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Extraction and Characterization of Konjac Glucomannan from Elephant Foot Yam *(Amorphophallus Paeoniifolius)*

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DECLARATION

I declare that this thesis entitled "title of the thesis" is the results of my own research except as cited in the references.

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ABSTRAK

Penyelidikan saintifik ini mengkaji kaedah pengekstrakan optimum untuk mendapatkan *Konjac Glucomannan* daripada Ubi Keladi Kaki Gajah atau lebih dikenali sebagaiubi Sarek (*Amorphophallus paeoniifolius*) dan mencirikan sifatnya untuk aplikasi yang berpotensi dalam pelbagai industri. Kajian ini merangkumi proses pengumpulan, penyediaan, pengekstrakan, dan pencirian sampel yang dijalankan di Universiti Malaysia Kelantan. *Konjac glucomannan*, yang diperolehi daripada ubi ini, ialah serat pemakanan larut air yang terkenal dengan sifat uniknya dan potensi manfaat kesihatan. Proses pengekstrakan melibatkan pra-rawatan bahan mentah, pengeringan ubi menggunakan haba kering, dan menggunakan teknik pengekstrakan berasaskan etanol. Pelbagai parameter seperti kepekatan pelarut, masa pengekstrakan, dan suhu dioptimumkan untuk memaksimumkan hasil dan kualiti. Pemeriksaan pencirian termasuk analisis mikroskop cahaya gel dan serbuk *konjac*, memfokuskan pada ciri-ciri struktur dan taburan saiz zarah. Di samping itu, pembelauan sinar-X (*XRD*) digunakan untuk menyiasat struktur kristalografi serbuk konjac, mendedahkan pandangan tentang ciri-ciri strukturnya. Kajian mendapati bahawa konjac glucomannan yang diekstrak mempamerkan sifat menyerap air, membentuk struktur gel yang stabil sesuai untuk pelbagai aplikasi. Analisis mikroskopik mendedahkan agregat heterogen dengan bentuk tidak sekata dan struktur berliang, menyumbang kepada sifat fungsinya. Tambahan pula, kajian itu menangani kehadiran kalsium oksalat dalam Ubi Keladi Kaki Gajah dan meneroka teknik memasak untuk mengurangkan potensi kesan sampingannya, memastikan penggunaan yang selamat. Kesimpulannya, penyelidikan ini menyumbang kepada pemahaman saintifik tentang pengekstrakan *konjac glucomannan* dan potensi aplikasinya dalam industri makanan, farmaseutikal dan kosmetik. Selain itu, pandangan tentang kandungan kalsium oksalat dan strategi pengurangan memberikan maklumat berharga untuk penggunaan yang selamat. Pengoptimuman dan penyelidikan lanjut adalah wajar untuk meningkatkan kecekapan pengekstrakan dan memaksimumkan penggunaan sumber ini.

Kata kunci: Konjac glucomannan, ubi keladi kaki gajah, pengekstrakan, kalsium oksalat, pencirian

ABSTRACT

This scientific research investigates the optimal extraction method for obtaining Konjac Glucomannan from Elephant Foot Yam (*Amorphophallus paeoniifolius*) and characterizes its properties for potential applications in various industries. The study encompasses sample collection, preparation, extraction, and characterization processes conducted at Universiti Malaysia Kelantan. Konjac glucomannan, derived from the corm of Elephant Foot Yam, is a water-soluble dietary fibre known for its unique properties and potential health benefits. The extraction process involves pre-treating the raw material, drying the corm using dry heat, and employing ethanol-based extraction techniques. Various parameters such as solvent concentration, extraction time, and temperature are optimized to maximize yield and quality. Characterization examinations include light microscopy analysis of konjac gel and powder, focusing on structural characteristics and particle size distribution. Additionally, X-ray Diffraction (XRD) is utilized to investigate the crystallographic structure of konjac powder, revealing insights into its structural characteristics. The study observes that the extracted konjac glucomannan exhibits water-absorbing properties, forming a stable gel structure suitable for various applications. Microscopic analysis reveals heterogeneous aggregates with irregular shapes and porous structures, contributing to its functional attributes. Furthermore, the study addresses the presence of calcium oxalate in Elephant Foot Yam and explores cooking techniques to mitigate its potential side effects, ensuring safe consumption. In conclusion, this research contributes to the scientific understanding of konjac glucomannan extraction and its potential applications in food, pharmaceuticals, and cosmetic industries. Additionally, insights into calcium oxalate content and mitigation strategies provide valuable information for safe consumption. Further optimization and research are warranted to enhance extraction efficiency and maximize the utilization of this sustainable resource.

Keywords: Konjac glucomannan, Elephant Foot Yam, extraction, calcium oxalate, characterization

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Konjac glucomannan is generally used as a food supplement due to its unique particles and implicit health benefits (Fang et al., 2023). One example of a product that utilizes konjac glucomannan as a key ingredient is konjac noodles or shirataki noodles.

Konjac noodles are a type of pasta substitute that is widely recognized for its low-calorie and low-carbohydrate content. These noodles are made from konjac glucomannan fibre mixed with water and lime water, forming a gelatinous substance that is shaped into noodle-like strands. They are a popular choice among individuals following low-carb or ketogenic diets, as well as those seeking to manage their weight.

The primary reason konjac noodles are valued as a food supplement is their ability to contribute to weight management. These noodles have a high water-absorbing capacity, making them very filling despite being low in calories (Chen et al., 2006). This can help reduce overall calorie intake and promote satiety, aiding in portion control and potentially supporting weight loss efforts.

Moreover, konjac glucomannan is a soluble fibre that forms a gel-like substance in the digestive system. This viscous nature can slow down the digestion and absorption of nutrients, including carbohydrates, which can help stabilize blood sugar levels and promote better glycaemic control. This characteristic makes konjac noodles a suitable option for individuals with diabetes or those looking to manage their blood sugar levels.

Amorphophallus is a genus of flowering plants known for their remarkable inflorescence, often referred to as the "corpse flower" or "*titan arum*."(Gregory M. Plunkett, 2022). These plants belong to the family *Araceae* and are native to tropical regions of Asia, primarily Indonesia and Sumatra. The genus name "*Amorphophallus*" is derived from the Greek words "*amorphos*," meaning shapeless, and "*phallos*," meaning phallus, referring to the unusual shape of the plant's spadix.

