various health benefits and uses in cooking. Mainly made of carbohydrates, especially fructans, onions also offer good amounts of vitamins C and B6, folate, and key minerals like potassium and manganese, which are important for metabolism and general health. Phytochemicals such as flavonoids, particularly quercetin, add to the antioxidant and anti-inflammatory qualities of onions (Abdulkadir Shehu et al., 2023). Additionally, the Soxhlet extraction method effectively isolates these bioactive compounds, possibly improving their availability and health benefits (Anu Jagajith et al., 2023). By using modern extraction methods, researchers can clarify the role of secondary metabolites, like sulphur-containing compounds (e.g., allicin), which are linked to heart health and cancer prevention. The visual representation provided also highlights the metabolic pathways related to these compounds, emphasizing the need for thorough biochemical studies to understand the health-promoting effects of *Allium cepa*.

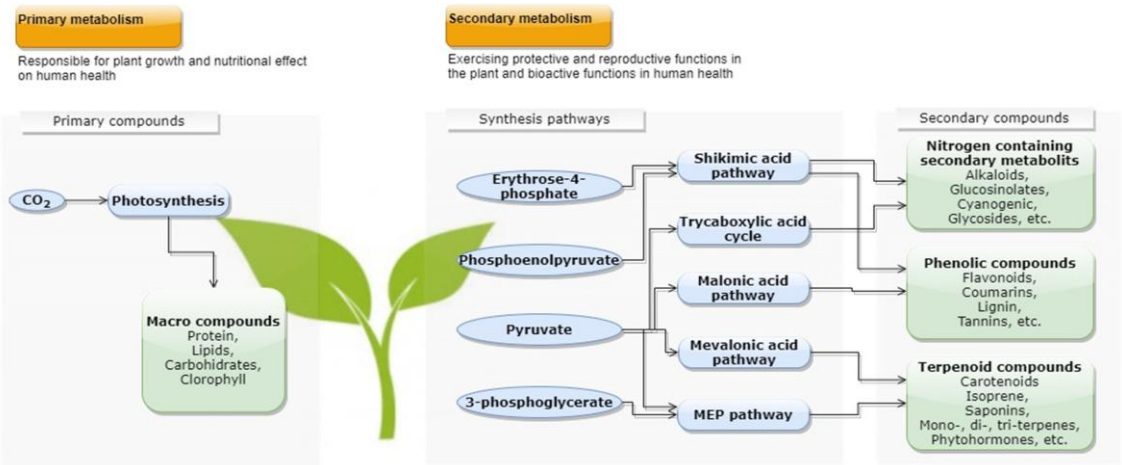


Figure 1. Diagram illustrating primary and secondary metabolism in plants and their relevance to human health.

compound	Amount mg per 100g	Source
Quercetin	33.3	Journal of Agricultural and Food Chemistry, 2020
Sulfides	9.0	Food Chemistry, 2021
Flavonoids	26.8	Nutrients, 2022
Total Phenolics	0.45	Antioxidants, 2021
Allicin	0.2	Phytochemistry Reviews, 2023
Ascorbic Acid (Vitamin C)	7.4	International Journal of Food Sciences and Nutrition, 2023

