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*Review Report*



# Polysaccharide Based-Mucilage and Their Adhesion, Textile and Paper Applications

**Uwa Orji Uyor[1*], Patricia Abimbola Popoola[1], Olawale Popoola[2]**

[1]Department of Chemical, Metallurgical & Materials Engineering, Tshwane University of Technology, P.M.B X680, Pretoria 0001, South Africa
[2]Department of Electrical Engineering, Tshwane University of Technology, P.M.B X680, Pretoria 0001, South Africa

***Correspondence:** Uwa Orji Uyor, Department of Chemical, Metallurgical & Materials Engineering, Tshwane University of Technology, P.M.B X680, Pretoria 0001, South Africa (Email: UyorUO@tut.ac.za).

**Abstract:** Mucilage are bio-substances derived from plants or microorganisms that have positive effects on health, including boosting the immune system, calming the gastrointestinal tract, and decreasing blood pressure. Overall, recent developments in mucilage research have shown the materials' potential for usage in variety of other fields, including adhesion or binding, textiles, papers, etc. However, there is limited widespread knowledge on the characteristics and use of mucilage in adhesion, textile, and paper industries. Therefore, this review navigates through the mucilage's chemical structure, and thermal, mechanical, physiochemical, and phytochemical features, weaving together their advanced applications. As the scientific community continues to unravel the advantages of mucilage extracts and harness their untapped potential, this review serves as both a testament to past achievements and a beacon guiding researchers towards a future enriched by the possibilities they hold.

**Keywords:** Binder, Mucilage, Phytochemical, Physiochemical, Textile

## 1. Introduction

Mucilage can be described as the synthesis of slimy substances, which are distinguished by their useful thickening, gelling, and binding properties (Kolhe, Kasar, Dhole, & Upadhye, 2014) and the microorganisms used for mucilage extraction, which shares significant similarities with that of mucilage (Del Negro et al., 2005). This area is populated by a variety of microbes, each of which produces distinct mucilage-like compounds that are useful tools in a variety of fields. They all have a polysaccharide-rich makeup, which makes them excellent options for increasing the texture, viscosity, and stability of products. Microorganisms have carved out important positions in a variety of fields when it comes to applications. Their contributions are advantageous to the food and beverage sector because they improve the quality and flavor of dairy products, sauces, and dressings. The pharmaceutical industry benefits from using mucilage to create medications with controlled release mechanisms and customized wound dressings. Their importance also extends to industrial uses, particularly in the production of paper and textiles, where their ability to thicken and bind materials is crucial (Ozbayram, Akçaalan, Isinibilir, & Albay, 2022).

Based on the precise mucilage-like substances, each type of microorganism produces different groups of microorganisms that are employed for mucilage extraction. The synthesis of xanthan gum, a common chemical in food and industry, makes Xanthomonas bacteria stand out (Becker, Katzen, Pühler, & Ielpi, 1998). In industries ranging from food to biotechnology, alginate-producing bacteria and yeast have found a niche that has helped enhance medication delivery and other specialized uses. There is an expanding group of microbial polysaccharides that show promise for a variety of industrial applications. In terms of location, these microbes are widespread throughout the world. Everywhere there is industrialization, Xanthomonas bacteria, and their desired xanthan gum may be found. Countries including the United States, China, and different European nations have flourishing alginate-producing equivalents, generating a rich tapestry of research and manufacturing. The wide range of microorganisms that make polysaccharides have different habitats, makes it possible to cultivate them in many different places. Essentially, the microorganisms involved in the synthesis of mucilage-like substances converge on the common language of polysaccharides, merging their responsibilities as crucial contributors to improved textures, cutting-edge pharmacological remedies, and industrial advancements across geographical borders. Therefore, this review navigates through the mucilage's chemical structure, and thermal, mechanical, physiochemical, and phytochemical features, weaving together their industrial applications.

