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Comparative Analysis of Glucomannan Properties from Wet and Dry-Extractions of *Porang* (*Amorphophallus muelleri* Blume) and Commercial Konjac Glucomannan

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Abstract

Porang tubers (*Amorphophallus muelleri* Blume) are known as konjac in Indonesian prominent glucomannan sources. The research objective is to compare the dry and wet extraction methods. Two extraction methods (dry and wet) were carried out. First, *porang* flour was obtained from a centrifugal grinder and purified twice with 70 % ethanol solution for 2 h, respectively. Next, the sample was milled with ethanol solution and precipitated twice with 70 % ethanol solution. The 2 samples were compared to a konjac commercial glucomannan for physicochemical and molecular properties. The study revealed that the physical characteristics of glucomannan extracted through the wet method significantly differed from those obtained via dry extraction and the commercially available Konjac glucomannan. Specifically, the glucomannan from dry extraction demonstrated poorer physical qualities compared to its wet-extracted counterpart, and even more so when compared to commercial Konjac. The wet-extracted porang glucomannan's viscosity (33,000 cPs) and whiteness level (70.04) were markedly different from the commercial Konjac, which had a viscosity of 39,000 cPs and a whiteness level of 83.17. In contrast, the dry extraction method yielded lower values, with a viscosity of 22,000 cPs and a whiteness level of 63.43. While FTIR, XRD and DSC analyses produced similar results across the board, the thermal properties of the wet-extracted *porang* glucomannan displayed a higher resistance to decomposition compared to the other 2 samples.

Keywords: *Amorphophallus muelleri,* Dry extraction, Molecular properties, Wet extraction, Konjac glucomannan

Introduction

Porang (*Amorphophallus muelleri* Blume) has become a hot topic in social media or print and an important source of glucomannan. Glucomannan, a heteropolysaccharide consisting of β-D glucose and β-D-mannose, is the most prevalent heteropolysaccharide found in nature, which is water-soluble, and has a high viscosity [1]. The yield of glucomannan extracted from *porang* corms has been reported to be as much as 74 - 90 % d.b. [2]. Glucomannan has various functions in food and pharmaceuticals [3].

Porang chips were manufactured for the production of glucomannan [4]. Commercial glucomannan is isolated from *porang* and konjac (*Amorphophallus konjac*) chips in China [2,5]. *Porang* flour has dark yellow, is slightly itchy in taste, has a fishy odour, and contains high calcium oxalate. It does

not meet the technical specifications of the food industry [6]. Many researchers reported the purification of konjac flour (KF) to produce konjac glucomannan in a compelling and high-yield extraction approach [7-9]. Wet and dry extraction using 50 % ethanol solution several times with no clear and specific information claimed to be successful in purifying *porang* glucomannan on a laboratory scale [10]. The use of multilevel extraction of *porang* glucomannan from fresh tubers with 60 % (first cycle), 70 % (second cycle) and 80 % (third cycle) ethanol solution testified to increase the glucomannan content to 90 % on a laboratory scale [11,12].

The molecular characteristics, including thermal and structural properties, as well as functional groups identified through FTIR analysis, are essential in establishing the unique molecular "fingerprint" of glucomannan powder. These properties are vital for determining its potential uses in the food industry [13] and other sectors, such as biomedicine [14]. A study involving 7 distinct purified konjac flours provided by YitZhi Biotech Co in China revealed that the molecular attributes of konjac glucomannan, particularly its structure, were thoroughly characterized and examined [15]. The molecular analysis of both konjac and porang glucomannan confirmed the presence of hydroxyl polysaccharides and hydrocarbon chains [16], the NH_2 and C=O functional groups typical of primary proteins, the N-C=O groups found in secondary and tertiary amide structures, and mannose molecules [17], as evidenced in 3 glucomannan powder samples [16]. Several scholars have explored the thermal characteristics of glucomannan molecules [18-21]. The diffractogram of glucomannan by XRD has been studied in a sample from fresh *porang* tubers [2,12], sahlep glucomannan [21] and native konjac [22]. Granule glucomannan of crude and purified *porang* flour showed an oval form, intact granules with a scale-like pattern reported by Faridah and Widjanarko [6]; Nurlela *et al.* [12]. However, a comprehensive study of glucomannan, from wet extraction, dry extraction and commercial konjac glucomannan is limited.