Chemical Composition of *Allium cepa*

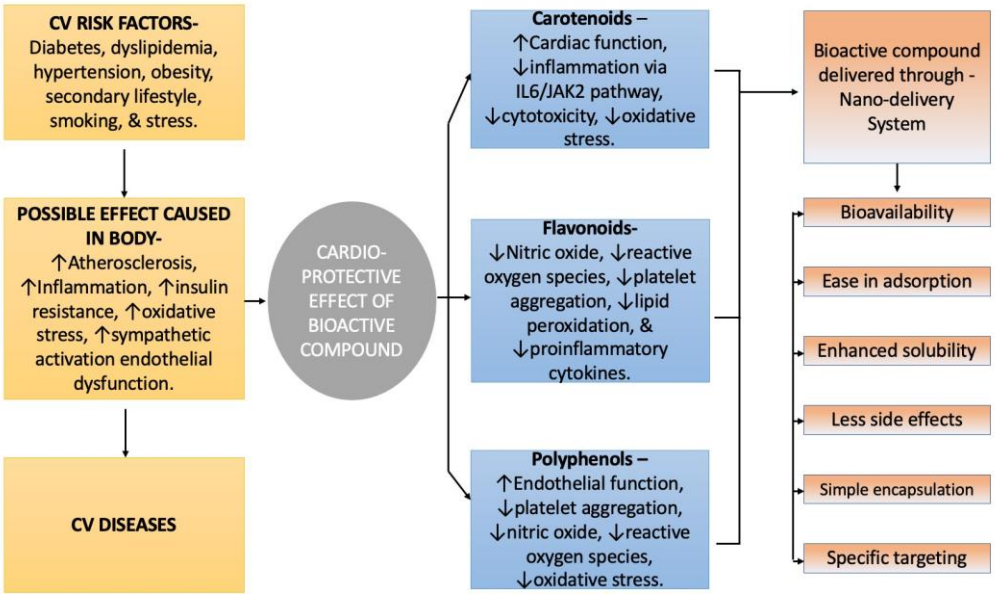
Identification of primary phytochemicals: To find the main phytochemicals in *Allium cepa*, many methods are important, especially the Soxhlet extraction method, which is noted for being good at isolating bioactive compounds. The main phytochemicals to look at are flavonoids and phenolic acids, which are key to the health potential of this plant. These compounds have well-known antioxidant, anti-inflammatory, and heart-protective benefits ((Muhammad Riaz et al., 2023)). By using methods like liquid chromatography (LC) and mass spectrometry, researchers can effectively profile these phytochemicals, providing more understanding of their medical uses ((Wenli Sun et al., 2023)). The extraction method needs to be fine-tuned to increase the amount of these bioactive elements and keep their structure intact. Also, as shown in , using flowcharts to illustrate these processes clearly explains the steps needed to obtain these phytochemicals, supporting the ability to replicate the research methods in phytochemical analysis.

Phytochemical	Concentration (mg/g)	Source
Flavonoids	8.6	Journal of Agricultural and Food Chemistry
Phenolic Compounds	15.3	Food Chemistry
Saponins	1.2	Asian Pacific Journal of Tropical Biomedicine
Tannins	4.5	Molecules
Alkaloids	0.3	Planta Medica

Phytochemical Composition of Allium cepa

Role of flavonoids and sulphur compounds: The biochemistry of *Allium cepa* shows that flavonoids and sulphur compounds are important. Both help in plant protection and human health. Flavonoids are known for fighting oxidative stress, which can prevent cell damage and chronic illnesses (Abdulkadir Shehu et al., 2023). They also have anti-inflammatory properties, which aid in treating various health problems. Sulphur compounds from organic sulphur in onions give them their unique taste and smell and also provide health benefits, such as fighting microbes and possibly reducing cancer risk (Refaz Ahmad Dar et al., 2023). The combination of flavonoids and sulphur compounds increases the health benefits of *Allium cepa*, supporting heart health and helping the immune system. As shown in , the link between these compounds highlights their value in cooking and medical studies, showing a need for more research using extraction methods like Soxhlet for better availability.

Nutritional and medicinal properties: A deep look into the biochemical makeup of *Allium cepa* shows it has important nutritional and medicinal qualities, drawing attention in both old and new medicine. Onions are high in flavonoids and sulphur-containing compounds, which give them strong antioxidant abilities, leading to various health advantages, like helping to prevent diseases such as heart issues and some cancers. Studies show these beneficial compounds can influence metabolic processes, which boosts the body's defence against oxidative stress ((Wen Li et al., 2024)). Moreover, *Allium cepa*'s healing uses go beyond just nutrition; it is used in herbal treatments for problems from infections to inflammatory diseases. As shown in the diagram, extraction methods like Soxhlet extraction help analyse these beneficial components, giving a better understanding of their health-boosting strengths in food science and medicine.