Konjac glucomannan is a dietary fibre derived from the corm of *Amorphophallus Paeoniifolius*, commonly known as Elephant Foot Yam. This natural polysaccharide has gained attention for its unique properties and potential health benefits. The extraction process involves collecting the corm of the Elephant Foot Yam and processing it to obtain the glucomannan.

However, it is important to note that individuals with specific health conditions, such as gastrointestinal disorders or allergies, should exercise caution when consuming konjac glucomannan and consult with healthcare professionals if necessary.

1.2 Problem Statement

Konjac glucomannan, a dietary fiber extracted from the corm of Elephant Foot Yam (*Amorphophallus Paeoniifolius*), has gained attention for its health benefits. However, Elephant Foot Yam contains calcium oxalate, which can have adverse effects when consumed. The corm is the edible part of the plant, and it is typically cooked before consumption.

Calcium oxalate is a compound found in many plants, including Elephant Foot Yam. Calcium oxalate crystals, which are found in many organs of plants, have different morphological forms. It can cause skin irritations and acridity, which is an irritative sensation in the mouth. Additionally, consuming calcium oxalate can potentially lead to the formation of kidney stone (Khan, 1995).

To ensure the safe consumption of Elephant Foot Yam corm without worrying about the side effects of calcium oxalate, few research has been conducted and various methods was used. One approach is to employ few cooking techniques that can reduce the levels of calcium oxalate in the corm.

Studies has investigated different methods such as boiling, steaming, soaking, and fermentation to reduce the content of calcium oxalate in Elephant Foot Yam corm. For example, research has shown that boiling the corm can significantly reduce the levels of calcium oxalate, making it safer for consumption (Amit Kumar Singh, 2018). Steaming has also been found to be effective in reducing the calcium oxalate content.

Furthermore, soaking the Elephant Foot Yam corm in water before cooking has been shown to leach out some of the oxalate content. One study found that soaking the corm in water for 24 hours resulted in a significant reduction in calcium oxalate levels. Fermentation has also been explored as a method to degrade calcium oxalate, with promising results in reducing its content in Elephant Foot Yam.

These cooking techniques help mitigate the potential side effects of calcium oxalate and make Elephant Foot Yam corm safer for consumption. It is important to note that these methods may not eliminate calcium oxalate completely, but they can significantly reduce its levels.

Further research is still needed to optimize the cooking methods for Elephant Foot Yam corm and assess the residual levels of calcium oxalate after processing. Additionally, individuals with specific health conditions, such as kidney stones or oxalate sensitivity, should consult with healthcare professionals before consuming Elephant Foot Yam or its derived products.

1.3 Objectives

This research is carried out to fulfil;

1. To prepare Konjac Glucomannan from Elephant Foot Yam *(Amorphophallus Paeoniifolius).*
2. To characterize the properties of Konjac Glucomannan Elephant Foot Yam *(Amorphophallus Paeoniifolius).*

1.4 Scope of Study

The objective of this study conducted in the lab at Universiti Malaysia Kelantan was to determine the optimal extraction method for obtaining Konjac Glucomannan from Elephant Foot Yam (*Amorphophallus paeoniifolius*). The project's scope encompassed sample collection and preparation, ensuring the availability of high-quality Elephant Foot Yam corms. Subsequently, the extracted konjac glucomannan underwent some characterisation examination. This examination aimed to assess various characteristics of the konjac glucomannan, such as its molecular structure, composition, solubility, and other relevant characterisation properties. By conducting a comprehensive examination, this study aimed to gain insights into the extracted konjac glucomannan's quality and potential applications in various industries, including food, pharmaceuticals, and cosmetics.

1.5 Significances of Study

The study of konjac glucomannan extraction from *Amorphophallus Paeoniifolius* holds significant importance for several reasons. Firstly, *Amorphophallus Paeoniifolius* is a rich source of glucomannan, a water-soluble dietary fibre with various potential health benefits. Understanding the extraction process allows to produce konjac glucomannan as a functional ingredient for food and pharmaceutical applications.

Secondly, the extraction of konjac glucomannan from *Amorphophallus Paeoniifolius* contributes to the utilization of this plant species as a sustainable resource. *Amorphophallus Paeoniifolius* is a traditional tuber crop with limited commercial applications. By exploring its glucomannan content, we can promote its value as a crop and contribute to the economic development of local communities.

Furthermore, investigating the extraction process allows for optimization of extraction parameters, such as solvent concentration, extraction time, and temperature, to maximize the yield and quality of konjac glucomannan. This optimization is essential for industrial-scale production, ensuring efficiency and cost-effectiveness.

Additionally, the study of konjac glucomannan extraction from *Amorphophallus Paeoniifolius* provides insights into the chemical composition and structural characteristics of the extracted glucomannan. This knowledge is crucial for understanding its functional properties, such as water absorption, and gel-forming ability, which are relevant for its applications in the food, pharmaceutical, and cosmetic industries.

Overall, investigating the extraction of konjac glucomannan from *Amorphophallus Paeoniifolius* not only contributes to the scientific understanding of this natural resource but also has practical implications for its utilization in various industries, promoting sustainability, economic development, and potential health benefits.

CHAPTER 2

LITERATURE REVIEW

2.1 *Amorphophallus Paeoniifolius*

Amorphophallus Paeoniifolius, commonly known as elephant foot yam or locally referred to as "ubi sarek," is a perennial tuberous plant belonging to the Araceae family (Behera & Ray, 2017). It is native to Southeast Asia and is extensively cultivated for its edible tuber. The tuber of *Amorphophallus Paeoniifolius* is known for its large size and culinary uses in various regional cuisines.

Figure 2.1 Photos of *Amorphophallus Paeoniifolius* [left:plant, right: corm]

(Source: Google)

Amorphophallus Paeoniifolius, commonly known as elephant foot yam, is a plant species native to Southeast Asia and India. Its tuber has been used in traditional medicine systems like Ayurveda and traditional Chinese medicine for its potential health benefits. Several studies have investigated the bioactive compounds and nutritional composition of *Amorphophallus Paeoniifolius* tuber, shedding light on its pharmacological properties.

