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The content of water-soluble and water-insoluble β-D-glucans in selected oats and barley varieties

Alena Gajdošová [a,*], Zuzana Petruláková [a], Michaela Havrlentová [b], Viera Červená [b], Bernadetta Hozová [a], Ernest Šturdík [a,c], Grigorij Kogan [d]

[a] Slovak University of Technology, Faculty of Chemistry and Food Technology, Department of Nutrition and Food Evaluation, Radlinského 9, 812 37 Bratislava, Slovak Republic
[b] Research Institute of Plant Production – Slovak Agricultural Research Centre, Department of Agricultural Biotechnology, Bratislavská cesta 122, 921 68 Piešt'any, Slovak Republic
[c] University of ss. Cyril and Methodius, Faculty of Natural Science, Department of Biotechnology, Nám. J.Herdu 2, 917 01 Trnava, Slovak Republic
[d] Institute of Chemistry, Slovak Academy of Sciences, Dúbravská cesta 9, 845 38 Bratislava, Slovak Republic

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Abstract

In this paper, data on the inter-variety variability in chemical composition of oats and barley are summarized. The obtained results show that the content of soluble glucans decreases in the following order: barley (3.75 ± 0.14–7.96 ± 0.09 g/100 g of dry mass) ⩾ naked oats (3.91 ± 0.15–7.47 ± 0.06 g/100 g of dry mass) > hulled oats (1.97 ± 0.08–4.09 ± 0.19 g/100 g of dry mass), whereas the content of insoluble glucans decreases in the order: hulled oats (33.73 ± 1.55–13.79 ± 0.51 g/100 g of dry mass) > barley (10.89 ± 0.60–21.70 ± 0.73 g/100 g of dry mass) > naked oats (5.15 ± 0.06–10.80 ± 0.54 g/100 g of dry mass). When comparing the content of insoluble β-glucan in whole flour, bran and flour it was found that the content decreases from the outer coat to the endosperm. These results were confirmed for both cereals mentioned.

In this work, the influence of warehousing duration on the change in quantity of soluble β-glucans when stored at room temperature (25 ± 2 °C) and in a refrigerator (8 ± 2 °C) was monitored. From the results obtained, it can be concluded that the content of soluble β-glucans decreases with time. Slower alteration in soluble β-glucans content was detected in samples stored in refrigeration; however, lower temperatures did not halt the decrease of soluble β-glucans content in ground samples. The results show the need for stating the duration of warehousing from the time the sample was processed.

Keywords: Oats; Barley; Water-soluble β-D-glucan; Water-insoluble β-D-glucan; Warehousing

1. Introduction

Oats and barley belong to the group of crops with high energy and nutritional value arising from a high content of biologically valuable proteins, high portion of lipids compared to other cereals, favourable saccharide composition as well as from significant levels of dietary fiber, vitamins and mineral substances (Demirbas, 2005; Jakubecová, 2004). β-D-Glucans have a positive impact on human health in terms of lowering cholesterol and blood glucose levels (Maier, Turner, & Lupton, 2000), increasing immunity against infection and the utilization of β-D-glucans in reducing diets (Minárik, 2004). Reduction of absorption in the bowel, typical for glucans, results in increased viscosity followed by deceleration of gastric excretion. This results in the reduction of LDL cholesterol level (Kerckhoffs, Hornstra, & Mensink, 2003) as well as glucose level and consequently in the prevention of cardiovascular diseases (Liu et al., 2005; Mälkki & Virtanen, 2001). Glucans have a beneficial effect for constipation, haemorrhoids as

* Corresponding author.
E-mail address: gajdosova.alena@yahoo.com (A. Gajdošová).

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well as probiotic activity. In addition, glucans reduce gall bladder problems and the symptoms of Crohn's disease (Zadák, 2003), lower the risk of absorbing various substances from the bowel and thereby minimize the intake of undesirable substances. Glucans also act as immunostimulants (Dongowski, Huth, & Gebhardt, 2003).

Within the context of health protection, nutritionists today focus mainly on one component of fiber, $(1\rightarrow3)(1\rightarrow4)$-β-D-glucans. Glucan structure consists of cellotriosyll (58–72 %) and cellotetraosyll (20–34 %) units bonded by the β-$(1\rightarrow3)$ linkages; in small amounts, parts bonded by $(1\rightarrow4)$ linkages also occur (Holtekjølen, Uhlen, Bråthen, Sahlstrøm, & Knutsen, 2006; Lazaridou, Biliaderis, Mcha-Screttas, & Steele, 2004; Roubroeks, Anderson, Mastromauro, Christensen, & Aman, 2001). β-Glucans found in yeasts, fungi (Sugawara, Takahasm, Osumi, & Ohno, 2004), algae and bacteria have the $(1\rightarrow3)$ and $(1\rightarrow6)$ linkages in their molecules. β-Glucans constitute a dominant component of the cell wall in cereals (Demirbas, 2005; Trogh et al., 2004; Virkki, Johansson, Ylinen, Maunu, & Ekholm, 2005). The molecular weight of β-glucans ranges from 13,900 to 15,000 Da (McCarthy, Hanniffy, Lalor, Savage, & Tuohy, 2005; Roubroeks, Skjak-Braek, Ryan, & Christensen, 2000).

