Influence of Temperature on the Extractibility of Polysaccharides in Barley

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Abstract

Barley contains substantial amounts of both soluble and insoluble non-starch polysaccharides (NSP). The main water soluble NSP in barley are highly viscous β-glucans. Monogastric animals, including humans and birds, cannot synthesize β-glucanase, and the amount of β-glucanase derived from barley grain and bacteria in the gastrointestinal tract is insufficient to completely hydrolyze β-glucans. In the present investigation, we have studied the influence of temperature and heating time on the extractibility of soluble polysaccharides in barley. Heating the barley samples at 60°C and 80°C before extraction has the effect of lowering the soluble fraction of the polysaccharides. The dynamic viscosity values of water extracts from barley decreased up to 21.68% when heating at 60ºC for 15 minutes, and up to 25.30% when heating at 80ºC for 15 minutes, when the determinations were made immediately after extract separation. Heating the barley samples for 15 minutes at 80°C deactivates the endogenous hydrolytic enzymes.

Keywords: barley, dynamic viscosity, non-starch polysaccharides.

1. Introduction

Most of the anti-nutritive activities of non-starch polysaccharides (NSP) which affect broiler performance have been attributed to soluble polysaccharides [1]. Most of polysaccharides give viscous aqueous solutions [2]. Barley contains substantial amounts of both soluble and insoluble NSP. The main water soluble NSP in barley are highly viscous β-glucans, composed of β-(1-4) linked glucose units separated every two to three units by a single β-(1-3) linked glucose and referred as to a mixed linkage β-glucan. Cereal β-Glucans are homopolysaccharides which exhibit considerable diversity in their structures, including the ratio of tri- to tetramers, the amount of longer cellulosic oligomers and the ratio of β-(1-4):β-(1-3) linkages [3, 4]. Not only the amount but also the molecular mass and structure of the β-glucans influence the viscosity of aqueous solutions. The β-glucans in the endosperm cell walls of barley consist of two fractions, one that is water soluble at 40–65°C, and one that is insoluble in water. An aqueous solution of β-glucans extracted from barley flour is viscous and the degree of viscosity is attributed to molecular weight and concentration of β-glucans [5]. Woodward et al. [6] determined the chemical structure and physicochemical properties of water-soluble barley β-glucans. These glucans consist of a population of molecules with molecular weights ranging from 10^4 to 10^7 and are responsible for the high viscosity of β-glucan solutions.

Monogastric animals including humans and birds cannot synthesize β-glucanase, and the amount of β-glucanase derived from barley grain and bacteria in the gastrointestinal tract is insufficient to completely hydrolyze β-glucans [7].

Thus, β-glucans in barley diets are suspected of creating a viscous environment in the chick digestive tract [8], causing poor absorption of dietary nutrients and reducing growth rate. Viscosity in the digestive tract may also play a vital role in the hypocholesterolemic function of barley.

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In the present investigation, we have studied the influence of temperature and heating time on the extractibility of soluble polysaccharides in barley.

2. Materials and methods

The experiments had in view the effect of temperature (60°C and 80°C) on the soluble fraction of NSPs, revealed by determination of water extract viscosity.
The barley samples, milled by a laboratory grinder at a 500 μm sieve, were heated in a forced air oven Froilabo AC60 for 5, 10 and 15 minutes. The soluble NSP were extracted from the barley samples, extraction temperature: 40°C and extraction time: 60 minutes. The extract was isolated by centrifugation for 10 minutes at 10.000 rpm, using a Hettich 320R centrifuge. The dynamic viscosity was determined using a cone/plate viscometer (Brookfield Model DVIII Cone CP-40) at 60 rpm and 25°C, at different times after the extract separation: 0, 30 and 60 minutes.

3. Results and discussion

The experimental data are presented in Table 1. The determined dynamic viscosity of unheated barley sample was 3.32 cP.
The heating of the samples at 60°C and 80°C before extraction induces a decrease in the soluble fraction of polysaccharides, revealed by the variation of the dynamic viscosity.
When heating the barley samples at 60°C and 80°C, all viscosity values measured immediately after the extract separation were lower than the viscosity of the unheated sample (Figures 1 and 2). The dynamic viscosity values of water extracts from barley decreased up to 2.60 cP (21.68% decreasing) when heating at 60ºC for 15 minutes, and up to 2.48 cP (25.30% decreasing) when heating at 80ºC for 15 minutes.
Heating the barley samples for 15 minutes at 80°C deactivates the endogenous hydrolytic enzymes, and consequently no decrease in the viscosity with the time elapsed after centrifugation was observed.

Table 1. Water extract viscosities of wheat samples heated at 60°C and 80°C

No.	Temperature (°C)	Heating time (min)	Time after centrifugation (min)	Dynamic viscosity (cP)
	60	5	0	2.88
			30	2.37
			60	2.20
		10	0	2.82
			30	2.50
			60	2.40
		15	0	2.60
			30	2.50
			60	2.40
	80	5	0	2.85
			30	2.60
			60	2.50
		10	0	2.54
			30	2.57
			60	2.30
		15	0	2.48
			30	2.40
			60	2.48

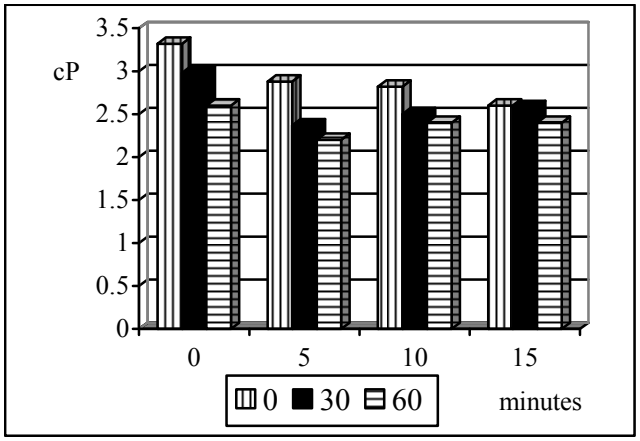

Figure 1. WEV of barley samples heated at 60°C, at different times after centrifugation of the extract

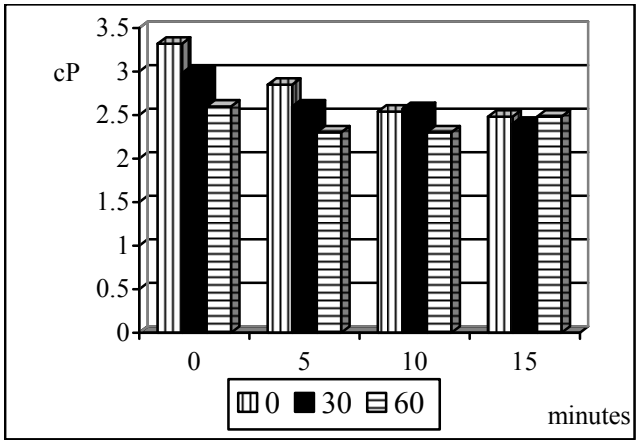

Figure 2. WEV of barley samples heated at 80°C, at different times after centrifugation of the extract

4. Conclusions

- Elevated temperatures affect polysaccharides solubility.
- Heating the barley samples at 60°C and 80°C before extraction, has the effect of lowering the soluble fraction of the polysaccharides.
- Heating the barley samples at 60°C and 80°C, all viscosity values were lower than the viscosity of the unheated sample, when the determinations were made immediately after extract separation.
- Heating the barley samples for 15 minutes at 80°C deactivates the endogenous hydrolytic enzymes, and consequently no decrease in the viscosity with the time elapsed after centrifugation was observed.

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