Carbohydrate Polymers 80 (2010) 308–311

Contents lists available at ScienceDirect

Carbohydrate Polymers

journal homepage: www.elsevier.com/locate/carbpol

Short communication

Characterization of glucomannan from some *Amorphophallus* species in Vietnam

Nguyen Tien An [a,*], Do Truong Thien [a], Nguyen Thi Dong [a], Pham Le Dung [a], Nguyen Van Du [b]

[a] Institute of Chemistry, VAST, 18-Hoang Quoc Viet Road, Hanoi, Viet Nam
[b] Institute of Ecology and Biological Resources, VAST, 18-Hoang Quoc Viet Road, Hanoi, Viet Nam

ARTICLE INFO

Article history:
Received 17 August 2009
Received in revised form 18 November 2009
Accepted 25 November 2009
Available online 29 November 2009

Keywords:
Amorphophallus paeoniifolius
Konjac glucomannan
Konjac flour

ABSTRACT

In this work, konjac glucomannans (KGM) have been isolated from *Amorphophallus* tubers (used three *Amorphophallus* species: *Amorphophallus panomensis, Amorphophallus paeoniifolius* and *Amorphophallus* tonkinensis) by a simple method without using toxic chemicals. The konjac glucomannan content was about 5–9% (w/w) of original *Amorphophallus* tubers. The structure, moisture uptake, molecular weight of konjac glucomannan were investigated by nuclear magnetic resonance spectroscopy (NMR), differential scanning calorimetry (DSC) and viscosimetry. The results indicated that the main component of konjac flour was glucomannan. The mannose/glucose molar ratio and molecular weight (M_w) of glucomannan isolated from *Amorphophallus paeoniifolius, Amorphophallus panomensis* and *Amorphophallus tonkinensis* were 1/0.13; ($M_w = 1.115 \times 10^6$), 1/0.10; ($M_w = 1.023 \times 10^6$) and 1/0.25; ($M_w = 1.043 \times 10^6$), respectively. The moisture uptake of konjac glucomannans was about 7.5–9.2%.

1. Introduction

Amorphophallus sp. is a perennial herbaceous herb. It grows in mountain or hilly areas in subtropical regions mainly in the South East of Asia. It has been used as food and food additives in China and Japan for more than 1000 years. Glucomannan (GM) is a polysaccharide of the mannan family, very abundant in nature, specifically in softwoods (hemicellulose), roots, tubers and many plants bulbs. Despite the variety of sources, the most commonly used type of GM is named konjac glucomannan (KGM), which is extracted from tubers of *Amorphophallus* plants. Irrespective of its origin, GM is composed of β-1,4-linked D-mannose and D-glucose monomers. However, the mannose/glucose monomer ratio may vary depending on the original source of GM. For example, it has been reported that konjac GM has a molar ratio of around 1.6:1, whereas GMs extracted from Scotch pine and orchid tubers have ratios of 2.1:1 and 3.6:1, respectively. These values should be regarded cautiously given the variability observed depending on the studies and, in particular, on the analytical procedures (Ishrud, Zahid, Viqar, & Pan, 2001).

The studies on glucomannan showed that glucomannan has many applications in many fields. Due to its biogradablility and gel-forming ability, konjac glucomannan can be widely used in drug delivery such as capsule for chronic stomach disease (Wang & He, 2002). Glucomannan has very good film-forming ability so several kinds of transparent blend films of konjac glucomannan with polyacylamide, gelatin, sodium carboxymethylcellulose, chitosan, xanthan sodium aginate and cellulose were invented (Li & Xie, 2000; Xiao, Gao, Wang, & Zhang, 2000; Xiao, Weng, & Zhang, 2002; Ye, Kennedy, Li, & Xie, 2006). In medicine field konjac glucomannan and its derivatives were also used to lower blood cholesterol and sugar level, help weight loss, promote intestinal activity and immune function etc. (Vuksan et al., 1999).