### *1.1. Statement of Problem and Study Rationale*

One of the advanced uses of mucilage is as a wall material for food and bioactive ingredients for nano- and micro-encapsulation. Mucilage is appropriate for use in encapsulation applications because it has an appreciable molecular weight and may create a thick network after drying (Archana, Abhishek, & Vijay, 2022; Tosif et al., 2021). The creation of edible coatings and film-based mucilage to extend the shelf life of fruits, vegetables, meats, and seafood items is another breakthrough in mucilage research. By preventing water loss and extending hardness, these coatings and films can enhance the quality and safety of food items. However, there are limited studies on the characteristics of mucilage such as mechanical, thermal, physiochemical, and phytochemical properties and their applications in adhesion, textile, and paper industries. Mucilage may be used to create nanofibers in the textile sector (Archana et al., 2022), making it useful materials in the industries. Therefore, covering this gap by showcasing the different features of mucilage and their applications as binder, textile and paper materials form the rationale behind this study.



*1.2. Purpose of the Study*

The general purpose of this research is to review and discuss the features of polysaccharide-based mucilage and their adhesion, textile, and paper usage in the industry. The specific purpose is:

(a) To review and discuss mechanical and thermal properties of mucilage
(b) To review and discuss the phytochemical and physiochemical features of mucilage
(c) To investigate the applications of mucilage as adhesion and binder
(d) To review the use of mucilage in the textile and paper industry

*1.3. Research Questions*

The following research question guided this study:

(a) What are the possible features of mucilage in terms of physiochemical analysis?
(b) What are the possible characteristics of mucilage in terms of phytochemical analysis?
(c) How can mucilage's thermal, mechanical, and chemical structure be investigated?
(d) Can mucilage be used in adhesion, binder, textile, and paper industries?

## 2. Materials and Methods

The resource materials for this review were obtained from Scopus, Google Scholar, and other relevant databases as previously used (Sodokin, Ujah, Von Kallon, & Adamon, 2023; Ujah, 2023). The author conducted a search using peer-reviewed literature, including books, articles, and conference papers, focusing on various topics related to mucilage extracts from plants and microorganisms and their characterization. The characterization includes chemical structure, mechanical, thermal, physiochemical, and phytochemical analyses. Application of the mucilage concerning adhesion, binder, textile, and paper productions were also included in this review.

## 3. Results and Discussion

### 3.1 Chemical Composition and Properties of Mucilage

Mucilage has a soluble in water component made up of many chemically functioning parts that may be good for human health (Soukoulis, Gaiani, & Hoffmann, 2018). Complex combinations of polysaccharides, such as arabinogalactans, pectins, xylans, and cellulose, make up mucilage extracts, which collectively contribute to their distinctive qualities. These extracts have physicochemical properties that make them adaptable for thickening, binding, and stabilizing in a variety of applications, including outstanding water absorption, swelling, viscosity, and adhesiveness. The existence of secondary metabolites such as flavonoids and terpenoids is revealed by phytochemical analysis, further enhancing their functional profile and possible health benefits. Notably, mucilage's inherent biodegradability highlights its environmental compatibility and encourages interest in sustainable uses ranging from packaging to farming methods, establishing mucilage extracts as useful and environmentally friendly biomaterials. This section discusses more on the chemical properties of mucilage looking at the structural, physiochemical, phytochemical, biodegradable properties, etc.

### 3.1.1 Structural Components of Mucilage

Plants and microbes create the gelatinous material known as mucilage. Mucilage's structural elements might differ depending on the source, but in general, it is mostly made up of proteins and carbohydrates (Mariel, Erick, Katherine, & Jose, 2017; Tosif et al., 2021). The classification of carbohydrates as mono- and polysaccharides is already widely known. It is well known that polysaccharides are incredibly useful natural ingredients that promote health (Pejin et al., 2019). Figure 1 enumerates the important parameters surrounding the mucilage extract, which could vary in different amounts. Water retention, seed adhesion, and pathogen defense are just a few of its many qualities. Mucilage is a complex of polymeric polysaccharides, according to Tosif et al. (2021), that is mostly made up of carbohydrates with highly branched structures made up of monomer units of L-arabinose, D-xylose, D-galactose, L-rhamnose, and galacturonic acid. Additionally, they include glycoproteins as well as several bioactive substances including steroids, alkaloids, and tannins. Depending on the sort of hydrolysis products owing to the polysaccharide's nature, mucilage can hydrolyze into an infinite number of monosaccharides. Due to its comparable physiological characteristics, it may also be further divided into pentose sugars (xylan) and hexose sugars (cellulose and starch), which are also regarded as gum-like components.

