Carbohydrate Polymers 188 (2018) 60–67

Contents lists available at ScienceDirect

Carbohydrate Polymers

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

Effect of natural flocculants on purity and properties of β-glucan extracted from barley and oat

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ARTICLE INFO

Keywords:
Beta-glucan
Extraction
Flocculant
Chitosan
Guar gum

ABSTRACT

In this study, β-glucan was extracted from wholegrain oat and barley flours by a novel extraction and purification method employing natural flocculants (chitosan, guar gum and gelatin). The use of flocculants decreased the total amount of extracted gum, which was highest in control samples (9.07 and 7.9% for oat and barley, respectively). The β-glucan specific yield, however, increased with the use of chitosan and guar gum, which were able to remove protein and ash impurities resulting in gums with a higher purity.The highest concentration of chitosan (0.6 %) resulted in gums with the highest β-glucan content (82.0 ± 0.23 and 79.0 ± 0.19 for barley and oat, respectively) and highest β-glucan specific yield (96.9 and 93.3 % for oat and barley, respectively). Explanation is in R&D section. The use of gelatin was not successful. All gum samples had a high content of total dietary fiber (> 74%) and a high water holding capacity (4.6–7.4 g/g), but differed in apparent viscosity, which was highest for the oat sample extracted with 0.6% chitosan. This sample also showed the highest β-glucan molecular weight among the oat samples, which were in general 10-fold higher than for the barley samples. Among the barley samples, β-glucan molecular weight was highest for the control.

1. Introduction

Cereal β-glucan is a constituent of dietary fiber present mainly in barley and oat. It is a polymer, which consists of linear β-(1,3) and β-(1,4) linked glucose monomers. β-glucan is a valuable food constituent that reduces serum LDL-cholesterol levels (AbuMweis, Jew, & Ames, 2010; Wolever et al., 2010) and plays a significant role in lowering post-prandial glucose levels (Behall, Scholfield, & Hallfrisch, 2017; Brummer, Duss, Wolever, & Tosh, 2012). The ability of β-glucan to lower plasma cholesterol concentrations and post-prandial glucose levels is mainly influenced by its molecular weight and viscosity (Brummer et al., 2012; Wang & Ellis, 2014; Wolever et al., 2010). High molecular weight β-glucans, which are able to form viscous solutions, are most effective. These are mainly found in native forms of oat or barley (≥1000 kDa) (Wilson et al., 2004), while food processing or extraction may reduce β-glucan molecular weight (Rieder, Ballance, Løvaas, & Knutsen, 2015; Rimsten, Stenberg, Andersson, Andersson, & Åman, 2003; Tosh et al., 2010). Consumption of β-glucan with its specific physiological benefits may be beneficial for people with diabetes or cardiovascular diseases (Chen & Raymond, 2008), which makes β-glucan an interesting food ingredient. β-glucan has also been shown to have antioxidant and pre-biotic properties (Harasym, Suchecka, & Gromadzka-Ostrowska, 2015; Shah, Gani, Masoodi, Wani, & Ashwar, 2017). The FDA and EFSA are two main authority bodies that have authorized the use of health claims for β-glucan from barley and oat. For example, the claim "lowering LDL-cholesterol levels" can be used for food products providing one gram per serving and over three grams per person per day (EEFSA Panel on Dietetic Products (2011); Izydorczyk, Chornick, Paulley, Edwards, & Dexter, 2008). Apart from being beneficial for human health, β-glucan could also be a valuable ingredient in food applications. Due to its viscosity, it is perceived as a non-caloric thickener for various foods (Limberger-Bayer et al., 2014). Moreover, it is used as a stabilizing agent in foams and emulsions (Lazaridou & Biliaderis, 2007) a texturizing agent (Kodama et al., 2015) and a fat substitute (Pintado, Herrero, Jiménez-Colmenero, & Ruiz-Capillas, 2016).

In oat and barley, which are the two main sources of cereal β-glucan, β-glucan is mainly located in the cell walls of endosperm and aleurone. While oat is usually subjected to a kilning process to inactivate lipases and thereby ensure lipid stability, barley does not

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https://doi.org/10.1016/j.carbpol.2018.01.090
Received 26 October 2017; Received in revised form 17 January 2018; Accepted 29 January 2018
Available online 03 February 2018