The aim of this study is to conduct a comparative analysis of the physicochemical and molecular characteristics, obtained through wet extraction, dry extraction and that of commercially available konjac glucomannan. To date, there has been a lack of documentation on the straightforward extraction process of *porang* glucomannan using a 70 % ethanol solution (technical grade) from both fresh tubers and dried chips specifically for the Indonesian market.

Materials and methods

Materials

The 70 % ethanol (technical grade) solution was applied for the wet extraction and the purification of the dry extraction method. Deionised water for glucomannan isolation was used. The 2 years old of *porang* tubers with an average weight of about 2,000 ± 2,500 g were obtained from *Klangon* Village, Madiun Regency, Jawa Timur, Indonesia, and were used. All other chemicals (analytical grade), such as hydrochloric acid, sulphuric acid, reagent Nelson A and B, formic acid, potassium permanganate and ammonium hydroxide (Merck & Co. PT. Merck Tbk, Indonesia).

Sample preparation

Three samples were prepared for the experiment: Konjac glucomannan commercial, *porang* glucomannan wet extraction and dry extraction methods. Kappa Carrageenan Nusantara Ltd, Indonesia, gave the konjac glucomannan commercial 500 g (Konson Konjac, China), which is used as a positive control treatment.

Dry extraction

The dry extraction of porang glucomannan was performed using ethanol, following the method outlined in reference [23]. The preparation of the samples was conducted according to the procedures described in Tatirat and Charoenrein [7]; Kumalla and Hermanto [24], with some minor adjustments. These adjustments included the use of a 70 % ethanol solution (of technical grade) during the wet extraction process and for the purification of *porang* flour to obtain porang glucomannan. To clean the *porang* corms, a locally manufactured washing machine was used to remove any dirt. Subsequently, a locally produced slicer machine cut the corms into chips that were 2 to 3 mm thick. Finally, the outer skin was peeled off using a knife. Fresh *porang* chips were dried in a locally manufactured oven, which was fitted with a hot air blower set at 55 °C. This drying process lasted for 24 h or until the chips were sufficiently dry and began to crack with ease. Once dried, the chips were ground using a locally crafted

centrifugal grinder that included cyclones. The denser portion of the *porang* powder was gathered and filtered through a 60 mesh screen, while the lighter fraction was discarded as waste. To purify the *porang powder*, it was treated with a 70 % ethanol solution at a 1:1 solid-to-liquid ratio for 4 h. Afterward, the moist *porang* fragments were placed in an oven at 45 °C for another 24 h to dehydrate, resulting in dry *porang* glucomannan. This product was then finely ground using a powder mill from China and passed through an 80 mesh screen to produce *porang* glucomannan powder. Finally, the powder was sealed in a plastic bag in preparation for subsequent analysis.

Wet porang extraction extraction

Fresh *porang* corms, once cleaned, were sectioned into pieces measuring 7×3×3 cm^3. These segments were then placed into a stainless-steel blender, which was locally fabricated by an Indonesian machinery workshop. The blender contained a 70 % ethanol solution and operated at a solid-to-liquid ratio of 1:2, transforming the corms into a slurry. This slurry underwent a 2-hour precipitation process using a fresh 70 % ethanol solution at the same 1:2 ratio. After the first precipitation, the retained substance was further purified with a new batch of 70 % ethanol solution, this time at a 1:1 ratio, for another 2 h in the second precipitation phase. The resulting *porang* glucomannan crumbles were then dried in an oven set at 45 °C for 48 h, yielding glucomannan powder. This powder was processed through a Chinese-made powder mill and filtered to achieve an 80 mesh granularity, suitable for wet extraction of *porang* glucomannan. Finally, the powder was securely packaged in a plastic bag in preparation for additional analysis.

Physico-chemical analysis

Viscosity

Ninety-nine mL of distilled water was added to an Erlenmeyer containing 1 g of glucomannan powder and agitated using a magnetic stirrer (MS-H280-PRO, Dragon Lab/Dlab, China) until all the flour granules were completely dissolved. The mixture was then placed in a water bath (Memmert WNB 14, Germany) at 75 °C for 3 h. Successive heating, the mixture was left to cool at room temperature of 25 - 30 °C and measured using a viscometer with the NDJ-1 brand spindle 4 at 12 rpm [23].

Degree of Whiteness (DoW)

A camera (Minolta CR-10, Minolta, Japan) was used to collect data for the values of L, a and b and estimated according to the following equation [24]:

$$W = 100 - \sqrt{(100 - L)^2 + a^2 + b^2}$$

where W is the degree of whiteness, L is Lightness, a is the Cherry-red (+) and greenness (−) and b is the lemon yellow (+) and blue color (−).