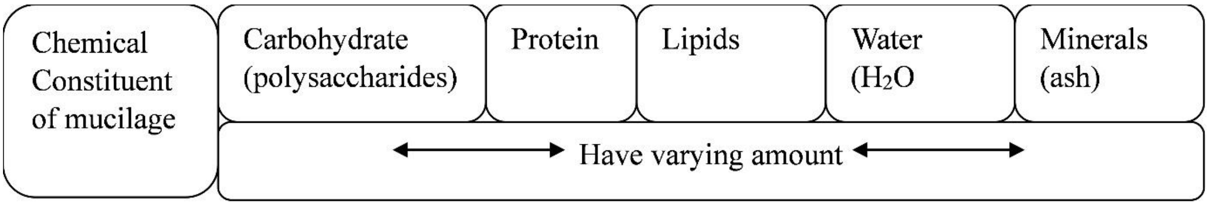


**Figure 1:** Parameters Showing the Constituent of Mucilage. Adopted from Dybka-Stępień, Otlewska, Góźdź, and Piotrowska (2021).

### 3.1.2 Mechanical, Rheological and Thermal Measurements

It is significant to remember that mucilage is a complex mixture of polysaccharides, proteins, lipids, and other components that might differ depending on the source and extraction technique when discussing the mechanical characteristics of mucilage. As a result, variables such as mucilage's viscoelastic behavior, flow characteristics, and structural stability may all be better understood, which have a significant impact on the mechanical characteristics of mucilage. Researchers have evaluated the viscosity, shear thinning behavior, and gel strength of mucilage-based formulations using techniques such as rheology. For instance, Zhu and Obara (2022) investigation into the rheological qualities of okra mucilage extract, revealed its pseudoplastic behavior and shear thinning traits. Due to the capacity to manipulate flow (rheology) parameters, formulations for controlled drug administration may be created that assure optimum extrusion from delivery devices while retaining stability and strength in the target environment. The proper mechanical strength and flexibility for efficient wound covering and protection are also determined by mechanical analysis, which is another factor in the customization of mucilage-based hydrogels for wound dressings (Katerina et al., 2022). Mucilage's elasticity, which is a measurement of its capacity to deform and then regain its original shape is another significant mechanical characteristic. Since mucilage is often quite elastic, it may be used in a wide range of processes, such as a binder in medicines and a foaming agent in food items. Some variables such as the mucilage content, the temperature, and the presence of other substances, can have an impact on the elasticity of mucilage (Rosskopf, Uteau, Peth, & 2021). Mucilage is excellent for a range of applications since it is often quite viscous and elastic.



The behavior of mucilage under stress and deformation is covered by its rheological properties, which also shed light on the features of its flow and viscosity. Mucilage behaves in a pseudoplastic manner, which means that as the shear rate rises, its viscosity falls. According to Hung and Lai (2019), the average molecular weight of the mucilage from Basella alba was discovered to be between 1.9 and 2.4, while leaf and stem mucilage solutions were found to have inherent viscosities of 2.48 and 9.20 dl/g, respectively. Hung and Lai (2019) added more details about the rheological characteristics of mucilage, according to the report, 2-6% of mucilage solutions exhibited mild shear thinning behavior and had flow behavior indices between 0.58 and 0.85. According to dynamic shear studies, 2-6% of mucilage solutions exhibited notable fluid characteristics, with a loss tangent value ranging from 1.1 to 3.4. Significant synergistic effects were seen when wheat starch was combined with it in a variety of ratios, especially when the ratio was 1.8 to 0.2 or 1.7 to 0.3, as shown by a significant rise in viscosity, storage modulus, and drop in loss tangent to less than one (0.2 to 0.3). On the other hand, adding mucilage to tapioca starch solutions did not result in a synergistic gelation. Even when mucilage was added to potato starch solutions, gelation was reduced. Mucilage's rheological qualities are often influenced by variables including concentration, the degree to which it is mixed with other components, and the makeup of those other substances. This rheological characteristic is very helpful in sauce compositions where it is intended to have simple pouring and spreading (Zhu & Obara, 2022). Designing products from mucilage with good texture and usability requires an understanding of the rheological characteristics of mucilage. Because it is often quite viscous, mucilage has a wide range of uses, including food product thickener, and lubricant in industrial operations. Mucilage's viscosity may also be influenced by some number of variables, including its content, temperature, and the presence of other substances (Tosif et al., 2021). The molecular weight of mucilage, a measurement of the size of the molecules that comprise it, can also have an impact on its rheological characteristics. Higher molecular weight mucilage is often more viscous and elastic than lower molecular weight mucilage. Some elements, including the plant source, the extraction technique, and the processing conditions, can have impacts on the molecular weight of mucilage. More so, mucilage has additional functional qualities in addition to these rheological ones that may be crucial for its usage in a variety of applications. Mucilage, for instance, can effectively contain water, making it useful as a thickening ingredient in foods, as a moisturizer in cosmetics, as an emulsifier in food items, and as a stabilizer in medicines.

