Food Research 6 (4) : 345 - 353 (August 2022)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Physicochemical properties of glucomannan isolated from fresh tubers of *Amorphophallus muelleri* Blume by a multilevel extraction method

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Article history:
Received: 3 August 2021
Received in revised form: 21 September 2021
Accepted: 10 January 2022
Available Online: 18 August 2022

Keywords:
Post-harvest,
Porang Tuber,
Polysaccharide,
Glucomannan,
Multilevel Concentration,
Ethanol

DOI:
https://doi.org/10.26656/fr.2017.6(4).580

Abstract

Post-harvest treatment of *Amorphophallus muelleri* Blume (porang) tubers carried out by Indonesian farmers is slicing tubers into chips, drying, exporting, or processing them to a porang flour before export. To increase the economic value of porang tuber, it can be directly extracted to obtain glucomannan. Glucomannan is a polysaccharide that has many benefits. This work investigated the simple extraction method to produce high purity of glucomannan from fresh porang tubers and study the physicochemical properties of glucomannan. Sliced porang tuber repeatedly (three times) extracted by 60% ethanol (fixed concentration method). In addition, repeated extraction was conducted by varying ethanol concentrations (multilevel concentration method), in the first extraction, the sample was milled in 60% ethanol, then the precipitated sample was extracted again with 70% ethanol and finally extracted in 80% ethanol. Glucomannan with high purity (90.00%), whiteness degree (89.91), viscosity (14696.86 mPa.s), and a small number of impurities: ash (0.92%), fat (0.01%), protein (5.18%), without starch content was isolated by multilevel ethanol extraction method. By varying the concentration of ethanol, the impurities with different polarities could be dissolved effectively without heating, repetition of extraction, and further purification. FTIR spectra confirmed the presence of functional groups composing the glucomannan compound. XRD pattern showed that the extracted glucomannan had a more crystalline phase than commercial glucomannan. SEM results verified the purity of the appearance of glucomannan particles.

1. Introduction

Amorphophallus muelleri Blume (synonyms: *A. oncophyllus* Prain and *A. blumei* (Schott) Engler) is native to Indonesia (Santosa and Sugiyama, 2016). *Amorphophallus muelleri* Blume, locally called porang, contained the highest glucomannan compared to other types that grow in Indonesia but lower than konjac glucomannan (KGM) content in *Amorphophallus konjac*. Glucomannan is a polysaccharide composed of β-1,4-linked D-mannose and D-glucose monomers (Behera and Ray, 2017). The characteristics and benefits of glucomannan have been widely studied. In the food industry, glucomannan was used as a food additive for thickening, texturing, gelling, emulsifying, stabilizing, and water-binding agents in some food, like soup, gravy, mayonnaise, jam, and edible film (Yang *et al*., 2017; Wang *et al*., 2019). As a functional food source, glucomannan is considered a low-calorie fibre with an important advantage as an indigestible dietary fibre (Horinaka *et al*., 2016), which has been known to help lower cholesterol levels, modification of intestinal microbial metabolism, and weight loss (Tester and Al-Ghazzewi, 2016). Glucomannan also can reduce fasting and postprandial glycemia, cardiovascular risk factors (Devaraj *et al*., 2019), and other lifestyle diseases such as type 2 diabetes, obesity, coronary heart disease, stroke, hyperlipidemia, hypercholesterolemia, diminution of constipation, treatment of hyperthyroidism, colorectal cancer, wound healing, and as an antioxidant and prebiotic (Behera and Ray, 2016; Deng *et al*., 2020). Due to its biodegradability and gel-forming ability in the pharmaceutical industry, glucomannan can be used in drug delivery (Zhang *et al*., 2014). According to the FDA (Food and Drug Administration), Glucomannan was recognized as a safe biomaterial in the USA, Health Canada, and European Union for food additive and therapeutic uses (Zhu, 2018).