Research has shown that the tuber of *Amorphophallus Paeoniifolius* possesses various therapeutic activities, including anti-inflammatory, antioxidant, antimicrobial, and antidiabetic effects. These effects have been attributed to the presence of bioactive compounds such as phenols, flavonoids, alkaloids, and saponins in the plant (Singh & Wadhwa, 2014).

The tuber's bioactive compounds contribute to its pharmacological properties and potential health benefits. Phenolic compounds, such as tannins and flavonoids, exhibit antioxidant activity and can scavenge free radicals, thereby protecting the body against oxidative stress. Alkaloids, on the other hand, have been reported to possess antimicrobial and antidiabetic properties.

In addition to its bioactive compounds, the nutritional composition of *Amorphophallus Paeoniifolius* tuber has also been studied. The tuber is rich in carbohydrates and dietary fibre, making it a valuable source of energy and beneficial for maintaining healthy digestion. Furthermore, it contains essential minerals like calcium, phosphorus, and iron, which are important for various physiological functions, including bone health and oxygen transport in the body.

Moreover, the tuber has a low-fat and low-protein content, which can be advantageous for individuals following specific dietary requirements, such as those seeking weight management or adhering to low-fat or low-protein diets.

It is important to note that while research has shown promising results regarding the potential medicinal properties and nutritional composition of *Amorphophallus Paeoniifolius* tuber, further studies are needed to fully understand its mechanisms of action and evaluate its efficacy and safety in various therapeutic applications.

2.2 Konjac Glucomannan

Konjac glucomannan is a water-soluble dietary fibre that is primarily extracted from the tubers of the konjac plant (*Amorphophallus Konjac*). (Amit Kumar Singh, 2018).

However, it is important to note that konjac glucomannan is primarily derived from *Amorphophallus Konjac* and not *Amorphophallus Paeoniifolius. Amorphophallus Paeoniifolius,* also known as elephant foot yam, belongs to the same genus as *Amorphophallus Konjac* but is a different species.

Amorphophallus Paeoniifolius is traditionally consumed as a staple food in some regions and has several medicinal uses. While *Amorphophallus Paeoniifolius* contains glucomannan, it is typically present in smaller quantities compared to Amorphophallus konjac.

Glucomannan, the main component of konjac glucomannan, is a polysaccharide composed of glucose and mannose units linked together. It possesses unique physicochemical properties that make it highly viscous and capable of forming gels when mixed with water. Due to its high water-holding capacity, konjac glucomannan can swell significantly, leading to increased viscosity and a feeling of fullness when consumed. This property has contributed to its use in weight management and as a food ingredient in various products (Yilan Sun & Pang, 2023).

Konjac glucomannan has been reported to contain calcium oxalate crystals. Calcium oxalate is a naturally occurring compound found in various plant tissues, including tubers and roots. One study stated that the composition of konjac foods, including konjac glucomannan, and reported the presence of calcium oxalate crystals (Fang et al., 2023). The researchers observed the presence of calcium oxalate in konjac flour, which is derived from the tubers of Amorphophallus konjac.

2.3 Extraction

Extraction methods are vital for isolating specific substances from complex samples. Two key approaches are chemical extraction, using solvents to separate compounds based on their properties, and dry extraction, minimizing liquid solvent use (Zhang et al., 2018). Combining these methods offers a versatile strategy.

Chemical extraction is effective but may introduce solvent-related challenges. Dry extraction methods, like solid-phase microextraction, provide solvent-free alternatives. Researchers can integrate these approaches for enhanced precision.

For instance, a chemical extraction can be followed by a dry step to remove solvents and concentrate compounds (Azmir et al., 2013). This synergy aligns with evolving research needs, optimizing substance isolation with minimal interference.

2.3.1 Oven Drying

The dry extraction method involves obtaining substances from raw materials without the use of liquid solvents. This approach is particularly relevant in the extraction of bioactive compounds from plant materials, where the absence of solvents can contribute to the efficiency, sustainability, and safety of the extraction process (Impaprasert et al., 2014). While the term "dry extraction" is broad and can encompass various techniques, here is an overview of the chosen dry heat extraction.

Dry extraction, using the oven drying method, refers to a process in which moisture or solvent content is removed from a substance or material through the application of heat in an oven. This method is commonly employed in various industries and laboratory settings to determine the moisture or volatile content of a sample. The material or substance under investigation is collected and prepared for analysis. This could be a solid or liquid sample. The initial weight of the sample is measured accurately. This provides a baseline for determining the percentage of moisture or volatile components.

The sample is then placed in an oven where it is subjected to controlled heat. The heat causes the moisture or volatile components to evaporate. The sample is left in the oven for a specified period to ensure that all the moisture is effectively removed. After the drying period, the sample is allowed to cool to room temperature. This is typically done in a desiccator to prevent reabsorption of moisture from the surroundings. The sample is weighed again after drying. The difference in weight before and after drying is used to calculate the percentage of moisture or volatile content in the sample. The dry extraction using the oven drying method is particularly useful in industries such as food, pharmaceuticals, and environmental analysis where the determination of moisture content is critical for quality control, research, and compliance with regulatory standards. It provides a reliable way to quantify the amount of water or volatile substances present in each sample.

2.3.2 Maceration

Maceration, in its essence, is a straightforward process requiring minimal equipment, making it a cost-effective extraction method. The fundamental setup involves immersing plant material, such as soursop leaves in the example provided, in a chosen solvent within a basic container. The solvent selection is a critical aspect, tailored to the specific compounds of interest. Common solvents include ethanol, methanol, or water, chosen based on their ability to effectively dissolve the target compounds (Tambun et al., 2021). One distinguishing feature of maceration is the extended extraction time.