Structure has an impact on the water solubility of β-glucans. Extensive research has been done on the structure and properties of water-soluble β-glucans in contrast to water-insoluble β-glucans (Johansson et al., 2000; Ren, Ellis, Ross-Murphy, Wang, & Wood, 2003). The content of β-glucans in various cereals, according to the literature references is shown in Table 3. As indicated by the study carried out by Johansson et al. (Genc, Mustafa, & Demirbas, 2001; Johansson, Tuomainen, Ylinen, Ekholm, & Virkki, 2004), which examined the structural differences between soluble and insoluble β-glucans in oats and barley, the molecular weights of soluble β-glucans are greater than those of the insoluble glucans, however, this ratio does not differ between oats and barley. Izydorczyk, Marci, and MacGregor (1998) studied the structural properties of non-starch polysaccharides with the result that, in contrast to the insoluble β-glucans, the soluble β-glucans have a greater ratio of β-$(1\rightarrow4)$ linkages as well as of cellotriosyll units. The more $(1\rightarrow4)$ linkages present in the molecule, the lower is the solubility found in the polymers. The most soluble polymers comprise approximately 30% of $(1\rightarrow3)$ linkages and 70% of $(1\rightarrow4)$ linkages (Lambo, Öste, & Nyman, 2005). The solubility in cereals decreases in the following order: oats > barley > wheat. The structure of β-glucan is of significant importance in activation of the immune system, with chains emerging laterally from the main chain, playing a crucial role in this process. Multipath branching of glucan, as well as its higher molecular weight, activates the immune system more intensely.

Cereals present potentially, the least expensive source of glucans and can thereby satisfy the first and determining condition for their application as nutritive supplements and food ingredients to functional foods accessible to the general public (Hozová & Šturdík, 2005). The addition of cereal β-glucans to food increases the nutritional value of food and improves the quality parameters, in particular, the stability during warehousing (Liu et al., 2005). Cereals offer many possibilities for preparing functional foods. Suggestions for increasing nutritional and sensory value can be found in the literature which recommends the exploitation of cereals in the form of oat flakes, oat milk, pudding, yoghurt (Hozová, Kuniak, & Kelemenová, 2004), biscuits (Sudha, Vetrimani, & Leelavathi, in press), cereal gruel as a dessert, cereal gravy (Müller, Bohatiel, Blortz, & Frank, 1995), fruit juices and drinks (Kovacs, 1998) as well as cereal soups (Gormley & Morrissey, 1999). It is also appropriate to produce various types of bread, store-bread and noodles using oat flour instead of wheat flour (Plaami & Kumpulainen, 1994).

In this paper, the inter-variety variability of oats and barley based on the content of water-soluble and water-insoluble β-glucans is compared. The aim of this study was to select the most suitable representatives for further exploitation based on the detection of the evaluated parameters. Cereals, as the least expensive source of glucans, can be utilized as nutritional supplements and food ingredients. The understanding of inter-variety variability of β-glucans content is of great importance also for exploiting this knowledge in the agricultural breeding and growing of oats and barley.

2. Experimental

2.1. Materials

Seed samples of 33 oat varieties (4 naked, 29 hulled) and 10 barley varieties have been used in this study. All samples were obtained from the Gene Bank of the Slovak Republic from the Research Institute of Plant Production – Slovak Agricultural Research Centre in Piešt'any.

The samples were prepared in two ways according to their next use. When observing the β-glucans content in whole grains, the whole flour with the granularity <0.30 mm was prepared. Whole grains with hulls were milled in laboratory conditions using Laboratory Vibrating Mill (VM4-386, OPS Přerov, Czech Republic). For the estimation of the β-glucans content in single fractions, fractions of white flour and bran were obtained using vibrating mill and set of sieves (size of holes 0.30 mm, wire thickness 0.20 mm). The ratio of flour and bran was in oats 1:1 and in barley 1:2.

2.2. Methods

2.2.1. Insoluble β-glucan

The content of insoluble β-glucan was determined by using the modified method of advance isolation and adjustment of fungal β-glucan of oyster mushroom (*Pleurotus ostreatus*) following the patent of KUNIAK and co-workers (Kuniak, Augustín, & Karacsonyi, 1992).