According to an interview with a porang farmer in

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Wonogiri, Central Java, Indonesia, at the end of 2019, the price of porang tubers per kilogram is around 10,000-13,000 IDR, while the price of porang chips per kilogram is up to 55,000-65,000 IDR, and flour containing only porang glucomannan is valued up to 1.2 million IDR per kilogram. The demand for porang chips for export to China reaches more than 1000 tons per month (1 USD = 14,637.0 IDR). In Indonesia, farmers have exported porang to China and Japan in large quantities, but in low value, since it was sold in chip form and flour (Harmayani *et al*., 2014). Generally, post-harvest processing of porang tubers carried out by farmers is slicing the porang tubers into chips and then drying them. Farmers did not have sufficient skills and tools to process porang chips into flour, even more, to extract glucomannan. Indonesia still imports glucomannan flour to meet demands. Therefore, it is important to explore the effective and efficient method to extract porang glucomannan to enhance its value.

Commonly, commercial glucomannan was extracted from the dried state of Amorphophallus tubers in the form of flour mechanically or chemically. The mechanical method involved milling dried porang chips into flour, which is subsequently purified by wind-sifting (Imeson, 2010; Jian *et al*., 2016). The most common chemical method is conducted by ethanol extraction due to its simplicity and high efficiency. The ethanol solvent is volatile, colourless, and non-toxic to human life. In the previous studies, Chua *et al*. (2012) used 50% ethanol, Harmayani *et al*. (2014) used 95% ethanol, Xu *et al*. (2014) used 40% ethanol and studied the effect of temperature in the extraction process. They used dried konjac and porang flour. Because of the drying process, the impurities encapsulated on the surface of the glucomannan granules were not easy to be removed and needed further purification using a high concentration of ethanol. The impurity removal will be easier if the granules are isolated directly from fresh tuber without tuber slices drying. The study of direct glucomannan extraction from fresh tubers has been reported but is still rare.

The research objective was to find a simple extraction method to get a high purity of glucomannan from the fresh porang tuber and study the physicochemical properties of glucomannan. This study extracted glucomannan from the fresh porang tuber with two simple methods using an ethanol solution. In the first method, the fixed concentration method (FC), sliced porang tuber (three times) are extracted with 60% ethanol. Increasing the concentration of ethanol to 60% and reducing the extraction repetition to three times, is expected to obtain glucomannan with high purity according to a previous study carried out by Yanuriati *et al*. (2017). They isolated high purity glucomannan by repeating the milling of sliced fresh porang tuber seven times in 50% ethanol, followed by filtration without further purification.

In the second method, the multilevel concentration method (MC), repeated extraction was conducted by varying ethanol concentrations. In the first extraction, the sample was milled in 60% ethanol, then the precipitated sample was extracted again with 70% ethanol and finally extracted in 80% ethanol. The ratio of porang tuber and ethanol was 1:3 and 1:5 in both methods. The impurities, such as starch, crude fibre, protein, and lipid-containing in porang tuber, have different polarities. By varying the ethanol concentration in the multilevel concentration method (MC), it was expected that the impurities with different polarities could be dissolved effectively during the milling process and removed during the filtering process. Therefore the milling and filtering process did not require a lot of repetition and further purification.

In this study, the extracted glucomannan was investigated for its physicochemical properties and glucomannan content, then characterized by Fourier Transform-Infrared (FTIR), X-Ray Diffraction (XRD), and Scanning Electron Microscope (SEM), then compared to commercial glucomannan.

2. Materials and methods

2.1 Materials and chemicals

The primary materials used in this study were fresh porang tubers from the species *Amorphophallus muelleri* Blume synonyms of *A. oncophyllus*. These porang tubers were harvested during dormancy at three years old in IPB University experimental garden, Bogor, Indonesia. The chemicals were ethanol, 3,5-Dinitro Salicylic Acid (3,5-DNS), phenol, sodium hydroxide, sodium bisulfite, potassium sodium tartrate, d-glucose, d-mannose, deionized water, distilled water, and other chemicals which were analytical grade from Merck Co., Tedia Co. Inc., and RCI Labscan Ltd.