This method necessitates patience, as the process unfolds over days to weeks. This prolonged immersion allows for a gradual and thorough extraction of compounds from the plant material into the solvent. Although this slow extraction may be time-consuming, it often results in a comprehensive extraction of a wide range of compounds. Temperature control is another consideration in maceration. While the method is typically conducted at room temperature, slight adjustments or controlled environments may be employed to optimize the extraction process. Some variations of the method also incorporate periodic agitation, such as shaking or stirring, to enhance the contact between the solvent and the plant material, thereby improving extraction efficiency. Following the extraction period, the mixture undergoes a filtration process to separate the liquid extract from the solid plant material. The filtrate, rich in the dissolved compounds of interest, undergoes further concentration to increase the potency of the extract. Concentration techniques, such as evaporation or distillation, are employed based on the solvent used.

The simplicity of maceration is underscored by its versatility. This method can be applied to a diverse array of plant materials, making it a valuable tool in the extraction toolbox. However, it is not without its challenges. The prolonged extraction time may render it unsuitable for processes requiring rapid results.

Additionally, maceration may not efficiently extract certain types of compounds, prompting the consideration of alternative extraction methods for specific applications. In conclusion, maceration stands as a testament to the elegance of simplicity in extraction methodologies. Its cost-effectiveness and versatility make it a valuable choice, particularly in scenarios where time is not of the essence, and a comprehensive extraction of diverse compounds is desired. Careful consideration of factors such as raw materials, solvent selection, extraction time, and additional process variables ensures the efficacy of the maceration method in harnessing the bioactive potential of natural sources.

2.4 Microscopic Analysis

Microscopic analysis stands as a cornerstone in the realm of scientific investigation, offering a window into the intricacies of the minute, the hidden, and the imperceptible. At the heart of this exploration lies the microscope—a tool that transcends the limits of human vision and enables researchers to delve into realms otherwise invisible to the naked eye (Olivo-Marin, 2006). This essay delves into the multifaceted significance of microscopic analysis across diverse fields, highlighting its pivotal role in biology, medicine, materials science, and geology.

In the field of biology, microscopic analysis serves as an indispensable instrument for unravelling the mysteries of life at its most fundamental level. Researchers employ various types of microscopes to study cells, tissues, and microorganisms, unravelling the delicate structures that underpin the functioning of living organisms. From understanding cellular processes to investigating the intricacies of genetic material, microscopic analysis in biology has paved the way for groundbreaking discoveries and advancements in fields such as genetics, microbiology, and physiology.

Moving into the realm of medicine, microscopic analysis takes center stage in diagnostics and research. The examination of tissue samples, blood cells, and other biological specimens under the microscope provides invaluable insights into the nature of diseases, facilitating accurate diagnoses and targeted treatments. Microscopic analysis in medicine is not confined to pathology alone; it extends to fields like microbiology, where the identification of pathogens relies heavily on the visualization of microorganisms at the microscopic level. In materials science, the microscopic lens unveils the hidden landscapes of matter. Researchers utilize microscopic analysis to scrutinize the composition and structure of materials with a level of detail that transcends traditional observation. This is particularly critical in the development of new materials with tailored properties, ranging from enhanced durability to specific electrical or thermal conductivity.

The ability to probe materials at the microscopic level empowers scientists to engineer substances with unprecedented precision, revolutionizing industries, and technologies. Geologists, too, find microscopic analysis to be an indispensable tool in their pursuit of understanding Earth's history and processes. From the examination of minerals and rocks to the intricate study of fossils, microscopic analysis aids in deciphering the geological tapestry of our planet. By scrutinizing microstructures, geologists can glean insights into the formation of landscapes, the evolution of species, and the forces that have shaped our world over millennia.

The techniques employed in microscopic analysis are as diverse as the fields it serves. Light microscopy, electron microscopy, and confocal microscopy represent just a few of the myriad approaches available. Sample preparation is a crucial step, often involving staining or sectioning to enhance contrast and visibility. The advent of digital imaging further augments the power of microscopic analysis, allowing for the documentation, analysis, and sharing of findings in unprecedented ways.

Microscopic analysis also can stand as a powerful gateway to the unseen realms that surround us. From the intricate dance of cells to the geological tales told by rocks, the microscope serves as an agent of revelation, enabling scientists to unlock the secrets of the infinitesimally small. Its significance resonates across biology, medicine, materials science, and geology, propelling scientific exploration into new frontiers and shaping the trajectory of human knowledge and innovation.

2.5 X-Ray Diffraction Analysis

X-ray diffraction (XRD) analysis is a powerful technique that has found widespread applications in various fields to study the crystallographic properties of materials. By analysing the diffraction pattern generated when X-rays interact with a crystalline material, valuable information about its atomic arrangement and structure can be obtained.

The principle underlying XRD analysis is Bragg's law, which states that X-rays incident on a crystal lattice will be diffracted at specific angles corresponding to the spacing between crystal planes. This diffraction occurs due to constructive interference between the X-rays scattered by the atoms within the crystal lattice. By measuring the angles and intensities of the diffracted X-rays, a diffraction pattern is obtained (Tan & McNeill, 2022).

The diffraction pattern contains peaks that correspond to the crystal planes present in the material. The positions and intensities of these peaks provide valuable insights into the crystal structure, lattice parameters, and orientation of the crystal lattice (Whittig & Allardice, 1986). Furthermore, by comparing the obtained diffraction pattern with known patterns in databases, the phases present in the sample can be identified.

Advancements in XRD technology have significantly improved its capabilities in recent years. Improved detectors with higher sensitivity and resolution allow for more accurate and precise measurements of diffraction patterns. High-resolution instruments enable the characterization of complex crystal structures with greater detail. Additionally, the integration of other techniques, such as simultaneous XRD and differential scanning calorimetry (DSC), allows for combined thermal and structural analysis of materials.

Recent research articles have demonstrated the wide range of applications of XRD analysis. In the field of pharmaceuticals, XRD is used to study the crystal structure and phase transitions of active pharmaceutical ingredients (APIs) and excipients. This information is crucial for understanding the stability, solubility, and bioavailability of drugs.

In materials science, XRD is employed to characterize nanomaterials and thin films, providing insights into their size, shape, and preferred crystallographic orientation. This knowledge is essential for tailoring the properties and performance of materials in various applications, such as electronics, energy storage, and catalysis.

