Separation of polymeric galactoglucomannans from hot-water extract of spruce wood

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HIGHLIGHTS

- We separated and purified high-Mw GGMs from a hot-water extract of spruce wood.
- Two separation techniques were evaluated and compared.
- Precipitation in ethanol separates exclusively pure polymeric hemicelluloses.
- Membrane filtration separates fractions rich in poly-, oligo- and monosaccharides.
- An economical purification solution might be achieved by combining both techniques.

ABSTRACT

Two methods for separation of polymeric galactoglucomannans (GGMs) from a hot-water extract of spruce wood, i.e., membrane filtration and precipitation in ethanol–water, were compared. Filtration through a series of membranes with different pore sizes separated GGMs of different molar masses, from polymers to oligomers. Only polysaccharides were precipitated in ethanol–water. With the optimal water content of 5–15%, the precipitated amount was about 6% on wood basis. The average molar mass of the precipitated polysaccharides was 10–12 kDa with a molar mass range of 4–20 kDa. GGMs comprised about 80% of the precipitated hemicelluloses. Other precipitated polysaccharides were mainly arabinogalacturonoxylans and pectins (rhamnogalacturonans). Analysis of a lignin-free, ethanol-precipitated GGM preparation by $^{13}$C NMR spectroscopy verified that it was structurally almost identical with a GGM-rich ethanol precipitate obtained from spruce wood by extraction at much milder conditions, 90 °C for 60 min.

1. Introduction

Galactoglucomannans (GGMs) have attracted growing interest in recent years because of their potential applications in many different areas. GGMs are the dominating hemicelluloses in spruce and other conifer wood, amounting to approximately 14–20% of the wood (Willför et al., 2005). GGMs are heteropolysaccharides, i.e., non-cellulosic polysaccharides. GGMs in wood have been reported to have an approximate degree of polymerisation of 100–150, corresponding to a molar mass of 16–24 kDa (Timell, 1967). The backbone of GGMs consists of $\beta$-(1 $\rightarrow$ 4)-$\alpha$-Manp and $\beta$-(1 $\rightarrow$ 4)-$\alpha$-GlcP units at a ratio of approximately 10:1.9–2.6, with side units of $\alpha$-(1 $\rightarrow$ 6)-$\alpha$-Galp on about every tenth mannoxyranosyl unit (Timell, 1967). The mannoxyranosyl units are acetylated at C-2 or C-3 with a degree of acetylation of about 0.5 in spruce wood (Capek et al., 2002) and 0.28–0.37 for GGMs dissolved in spruce TMP waters (Hannukela and Hervé du Penhoat, 2004). GGMs are located primarily in the secondary cell wall layer of softwood fibres (Meier, 1985). GGMs have been extensively studied for over 50 years, initially mainly because of their importance in pulping and papermaking. More recently, research has been more focused on extraction of GGMs from wood and novel applications, as part of biorefinery concepts.

GGMs have potential to become high added-value products with various applications in food, health, papermaking, textile and cosmetic industries (Ebringerová et al., 2005; Mikkonen et al., 2012; Willför et al., 2008). Different applications request GGMs in different forms, e.g. different molar masses.

GGMs can be separated from thermomechanical pulp waters (Willför et al., 2003a, 2003b) and also directly from wood. GGM extraction from softwoods has been studied for years, such as from pine (Casebier et al., 1969). Extraction of GGMs from spruce wood has been studied by water at temperatures below 100 °C (Örså et al., 1997), by microwave heat-fractionation (Lundqvist et al., 2003), by alkaline extraction (Capek et al., 2000) and by pressurised hot-water extraction (Leppänen et al., 2010, 2011; Song et al., 2008, 2011a, 2011b, 2012).