BIOMASS AND BIOENERGY 61 (2014) 254–264

Available online at www.sciencedirect.com

ScienceDirect

http://www.elsevier.com/locate/biombioe

Comparative study of alkaline extraction process of hemicelluloses from pear pomace

Holy Nadia Rabetafika [a,*], Brahim Bchir [b], Christophe Blecker [b], Michel Paquot [a], Bernard Wathelet [a]

[a] University of Liège, Gembloux Agro-Bio Tech, Department of Industrial, Biological Chemistry, 2, passage des déportés, B-5030 Gembloux, Belgium

[b] University of Liège, Gembloux Agro-Bio Tech, Department of Food Science and Formulation, 2, passage des déportés, B-5030 Gembloux, Belgium

ARTICLE INFO

Article history:
Received 3 July 2013
Received in revised form
12 December 2013
Accepted 22 December 2013
Available online 18 January 2014

Keywords:
Pear pomace
Alkaline extraction
Hemicelluloses
Value-addition
Delignification
Cellulose

ABSTRACT

Hemicelluloses were produced from pear pomace using direct alkaline extraction (sodium hydroxide and hydrogen peroxide) and two-step extraction with delignification pretreatment (acidified sodium chlorite/sodium hydroxide). The aim of the study was to compare the extraction yield, composition and physicochemical characteristics of isolated hemicelluloses by size exclusion chromatography, FTIR and thermogravimetric analyses. Solid residues were analysed in order to evaluate the effect of processes on co-products (lignins and cellulose). Delignification of material (up to 995.4 g kg^{-1} of original lignins) during the direct alkaline hydrogen peroxide and two-step acidified sodium chlorite/sodium hydroxide processes improved the hemicellulose extraction yield attaining up to 945.3 g kg^{-1}. Hemicelluloses were mainly composed of xylans (xylose/glucose ratio of 4.6–16.2) and had low lignin content (53.5–61.0 g kg^{-1} dry matter). Those from direct sodium hydroxide extraction were composed of xylans and glucans (xylose/glucose ratio of 1.5) with high content of lignins (149.3 g kg^{-1} dry matter). All isolated fractions were a mixture of polymers and oligomers with a molecular mass ranging from 1710 g mol^{-1} to 8 870 000 g mol^{-1}. The two-step process gave the most pure cellulose residue (799.2 g kg^{-1} dry matter). According to results, the direct alkaline extraction with hydrogen peroxide was a promising process for the production of pure xylose-rich hemicelluloses from pear pomace solubilizing 802.2 g kg^{-1} of the original hemicelluloses but induced fragmentation of hemicelluloses.

1. Introduction

The use of agri-food residues in order to create new added-value products has been developed within the optimization of biomass utilization and waste management. For example, the solid residues called "pomace" from fruit manufacturing are produced annually in huge amounts of up to more than 28.8 Mt [1]. Such residues are often dedicated to animal feed or disposed causing environmental issues and income losses for their valuable components.

Fruit pomace, mainly constituted by peels, pulps, stems, cores and seeds, is lignocellulose-rich material. They may play a crucial role in a lignocellulose feedstock-based biorefinery for the processing of three output streams (cellulose,

* *Corresponding author*. Tel.: +32 (0)81 62 26 22; fax: +32 (0)81 62 22 31.
E-mail address: hnrabetafika@ulg.ac.be (H.N. Rabetafika).
0961-9534/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biombioe.2013.12.022