Although they had been investigated for so many years, glucomannan and its derivatives still need to be well investigated compared with other polysaccharides such as cellulose and starch etc. In Vietnam, there were about 20 species of *Amorphophallus* sp. – Araceae family in the forest and hilly areas from the North to the South but the konjac glucomannan from three *Amorphophallus* species: *Amorphophallus panomensis*, *amorphophallus paeoniifolius* and *Amorphophallus* tonkinensis has not been studied. Therefore, this paper reports work aimed at the isolation glucomannan from these above *Amorphophallus* species. The structural component and molecular weight of glucomannan were investigated by NMR spectroscopy and viscosimetry, respectively.

2. Experimental

2.1. Materials

Amorphophallus tubers were collected from the mountain and hilly areas in tropical regions mainly in the North West of Vietnam. All other chemicals and reagents used were of analytical grade.

* Corresponding author. Tel.: +84 4 37564308.
E-mail address: nguyentienanvhh@gmail.com (N.T. An).

0144-8617/$ - see front matter Crown Copyright © 2009 Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.carbpol.2009.11.043

2.2. Isolation and purification of polysaccharide from Amorphophallus tuber

Amorphophallus powder from the tuber of *Amorphophallus* plant (named konjac powder or konjac flour) was extracted and purified as follows: *Amorphophallus* tubers were sliced, ground and then the obtained crude flour was dispersed in distilled water and laid for a time, the white powder was separated and then washed many times by water. Lastly, the white powder was dried so konjac flour was obtained. For example, *Amorphophallus* tubers (1 kg) were sliced to about 8 mm in thickness, then ground by a mill for obtaining a crude flour. After that, this crude flour was dispersed in 5 l of distilled water and laid for 3 h. The white powder at the bottom of dispersed medium was separated and then washed three times by 3 l of water (one liter for one time). Lastly, the white powder was dried at 50 °C in an oven and then weighed for determining the konjac flour content. This final konjac flour was used for further characterization. The konjac flour content (KF) was calculated using the following formular:

$$KF\% = (m_1/m_2) \times 100\%$$

where m_1 and m_2 were weight of final white powder and original *Amorphophallus* tubers, respectively.

2.3. Characterization of polysaccharides

^{1}H NMR and ^{13}C NMR spectra of konjac glucomannan were recorded on the 500 MHz Bruker Avance spectrometer, the sample concentrations being about 5 and 20 g/l, respectively, in 0.5 N NaOH/D_2O at 303 K.

Thermal analysis of KGM was conducted with a Netzsch TG 209 (Germany) under air atmosphere with a flow capacity of 20 mL/min. The scan was carried out at a heating rate of 10.0 °C/min from 20 to 700 °C. The sample weight was about 6.0 mg.

The intrinsic viscosity of konjac glucomannan was measured by Ubbelohde viscometer according to methods of Li and Wanchun. Mark-Houwink parameters were fixed according to $\eta = 5.96 \times 10^{-2} \times M_w^{0.7317}$ (Li & Xie, 2006; Yin, Zhang, Huang, & Nishinari, 2008).

3. Results and discussion

3.1. Isolation of polysaccharide from Amorphophallus tubers

The isolation of konjac glucomannan from *Amorphophallus* plant was one of the most important state. According to the traditional methods, these processes were often carried out in the dried state of *Amorphophallus* tubers, that mean the tubers of *Amorphophallus* plant were dried before the konjac glucomannan was isolated (Ye et al., 2006). In the our konjac flour isolation process, because of the hard solubility and the higher density than other components in *Amorphophallus* tuber, konjac glucomannan could be directly separated from the crude flour by dispersion in water. In this process, the fat and protein were also dissolved by water. The konjac flour content of *Amorphophallus panomensis*, *Amorphophallus* paeoniifolius and *Amorphophallus* tonkinensis was about 5%, 9% and 7.2% (w/w), respectively. Thus, konjac flour could be easy isolated from *Amorphophallus* tubers without using the toxic chemicals that pollute to environment and might limit the ability of applying of this product especially as a food and medicine for human. The molecular weight of glucomannan isolated from *Amorphophallus paeoniifolius*, *Amorphophallus* panomensis and *Amorphophallus* tonkinensis was 1.115×10^6, 1.023×10^6 and 1.043×10^6, respectively.

3.2. ^{1}H NMR spectroscopy

The ^{1}H NMR spectrum of the glucomannan from *Amorphophallus* paeoniifolius was shown in Fig. 1, (the ^{1}H NMR spectra of the glucomannans from *Amorphophallus* panomensis and *Amorphophallus* tonkinensis were similar to that of *Amorphophallus* paeoniifolius and not shown here).