The capacity of mucilage to preserve structural integrity and functional qualities under high temperatures is referred to as thermal stability. According to the study by Kurd, Fathi, and Shekarchizadeh (2017), methods like thermogravimetry analysis (TGA), which calculates a sample's mass fluctuation as a function of temperature in a stable environment, can be used to gauge mucilage's thermal stability. Mucilage's thermal stability may be assessed in two different situations: isothermal (where the temperature is maintained constant) and dynamic (where the temperature rises linearly) (G. Archana et al., 2013). The study offers a case study of seed mucilage from Manilkara zapota (Linn.) that was assessed using TGA for its heat stability. The derivative thermograms and primary thermograms revealed that heating the mucilage at a rate of 10°C/min from 0°C to a maximum of 900°C caused two mass loss events (Singh & Bothara, 2014). The origin of the mucilage, the makeup of the polysaccharides, and the environment in which the substance is utilized are some examples of the variables that might affect the material's thermal stability. Overall, mucilage's thermal stability is a crucial characteristic that might affect whether or not it is suitable for use in a variety of processes, such as food processing or medicines.



### 3.2 Physicochemical Properties

Mucilage is a gel-like material generated from a variety of plant sources, and its physiochemical characteristics are key to its varied use in a wide range of industries. A thorough comprehension of the physiochemical characteristics not only clarifies the behavior of mucilage but also directs its application in a variety of fields, including food, cosmetics, medicines, and more. The physicochemical characteristics of mucilage are explored in this article, including their solubility, antioxidant activity, water and oil holding capacity, etc. The amount of water and oil that a substance can hold is known as its water and oil holding capacity respectively (Deore & Mahajan, 2022).

#### 3.2.1 Water and Oil Holding Capacity

The term "water-holding capacity" describes a substance's capability to hold onto water when subjected to an outside force, such as compression or centrifugal gravity. Whenever it pertains to some industries, the ability to hold water is an important characteristic. The usage of mucilage in items like baked materials, where it increases softness and shelf life, is influenced by its capacity to bind and hold water. Water retaining capacity is a crucial functional characteristic of mucilage obtained from plants that makes it valuable in a variety of applications. Because of the presence of hydroxyl groups and protein substituents in the gum and mucilage structure, mucilage has a high water-holding capacity. Mucilage can absorb and hold a lot of water, which makes it a good thickening, emulsifying, and stabilizing ingredient for food items. Mucilage's ability to hold water may be affected by a variety of elements, including its source, the makeup of the polysaccharides, and the environment in which it is utilized. Mucilage has a significant functional characteristic that makes it a potentially desirable material for use in a range of applications: the ability to store water. The swelling feature of the mucilage-related substances can be attributed to their functional groups, their hydrophilic feature, and the ability of their network structure to enlarge when in contact with water (Deore & Mahajan, 2022). Mucilage's ability to store oil affects how it is used in formulations that contain oil. This characteristic is crucial in fields like food, where mucilage may function as a natural stabilizer in emulsified goods. In the final analysis, an in-depth comprehension of mucilage's behavior and possible uses may be gained by studying its physicochemical characteristics. Armed with the knowledge of the oil holding capacity, producers and researchers may make use of mucilage's special qualities to develop inventive, useful, and sustainable goods that satisfy a variety of customer demands.