XRD analysis is also extensively used in geology and mineralogy to identify and quantify mineralogical compositions in geological samples. It helps in understanding the formation processes, geological history, and environmental conditions of rocks and minerals.

In conclusion, X-ray diffraction (XRD) analysis is a versatile technique that plays a vital role in studying the crystallographic properties of materials. With advancements in technology, XRD has become more precise and capable, enabling detailed structural characterization and phase identification across a wide range of materials and applications (Asif Ali, 2022).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

In conducting research on the potential medicinal properties and chemical composition of Elephant Foot Yam (*Amorphophallus Paeoniifolius*), it is essential to obtain the main material, the yam corm. The corm can be sourced from the nearest market or harvested directly from the nearest forest but in this research, the corm was collected from Agrotechnology Park at UMK. In addition to the corm, various other materials and apparatuses are required for the research and these resources are available at the Laboratory of Universiti Malaysia Kelantan, facilitating the extraction and characterization process with a commercial glucomannan powder purchased to differentiate the characterization.

3.1.1 Corm collection

The research begins with the collecting the Elephant Foot Yam corm. The corm can be obtained from nearest market or in wild, where it is commonly available for culinary purposes. Alternatively, if the study aims to analyse wild or locally sourced varieties, the corms can be harvested directly from the nearest forest or suitable locations where the plant grows naturally. There were some differences between the ripe and unripe corm such as the colour of its corm when cut into two. Figure 3.1 shows the difference between those two corms.

Figure 3.1 the differences of the ripe (left) and unripe (right) corm colour

3.1.2 Extraction Process

To explore the potential medicinal properties of Elephant Foot Yam, the active compounds need to be extracted from the corm. 300 gram of both ripe and unripe corm was used and shredded. After that, the shredded corm was put on the aluminium foil and inserted in the oven for 24 hours on 60 degrees Celsius. After the corm dried, it grinded using a multipurpose blender, and sieve using a size 16 sieve (1.18mm opening). The fine powder was labelled as unripe powder and ripe powder.

3.1.3 Characterization and Analysis

Once the extraction process is complete, the obtained powder is further processed to concentrate the extracted compounds. The aluminium foil used to dry the extract and the final extract in powder form is then subjected to various analytical techniques for characterization and analysis.

This research employs microscopic analysis, specifically utilizing light microscopy, to investigate the structural characteristics of konjac gel and powder derived from konjac glucomannan and from the commercial powder. Meticulous sample preparation involves creating thin sections for observation under a light microscope. The analysis encompasses the macroscopic features of konjac gel, such as colour, transparency, and overall organization, with a focus on microstructure at varying magnifications.

For konjac powder, light microscopic observations are utilized to assess particle size distribution. The study aims to provide a detailed understanding of the microscale attributes of these konjac-derived products, offering insights into their quality and potential applications.

This study utilizes X-ray Diffraction (XRD) to investigate the crystallographic structure of konjac powder, a derivative of konjac glucomannan. Providing a concise overview of XRD's fundamental principles and the applied methodology for konjac powder analysis, the study aims to reveal essential insights into its structural characteristics. The findings contribute to an enhanced understanding of konjac powder's crystallography, holding implications for diverse industrial applications.

3.1.4 Konjac Glucomannan extraction

The extraction process that carried out start with pre-treatment of the raw material which is the Elephant Foot Yam by cleaning the corm with running water to remove the debris. The dry heat extraction method involves subjecting the ground or milled raw material to elevated temperatures without the use of any liquid solvents. In this research, oven drying was been chosen to be used.

The temperature and drying duration were controlled during the dry heat extraction process. These parameters are crucial for optimizing the extraction efficiency while avoiding degradation of the target compounds. Monitoring the temperature carefully ensures that the process remains a "dry" extraction without introducing any liquid solvents. After the dry heat treatment, the extract containing konjac glucomannan and other bioactive compounds is collected. This may involve additional steps such as sieving or filtration to separate the extract from the residual plant material.

In the initial phase,100 grams each of the powder were measured and transferred into a glass beaker containing ethanol (with a concentration ranging from 40% to 60% and a solvent to flour ratio of 6:1 - 10:1 mL/g). The mixture underwent agitation using a magnetic stirrer at a moderate speed for a duration of 40 to 80 minutes. Subsequently, the powder was filtered, resulting in the first residue.

Moving on to the second stage, the first residue underwent another round of rinsing with ethanol of the same concentration as in the first stage (40% - 60%, with a solvent to powder ratio of 6:1 - 10:1 mL/g). This was followed by agitation at a speed of 440 rpm for 40 to 80 minutes and subsequent filtration to obtain the second residue. The second residue underwent a repeat of the procedure from the second stage to yield the final residue. The final residue was then dried in a tray dryer at a temperature of 45±5°C for a period of 5 hours. The resulting dried powder was stored for further analysis.

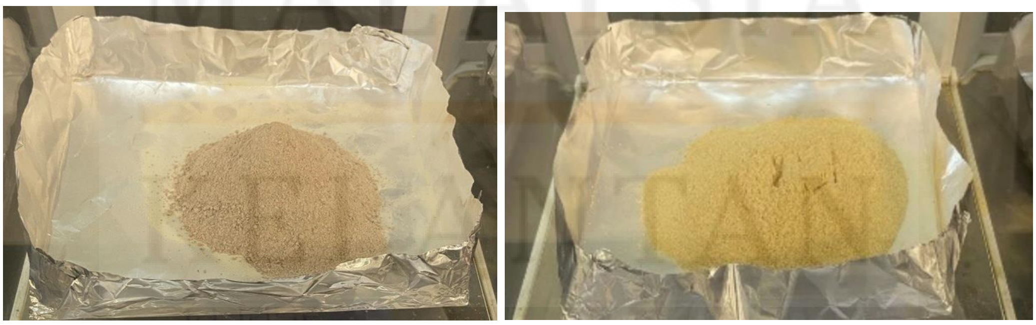

Figure 3.2 the final purified powder after being extracted (left: unripe, right: ripe)

3.1.5 Microscopic Analysis

Sample preparation involves a thin section of konjac gel for light microscopy analysis. The examination begins with an overview of konjac gel, assessing colour, transparency, and overall organization. Higher magnifications (40x and 100x magnifications) are then employed to investigate the microstructure of the gel. For konjac powder, the microscope is utilized to assess particle size distribution, providing quantitative data on the granular composition.