2.2 Extraction of glucomannan from porang fresh tuber

The porang tubers were washed and cleaned from attached soil, peeled, sliced to about 3-5 mm thick, and then shredded. In the first method i.e. fixed concentration method (FC), the shredded tubers were milled in 60% ethanol at around 11000 rpm for 7 mins then filtered. Then, filtered granules were milled in 60% ethanol and filtered. Filtering and milling were repeated once more. The filtered granules are known as glucomannan. Then, the glucomannan granules were dried in the oven at 50° C, 24 hrs.

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In the second method, the multilevel concentration method (MC), the shredded porang tubers were milled in 60% ethanol at 11000 rpm for 7 mins and then filtered. This process was repeated in 70% ethanol (second stage) and then in 80% ethanol (third stage). The obtained glucomannan granules were dried in the oven at 50°C, 24 hrs. The ratio of tubers (g) and ethanol (mL) applied in both methods (FC and MC) was 1:3 and 1:5. In the previous work by Nurlela *et al*. (2021), extracted porang tubers with technical grade ethanol in a ratio of tubers to ethanol 1:3 was carried out, producing glucomannan with fairly high purity. Therefore in this study, ratios 1:3 and 1:5 were used with varying concentrations of ethanol to obtain high-purity glucomannan. Thus, there were four samples of extracted glucomannan: fixed concentration method with the ratio of tubers to ethanol 1:3 and 1:5 (FC13 and FC15), multilevel concentration method with the ratio of tubers to ethanol 1:3 and 1:5 (MC13 and MC15).

2.3 Proximate analysis

Proximate analysis was performed on porang tubers and all extracted glucomannan. The moisture, ash, fat, and protein content were determined according to AOAC methods (967.03, 942.05, 920.39, and 981.10) (AOAC, 2006). In addition, the starch was analyzed qualitatively by staining glucomannan granules using I_2-KI.

2.4 Glucomannan content

Glucomannan content was analyzed using 3,5-dinitro salicylic acid (3,5-DNS) colorimetric assay (Chua *et al*., 2012). The first step was the preparation of the 3,5-DNS reagent. It was made by mixing solution A (0.7 g phenol, 1.5 mL of 10% sodium hydroxide, 5 mL distilled water, and 0.7 g sodium bisulfite) with solution B (22.5 g potassium sodium tartrate, 30 mL of 10% sodium hydroxide, 88 mL dinitro salicylic acid 1%).

The second step was the construction of standard d-glucose and d-mannose calibration curves. d-glucose stock solution (1 mg/mL) was placed (0.40, 0.80, 1.20, 1.60 and 2.00 mL) into 25 mL volumetric flasks, respectively (using DI water as a blank). DI water was then added to the volume of 2.00 mL, followed by 3,5-DNS (1.50 mL) to each flask. Each mixture was heated for 5 mins in a boiling water bath and cooled to room temperature before diluting it to 25 mL with DI water in a volumetric flask. Absorbance was measured at 550 nm, and a plot of the measured absorbance against the glucose content (mg) was constructed. A d-mannose standard curve was constructed using the procedure as described for glucose.

The third step was the preparation of glucomannan sample solution and glucomannan hydrolysate. The glucomannan sample solution was made by dissolving 0.2 g extracted glucomannan in buffer solution (formic acid-sodium hydroxide 0.1 mol/L 50 mL), then magnetically stirred for 4 hrs at room temperature. The mixture was then diluted with formic acid–sodium hydroxide buffer to 100 mL in a volumetric flask, followed by centrifugation at 4000 rpm for 20 mins, the supernatant was glucomannan sample solution. The next step was to make glucomannan hydrolysate, 5 mL of glucomannan sample solution was added to a 25 mL volumetric flask followed by the addition of 2.5 mL of 3nM sulfuric acid, heated in a boiling water bath for 90 mins. The solution allowed it to cool to room temperature, added 2.5 mL of 6 M NaOH, and then diluted with distilled water to 25 mL. Both the glucomannan sample solution and hydrolysate (2 mL) were added with 3,5 DNS reagent (1.5 mL). Absorbance was measured at 550 nm using a UV-VIS spectrophotometer. The following equation calculated the glucomannan content (Chua *et al*., 2012):

$$\mathrm{GMcontent}(\%) = \frac{5000\ f\ (5T - To)}{m\ (1 - w)}$$

Where f = correction factor, T = glucose content of glucomannan hydrolysate (mg), To = glucose content of glucomannan sample solution (mg), m = mass of extracted glucomannan (200 mg) and w = water content of glucomannan