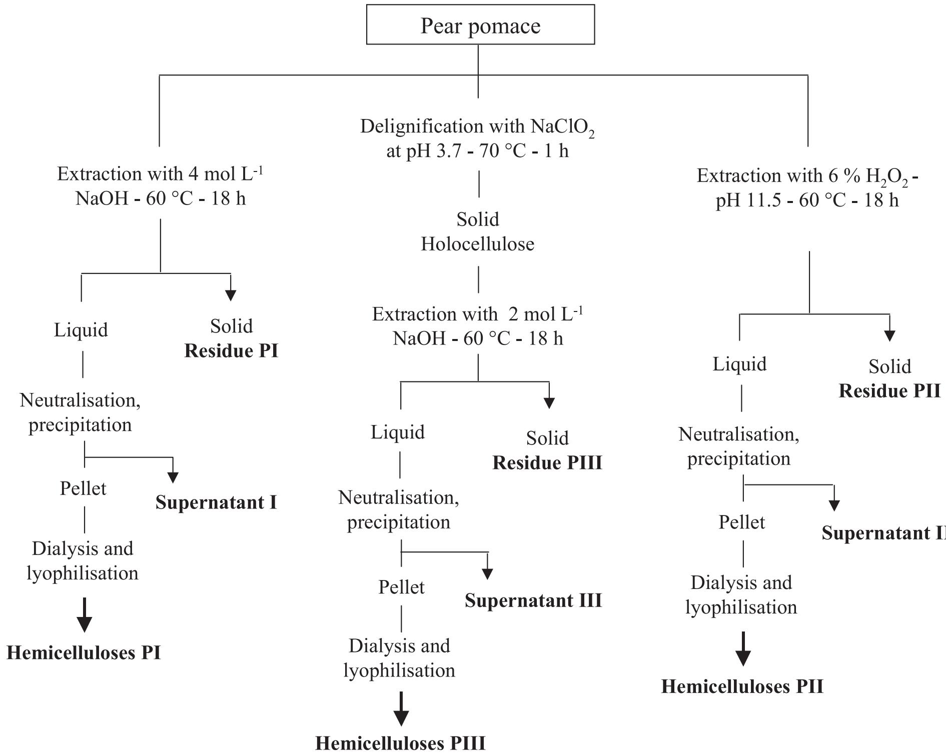

Fig. 1 – Alkaline extraction of hemicelluloses from pear pomace.

hemicelluloses and lignins) into chemicals and biofuels [2]. Hemicelluloses are the second most abundant components next to cellulose in fruit pomace and represent up to 15–30% of the dry matter [3]. In pear pomace, the hemicellulose fraction is mainly composed of β-D-xylose, β-D-glucose, α-L-arabinose, α-D-galactose residues and trace of uronic acids from glucuronoxylans, xyloglucans and mannans [4,5]. Because of their structural diversity, hemicelluloses are attractive as biopolymers which can be utilized in their native and modified forms in various areas including food and non-food applications such as films, adhesives, gelling, stabilizing and viscosity enhancing additives in food, pharmaceutical and other industrial field [6,7]. In recent years, isolation of hemicelluloses has received much attention because of its practical applications in various agro-industrial processes, such as conversion of hemicellulosic biomass into fuel or chemicals [8]. Various multistage procedures have been proposed for the extraction of hemicelluloses which usually include an alkaline extraction step with sodium, potassium or calcium hydroxide [6]. At industrial scale, one-step cost-efficient methods for the isolation of hemicelluloses are beneficial. The isolated coloured lignin-rich products may offer an advantage in film properties [9]. Although, the strong interaction between hemicelluloses and lignins often hinders hemicellulose extraction. Delignification pretreatment is therefore a critical process towards the efficiency of hemicellulose extraction. Various methods have been proposed to delignify materials generally achieved through the use of acids, alkalies and solvents [10]. However, according to the technologies and chemicals, undesirable solubilization and degradation of hemicelluloses occur. The delignification with acidified sodium chlorite, based on the oxidative action of chlorine dioxide, is the most selective in removing lignin with low dissolution of hemicelluloses [11]. Its major drawback comes from environmental hazards [12]. The alkaline pretreatments based on the saponification of intermolecular ester bond between lignin and hemicelluloses, generally not allow complete delignification of materials and limit degradation of hemicelluloses [10]. The fractionation of lignocellulose by alkaline hydrogen peroxide has been the subject of various works producing bleached hemicelluloses [13]. Indeed, hydrogen peroxide dissociates to form the hydroperoxy anion (HOO^-) with a pKa of 11.5–11.6. The hydroperoxy anion reacts with undissociated H_2O_2 to form highly reactive hydroxyl radicals (°OH) that cleaves ester link between hemicelluloses and lignins. HOO^- is responsible for lignin oxidation and discolouration [14]. The action of hydrogen peroxide causes less damage to carbohydrates and delignification is more efficient [15].

In the literature, various industrial by-products have been used for the extraction of hemicelluloses such as apple pomace [16], sugarbeet pulp [17] and rapeseed cake [18]. In the best of our knowledge, there is less study on hemicellulose extraction from pear pomace. Hemicelluloses represent however more than 20% of dry matter in pear pomace [4]. Therefore, this lignocellulosic material could be an important resource for sugar-based biorefinery platforms [2].

The aim of this study was to compare three conditions of alkaline extraction of hemicelluloses from pear pomace in terms of yields and physicochemical properties. The potential use of hemicelluloses from pear pomace depends on yield, composition and purity of products. The first two were one step alkaline extractions; the third one was the combination of a delignification and alkaline extraction. The solid residues