Solubility

The glucomannan powder solubility is analyzed by the method, reported by Du *et al.* [25]. The dissolution was estimated as follows:

$$\text{Solubility (\%)} = \frac{m \times 2.5}{W} \times 100$$

Note that, m is the fraction mass dissolved in 10 g supernatant and W is the total sample used.

Gel transparency

One g glucomannan powder was dissolved in 99 mL distilled water. The mixtures were transferred into a shaker water bath (Memmert WNB 14, Germany) for 2 h at 30 °C. The sample solution was cooled to 25 °C for 1 h, and the absorbance was taken by UV-VIS spectrophotometer at 550 nm (UVmini-1240 Shimadzu Cooperation Inc, Japan) [26].

Granule morphology

The granule morphology of glucomannan powder was inspected using Scanning Electron Microscopy (SEM) (Inspect-S50, FEI, USA) at magnifications of 70×, 200×, 750× and 2,000× based on the method described by Tatirat and Charoenrein [7].

Functional group

The glucomannan functional group profiles of glucomannan powder were evaluated using the Fourier Transform Infrared (Shimadzu IRSpirit/ATR-S Serial No. A224158, Japan) at wavelengths 400 - 4,000 cm^{-1} [27].

Thermal analysis

The thermal analysis (melting point) of glucomannan powder was analyzed using Differential Scanning Calorimetry (DSC) (X-DSC7000, Hitachi, Japan) flushed with nitrogen gas at a flow rate of 25 mL/min, at temperatures ranging from 25 - 400 °C with a temperature increase of 10 °C/min [28].

X-ray diffraction

X-ray diffraction (XRD) equipment (Expert Pro, Malvern PANalytical, England) at a Bragg angle of 10 - 90 ° was chosen to collect data on the XRD pattern of the glucomannan sample. The degree of crystallinity can be predicted by estimating the ratio of the obtained crystalline diffraction area to the total diffraction area [29].

Statistical analysis

Data analysis was conducted using a 1-way ANOVA to determine the effects of the 3 samples on the measured responses. This analysis was performed with Minitab software, version 17. The physicochemical data were taken from 3 replications.

Results and discussion

Physical properties of glucomannan powder

Viscosity and whiteness levels are crucial characteristics of konjac flour, also known as glucomannan powder. From the consumer's perspective, the solubility and clarity of the gel are significant physical attributes of glucomannan powder. These properties, when the powder is mixed with water, determine its acceptability. The average values for viscosity, whiteness, solubility and gel clarity are detailed in **Table 1**.

Table 1 The means of viscosity, degree of whiteness, solubility and gel transparency of glucomannan powder.

Glucomannan powder from	Viscosity (cPs)	Degree of whiteness	Solubility (%)	Gel transparency (%)
Wet	33,667 ± 2,626 b	70.04 ± 0.17 b	78.30 ± 1.27 a	34.34 ± 2.59 b
Dry	22,583 ± 1,876 c	63.42 ± 0.26 c	59.73 ± 5.83 b	9.28 ± 4.18 c
Konjac commercial	39,833 ± 1,041 a	83.17 ± 0.29 a	81.83 ± 0.75 a	52.49 ± 3.78 a

Note: Data signed by a similar letter are not statistically different at $p < 0.05$.

The key point for glucomannan powder trading is its viscosity. The wet extraction process improves its viscosity than dry extraction. Although it is still lower than commercial konjac (**Table 1**). Konjac glucomannan from *A. konjac* shows the viscous solution with water [30]. This data agrees with the findings Faridah and Widjanarko [6], in which *porang* flour viscosity was lower than commercial konjac. The whiteness of glucomannan commercial determines the gel transparency (**Table 1**). When purified with DMSO using reflux at 100 °C, konjac flour exhibited clear gel compared to the control [26]. The result shows that wet extraction resulted in a solubility value similar to the commercial samples (**Table 1**). Solubility is a critical property for food powders because it determines how well the powder can dissolve in a liquid, which is essential for both ease of use and functionality. Food powders with good solubility can be easily incorporated into liquids, making them convenient for consumers to use. Soluble food powders can deliver their intended health benefits more effectively. During production, solubility influences the behaviour of powders in formulations, affecting processes like mixing and homogenization. Solubility represents the concluding phase in the dissolution process of powdered substances and is deemed the critical factor influencing the comprehensive quality of reconstitution in food powders [31].