The glucomannan yield was calculated by the following formula:

$$\mathrm{Yield} = \frac{m_1 (1 - w_1) \times 100\%}{m_2\ (1 - w_2)}$$

Where m_1 = mass of dried glucomannan, m_2 = mass of wet peeled porang tuber, w_1 = water content of dried glucomannan, and w_2 = water content of wet peeled porang tuber.

2.5 Whiteness

The whiteness degree of glucomannan powder was analyzed with a Spectrophotometer reflectance elrepho. The standard used was MgO.

2.6 Viscosity

Glucomannan sol (1%) was agitated for about 1 hr, 30°C. The measurement was conducted using a Brookfield Digital Rheometer DVIII+ULTRA at 30°C with spindle LV4 at 12 rpm.

2.7 Fourier Transform Infra-Red spectroscopy analysis

The functional groups of glucose and mannose of extracted glucomannan were determined using the Fourier Transform Infra-Red (FTIR) UATR Perkin Elmer.

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2.8 X-Ray Diffraction analysis

The X-ray diffraction (XRD) pattern for glucomannan was analyzed using XRD Maxima 7000 Shimadzu. The diffraction angle ranged 2θ = 10-80°. The XRD analysis was conducted to determine the phase of glucomannan granule and crystallinity of extracted glucomannan, then compared with the commercial glucomannan.

2.9 Scanning Electron Microscope analysis

To study the morphology of extracted glucomannan, the Scanning Electron Microscope (SEM) photomicrographs were recorded by using the SEM-EDX Carl Zeiss Bruker.

2.10 Statistical analysis

Statistical significance of the chemical properties, whiteness, and viscosity of extracted glucomannan was assessed with a one-way analysis of variance (ANOVA). In addition, the effect of the two extraction methods and the ratio of tuber and ethanol based on the obtained glucomannan were statistically analyzed by two-way ANOVA when differences were significant ($p<0.05$), and the means were compared using Duncan's multiple range tests using SPSS Statistics (IBM SPSS Statistics) for the Windows program.

3. Results and discussion

3.1 Proximate composition of raw material

Porang carbohydrates consist of starch, mannan, crude fibre, free sugar, other polyose, and calcium oxalate causing itchy skin. Glucomannan content varied depending on the part of tubers, where they have grown, and when they were harvested (Nurlela *et al*., 2019). The levels of glucomannan on *Amorphophallus muelleri* Blume tuber in the three growing periods were 47-55%. The proximate composition of fresh porang (*Amorphophallus muelleri* Blume) tubers that were used in this study are displayed in Table 1. Moisture content was the highest in porang tubers. High moisture content in raw food causes microbial growth and affects chemical changes (Hunaefi *et al*., 2021). Therefore, post-harvest processing of porang tubers must be completed fast and precise. Porang farmers usually dry the slice tubers and sell them to collectors immediately, although some farmers grind them into porang flour.

Table 1. Proximate composition of fresh porang (*Amorphophallus muelleri* Blume) tubers

Chemical properties	Average value (%)
Moisture	80.01
Ash	0.83
Fat	0.30
Protein	9.50
Crude fibre	5.20
Starch	4.16

3.2 Extraction of glucomannan from Amorphophallus muelleri Blume tubers

Glucomannan obtained from extraction by multilevel concentration method with ratio tuber and ethanol 1:5, MC15 (Table 2), produced the highest purity with a small number of impurities (ash and lipid, without starch content). A small number of impurities indicated that the extraction using ethanol with a multilevel concentration method could dissolve other compounds than glucomannan contained in porang tuber such as starch, protein, and lipid, which have different levels of polarity. The size of the glucomannan granule is larger 5-10 times than those of ordinary cells (impurities) (Chua *et al*., 2013), resulting in easy removal of impurities from glucomannan granules during extraction with ethanol solutions in various concentrations. Porang extraction method with ethanol would dissolve other compounds than glucomannan because glucomannan is insoluble in ethanol (Li *et al*., 2014).