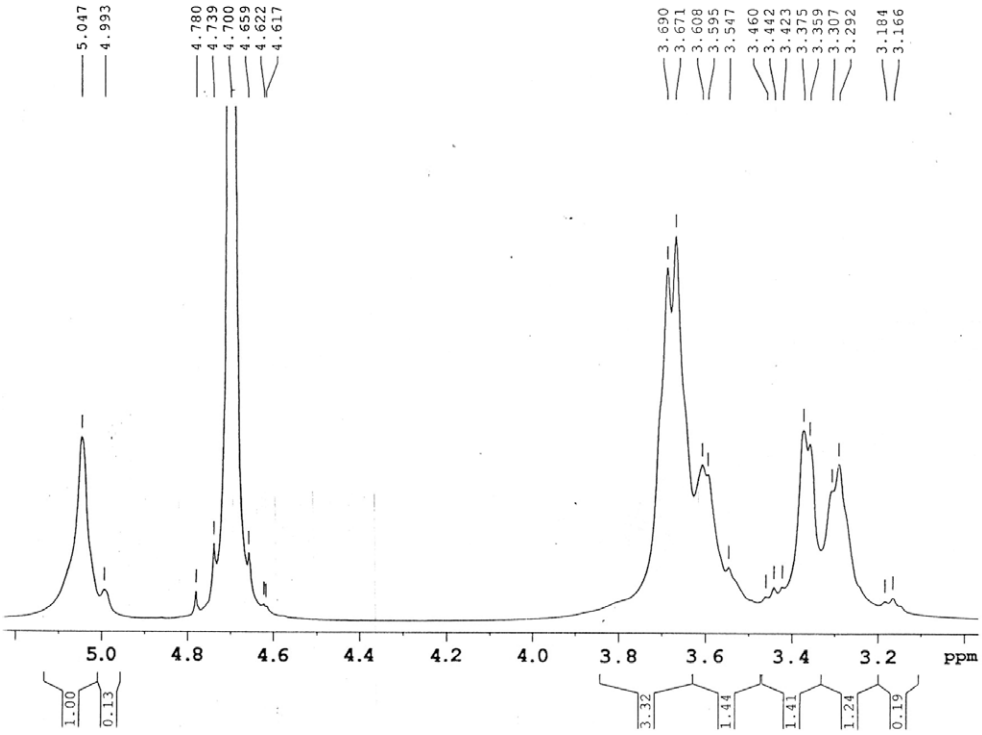

Fig. 1. ^{1}H NMR spectrum of glucomannan isolated from *Amorphophallus paeoniifolius*.

Table 1
^{1}H NMR chemical shift data of konjac glucomannan.

Species	H1 (δ ppm) M/G	H2–H6 (δ ppm) M/G
Amorphophallus paeoniifolius	5.047/4.993	3.166–3.690
Amorphophallus panomensis	5.105/4.998	3.172–3.721
Amorphophallus tonkinensis	5.091/4.781	3.175–3.713

The peaks were assigned by comparison with chemical shift data reported in the literature (Ishurd, Kermagi, Elghazoun, & Kennedy, 2006). Fig. 1 showed that the signals attributed to the hydrogens linked to C2–C6 of both glucose and mannose units were not well separated. This was due to the complex nature of the spectra of polysaccharides. Meanwhile, the signals attributed to the hydrogen-H1 linked to the carbon-C1 of both glucose unit (4.993 ppm) and mannose unit (5.047 ppm) were well separated. Therefore, the mannose/glucose ratio in glucomannan molecule could be calculated using the integrals of H1 in the ^{1}H NMR spectrum. According to this method, the mannose/glucose molar ratio in glucomannan molecule from *Amorphophallus panomensis*, *Amorphophallus paeoniifolius* and *Amorphophallus tonkinensis* was 1/0.10, 1/0.13 and 1/0.25, respectively. The ^{1}H NMR chemical shift data of glucomannan isolated from three *Amorphophallus* species were summaried in the Table 1.

3.3. ^{13}C NMR spectroscopy

The ^{13}C NMR spectrum of glucomannan from *Amorphophallus paeoniifolius* was shown in the Fig. 2.