FTIR glucomannan powder

FTIR Spectrum from molecule complex organic reveals the presence of various organic compounds based on their unique absorption spectra. These could include but are not limited to, polysaccharides like hydroxyl groups, proteins indicated by amide groups and other organic compounds that are part of the

complex molecular structure of the food sample, including glucomannan powder. The vibration of functional groups acts as a distinctive molecular fingerprint that appears when FTIR analysis identifies the chemical bond in organic molecules [27,32,33]. Profiles of functional groups of glucomannan powder from 3 different models are presented in **Figure 1** and **Table 2**.

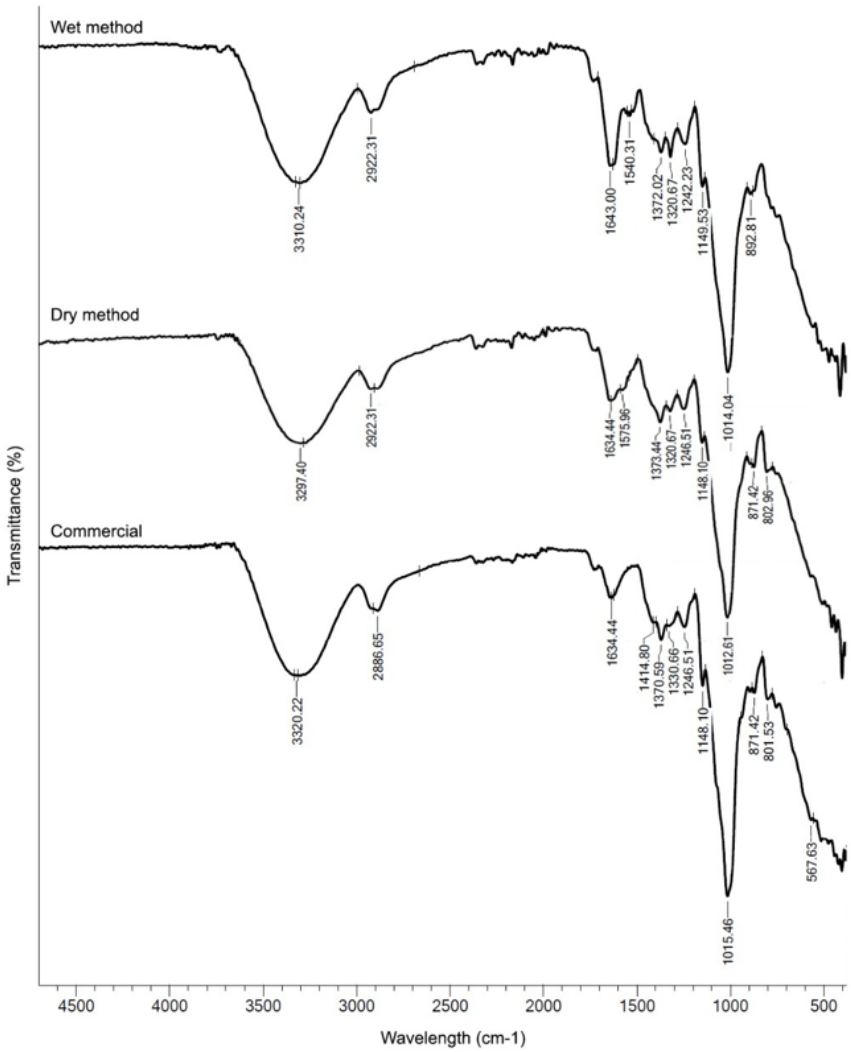

Figure 1 Absorption spectrum FTIR of glucomannan powder commercial, *porang* dry and wet extraction.

A wavelength at 3,310.24 - 3,320.22 cm^{-1} reveals hydroxyl of polysaccharides, while spectrum FTIR at 2,886.65 - 2,922.31 cm^{-1} indicates hydrocarbon groups (C-H) of glucomannan molecule [34]. The appearance peak at a wavelength 1,634.44 and 1,643.00 cm^{-1} (**Table 4**) indicates NH_2 and C=O functional groups of primary protein [35]. Spectrum FTIR at 801.53 and 802.96 cm^{-1} appears from glucomannan commercial and dry extraction but does not show up from wet extraction; exhibited molecule glucose disappeared at wet extraction [36]. Sharp vibration spectrum FTIR at 1,012.61 - 1,015.46 cm^{-1} expresses responsiveness carbonyl groups (C=O) on the surface of glucose and mannose of molecule glucomannan. Chua *et al.* [9] claimed that a sharp peak at 1,016 up to 1,024 cm^{-1} is representative of a distinctive molecular fingerprint of the carbohydrate molecule. Notably, the peak FTIR at 871.42 and 892.81 cm^{-1} proposes molecule mannose from 3 samples of glucomannan powder [33]. In contrast, the absorption spectrum FTIR at 567.63 cm^{-1} recommends functional groups of N-C=O bending vibration, secondary and tertiary amides [35] of glucomannan molecules of commercial powder but not at dry and wet extraction.