3.1.6 X-Ray Diffraction analysis

The pattern of the X-ray diffraction (XRD) for konjac glucomannan will be analyse using the XRD machine with the angle around 10-90°. After that, the result was then analyzed using Bruker DIFFRAC EVA 5.2 software. This procedure is run to determine the phase of crystallinity and glucomannan granule of extracted konjac glucomannan.

CHAPTER 4

RESULT AND DISSCUSSION

4.1 Result

4.1.1 Konjac Gel production

After following the outlined production process, several key observations and results were noted. As for the gel formation, the 1:6 w/v ratio of crude powder to water resulted in the successful formation of a gel-like consistency. The glucomannan in konjac exhibited its water-absorbing properties, creating a stable gel structure. After that, the konjac gel exhibited a smooth and elastic texture, making it suitable for various culinary applications. The 1:6 ratio provided a balanced consistency, neither too firm nor too liquid. The commercial gel also produced maintained a clear and transparent appearance but the both ripe and unripe crude powder produce a dark colour gel, but still indicating a well-hydrated and homogeneous mixture. This attribute is particularly desirable in applications where visual appeal is crucial. The hydration process, lasting approximately 10-15 minutes, allowed sufficient time for the konjac powder to absorb water and transform into a gel. Monitoring the hydration period is essential for achieving the desired results.

4.1.2 Microscopic Analysis

Light microscopy examination of konjac glucomannan particles revealed heterogeneous aggregates with irregular shapes. Some particles exhibited granular morphology, while others appeared fibrous. Aggregates ranged in size from 5 to 50 micrometers in diameter, with larger structures composed of fused smaller particles (Li et al., 2014). Internal heterogeneity was observed, indicating variations in density and opacity within particles. Fibrous structures suggestive of intertwined glucomannan fibres were evident in certain particles.

Microscopic analysis of konjac gel reveals some of the gel features, with detailed insights into the gel's microstructure (Figure 4.1). Under 40x magnification, all three gels do not have any differences but at the unripe gel, there were some needles like particles.

Under the 100x magnification, the examination of konjac powder focuses on observing and quantifying particle sizes, shedding light on the granular composition and distribution within the powder (Figure 4.2).

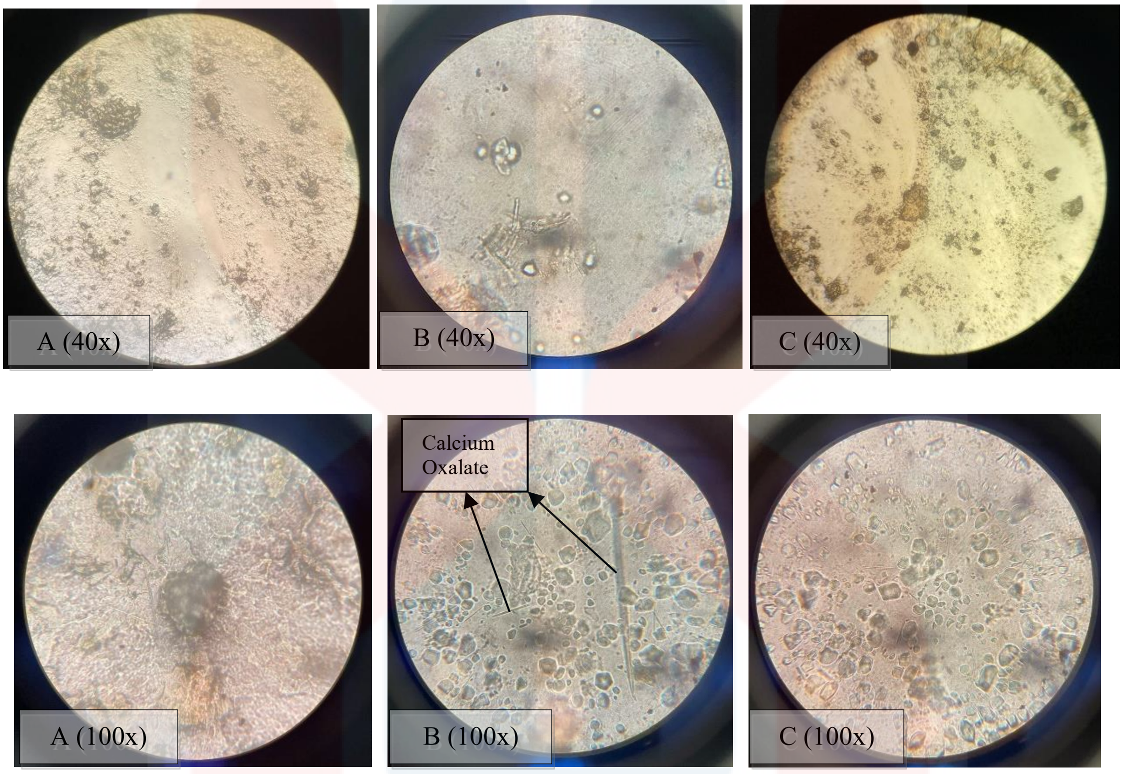

Figure 4.1 Microscopic images of commercial gel (A), unripe gel (B), ripe gel (C) under 40x and 100x magnification

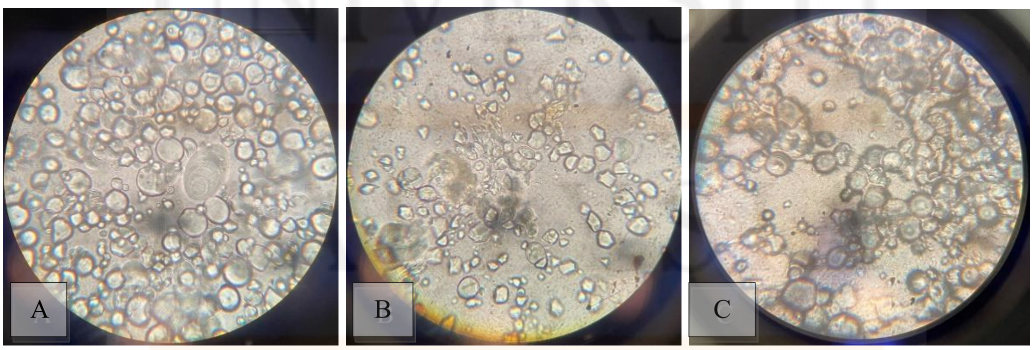

Figure 4.2 Microscopic images of commercial powder (A), unripe powder (B), ripe powder (C) under 100x magnification

Upon closer examination at higher magnifications, konjac glucomannan fibres reveal a porous or sponge-like structure. This porosity contributes to the fibre's capacity to absorb water and form a gel-like consistency upon hydration, a key functional attribute of glucomannan.