Table 2. Chemical properties of extracted glucomannan

Chemical properties (%)	Fixed concentration with the ratio of tuber (g):ethanol (ml)		Multilevel concentration with the ratio of tuber (g):ethanol (ml)	
	1:03 (FC13)	1:05 (FC15)	1:03 (MC13)	1:05 (MC15)
Moisture	5.16^{a}	5.67^{a}	5.85^{a}	6.80^{a}
Ash	1.74^{d}	1.15^{c}	1.02^{b}	0.92^{a}
Fat	0.01^{a}	0.01^{a}	0.01^{a}	0.01^{a}
Protein	4.92^{a}	5.49^{c}	5.60^{d}	5.18^{b}
Starch(I_2-KI test)	-	-	-	-
Glucomannan^{z}	$81.14±1.09^{A}$	$84.44±0.94^{B}$	$88.29±1.04^{C}$	$90.00 ± 1.44^{D}$
Yield^{z}	56.57^{B}	50.19^{A}	66.40^{D}	57.64^{C}

Values with different superscripts within the row are significantly different ($p \leq 0.05$).
^{Z} data ware based on a dry basis
- , no color (negative/no starch content)

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The higher ethanol concentration caused lower levels of polarity. In the first stage, the porang tuber is extracted using 60% ethanol. The high moisture content of porang tubers is 80.01% (Table 1) adding polarity to the 60% ethanol solution used as a solvent in the extraction process, at this stage, polar impurities such as protein and sugar are more easily dissolved (Xu *et al*., 2014). Starch might dissolve in 70% ethanol (second stage), while lipid and calcium oxalate dissolves in low polarity of 80% ethanol (third stage). The protein content was still quite high, probably due to protein coagulation in the presence of ethanol, therefore coagulated protein was filtered along with glucomannan during the filtration process.

A two-way analysis of variance was conducted on the influence of two independent (extraction methods and the ratio of tuber (g) and ethanol (mL) on the glucomannan content. The extraction method included two levels (fixed concentration method and multilevel concentration method). The ratio of tuber and ethanol included two levels (1:3 and 1:5). All effects were statistically significant at the 0.05 significance level. The main effect for the extraction method yielded an F ratio of $F(1,4) = 3{,}099.31$, $p<0.001$ indicating a significant difference between fixed concentration (M = 82.89, SD = 1.99) and multilevel concentration (M = 89.21, SD = 0.92). The main effect for the ratio yielded an F ratio of $F(1,4) = 490.80$, $p<0.001$ indicating that the effect of the ratio was significant, ratio 1:3 (M = 84.80, SD:4.19) and ratio 1:5 (M = 87.31, SD = 3.11). The interaction effect was significant $F(1,4) = 67.84$, $p<0.001$.

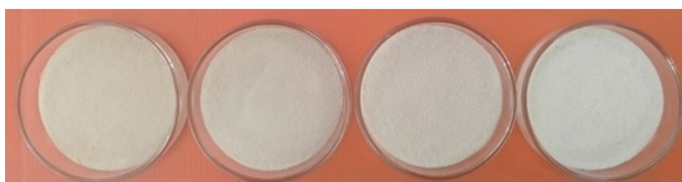
Both fixed and multilevel concentration methods with a ratio of tuber and ethanol 1:5 (FC15 and MC15) produced higher purity glucomannan than the ratio of 1:3. The greater amount of solvent affected the contact area of the solid with the solvent. The more solvent, the greater the contact area, and the distribution of the solvent to the solid will be even greater. The amount of solvent would reduce the saturation level of the solvent that the impurities will leach out, and the glucomannan will be perfectly extracted. However, the low yield (Table 2) is probably due to the partial small granules of glucomannan leaching during filtration.

Commercial glucomannan purification was generally carried out on porang that has been dried and made flour (Chua *et al*., 2012; Harmayani *et al*., 2014; Xu *et al*., 2014). The drying process would cause the impurities to stick to the surface of the glucomannan granule, therefore it would be difficult to be removed and cause a decrease in purity.