Table 2 Absorption spectrum FTIR (cm^{-1}) of dry, wet extraction and commercial konjac glucomannan.

No	Spectrum FTIR (cm^{-1})			Functional groups
	Porang wet	Porang dry	Konjac commercial	
1	3,310.24	3,297.40	3,320.22	-OH *strech*
2	2,922.31	2,922.31	2,886.65	C-H *vibration*
3	1,643.00	1,634.44	1,634.44	NH_2 and C=O *vibration*
4	1,540.31	1,575.96	1,414.80	CH_3 *bend. antisymmetric*; CH_2 *bend*; *ring aromatic stretch*; C-N *stretch*
5	1,372.02	1,373.44	1,370.59	CH_3 *symetric bend*
6	1,320.67	1,320.67	1,330.66	*Syringyl ring konjac*
7	1,242.23	1,246.51	1,246.51	C-O *stretch, carboxylic acids dimers*
8	1,149.53	1,148.10	1,148.10	C=O *stretch*
9	1,014.04	1,012.61	1,015.46	C=O *stretch*
10	892.81	871.42	871.42	C-H *vibration*
11	-	802.96	801.53	C-H *vibration*
12	-	-	567.63	N-C=O *bending vibration, secondary and tertiary amides*

X-Ray Diffraction (XRD) glucomannan powder

One of the non-destructive analyses utilized to analyse many substances, like fluids, powders and crystals is the X-ray Diffraction method [37]. Spectrum XRD implies a correlation between intensity and angle diffraction of a crystalline or amorph crystal of powder granules. This diffraction pattern of the sample is represented as a chemical fingerprint. Therefore, the chemical composition of a powder can be predicted by comparing the diffraction pattern of the sample to the database of known patterns. XRD pattern of glucomannan powder from commercial samples, dry and wet extraction is presented in **Figure 2**.

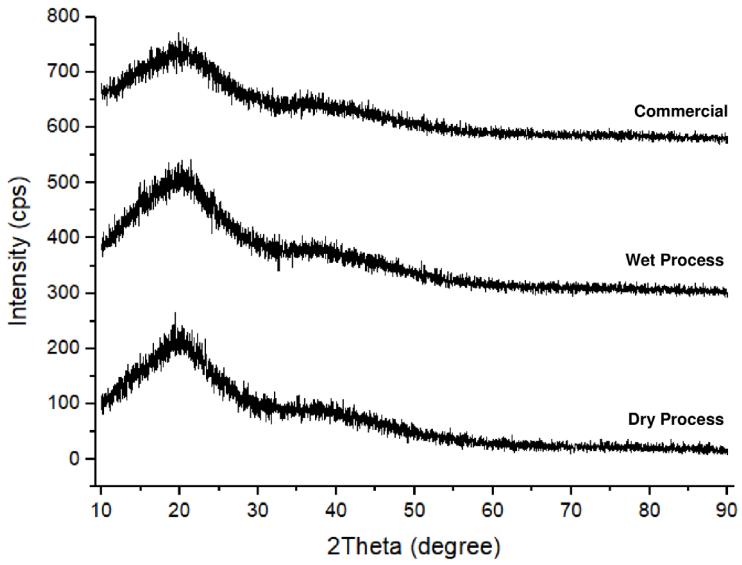

Figure 2 XRD pattern of konjac commercial glucomannan, *porang* wet and dry extraction glucomannan.

XRD studies confirmed that 3 samples had several solid states and a few amorphous ones. **Figure 2** shows diffractogram XRD pattern of the 3 samples is virtually similar and exhibits broadband with several sharp peaks. The pointed peak pattern is the crystalline solid state, whilst the broad and wide peak diffraction means a solid and amorphous state of matter. The 3 diffractogram samples of glucomannan commercial, wet and dry extraction have a high and pointed peak at 2θ = 20 ° and a small height at 2θ = 38 °.