4.1.3 X-Ray Diffraction Analysis (XRD)

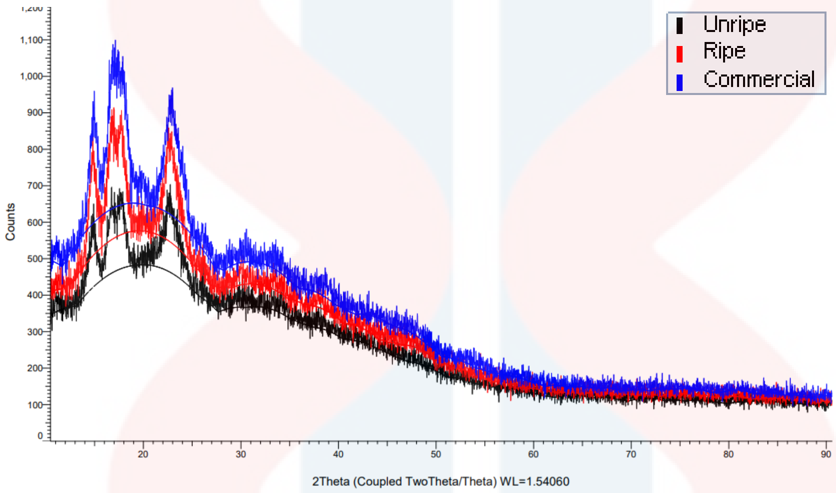

Figure 4.3 XRD Pattern of glucomannan extracted from ripe (RG) and unripe (UG) corm, and commercial glucomannan (CG)

Based on Figure 4.3, the diffractogram patterns of all extracted glucomannan that were similar, exhibited varying broadband with several peaks. That was consistent with the data reported. The sharp diffraction peak is the crystalline state, whereas the widened peak diffraction appears solid and the amorphous state. The diffractogram of all extracted glucomannan has high and sharp peaks at 2θ = 15-20° and around 22°, whereas the unripe glucomannan diffractogram has a high peak at 2θ = 15-17° with more sloping intensity compared to ripe and commercial glucomannan peaks, which indicated that the structure of commercial glucomannan had more crystalline phase than unripe glucomannan which had a more amorphous phase. The degree of crystallization of commercial glucomannan was 36.9%, higher than ripe and unripe glucomannan (32.8%, 31.5%). The degree of glucomannan crystallinity could be increased due to the commercial glucomannan had been added with some other substance, dehydration of glucomannan granules strengthen hydrogen bonds between molecules and intramolecular, thereby increasing the degree of crystallinity.

4.2 Discussion

The physical characteristic that can be seen by naked eyes for the tuber was the differences between the colour of the tuber. As it was not fully ripe, the colour of the tuber more likely pinkish colour compared by the ripe one, the colour was more yellowish-white. During the extraction, the drying process need to be considered due to the temperature used during drying and time of drying to avoid it to be too dry to be test afterward (Prakash et al., 2023). After drying the tuber and being grinded, the powder produced need to be sieved to get a fine dust powder as the fine series size to make sure during the gel production, it does not leave any unwanted lumps in the gel.

The successful formation of a gel-like consistency using a 1:6 w/v ratio of crude konjac powder to water underscores the water-absorbing properties of glucomannan in konjac. This observation aligns with previous research indicating glucomannan's ability to form stable gel structures due to its high-water absorption capacity. The smooth and elastic texture of the konjac gel suggests its potential suitability for various culinary applications, where texture plays a crucial role in consumer acceptance. The balanced consistency achieved with the 1:6 ratio indicates the importance of precise formulation parameters in controlling gel properties. Additionally, the clear and transparent appearance of the commercial gel further highlights its potential for applications where visual appeal is paramount. The darker coloration observed in gels derived from both ripe and unripe crude powder suggests that other compounds present in the crude powder may contribute to the colour, but do not significantly affect the gel's overall hydration and homogeneity.

Light microscopy examination of konjac glucomannan particles revealed heterogeneous aggregates with irregular shapes, indicating the complex nature of glucomannan morphology. The presence of granular and fibrous morphology within these aggregates suggests variations in molecular arrangement and packing. The observed internal heterogeneity, including variations in density and opacity, further underscores the diverse composition of konjac glucomannan particles. Notably, the presence of fibrous structures indicative of intertwined glucomannan fibres provides insights into the hierarchical organization of glucomannan molecules within the aggregates, which may influence their functional properties.

Microscopic analysis of konjac gel highlighted specific features of the gel's microstructure, shedding light on its porous or sponge-like structure. This porosity is attributed to konjac glucomannan fibres, which contribute to the gel's water-absorbing capacity and ability to form a stable gel-like consistency upon hydration. The porous structure observed at higher magnifications suggests that the gel's functional attributes, such as water retention and texture, are influenced by its microstructural characteristics. Based on Figure 4.1 and Figure 4.2, the commercial gel and commercial powder shown a very clear and does not have any dirty compound compared to the self-extract due to the commercial powder already had purified with some other solvent to be commercialized in the market.

Diffractogram analysis revealed variations in the crystalline structure of glucomannan extracted from different sources. Commercial glucomannan exhibited a higher degree of crystallinity compared to unripe and ripe glucomannan samples, as evidenced by sharper diffraction peaks indicative of a more ordered molecular arrangement. The presence of additional substances and the dehydration process during commercial production likely contributed to the increased degree of crystallinity observed. These findings highlight the importance of processing methods in modulating the crystalline structure of glucomannan and its functional properties.