Glucomannan obtained from extraction using the multilevel concentration method (MC15), without heating and a lot of repetition of extraction (three times) have a purity of 90.00%, close to the purity of glucomannan obtained by Yanuriati *et al.* (2017) where the isolated glucomannan from fresh tubers using 50% ethanol as solvent at 45-50°C and was extracted seven times (purity was 90.98%). Xu *et al.* (2014) obtained glucomannan with a purity of 90.63% from the purification of konjac flour at a temperature of 68°C without varying the ethanol concentration and repeated extraction. According to the result, it could be concluded that the temperature, ethanol concentration, and extraction repetition affected the purity of glucomannan. Compared to those studies, MC15 extracted glucomannan by a more simple method had lower purity but remained qualified as a purified glucomannan based on the Professional Standard of the Konjac Flour (The Ministry of the People's Republic of China, 2002). The yield obtained by all extraction methods is more than 50% and the moisture content of all extraction methods meets the requirement of the standard of konjac flour by the people's Republic of China (<14%).

3.3 Whiteness

The whiteness degree of glucomannan isolated by all extraction methods was significantly different (Figure 1). Glucomannan isolated by MC15 has the highest whiteness degree. The low impurities resulted in whiter glucomannan granules. This result is in accordance with the previous study by Yanuriati *et al.* (2017).



FC13 = 81.98[a] FC15 = 84.34[b] MC13 = 86.65[c] MC15 = 89.91[d]

Figure 1. Whiteness degree of glucomannan extracted by FC13, FC15, MC13, MC15. Values with different superscripts within the row are significantly different ($p \leq 0.05$).

3.4 Viscosity

The viscosity of the porang glucomannan sol was shown in Table 3. Glucomannan extracted by FC13 has the highest viscosity level, which is significantly different from other extracted glucomannan. Glucomannan has a high molecular weight and very high viscosity (Hu *et al*., 2020). It also has low solubility despite its hydrophilic property (Pan *et al*., 2013). Konjac mannan is a water-soluble polymer, but it needs a special technique to dissolve it in water completely (Phillips and Williams, 2000). Glucomannan with high purity grades is difficult to solubilize (Imeson, 2010). This was consistent with the results of the experiment. The glucomannan obtained from the MC15 method

eISSN: 2550-2166

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(highest purity) has a low viscosity level due to the low solubility of glucomannan.

Table 3. The viscosity level of porang glucomannan

Extraction methods	Viscosity (mPa.s)
FC13	15946.59[a]
FC15	15046.79[b]
MC13	14330.28[d]
MC15	14696.86[c]

Values with different superscripts are significantly different ($p \leq 0.05$).

3.5 Glucomannan characterization

All extracted glucomannan was characterized using XRD, SEM, FTIR, then compared with the results of commercial glucomannan (CG) characterization.

3.5.1 X-Ray Diffraction (XRD) analysis

The diffractogram of extracted glucomannan (FC13, FC15, MC13, and MC15) and commercial glucomannan (CG) is shown in Figure 2.

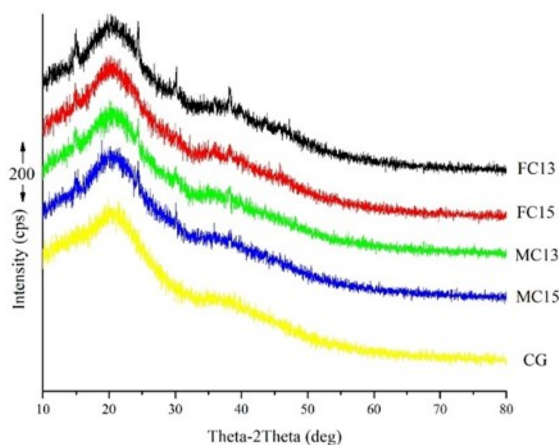

Figure 2. XRD Pattern of glucomannan extracted by FC13, FC15, MC13, MC15, and Commercial Glucomannan (CG).