The peak at 2θ = 20 ° suggests a strong reflection from a specific set of crystallographic planes within the glucomannan structure. This is indicative of a well-ordered molecular structure, where the glucomannan chains are arranged in a regular, repeating pattern [38]. The smaller peak at 2θ = 38 ° might correspond to a less distinct set of crystallographic planes or reflect regions within the material that are less ordered. This smaller peak suggests that the XRD pattern of the 3 glucomannan samples may include impurities, which contribute to the less ordered regions of the material. This result is in agreement with the data [2], but slightly different from the data [12] and the peak XRD from sahlep glucomannan [39] and pattern of the height XRD from native konjac [22].

Differential Scanning Calorimetry (DSC)

Differential Scanning Calorimetry (DSC) is a thermal analysis technique used to study the thermal properties of materials, including konjac. In the context of konjac, DSC can help determine several key thermal characteristics such as thermal stability, melting point and glass transition and heat capacity changes. DSC can identify the melting point and the first and the second exothermic temperature, which is crucial for processing and storage of Konjac [40]. DSC is an advanced machine to determines the thermal conductivity of a molecule by absorbing or releasing heat with time. DSC can also determine the purity of food products through the melting temperature of organic substances. DSC technique has been used to identify food adulteration in oils, carbohydrates or solid or liquid food products, particularly exotic and economic food products. DSC has been reported to detect lard and pork exist in food products [41] adulteration in extra virgin oils [42]. The relationship between DSC data and konjac's properties is significant because it provides insights into how konjac will behave under various temperature conditions, which is essential for its use in food products and packaging. DSC endothermic and exothermic thermogram commercial, dry and wet extraction is presented in **Figure 3**.

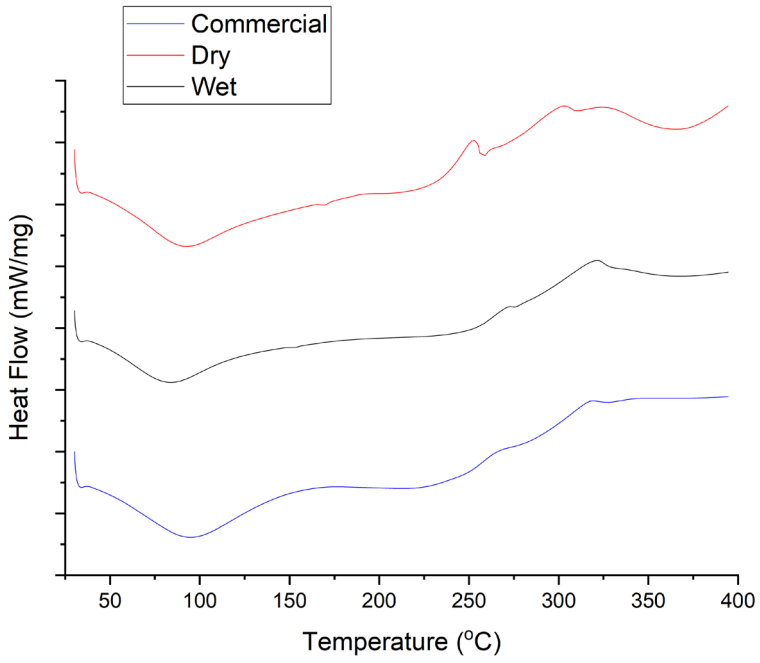

Figure 3 Endothermic and exothermic curve DSC thermogram of konjac commercial glucomannan, *porang* glucomannan dry and wet extraction.

Table 3 DSC of glucomannan commercial, dry and wet extraction.

Glucomannan powder	T_{onset} (°C)	T_m (°C)	T_{endset} (°C)	Enthalpy (ΔH) J/g	$T_{exothermic}$ I (°C)	$T_{exothermic}$ II (°C)
Commercial	37.6	94.2	196.6	16.6	265.9	318.6
Dry extraction	37.7	92.6	165.4	12.4	253.0	302.9
Wet extraction	37.1	82.9	148.0	13.6	272.4	321.2

The thermal conductivity of the 3 samples showed that the molecule of glucomannan started to decompose over 325 °C (**Figure 3**).