### 3.3 Phytochemical Properties

The complex makeup of plant-based products may be uncovered by phytochemical analysis, which also sheds light on their nutritive and functional qualities (Alobo & Arueya, 2017). The nutrient content is also essential for good health when used for food processing and packaging (Jembi, Emmanuel, & Ibraheem, 2023; Kalu, 2023). Mucilage's potential advantages and uses in various fields are revealed by a careful analysis of its phytochemical components. In this article, the phytochemical examination of mucilage is discussed, with a focus on carbohydrates, polysaccharides, protein, the levels of nitrogen and oxygen, the pH, etc.

#### 3.3.1 Carbohydrate Contents

The main components of mucilage are carbohydrates, which contribute to its special ability to create gels. Complex carbohydrates included in mucilage, such as polysaccharides and oligosaccharides, are important for its functional properties. Various plant sources of mucilage, including flaxseed, okra, aloe vera, etc have varied carbohydrate contents (Sa’eed & Neela, 2016). When hydrated, these carbohydrates create a matrix that resembles gel, which helps mucilage to have sticky, thickening, and stabilizing qualities. Plant species, environmental circumstances, and extraction procedures, among other things, all have an impact on the composition of carbohydrates.

#### 3.3.2 Polysaccharide Contents

Mucilage contains a sizeable amount of polysaccharides composed of three types — pectins, cellulose, and hemicelluloses, which support the variety of functions it performs (Kreitschitz, Kovalev, & Gorb, 2021). For instance, apples and citrus fruits contain pectin, a typical mucilage polysaccharide, whereas other sources produce diverse kinds of mucilage polysaccharides. Mucilage's capacity to create gels, thicken liquids, and act as a binder is due to its polysaccharides. These polysaccharides are identified and quantified using analysis techniques including chromatography and spectroscopy, providing information on their complicated structural makeup and possible uses (Ray et al., 2013).

#### 3.3.3 Protein, Nitrogen, Oxygen, and pH Level

Despite the fact that mucilage mostly consists of carbohydrates, its phytochemical profile also contains additional substances that support the substance's overall qualities. For instance, seed mucilages such as linseed, basil, dragon head, and quince have been noted to contain significant amounts of protein content (Alobo & Arueya, 2017). Mucilage's adhesive and stabilizing properties are influenced by the protein level, which varies depending on the plant source and extraction technique. The molecular structure of mucilage is revealed by nitrogen and oxygen levels, which have an impact on how it interacts with water and other substances. The stability and behavior of mucilage in various formulations, which affect its gel formation and viscosity, are greatly influenced by pH levels.



### 3.3.4 Oil content

Although often modest, fat content contributes to the nutritional value and sensory qualities of goods based on mucilage. Oil levels have been found in most mucilage plants (Shi, Katavic, Yu, Kunst, & Haughn, 2011). There are some conditions responsible for the reduction of the oil content. For instance, research conducted by Zare et al. (2023) assessed the genetic potential of yellow and brown seeds of Flaxseed (Linum usitatissimum L.) under different water conditions concerning seed yield, oil, protein, fiber, mucilage, and lignans content. This is as a result of water stress negatively affecting the oil yield, while positively affecting the protein content. In general, under water stress circumstances, had greater levels of all unsaturated fatty acids, suggesting the increased nutritional value of the oil. Another study has revealed that the environment has a significant impact on the quantity of unsaturated fatty acids, such as oleic acid, LA, and ALA (Shin, Craft, Pegg, Phillips, & Eitenmiller, 2010).