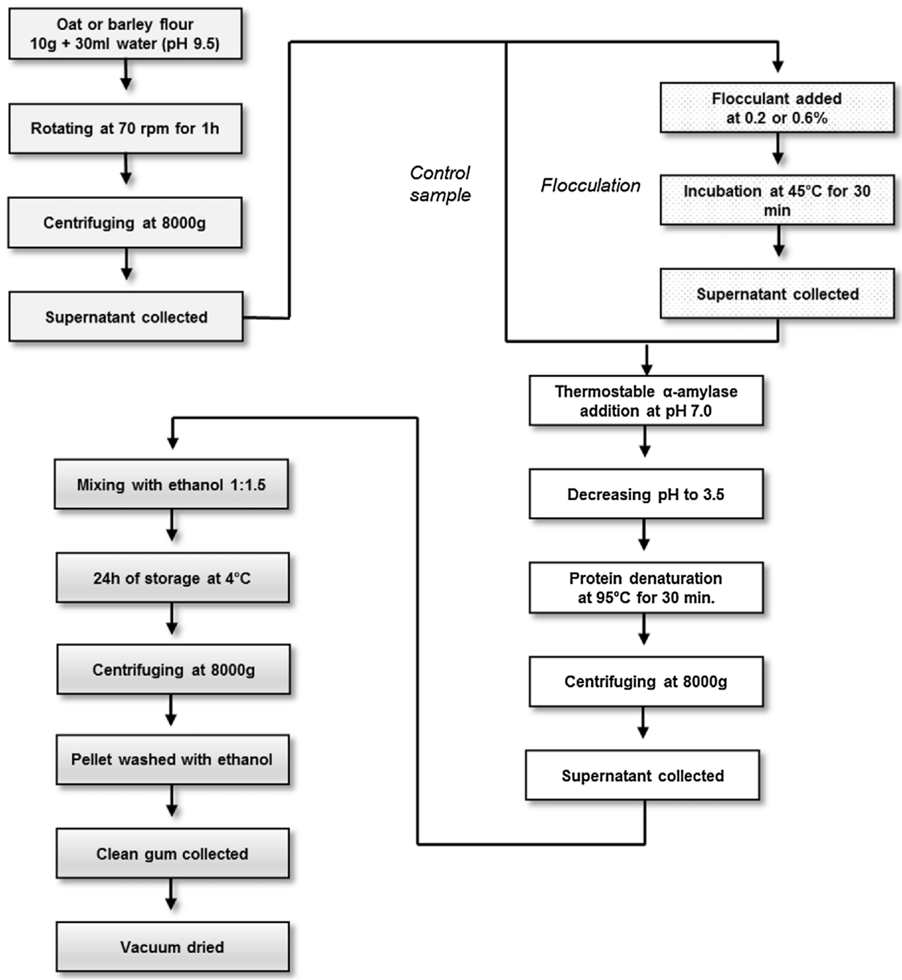

Fig. 1. Scheme of beta-glucan purification with flocculants.

normally undergo a heat treatment before further processing. However, kilning as a heat process may inactivate other enzymes besides lipases (Londono, Smulders, Visser, Gilissen & Hamer, 2015). The presence of active β-glucanases in barley flour has been shown to result in β-glucan degradation during processing (Rieder, Ballance, & Knutsen, 2015; Rieder, Ballance, Løvaas et al., 2015). However, β-glucans are only a minor constituent in grains, which also consist of non-starch polysaccharides, starch, proteins, and lipids that need to be washed out during β-glucan extraction. Therefore, extraction processes of β -glucan have to be multistage taking into consideration the other substances present in grains (Hematian Sourki, Koocheki, & Elahi, 2017).

The extraction and purification of β-glucan from cereals are mainly divided into two main groups: wet and dry processes (Benito-Román, Alonso, & Lucas, 2011). Extraction performed in dry conditions is carried out by milling and sieving and wet conditions usually involve an enzymatic treatment, alkaline solvents, or ultrasounds (Ahmad, Anjum, Zahoor, Nawaz, & Ahmed, 2010; Benito-Román, Alonso, & Cocero, 2013). Generally, β-glucan extraction with wet-methods results in an efficient purification because it achieves up to > 80% pure β-glucan and various molecular weight distributions could be obtained depending on the pH and solvents used (from 60 000 to 2 200 000 g/mol) (Harasym et al., 2015; Limberger-Bayer et al., 2014). Due to the health advantages and benefits for food technology, there is still a constant demand to extract and purify β-glucan taking into consideration its yield, purity and molecular weight.

During β-glucan extraction water or other solvents are used. However, impurities (protein-based or non-starch polysaccharides) are present in solutions during enzymatic treatment, though these fine particles could be removed by adding external flocculants, which aggregate solids to form flakes that can easily be removed from solutions (Meraz et al., 2016). Natural flocculants are very promising agents in improving food processing operations due to their safety and ecological benefits. Several flocculants could be used in foods: guar gum, alginates, chitosan or gelatin, which are used in extractions or the isolation of different food constituents (de Oliveira, Mahl, Simões, & Silva, 2012; Jain et al., 2017; Wang, Wang, Li, Cao, & Sun, 2013).

There is a need to examine the possible applications and differences in the properties of extracted β-glucan with the aid of natural flocculants. Therefore, the objective of this study was to evaluate the characteristics of extracted β-glucan with the application of chitosan, guar gum, and gelatin as examples of natural flocculants. The hypothesis of work was: Flocculants employed in the process of β-glucan extraction improved its extraction yield with changing its properties.

2. Materials and methods

2.1. Materials

For the purpose of this study, we used barley flour (Rastik variety) and oat flour (Poseidon variety) milled using KitchenAid with 5KGM of grain mill (KitchenAid, MI, USA). The flours were produced using whole grains. In terms of oat dehulled grains were used to obtain oat flour. Then, flours were sieved through 0.5 mm screen with rotor mill. β -glucan content for barley flour was 4.58 ± 0.15 g/100 g dry basis and for oat flour was 3.56 ± 0.21 g/100 g dry basis. Molecular weight for β -glucan in oat flour was 1 127 × 10^3 (g/mol) and in barley flour