All samples begin to show thermal activity at 37.0 °C, known as the onset temperature (T_{onset}). The lowest melting point observed, 82.9 °C (T_m), was for glucomannan extracted from *porang* using the wet method, as shown in **Table 3**. The melting point is the temperature at which a material shifts from solid to liquid. For commercial konjac glucomannan (KGM) and glucomannan derived from porang flour by the dry method, a higher melting point indicates that more heat is needed for the substance to melt. This suggests that KGM and glucomannan processed by the dry method have a more robust structure, making them less prone to melting. The wet extraction method, which typically involves water, can cause partial breakdown of the molecular structure, leading to a lower melting point, as indicated in **Table 3**. In contrast, the dry method may better maintain the structural integrity of glucomannan, resulting in a higher melting point. Differential Scanning Calorimetry (DSC) analysis suggests that the KGM powder was likely produced using a dry method. The glucomannan molecules from wet extraction start to decompose at 272.4 °C and oxidize at 321.2 °C, as detailed in **Table 3**. Li *et al.* [43] have reported that for deacetylated glucomannan powder from China, the first and second exothermic reactions occur at 243.2 and 320.5 °C for the Da0 treatment, and at 280.6 and 330.5 °C for the Da6 treatment, respectively. There are limited publications on DSC studies of dry and wet extraction methods.

Scanning Electron Microscope (SEM)

SEM plays a key role in the field of food science. It gives scientists the ability to closely inspect food at a very small scale. This method captures extremely clear and detailed pictures of the food's exterior, showing its landscape and form. In other words, it reveals the intricate details of the food's surface texture, whether it's smooth or bumpy. SEM is particularly useful for spotting changes in the food's structure that result from various treatment processes, such as drying or freezing. Additionally, it's an essential tool for finding unwanted substances or pollutants in food, which is crucial for ensuring the food we consume is safe.

Microscopic of konjac commercial glucomannan, wet and dry extraction was observed by SEM and the measurement of granule glucomannan was measured at several magnificent to get a clear picture of physical appearances microscopically. The results collected are shown in **Figure 4**. The granules of *porang* glucomannan dry extraction (C_1 and C_2) are rough and oval, with a scale pattern and intact shape, which indicates that impurities are still attached firmly to the surface. SEM of glucomannan (GM) in polished konjac flour showed a similar patchwork pattern of C_1 and C_2 of GM dry extraction [44]. While *porang* wet extraction granules (B_1 and B_2) look smooth on the surface, with an oval shape, but scale-like pattern disappeared. Nurlela and colleagues observed that glucomannan, when extracted from fresh tubers using a multilevel concentration (MC) method applied 3 times, resulted in granules with a noticeably smoother and clearer surface compared to those extracted with 50 and 96 % technical-grade ethanol solutions [45]. The disappearance of scale-like patterns may be due to the damp extraction dissolving some impurities, and the granule glucomannan becomes soft and easy to break up during the extraction process. SEM of *porang* glucomannan washed 5 times with ethanol solution showed a crack on the surface of the glucomannan granule and looked smooth on the surface granule. SEM of GM konjac commercial (A_1 and A_2) are irregular in shape and resemble data [2]. The GM granules Konjac commercial appear to be flat and not intact. This may be due to the extraction process and resemblance to the data [12].

