DOMESTIC HULLESS BARLEY AND MALT AS AN EASILY AVAILABLE SOURCE OF *β*-GLUCAN

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ABSTRACT

β-Glucans are described as non-starch polysaccharides, characterized by (1→3), (1→4) β-D-glucose linkage. In human nutrition, they are regarded as extremely wanted because of their bioactive and medicinal properties. Since *β*-glucans comprise soluble fibres that have the ability to lower cholesterol, regulate blood sugar, reduce the risk of heart disease and colon cancer. Especially desirable are (1,3)-*β*-D-glucans because they act as immunomodulatory agents. The aim of this paper was to determine the mass fraction of *β*-glucans and the ratio of total and soluble *β*-glucans in barley and malt in domestic hulless barley varieties. Hulless barley is an accesible and cheap source of *β*-glucans. Four different domestic varieties of hulless barley obtained from the Agricultural Institute Osijek were examined. The results indicate that all tested varieties have higher *β*-glucans content than standard winter and spring varietes. Variety Matko showed close relation to the EFSA (European Food Safety Authority) recommendations of 750 mg of soluble *β*-glucans per serving.

Keywords: Croatian hulles barley varieties, *β*-glucan content, solubility of *β*-glucan

INTRODUCTION

β-Glucans are polysaccharides that can be found as components of the cell walls of barley, oats, wheat, rye, corn, rice, and sorghum (Polonskii and Sumina, 2013). Cereal's cell walls contain high amounts of heteroxylanes and small amounts of cellulose and pectin molecules. According to several authors, β-glucans form the inner lining of cell walls in the endosperm of barley (Bamfort and Kanauchi, 2001; Woodward et. al., 1983). The starchy endosperm in barley grain is surrounded with thin walls containing approximately 70% *β*-glucans, 25% arabinoxylans, 2% cellulose, and 2% glucomannans (Fincher, 1975; Wilson et al., 2006). Barley and oats have the highest *β*-glucan content (Gajdosova et. al. 2007; Lee et. al. 1997) with barley having an average content of *β*-glucans 3-9% (Zhang et. al., 2002; Henry, 1986; Aman and Newman 1986; Kalra, 2000; Xue et. al. 1997; Perez-Vendrell et al., 1995). Some barley varieties have low accumulation of starch and increased *β*-glucans. That can partially or completely replace the loss of starch. Some mutants of certain barley lines can have *β*-glucan content as high as 20% (Polonskii and Sumina, 2013). Knutsen and Holtekjolen (2007) compared hulless and covered barley varieties (16 varieties of hullesss and covered barley), and Griffey et. al., 2010 did the same thing on 14 samples of covered and 37 hullesss barley. According to their findings, these two types of barley showed no significant difference in the *β*-glucan content and water-soluble arabinoxylans in grain. Other authors determined that hullesss barley has more β-glucans than covered (Fastnaught et. al., 1996; Huth et. al., 2002). The highest content of β-glucans was recorded in the grain of Tibetan hulless barley (Zhang et. al., 2002) and Anderson et al. (1999) showed that hullless barley is extremely rich in β-glucans up to 15-18%. The research conducted by Krstanović et al. (2016a; 2016b) on domestic hulless barley varieties showed a significantly higher *β*-glucan content (soluble and total) than covered barley varieties. Since they are insoluble in water, different modification methods for transformation of *β*-D-glucan chemical structure to a soluble form have been investigated (Zeković and Kwiatkowski, 2005; Jirsa et. al., 2018). Sulfation, phosphation, and carboxymethylation have been applied. *β*-glucans exhibit bioactive and medicinal properties, (immunestimulation, anti-inflammatory, antimicrobial, antitumoral, hepatoprotective, cholesterol-lowering, antifibrotic, antidiabetic, and hypoglycemic) (Zeković and Kwiatkowski, 2005). *β*-glucans have also been employed to bind mycotoxins from feed (aflatoxins, ochratoxins, zearalenone, T-2 toxin, vomitoxin, and the fumonisins). The solubility of β-glucans increases with the lower degree of polymerization of the (1→3)-*β*-glucan. This being said, it is clear that solubility increases β-glucans value in terms of being a functional food supplement. Malting is a technological procedure that simulates the natural germination process of barley grain and this actually contributes to the solubility of *β*-glucans. This is why malt is a topic of this research, because it represents a cheap and easily available source of β-glucans.

MATERIALS AND METHODS

Four hullesss barley varieties samples were obtained from field trials of the Institute of Agriculture Osijek in 2017 (Osvit, Osk.5.119-10-12, GZ-184 and Matko). The barley varieties were grown under natural conditions on location Osijek (OS). The experiments were conducted in randomized block designs (RCBD) with six replications; plot size was 7.56 m^2. Sampling (5 kg per sample) was performed on cleaned and processed barley grains (according to the EBC 3.3.1. method) and the samples were kept refrigerated in sterile dry containers. Grain samples (5 kg per sample) were collected as untreated and conditioned grain, scaled and packed into in double-walled paper bags (1 kg). Until micromalting the material was stored in sterile dry containers for two months in a dry and cool place (18-20 °C) to overcome post-harvest grain dormancy. Laboratory micro-malting of barley was carried out (Table 1) in the micromalting plant Joe White Malting Systems (Pty. Limited East Melbourne, Victoria, Australia; Automatic Micro Malt Unit, 10 kg capacity). Four samples of 2×1 kg of each barley variety were subjected to malting. Degermination of dry malt was performed manually. After the micromalting, malt samples were weighed on 500 g samples and stored in paper bags for one month for the moisture content stabilization.