The diffractogram patterns of all extracted glucomannan that were similar, exhibited varying broadband with several peaks. That was consistent with the data reported by Yanuriati *et al.* (2017). 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 = 20-25° and around 38°, whereas the commercial glucomannan diffractogram has a high peak at 2θ = 21-22° with more sloping intensity compared to extracted glucomannan peaks, which indicated that the structure of extracted glucomannan had more crystalline phase than commercial glucomannan which had a more amorphous phase. The degree of crystallization of MC15 was 6.28%, higher than CG (3%). The degree of crystallization MC15 was also higher than the glucomannan obtained by Yanuriati *et al.* (2017) which was extracted using 50% ethanol with 7 repetitive millings (5.43%). The degree of glucomannan crystallinity could be increased due to extraction using higher concentrations of ethanol, dehydration of glucomannan granules strengthen hydrogen bonds between molecules and intramolecular, thereby increasing the degree of crystallinity (Wang *et al.*, 2011).

3.5.2 Scanning Electron Microscope analysis

The morphologies of all extracted glucomannan and commercial glucomannan were characterized using SEM to observe the shape of the particles. Morphological observations were displayed in magnification 200×. The results obtained in Figure 3 showed that the granules form of all extracted glucomannan were round and oval, while commercial glucomannan tends to be flattened, possibly through a grinding process. The surface of CG was smoother, which indicated the surface of CG was still covered by impurities.

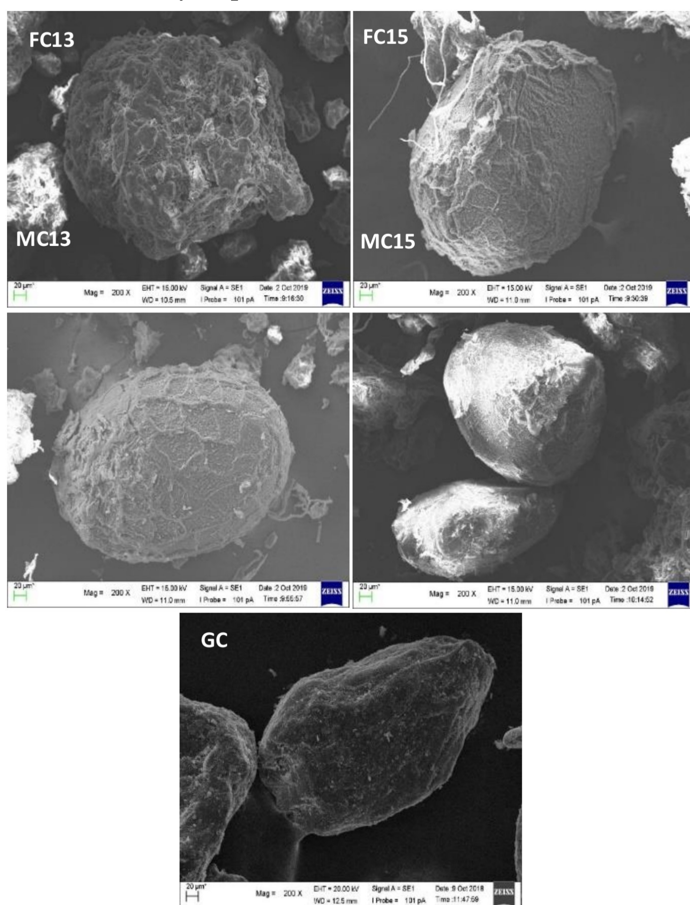

Figure 3. SEM Photographs of glucomannan extracted by FC13, FC15, MC13, MC15, and Commercial Glucomannan (CG) with 200× magnification

The structure of konjac glucomannan consisted of lamella structure units and the scale-like pattern became clear on the surface of the purified konjac glucomannan (Phillips and Williams, 2000). That scale-like pattern on the lamella structure unit appeared on glucomannan extracted by MC13 and MC15. The lamella structure units were not visible on the surface of glucomannan granules FC13, it was thought that impurities still cover the glucomannan granules. This was consistent with the

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data in Table 2 which showed that the levels of ash and protein contained in glucomannan extracted by FC13 were high.