The ^{13}C NMR spectrum showed characteristic anomeric signals at 102.47 ppm due to C-1 resonances of β-D-glucose residues, at 102.04 ppm due to C-1 resonances of D-mannose residues. The C-4 chemical shifts of the glucosyl and mannosyl units involved in glycosidic linkages appeared at 80.16 and 79.69 ppm, respectively. The signals at 74.33, 72.70 and 71.51 ppm were assigned to C-5, C-3 and C-2 of mannose residues, respectively. The characteristic resonances of C-5, C-3 and C-2 of β-1,4-linked glucose residues were observed at 74.88, 73.37 and 70.27 ppm, respectively. The signals in the high magnetic field at 61.14–60.77 ppm were generated by the resonances of nonsubstituted C-6 of glucosyl and mannosyl residues. Besides, a low intensity signal at 70.27 ppm could be assigned to substituted C-6 of glucosyl or mannosyl residues. Thus, the results confirmed a linear structure of glucomannan composed of 1,4-linked D-mannosyl and D-glucosyl units in the mole ratio of 1/0.13, respectively, the β configuration of glycosidic bond in the main chain and the presence of short side chains at C-6. The ^{13}C NMR spectra of glucomannan isolated from *Amorphophallus panomensis* and *Amorphophallus tonkinensis* were also similar to that of *Amorphophallus paeoniifolius*. The chemical shift data of glucomannan isolated from three *Amorphophallus* species were summaried in the Table 2.

3.4. Thermal analysis

The characteristic TG and DSC curves of KGM was presented in Fig. 3. The sample involved four steps of degradation, after the first stage loss of moisture (7.82%) at low temperature, the major weight loss occurred. As could be seen in Fig. 3, KGM began to decompose at about 250 °C, rapidly loses 67.4% of its weight up to 392 °C and then left about 20.11% up to 600 °C. The maximum rate of weight loss occurred at 348.3 °C. The result of TG analysis indicated that the weight loss of KGM during heating could be attributed to a complex process including degradation of the saccharide rings and disintegration of macromolecule chains of KGM. This results were in agreement with the results of Yu, Huang, Ying, and Xiao (2007) The TG and DSC curves (not shown) of konjac glucomannan isolated from *Amorphophallus panomensis* and *Amorphophallus tonkinensis* were also similar to that of *Amorphophallus paeoniifolius*.