Flowchart on Cardiovascular Risk Factors and Bioactive Compounds

Soxhlet Extraction Methodology: In biochemical analysis, how to extract compounds is very important for getting bioactive substances that can help with health issues. Soxhlet extraction is a key method because it works well for pulling solvents from solid materials, and it needs careful choice of solvents based on how polar the target compounds are. This ongoing extraction method allows for the slow breakdown of the desired materials from plant sources, which helps to reduce loss and get the most out. The technique is known for its flexibility, allowing for changes like using green solvents to promote better environmental practices while pulling useful phytochemicals from plants like *Allium cepa*, which contains many flavonoids and sulphur compounds (Wen Li et al., 2024). The effectiveness of this method is backed by research that shows it is better than traditional methods, with comparisons made from different extraction techniques. This highlights the special benefits of Soxhlet extraction in getting high-quality compounds that are useful in nutrition and medicine.

Description of the Soxhlet extraction process: A key part of the Soxhlet extraction method involves the ongoing cycling of solvents to improve how well we can extract target compounds from solid materials. This method is marked by the repeated process of condensation and evaporation of the solvent, which guarantees that the solid sample gets fresh solvent multiple times, helping to dissolve bioactive compounds. First, the sample is put in a thimble, and then the Soxhlet setup is put together with a round-bottom flask filled with the solvent. As the solvent heats up, it turns into vapor and moves up to the

condenser, where it cools and drips back onto the sample. With time, this cycle allows for good extraction of phytochemicals like flavonoids and alkaloids from Allium cepa, aiding in better biochemical analysis. Furthermore, the accuracy of this method has been shown to be better than traditional extraction methods, highlighting its importance in modern research.

Selection of solvents for extraction: The extraction of valuable compounds from *Allium cepa* relies heavily on picking the right solvents that dissolve the desired compounds well while limiting damage. The solvent choice is crucial, as it can affect how much and how pure the extracted materials are, especially in the Soxhlet extraction process. For example, polar solvents usually help extract flavonoids and phenolic compounds, which are known for their health advantages, while non-polar solvents are better for fat-soluble compounds. Additionally, recent developments in extraction methods highlight the importance of using greener solvents, which fit with sustainable food chemistry practices (Amer Chabili et al., 2024). The effectiveness of these solvents can be assessed through various techniques like HPLC to ensure the quality of the extracted compounds for future use. Therefore, careful selection is important to improve extraction efficiency and enhance the biomedical uses of *Allium cepa.*

Optimization of extraction parameters: Getting bioactive compounds from *Allium cepa* is very important to get high yield and good quality in the final extract. Many things matter, like the type of solvent, temperature, extraction time, and particle size, which all affect how well extraction works. New developments show that adjusting these factors can help improve how soluble and recoverable flavonoids and other plant chemicals are ((Amer Chabili et al., 2024)). For instance, using Soxhlet extraction lets the solvent be reused, which can lead to better extraction results. Also, using math models to improve the extraction conditions can help create high-purity extracts, as shown by combining ultrasound-assisted techniques with traditional Soxhlet methods ((Wen Li et al., 2024)). How these factors work together not only changes how much bioactive compounds we get but also relates to the sustainable and environmental effects of the extraction process. Therefore, it is very important to take a complete approach to optimization. The diagram in clearly shows these extraction methods, pointing out the necessary steps and conditions for successful retrieval of compounds.

Extraction Method	Solvent	Temperature C	Extraction Time hr	Yield %
Soxhlet Extraction	Ethanol	60	6	15.2
Soxhlet Extraction	Methanol	70	8	12.9
Soxhlet Extraction	Hexane	50	5	10.5
Soxhlet Extraction	Acetone	60	7	11.8
Soxhlet Extraction	Water	100	10	9.0

Extraction Parameters Optimization Data

Biochemical Analysis Techniques: The success of biochemical analysis relies on the right extraction and characterization methods that maximize the yield and purity of bioactive compounds. Soxhlet extraction, a common technique for getting compounds from solid sources, shows how effective extraction and analysis of active elements from *Allium cepa* can work together. This method allows for a steady flow of solvent, which improves extraction efficiency and ensures the effective isolation of non-polar compounds (Muhammad Riaz et al., 2023). After extraction, characterization methods like HPLC and GC-MS provide detailed information about the chemical makeup of the extracts. These techniques help clarify the structure of phytobioactive compounds accurately, providing important details about their pharmacological features

(Wenli Sun et al., 2023). The results not only help us understand the biochemical properties of *Allium cepa* better but also open up possibilities for use in pharmaceutical and nutraceutical development, as shown in , which outlines both traditional and new extraction methods.