3.5.3 Fourier Transform-Infrared (FTIR) Analysis

Characterization with an Infrared Spectrophotometer (FTIR) aimed to determine the functional groups of glucose and mannose on glucomannan structure. The results of the functional group of extracted glucomannan granules were compared with the commercial glucomannan (CG). Figure 4 shows that all FTIR spectra had almost the same absorption band pattern but with different intensities.

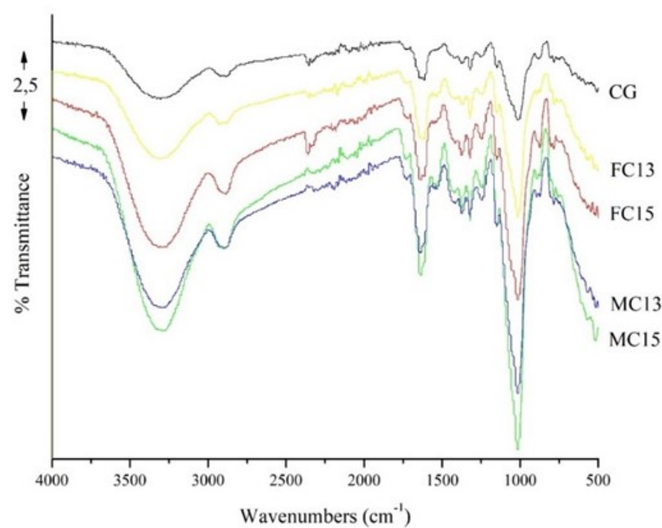

Figure 4. FTIR Spectrum of Glucomannan Extracted by FC13, FC15, MC13, MC15, and Commercial Glucomannan (CG)

In FTIR data spectra, there was broadband at wave number 3432 cm^{-1} representing OH groups in glucose and mannose composing the glucomannan compounds (Wang *et al*., 2020), absorption bands in the range of 2850-2925 cm^{-1} showed stretching asymmetry and symmetry vibration of the alkane group, CH (Wang *et al*., 2015), CH_2, and CH_3 (Xing *et al*., 2014), whereas the C = O group was in the absorption band of 1878 cm^{-1} and the C-O acetyl group at 1323 cm^{-1} (Wang *et al*., 2015). The absorption band at 1640.23 cm^{-1} corresponded to the C-O stretching vibrations related to –OH (Ye *et al*., 2017). Furthermore, the absorption band at 1444 cm^{-1} and 1383 cm^{-1} showed asymmetric bending vibrations and CH, CH_2, and CH_3 alkane symmetry. The shift of stretched vibrations C-O-C was shown in the 1158 cm^{-1} band (Li *et al*., 2017). β-pyranose in mannose and glucose bonds were shown in the absorption band of 890 cm^{-1} (Wang *et al*., 2014; Wang *et al*., 2017).

4. Conclusion

Direct extraction method from fresh porang tuber using a multilevel concentration of ethanol (60, 70, 80%), with a ratio of tuber (g) and ethanol (mL) 1:5 (MC15) was an effective and simple method in producing high purity glucomannan without heating, a lot of repetition of extraction and further purification. The extracted glucomannan has high purity (90.00%), whiteness degree (89.91), viscosity (14696.86 mPa.s), and yield (57.64%). It was found a small number of impurity compounds such as ash, fat, protein, and starch. FTIR spectra confirmed the presence of functional groups (O-H, C = O, C-O, C-H) and β-pyranose in mannose and glucose bonds, composing the glucomannan compound. Characterization using XRD showed the structure of extracted glucomannan had a more crystalline phase than commercial glucomannan which had a more amorphous phase. The scale-like pattern on the lamella structure unit appeared on the surface of glucomannan particles observed by SEM, verifying the purity of glucomannan granules. To complete the characterization data of porang glucomannan is required further research, determination of the mannose/glucose ratio using HPLC, and molecular structure of porang glucomannan using NMR.

Conflict of interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Acknowledgements

This research has been funded by The Directorate of Research and Community Service, Directorate-General for Research and Development, Ministry of Research, Technology, and Higher Education of Indonesia.

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