### 3.3.5 Biodegradable Properties – Soil Burial Mode

Plant-based mucilage has been shown to exhibit good biodegradability in soil burial tests. This is due to their high content of polysaccharides, which are readily broken down by microorganisms in the soil. A typical technique for assessing a material's biodegradability is the soil burial test. In this test, a sample of the substance is buried in soil and its decomposition rate is tracked over time. The test may be carried out in a controlled laboratory setting or a natural setting. Soil burial tests are mostly used to test the biodegradable properties of mucilage, hence, their application in the packaging industry (Mishra, Mohite, & N., 2022). In soil burial studies, seed mucilage has demonstrated strong biodegradable characteristics. This is because they are organic compounds that may be decomposed by soil bacteria. The types of mucilage, their composition, and the climatic conditions may all affect how quickly mucilage degrades. Depending on the exact material and environmental factors, studies have indicated that seed mucilage-based films and coatings can break down in soil from a few weeks to a few months. For instance, research on basil seed mucilage-based films discovered that, in soil burial experiments, they deteriorated by 80% after 60 days. When buried in soil for 90 days, chia seed mucilage-based films, according to another study, deteriorated by 90%. Overall, seed mucilage-based films and coatings offer a viable substitute for synthetic polymers in food packaging applications due to their biodegradable qualities (Beikzadeh, Khezerlou, Jafari, Pilevar, & Mortazavian, 2020).

## 4. Applications of Mucilage

The adhesive and binding qualities of mucilage, as well as its uses in the paper and textile sectors, show its adaptability and promise for sustainable solutions. Mucilage-based materials offer several advantages across several industrial sectors, from supplying strength and durability in the manufacturing of corrugated cardboard to boosting textile and paper processes through sizing and printing as discussed below.



## 4.1 Adhesive and Binder

Pectin, cellulose, and hemicelluloses are the three forms of polysaccharides that make up seed and fruit mucilage, which after being hydrated exhibit sticky qualities. The ability of the mucilage to allow seeds to adhere to various natural surfaces is one of its crucial roles. The diaspore can be fixed to the substrate (soil) or connected to an animal's body and distributed over a variety of distances due to its adhesive qualities, which grow after dehydration (Kreitschitz et al., 2021; Saeedi, Morteza-Semnani, Ansoroudi, Fallah, & Amin, 2010). The inherent adhesive qualities of mucilage make it a sustainable substitute for synthetic adhesives and binders that may be used in a variety of applications, from building to packaging. Paper production is one significant use (Dybka-Stępień et al., 2021). To bind paper layers together while making corrugated cardboard, paper bags, and envelopes, the paper industry uses mucilage-containing substances such as starch-based adhesives. Psidium Guajava was used by Chaudhari S. R and Deshmukh N.S as natural binders in their recent article, this is because they are biodegradable and made from renewable resources, these adhesives produce a strong bind while having a minimal negative impact on the environment (Chaudhari & Deshmukh, 2021). Also, the plant material from seeds of six different plant taxa: Linum usitatissimum L. (flax), Lepidium sativum L. (garden cress), Ocimum basilicum L. (basil), Plantago lanceolata L. (plantain), Plantago ovata L. (blond plantain), Salvia hispanica L. (Chia) showed high adhesive strength with adhesion force, where cellulose mucilage of Ocimum basilicum and Plantago ovata having the least (Kreitschitz et al., 2021). Mucilage-based adhesion is a classic way of attaching wooden parts in the woodworking and carpentry industries. Mucilage-containing animal-based glues have been used for millennia in the manufacture of musical instruments and furniture to form strong connections. This adhesive is popular because it can sever wood fibers and form strong bonds that endure strain and tension over time.

## 4.2 Textile and Paper Industries

Due to mucilage's special qualities that can improve the quality and features of products in various sectors, mucilage is used in the paper and textile industries. Certain mucilage-containing materials are employed as organic sizing agents in the textile industry. The process of sizing involves treating textiles to increase their processing-related stiffness, smoothness, and wear resistance. Because they may create a thin layer on the surface of the fabric, plant-derived mucilage like guar gum or tamarind gum is frequently employed as a sizing agent. To facilitate weaving and minimize yarn breakage during the production process, this coating temporarily stiffens the cloth. A proper instance is the making of Japanese paper with the use of a vegetable mucilaginous plant known as Neri (Maematsu & Motoki, 1998). The usage of this non-ionic surface-active ingredient, or dimethyloleilamine oxide, was proven to be efficient for Japanese paper manufacture by real paper-making testing. Furthermore, it was discovered that a compound's low molecular weight promotes spinnability and excellent sheet formation. Additionally, research by Suzuki (1952) confirmed this, but in this case, Nori (a vegetable mucilage) was used to style the Japanese paper.