In conclusion, the observed gel formation, microstructural characteristics, and crystallinity of konjac glucomannan have significant implications for its applications in various industries. The water-absorbing properties, heterogeneous morphology, and porous microstructure of konjac glucomannan contribute to its functionality as a stabilizing and thickening agent in food formulations. Furthermore, the degree of crystallinity influences the structural integrity and functional properties of glucomannan, impacting its suitability for different applications. Continued research into the structure-function relationships of konjac glucomannan is essential for optimizing its performance and expanding its applications across diverse industries.

Calcium oxalate crystals can adopt different shapes, including prismatic, raphides, druses, stellar, and crystal sands, depending on genetic factors and environmental conditions. The diverse structures of calcium oxalate crystals are a testament to their adaptability and importance in plant physiology (Tütüncü Konyar et al., 2014). In this research, the crystal shape is known as raphides and are a defense mechanism against herbivores, and in human and animal urinary tracts, where they can contribute to the formation of kidney stones. In terms of appearance under a microscope, calcium oxalate crystals can exhibit various shapes, but in this study the shape of calcium oxalate detected was in needle-like form (Figure 4.1).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the project on the optimization of konjac glucomannan extraction and the investigation of physicochemical properties in Elephant Foot Yam (*Amorphophallus Paeoniifolius*) through the dry extraction method has yielded significant insights and findings. Through meticulous experimentation and analysis, several key points can be summarized.

The project successfully gains konjac glucomannan from Elephant Foot Yam into powder form using the dry extraction method. The konjac glucomannan gel was also successfully produced using the powder and it shown that the powder obtain was in a right form of konjac glucomannan. After that, the characterization analysis provided some of the properties such as the morphology of konjac glucomannan extracted from Elephant Foot Yam.

This study excavated into the impact of some parameters on the quality of konjac glucomannan, a polysaccharide deduced from the tuber of the Elephant Foot Yam. Factors similar as temperature, extraction or preparation time, and solvent attention were totally examined to interpret their goods on the final product. This comprehensive analysis exfoliate light on the implicit functional operations of konjac glucomannan, particularly pressing its unique parcels similar as high water- immersion capacity and gel- forming capacities.

Based on the research that has been conducted, the objective has been achieved where the preparation and extraction of elephant foot yam corm has been successfully implemented and the powder has been successfully used to produce konjac glucomannan gel. In the meantime, the production process of the konjac glucomannan powder needs to be emphasized such as temperature and preparation time. In the characterization session, all the samples tested showed a positive effect where these corms are safe to consume even though they need to be processed with many stages of preparation before being consumed by human. In food industry, this corm also needs to undergo several further purification processes to ensure that it can be consumed by everyone without any side effects.

The optimized process duration not only enhances the quality of konjac glucomannan but also holds significant for its function in few industries including food, medicinal, and ornamental sectors. In the food assiduity, konjac glucomannan serves as a thickening and gelatinizing agent, contributing to the texture and density of food products while also furnishing health benefits similar as salutary fibre supplementation. Pharmaceutical operations include its use as an excipient in medicine phrasings due to its film- forming and binding parcels, while in cosmetics, it finds mileage as a stabilizer and emulsifier in skincare and particular care products.

Also, the application of Elephant Foot Yam as a source for konjac glucomannan underscores the growing interest in sustainable and factory- grounded coffers. By optimizing the birth process, not only is the quality of the final product bettered, but there is also a positive impact on the profitable viability and ecological sustainability of exercising this precious botanical resource. This aligns with the broader trend towards sustainability and the adding preference for natural, factory- deduced constituents in colourful diligence.

Overall, the study contributes to a deeper understanding of konjac glucomannan birth and its implicit operations, emphasizing its part as a protean and sustainable component with wide- ranging benefits across different sectors.

5.2 Recommendation

Based on the findings from the comprehensive physicochemical characterization of konjac glucomannan extracted from Elephant Foot Yam, several recommendations emerge for future research and practical applications. Firstly, further investigations into the relationship between extraction parameters and the physicochemical properties of konjac glucomannan are warranted. Fine-tuning extraction conditions such as temperature, extraction time, and solvent concentration could reveal subtle variations in the material's molecular structure and crystallinity, offering opportunities to optimize the extraction process for enhanced yield and quality. Moreover, the identified functional groups and molecular characteristics from FTIR analysis open avenues for targeted modifications of konjac glucomannan for specific applications.

Researchers may explore chemical modifications or derivatization techniques to tailor the material's properties, thus expanding its functionality in industries such as food, pharmaceuticals, and cosmetics. The crystalline structure information provided by XRD analysis prompts the need for investigations into the effects of processing conditions on the crystallinity of konjac glucomannan. Understanding how variations in extraction parameters influence the crystalline regions of the material can guide the development of extraction protocols that maximize crystallinity for applications requiring specific structural characteristics.

Additionally, the research suggests exploring the potential synergies between konjac glucomannan and other natural or synthetic polymers. Blending konjac glucomannan with compatible materials may lead to the development of composite materials with enhanced properties, opening new possibilities for innovative and sustainable product formulations. In practical terms, industries involved in the production of food, pharmaceuticals, and cosmetics may consider incorporating konjac glucomannan into their formulations. The material's water-absorbing capacity, molecular structure, and unique characteristics revealed in this research make it a promising candidate for various applications, particularly as a functional ingredient in products requiring thickening, gelling, or stabilizing properties.

In conclusion, this research not only contributes to the understanding of konjac glucomannan extracted from Elephant Foot Yam but also provides a foundation for future explorations, optimizations, and applications in diverse industries. The insights gained pave the way for sustainable and innovative uses of this natural resource, aligning with the growing demand for eco-friendly and functional materials in contemporary product development.

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APPENDIX A

Elephant Foot Yam (*Amorphophallus Paeoniifolius*) corm raw plant

APPENDIX B

Elephant Foot Yam (*Amorphophallus Paeoniifolius*) corm sample preparation

APPENDIX B

Extraction process of konjac glucomannan from Elephant Foot Yam