The Effect of Temperature on Soluble Dietary Fiber Fraction in Cereals

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Abstract
Dietary fiber (DF) consists of a mixture of components with a varying degree of solubility. Wheat and barley contain substantial amounts of both soluble and insoluble DF. Most of food processes are essentially based on heating for a certain time. Thermal processing of plant tissues alters the physical and chemical properties of cell wall, and modifies fiber solubilization, which modifies the water extract viscosity (WEV). The study had in view the effect of temperature on WEV of wheat and barley flours. Thermal treatment at 100°C produced an increase of WEVs, suggesting a conversion of the insoluble DF into soluble DF. The increasing of relative viscosity values of water extracts was up to 21.8% for wheat, when heating at 100°C for 10 minutes, and up to 29.5% for barley, when heating at 100°C for 15 minutes. Determinations of WEVs at different time intervals after extract separation showed that heating the wheat and barley flours at 100°C for 15 minutes deactivated the endogenous hydrolytic enzymes.

Keywords: dietary fiber, wheat, barley, water extract viscosity

1. Introduction
Food quality is mainly related to the nutritional quality and the effect on consumers’ health. The interest in nutritional and therapeutic properties of food and in the relationship between food and health is growing every day. Many processed foods are deprived of some substances having great importance for health, among which the dietary fiber (DF). DF has beneficial physiological effects, such as: improving the bulk motility, blood cholesterol and glucose decreasing, constipation and cancer preventing, prebiotic acting [1-4].

Dietary fiber is defined as the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine [5]. There are 4 main components of DF: total nonstarch polysaccharides (NSPs), inulin and fructo-oligosaccharides, resistant starch, and lignin. NSPs major food sources are cereals and vegetables, which contribute approximately 40% to 50% of the DF. Total NSPs can be classified into water-soluble and water-insoluble fractions, which delineate their functions and chemical structures [6-9]. NSPs solubility is determined by their primary structure, and by the way they are bound to other cell wall components. Water-soluble fiber fractions have opposite effects on water binding capacity and viscosity than the insoluble fractions [10]. The water insoluble fraction includes cellulose, galactomannans, xylans, xyloglucans, and lignin, while the water-soluble fibers are the pectins, arabinogalactans, arabinoxylans, and β-glucans [11].

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β-Glucans are linear polymers of glucose with β-(1,3)(1,4) glycosidic links. Arabinoxylans consist of long backbone chains of β-(1,4) anhydro-D-xylopyranosyl with single α-L-arabinofuranosyl residues attached at the 2- or 3-position [12].

Almost all water-soluble polysaccharides produce viscous solutions. The viscous properties of DF are determined by several factors, including their chemical composition, molecular size, and composition of the extraction media. Wheat and barley contain substantial amounts of both soluble and insoluble DF. The predominant water soluble DF in wheat is arabinoxylan (6-8%), while β-glucan is the predominant water soluble DF in barley (7.6%). Most of food processes are essentially based on heating for a certain time, and thermal processing of plant tissues alters the physical and chemical properties of plant cell wall and modifies fiber solubilization, which modifies the water extract viscosity (WEV). The study had in view the effect of temperature on WEV of wheat and barley flours.

2. Materials and Method

The effect of temperature on WEV (which is correlated with the soluble DF content) obtained from wheat and barley flours was determined. The influence of the time elapsed after extract separation on WEV was also determined.

Wheat and barley samples were milled to 500 µm granulation, and heated for 5, 10 and 15 minutes at 100°C in a Froilabo AC60 forced air oven.

The water-soluble fractions were obtained by a single extraction at a ratio 1/2 (flour/water), by shaking the tubes at 150 rpm, for 60 minutes at 40°C, using a LabTech LSB-015S water bath.

The extracts were centrifuged for 10 minutes at 5,000 rpm and 25°C, using a Hettich 320R centrifuge. The dynamic viscosity was determined using a cone/plate viscometer Brookfield Model DVIII Cone CP-40, at 100 rpm and 25°C, immediately after separation, and at 30 and 60 minutes after centrifugation. The relative viscosity was calculated.

3. Results and Discussion

The changes in the DF composition may be attributed partly to the redistribution of the insoluble and soluble components of DF.

The obtained experimental results, presented in Table 1, show the effect of thermal treatment on the soluble fraction of DF, effect revealed by the determined values of the water extract viscosities. The relative viscosity values of water extracts from untreated samples were 2.57 cP for wheat, and 2.95 cP for barley.

Thermal treatment at 100°C produced an increase of water extracts viscosities. The proportion of soluble DF from total DF increased, suggesting a conversion of the insoluble DF into soluble DF. An increased temperature breaks weak bonds between polysaccharide chains and split glycosidic linkages in the DF polysaccharides [13]. As consequence, the architecture of the fiber matrix may be modified and insoluble fiber solubilized [14].

The relative viscosity values of water extracts from wheat increased up to 3.13 cP (21.8% increasing) when heating at 100°C for 10 minutes. The relative viscosity values of water extracts from barley increased up to 3.82 cP (29.5% increasing) when heating at 100°C for 15 minutes (Figure 1).

![Figure 1](image-url)  
**Figure 1.** Relative viscosity values of water extracts from wheat and barley flours heated at 100°C for 5, 10 and 15 minutes

Determinations of WEVs at different time intervals elapsed after extract separation, show that heating the wheat and barley flours at 100°C for 15 minutes deactivated the endogenous hydrolytic enzymes. No significant decrease of WEV values with the time elapsed after extract separation was observed (Figures 2 and 3).
Table 1. WEV of wheat and barley flours heated at 100°C

<table>
<thead>
<tr>
<th>Sample</th>
<th>Heating time (minutes)</th>
<th>Time after centrifugation (minutes)</th>
<th>Dynamic viscosity (cP)</th>
<th>Relative viscosity (cP)</th>
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<td>2.24</td>
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<td>60</td>
<td>2.90</td>
<td>3.60</td>
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</table>

Figure 2. WEVs of the wheat samples heated at 100°C, at different times after centrifugation of the extract

Figure 3. WEVs of the barley samples heated at 100°C, at different times after centrifugation of the extract
4. Conclusions

Thermal treatment of wheat and barley flours at 100°C produced an increase of water extracts viscosities, suggesting a conversion of the insoluble dietary fiber into soluble dietary fiber.

The increasing of relative viscosity values of water extracts was up to 21.8% for wheat, when heated at 100°C for 10 minutes, and up to 29.5% for barley, when heated at 100°C for 15 minutes.

Heating the wheat and barley flours at 100°C for 15 minutes deactivated the endogenous hydrolytic enzymes, so no significant decrease of WEV values with the time elapsed after extract separation was observed.

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References