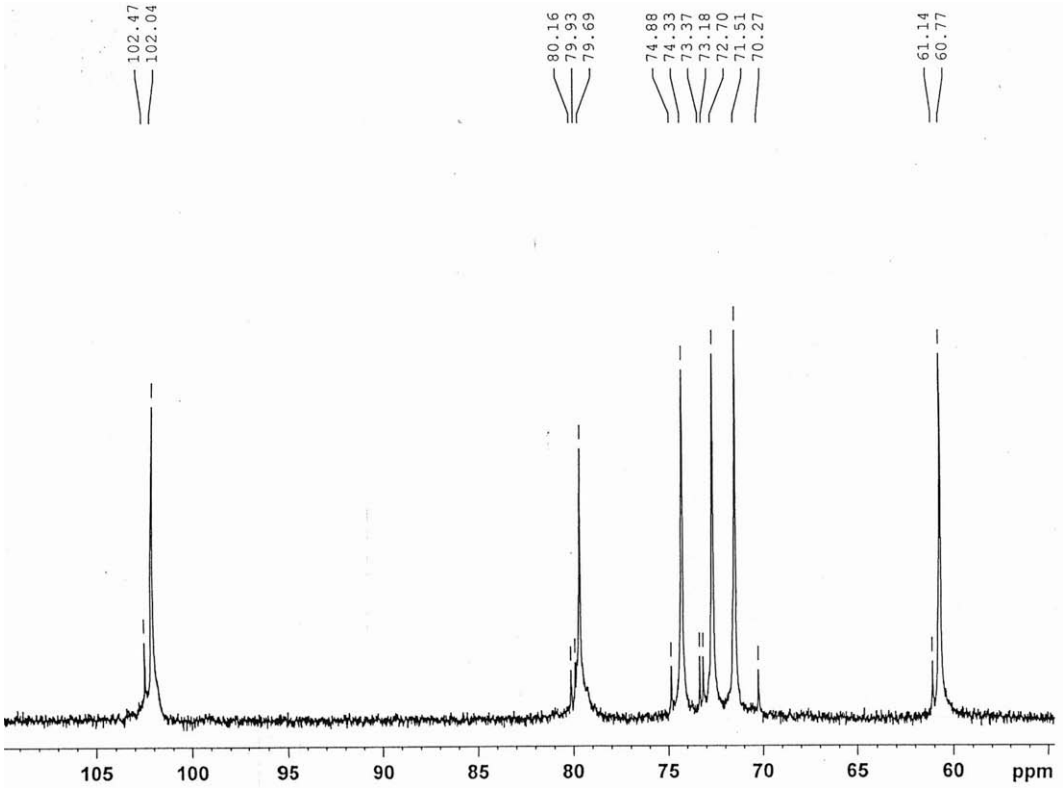

Fig. 2. ^{13}C NMR spectrum of glucomannan isolated from *Amorphophallus paeoniifolius*.

Table 2
^{13}C NMR chemical shift data of konjac glucomannan (δ ppm).

Species	C1 M/G	C2 M/G	C3 M/G	C4 M/G	C5 M/G	C6 M/G
Amorphophallus paeoniifolius	102.04/102.47	71.51/70.27	72.70/73.37	79.69/80.16	74.33/74.88	60.77/61.14
Amorphophallus panomensis	101.99/102.39	71.77/70.59	73.32/73.54	79.56/79.87	74.47/74.95	61.07/61.33
Amorphophallus tonkinensis	102.06/102.45	71.78/70.33	72.92/73.35	79.65/80.08	74.59/74.91	61.06/61.35