Hence, mucilage-based thickeners are used in textile printing to regulate how much dye and pigment is applied to the cloth. Such thickeners make sure that the dye sticks to the cloth uniformly, producing vivid and accurate prints. In addition, natural dyes containing mucilage are used to color textiles in a sustainable and ecologically friendly manner, in line with the industry's expanding need for such techniques. Finally, mucilage-based goods are projected to experience rapid market expansion in other sectors such as pharmaceutical, healthcare, and medical sectors. Mucilage is a substance that may be useful for use in medicines and medical treatments since studies have shown that it has positive effects on health, including boosting the immune system, calming the gastrointestinal tract, and decreasing blood pressure.

## 5. Limitations and Suggestions for Future Research

Mucilage faces several challenges and restrictions. Seasonal and environmental conditions can affect its production and quality, affecting accessibility (Tosif et al. 2022). Extracting and purifying mucilage can be challenging, and physical damage can affect the amount and consistency of the product. This presents a significant challenge in terms of costs and mass production feasibility. Mucilage may also contain contaminants, which can diminish its quality and restrict its industrial use as binders, adhesion, textile, and paper products. Additionally, biological constituents in mucilage may promote bacteria growth, increasing the risk of microbial contamination. In general, mucilage has a variety of potential applications, but there are some challenges and limitations associated with its production and utilization that must be addressed in order to fully exploit its potential (Mukherjee, RLerma-Reyes, Thompson, & Schrick, 2019; Sébastien, Vincent, & Christophe, 2020).

Mucilage has numerous applications in food processing, pharmaceuticals, textiles, paper production, etc. However, it is crucial to develop specific protocols and methods to maximize its potential. Proper production and purification processes, which are essential for mucilage's quality and purity should be further investigated and develop. Biological components in mucilage can promote bacteria growth, so conservation of mucilage is essential to prevent contamination and should be an issue of research. Mucilage's environmental benefits are significant, but it's crucial to evaluate its production and usage to mitigate negative effects. The rules for using mucilage emphasize its exceptional quality, purity, and safety in many products. By following proper guidelines, the full understanding of the potential of mucilage, and its effective utilization in various industries can be achieved.

## 6. Conclusion

Recent advancements in mucilage research have revealed their potential applications in various sectors, including adhesion, textiles, and paper production. However, there is limited widespread knowledge regarding the characterization and utilization of mucilage in these sectors. This review explores the mechanical, thermal, physiochemical, and phytochemical characterization of mucilage, as well as its advanced applications. Other applications of mucilage include but are not limited to wall material for nano- and micro-encapsulation of food and bioactive components, food backing, drug delivery, edible coatings and films for prolonging the shelf life of fruits, vegetables, meats, and seafood products. Nevertheless, this review brings information on various analyses regarding mucilage, including their mechanical, thermal, physiochemical, and phytochemical analyses, as well as their potential applications in the adhesive, textile, and paper sectors. As scientists continue to uncover the potential of mucilage extracts and their untapped benefits, this review serves as a testament to past achievements and a guide towards a future enriched by their possibilities. Overall, recent developments in mucilage research have shown the material's potential for usage in a variety of fields, including food processing, textiles, paper, medicine, etc. Therefore, this review is expected to facilitate the use of mucilage as a natural product for advanced and sustainable applications.



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**Conflict of Interest**

The authors have no competing interests to declare that are relevant to the content of this article

**Author Contributions**

UOU: Conceptualization, Methodology, Writing Original Draft, and final proofreading.
PAP: Conceptualization, Supervision, Methodology, and final proofreading.
OP: Conceptualization, Supervision, Methodology, and final proofreading.

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