Table 1. Micromalting scheme of barley samples

	micromalting stage	air flow (%)	T (°C)	T (h)
STEEPING	immersion steeping	-	16	5
	dry steeping	100	17	12
	immersion steeping	-	17	6
	dry steeping	100	18	12
	immersion steeping	-	17	2
		-	-	-
	dry steeping	moisture correction to 44.5% by spraying with water		
GERMINATION	germination parameters	75	17	96
	turning over time: 2			
	number of rotation during turn over: 3			
KILNING	first phase	100	60	6
	second phase	100	65	3
	third phase	90	68	2
	fourth phase	90	70	2
	fifth phase	50	80	2
	sixth phase	50	83	2
	seventh phase	40	85	1

Determination of total β-glucan content: firstly, the barley samples were milled using a standard laboratory mill with a 1 mm sieve (MF10.2 basic, IKA Labortechnik, Germany) and after that using a kitchen coffee grinder (Braun KMM 10). The grinded samples were kept in sealed plastic bags until the enzymatic determination of total β-glucan content in barley using a commercial assay kit (Mixed linkage β-glucan assay kit, Megazyme Int., Bray, Ireland) (EBC Method 3.10.1., 1998). Assay procedure for β-glucan content in malt was carried out according (EBC Method 4.16.1., 1998), and soluble β-glucan content was determined according (EBC Method 8.13.1., 1998).

RESULTS AND DISCUSSION

When considering the results of this research, regarding to β-glucans as functional food supplements, it should be taken into an account that the recommended values for their daily intake differ from source to source. On the other hand, this is highly dependent on the age and health condition of the consumer. Some studies and researchers have established a recommended human dosage of approx. 2 mg of *β*-glucans daily per kilogram of body weight (Beta Glucan Products FAQ, 2018) and some recommend dosages between 3-15 g (Nicolosi et al., 1999). Nicolosi et al. (1999) concluded that higher dosage gives better results. It is very difficult to determine the minimum and maximum doses that boost the immune system. However, Cooper (2017) claims that most manufacturers of *β*-glucan supplements suggest daily doses up to 1 g/day. The Food and Drug Administration (FDA, 2006) approved a health claim on the positive effect of *β*-glucans from barley on cholesterol reduction and risk of heart disease for soluble *β*-glucans in the daily consumption of 3 g. These claims may be applied to foods that contain at least 0.75 g of soluble *β*-glucans per serving; EFSA (European Food Safety Authority) also stated the same thing for *β*-glucans from oats and barley (EFSA, 2009; EFSA, 2011). The selection of tested barley varieties for this research was encouraged by the previous research result on *β*-glucans in barley originating from the Institute of Agriculture Osijek for three consecutive seasons (2015/2017). The results in Table 2 show that all tested varieties in this research have a higher share of *β*-glucans than winter or spring varieties tested in previous research (Krstanović et. al., 2016a; Krstanović et. al. 2016b).

Table 2. Mass fractions and mass difference of *β*-glucans in barley, malt and soluble *β*-glucans from malt for chosen varieties

	***β*-glucan**				
	(g/100 g dm)			(%)	(mg/L)
	Barley	**Malt**	**Δm**	**Δm***	**Soluble**
Osvit	4.83	2.78	2.12	43.9	312
Osk.5.119-10-12	4.51	2.93	1.58	35.0	280
GZ-184	3.56	2.01	1.55	43.5	320
Matko	4.05	3.59	0.46	11.6	500

Δm = Δm *β*-glucan (barley – malt); **Δm*** = % of degraded *β*-glucan in malt in regards to the starting
β-glucan in barley); Soluble = soluble β-glucan

Variety Matko showed the lowest loss of *β*-glucan mass in malt in regards to starting β-glucans in barley, 0.46 g (11.58%). In comparison to other tested varieties, they also exhibit a lower *β*-glucan loss during malting. At the same time, the results regarding soluble *β*-glucans indicate that Matko has the highest soluble *β*-glucans value, 500 mg/L (Table 2). If we compare the results obtained in this study (for *β*-glucans in barley (4.83 g/100g dm) and soluble *β*-glucans (500 mg/L)) with the recommended values from other research and institutions, it can be concluded that the daily intake of 100-150 g of hulless barley could satisfy the needs for *β*-glucans in a healthy, average person. Of course, it should be taken into an account that the recommended values of *β*-glucan daily intake for persons with compromised immune system or chronic illnesses should be separately determined and adjusted.

CONCLUSIONS

It has been determined that the testes varieties of hulless barley have higher mass fractions of total *β*-glucans barley and malt than winter and spring varieties. The same goes for soluble *β*-glucans in malt. Furthermore, it has been established that Matko variety contains enough total and soluble β-glucans to satisfy the RDI values and can be declared as *β*-glucans source in functional food.

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