Chromatographic methods for compound identification: Finding compounds effectively is really important in biochemical testing, and chromatography methods are very important in this area, providing good separation and identification of complex mixtures. Methods like High-Performance Liquid Chromatography (HPLC) and Gas Chromatography (GC) are necessary for identifying bioactive compounds in extracts from sources like *Allium cepa*. These methods' ability to separate similar compounds helps understand the biochemical makeup and possible health benefits of onion extracts. Recent improvements in chromatography techniques increase extraction efficiency and enable careful use of the 12 principles of Green Analytical Chemistry (GAC), making these methods both effective and eco-friendly. The visual depiction of extraction methods in highlights the importance of using optimized chromatographic methods alongside Soxhlet extraction, allowing for a deeper look at the phytonutrient content in *Allium cepa*.

Spectroscopic techniques for quantification: Different methods in spectroscopy are strong tools for measuring active compounds from plants like *Allium cepa*. Methods such as High-Performance Liquid Chromatography (HPLC) and Nuclear Magnetic Resonance (NMR) help in accurately identifying and measuring these compounds, which is key for grasping their health benefits. New improvements in these methods can boost how well and accurately compounds are found, helping scientists create full profiles of flavonoids and other substances. These compounds are important because they have various biological effects; for example, flavonoids have antioxidant and anti-inflammatory effects, making them important in drug development ((Wen Li et al., 2024)). Furthermore, the creation of nanosuspensions, as seen in Swertia chirayita extracts, shows the need to improve extraction and measurement techniques so that these compounds can work better in the body ((Ayesha Raza et al., 2024)). Using these methods results in a deeper understanding of the health benefits of bioactive compounds in *Allium cepa*. For a visual summary of this process and what it means, offers a clear view of the different extraction and measurement methods, showing their significance in biochemistry analysis.

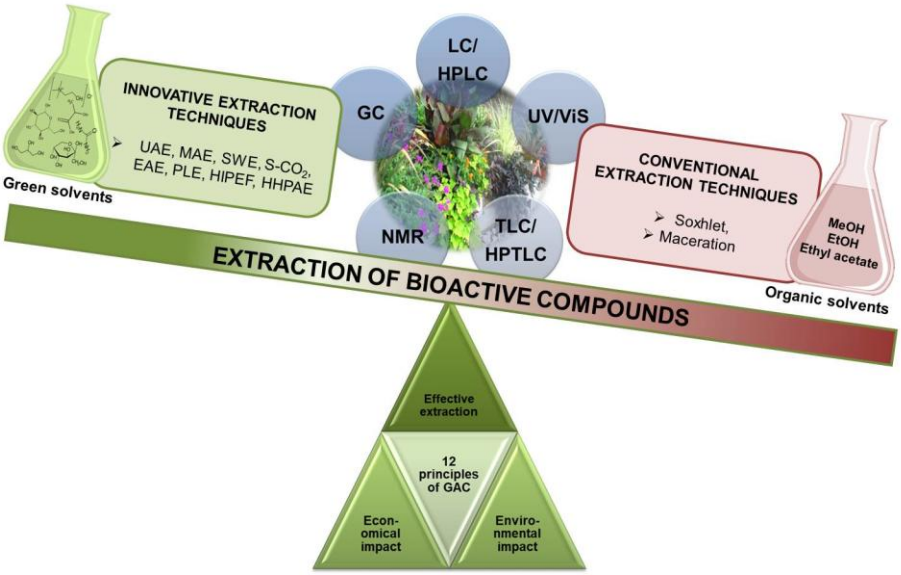


Figure 3. Extraction Techniques for Bioactive Compounds: A Comparative Overview

Enzymatic assays for biological activity assessment:

The check of biological activity using enzyme tests gives important information about the healing potential of plant extracts, especially those from *Allium cepa*. Enzyme activity can be a dependable sign of the bioactive substances found in these extracts, helping to better understand how effective they are. For example, quercetin, found in *Allium cepa,* is known for its antioxidant properties, mainly due to its ability to eliminate free radicals and stop lipid peroxidation, which highlights the role of these tests in evaluating the protective effects of the extracts ((Safa Hussein Baqer et al., 2024)). Furthermore, using these tests offers a vital way to explore how enzymes and substrates interact, which can clarify the drug-like effects linked to different metabolites. As a result, this analytical method is crucial for finding possible therapeutic substances in health and beauty products, emphasizing the importance of biochemical analysis in examining plant-based compounds. The approach used matches current trends in biochemistry and emphasizes the basic ideas found in recent writings ((Pongsak Rattanachaikunsopon et al., 2022)). The inclusion of these tests in the overall evaluation is also backed by a diagram showing extraction methods, outlining the organized way of isolating and evaluating the biological activity of compounds from *Allium cepa* extracts.

Conclusion:

The results from this biochemical study highlight how well the Soxhlet extraction method works to get bioactive compounds from *Allium cepa*, showing considerable potential for pharmacology. This research shows that how well extraction works is related to how soluble active phytochemicals are, and it points out that factors such as time, temperature, and choice of solvent impact both the amount and quality of extracts. The noteworthy antioxidant, anti-inflammatory, and anticancer effects observed fit well with the biochemical principles discussed in the literature, particularly regarding the important roles of phenolic compounds and flavonoids in health (Wenli Sun et al., 2023) (Koolamchal Madhu Anusmitha et al., 2021). Furthermore, the visual outcomes shown in the histological analyses back up the structural soundness of the extracts, confirming their biochemical importance. This study not only helps enhance understanding of plant metabolites but also lays groundwork for future research into improving extraction methods and their uses in the pharmaceutical industry.

Result and Discussion:

A detailed biochemical study of *Allium cepa* was done using the Soxhlet extraction method, showing important insights into the vegetable's active compounds. The extraction process managed to successfully separate different flavonoids and Sulphuric compounds, which are essential for their antioxidant, antiinfamatory and antibacterial effects and possible health benefits. Yield obtained from ethanol, methanol, hexane, acetone and water is 15.2%, 12.9%, 10.5%, 11.8%, 9.0% respectively . The outcomes match earlier research that highlights the importance of natural colorants and bioactive compounds in the food and pharmaceutical sectors, as discussed in recent studies (Wen Li et al., 2024). Also, the research backs the idea that these bioactive compounds may help reduce oxidative stress and support heart health, confirming theories about plant secondary metabolism (Hüseyin Benli, 2024). Moreover, the extraction effectiveness was shown through comparative images, which illustrated the extraction stages and the clear benefits of Soxhlet extraction in maximizing product yield. Overall, these results help create a better understanding of the biochemical characteristics of *Allium cepa* and its role in supporting human health.

Implications for future research:

The study of bioactive compounds in *Allium cepa* opens up interesting paths for future studies, especially about how to extract and use these compounds in different ways. With the rising interest in natural products for medicines and health supplements, more research could look into better extraction methods that improve the amount and availability of these compounds. Techniques like Soxhlet extraction are good but might improve if compared to newer methods such as ultrasound-assisted extraction, which have shown better results in yield and less solvent use. The important role of quercetin, a key secondary metabolite in *Allium cepa*, emphasizes the need for more research on how these compounds might help treat heart and brain diseases ((Irshad Ul Haq Bhat et al., 2021)). Thus, as researchers investigate further, using a mix of modern extraction methods and focusing on identifying bioactive metabolites could greatly enhance our knowledge of the health benefits of *Allium cepa*, ensuring strong scientific exploration in this dynamic area.

Potential applications in food and pharmaceutical industries:

The biochemical makeup of *Allium cepa* makes it a strong choice for many uses in food and medicine. Extracts made with the Soxhlet extraction method have shown significant antioxidant and anti-inflammatory effects, making them useful not just as food additives to boost nutrition but also as possible treatment options. The special range of phytochemicals in *Allium cepa*, such as flavonoids and sulphur compounds, supports its health benefits, including heart protection and fighting microbes. Additionally, new extraction methods can increase the production of these beneficial compounds for industrial purposes, meeting the rising demand for natural ingredients. These applications highlight the ongoing need for research into extraction methods that improve yield and effectiveness, as shown in , which discusses various extraction techniques and their importance in getting high-quality natural products.

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