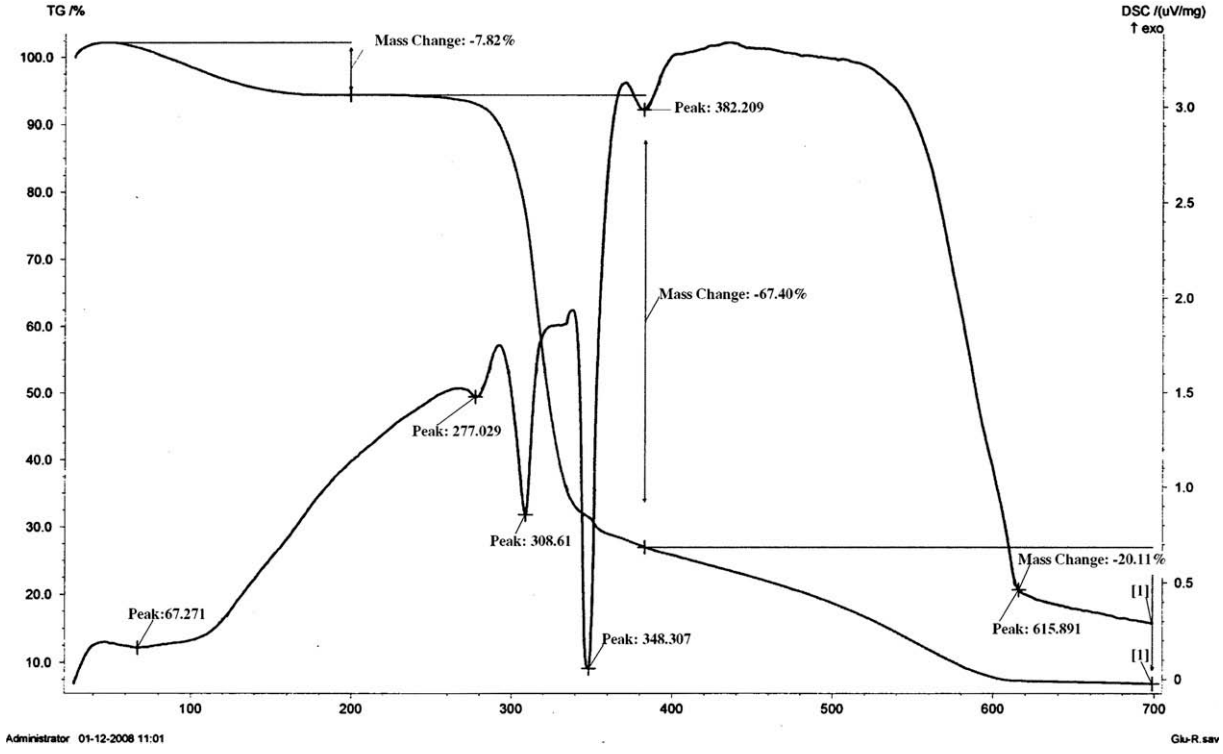

Fig. 3. The TG and DSC curves of KGM isolated from *Amorphophallus paeoniifolius*.

4. Conclusions

A simple method without using toxic chemicals for isolating konjac glucomannan from *Amorphophallus* tubers has been investigated. The konjac glucomannan from *Amorphophallus* tubers was white, hard to dissolve in water and its content was about 5–9% (w/w). The structure and molecular weight of glucomannan from *Amorphophallus* species have been investigated by NMR spectroscopy and viscosimetry. The results shown that the structural component of glucomannan from *Amorphophallus panomensis*, *Amorphophallus paeoniifolius* and *Amorphophallus tonkinensis* was consisted of β-1,4-linked D-mannosyl and D-glucosyl units in the mole ratio of 1/0.10, 1/0.13 and 1/0.25, respectively. The presence of short side chains at C-6 was also observed. The molecular weight of glucomannan from these above *Amorphophallus* species was $M_w = 1.023 \times 10^6$, $M_w = 1.115 \times 10^6$ and $M_w = 1.043 \times 10^6$ Da, respectively. The konjac glucomannan from three *Amorphophallus* species in Vietnam exhibited a potential application as both a food and medicine for human.

References

Vuksan, V., Jenkins, D. J. A., Spadafora, P., Stevenpiper, J. L., Owen, R., Vidgen, E., et al. (1999). Konjacmannan (Glucomannan) improves glycemia and other associated risk factors for coronary heart disease in type 2 diabetes. *Diabetes Care, 22*, 913–919.

Li, B., & Xie, B. J. (2000). Study on edible membrane material made from konjac glucomannan (II)[J]. *Shipin Kexue, 21*(2), 24–26 (Chinese).

Xiao, Ch., Gao, S., Wang, H., & Zhang, L. (2000). Blend films from chitosan and konjac glucomannan solutions. *Journal of Applied Polymer Science, 4*, 509–515.

Ishrud, O., Zahid, M., Viqar, U.-A., & Pan, Y.-J. (2001). Isolation and structure analysis of a glucomannan from the seeds of Libian dates. *Journal of Agricultural and Food Chemistry, 8*, 3772–3774.

Wang, K., & He, Z. (2002). Alginate-konjac glucomannan–chitosan beads as controlled release matrix. *International Journal of Pharmaceutics, 244*(1–2), 117–126.

Xiao, C., Weng, L., & Zhang, L. (2002). Improvement of physical properties of crosslinked alginate and carboxymethyl konjac glucomannan blend films. *Journal of Applied Polymer Science, 84*, 2554–2560.

Li, B., & Xie, B. J. (2006). Single molecular chain geometry of konjac glucomannan as a high quality dietary fiber in East Asia. *Food Research International, 39*, 127–132.

Ishurd, Omar, Kermagi, Adel, Elghazoun, Mohamed, & Kennedy, John F. (2006). Structural of a glucomannan from Lupinus varius seed. *Carbohydrate Polymers, 65*, 410–413.

Ye, X., Kennedy, J. F., Li, B., & Xie, B. J. (2006). Condensed state structure and biocompatibility of the konjac glucomannan/chitosan blend films. *Carbohydrate Polymers, 64*, 532–538.

Yin, Wanchun, Zhang, Hongbin, Huang, Long, & Nishinari, Katsuyoshi (2008). Effects of the lyotropic series salts on the gelation of konjac glucomannan in aqueous solutions. *Carbohydrate Polymers, 74*, 68–78.

Yu, H. Q., Huang, Y. H., Ying, H., & Xiao, C. B. (2007). Preparation and characterization of a quaternary ammonium derivative of konjac glucomannan. *Carbohydrate Polymers, 69*, 29–40.