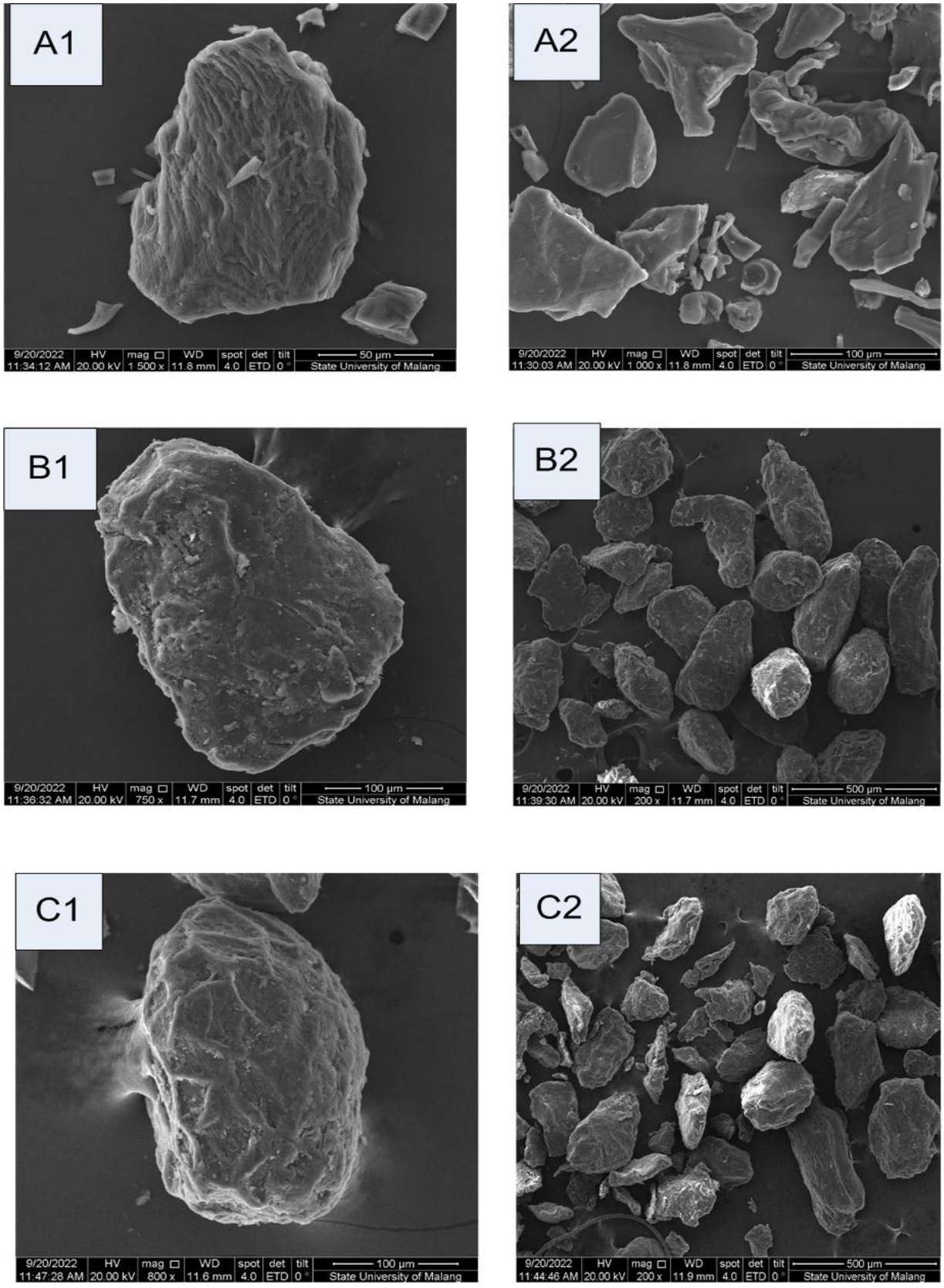

Figure 4 SEM glucomannan granule. A_1 and A_2 of commercial GM* 1,500× and 1,000×. B_1 and B_2 of wet extraction 750× and 200×; C_1 and C_2 of dry extraction 800× and 200×, respectively. *GM = glucomannan.

An FTIR analysis indicated the absence of glucose's functional group in glucomannan obtained through the wet extraction method, likely due to leaching. In contrast, this functional group was detected in glucomannan sourced from commercial products and extracted using the dry method. A DSC assessment revealed that glucomannan from wet extraction possesses the lowest melting point, suggesting a higher susceptibility to melting. XRD diffractograms showed virtually identical patterns of crystalline and amorphous phases across all 3 samples. SEM imaging of wet-extracted *porang* glucomannan displayed a smooth and oval surface, similar to commercial glucomannan granules. However, glucomannan granules extracted via the dry method exhibited a rough, scaled and intact surface, hinting at the presence of surface-bound impurities. The combined molecular analyses from FTIR, XRD, DSC and SEM studies confirm that the molecular structure of glucomannan in all 3 samples is consistent and identical.

Conclusions

Utilizing a 70 % technical-grade ethanol solution in the wet extraction process for porang glucomannan powder yields a superior quality profile and improves the extraction technique over the dry method. Notably, the glucomannan's solubility is significantly enhanced when derived from the wet extraction process. Additionally, the transparency of the gel produced by wet extraction has increased by 270 %, from 9.28 to 34.34 %. The wet extraction process not only simplifies the procedure but also enhances the viscosity, making it a more practical method for producing glucomannan that closely resembles the quality of commercial konjac glucomannan. When comparing the molecular characteristics of *porang* glucomannan derived from both wet and dry extraction methods with commercial konjac glucomannan, using techniques such as FTIR, XRD, DSC and SEM, we find they are virtually identical. The only exception is the SEM analysis of commercial konjac glucomannan, which reveals a flat and smooth surface with an irregular shape. Furthermore, the DSC thermogram indicates that wet extraction yields higher exothermic peaks I and II than both dry extraction and commercial konjac glucomannan. In light of these findings, the wet extraction technique for *porang* glucomannan stands out as a promising direction for the future development of the glucomannan powder segment in the food industry.

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