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Effect of Microwave Treatment and Digestive Enzymes on Cereal Water-Retention Capacity

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Abstract

Different hydration characteristics of dietary fibers are related to their chemical structure. Processing conditions can modify the physical properties of the fiber matrix and consequently affect their hydration properties. Microwave treatment of cereals and legumes is able to increase the water retention capacity (WRC), which often is required in baked products to make the texture harder and crispy. The present study investigated the effect of microwave radiations on WRC of wheat and barley submitted to *in vitro* simulated digestion. A slightly higher WRC was observed in treated wheat, from 0.96 g water/g DM (untreated) to 1.015 g water/g DM (treated for 30 s). Greater WRC values were recorded in barley, due to the higher β-glucan content: from 1.026 g water/g DM (untreated) to 1.361 g water/g DM (treated for 30 s).

Keywords: water-retention capacity, *in vitro* digestion, microwave treatment, wheat, barley

1. Introduction

Water-retention capacity (WRC) is one of the functional properties of fiber related to human colonic digesta passage [1-3]. Water associated with fiber is a significant physical property related to the effects of dietary fiber in food and feed. WRC influences the metabolic activity of dietary fiber along the gut and has physiological effects both in the upper and lower gastrointestinal tract. The dietary fibers swell in the aqueous environment of the intestinal lumen by taking up water and small molecules [4]. Previous studies of some fiber concentrates suggest that WRC is determined mostly by the fiber structure than by the chemical composition [3,5,6]. Hydration of fiber occurs by adsorption to the surface of the macromolecules and by the ability of the fiber to immobilize water within its matrix [7].

Processing of foods affects the content of carbohydrates and micronutrients and their bioavailability with either desirable or adverse effects on the nutritional value [6,8]. The *in vitro* determination of WRC of dietary fiber can predict the *in vivo* physiological effects of dietary fiber [9,10].

Processing conditions can modify the physical properties of the fiber matrix and consequently affect their hydration properties. Thermal processing affects the dietary fiber especially by degrading the original matrix due to the breakage of weak bonds between polysaccharide chains and between the glycoside linkages in the dietary fiber. These changes are important from analytical, functional and nutritional points of view. Even if processing has sometimes little effect on the content and physicochemical properties of dietary fiber, the effect on the functional and physiological properties (e.g. viscosity and hydration) is high.

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Thermal processing also affects the dietary fiber content and its properties by formation of Maillard reaction products and of resistant starch fractions. Structural alterations in the cell wall architecture during processing can change the sensory and nutritional characteristics.

Microwave energy is used in the food industry, especially in the drying of pasta and post-baking of biscuits. Microwave processing of cereals and legumes may increase WRC, which is often necessary in baked products to make the texture hard and crispy. Microwave treatment is responsible for many changes in the structures of macro and micro molecules including gelation, viscosity, hydrophobicity, etc.

The objective of the laboratory experiments was to determine the effect of microwave treatment, followed by *in vitro* simulated digestion, on wheat and barley WRC.

The *in vitro* digestion is based on consecutive incubations with pepsin and pancreatin, that contains all the necessary enzymes to dissolve the potentially digestible nutrients [11,12,13]. The two-step pepsin-pancreatin system simulates the digestion in the stomach and the small intestine, although it does not consider certain aspects of digestion *in vivo*, like endogenous secretions, absorption and transit [14,15].

2. Materials and Methods

Wheat and barley samples were milled to 500 μm granulation. The samples were exposed to microwave radiations for different periods of time: 0, 30, 60 and 90 seconds. The microwave treatment was made in a Vortex WD800D-823 oven (800 W and 2450 Hz). WRC of all the samples was evaluated in duplicate following gastric and intestinal digestion [16]. The experiments were conducted with the two-step pepsin-pancreatin procedure which involves sample incubation with pepsin at 37ºC and pH 2, followed by the incubation with pancreatin at 37ºC and pH 6.8.

The amount of sample submitted to analysis was recorded (W_0) as well as the weight of the screw cap tube plus sample (W_1). After incubation, WRC was determined by centrifugation for 20 min at 5000×g. Supernatant was carefully removed and tubes were kept upside down for 10 min to ensure that the non-retained water was drained. The tubes with the samples were then weighed (W_2), dried in the oven at 100 ºC for 16 h to ensure the complete drying of the insoluble residue, and then weighed again (W_3).

WRC determined after centrifugation was calculated as grams of water retained by 1 g dry matter (DM):

$$WRC_{DM} = \left[\frac{W_2 - W_3}{W_0} \right]$$

3. Results and Discussion

The obtained results (Figures 1 and 2) indicate the dependence of WRC on the type of grain and on the time of microwave treatment.

A slightly higher WRC was observed in treated wheat (Figure 1), from 0.96 g water/g DM (untreated) to 1.015 g water/g DM (treated for 30 s). Greater WRC values were recorded in barley, due to the higher β-glucan content [17,18]: from 1.026 g water/g DM (untreated) to 1.361 g water/g DM (treated for 30 s).

The microwave treatment increased only slightly WRC in wheat, with a maximum increase of 5.73% at 30 seconds. The microwave treatment improves WRC in barley with up to 32.65% at 30 seconds treatment. A longer processing time resulted in lower WRC both in wheat and barley. WRC of samples exposed to microwaves for 90 seconds were higher than those of unprocessed samples, with only 3.75% in wheat and 24.65% in barley (Figure 2).

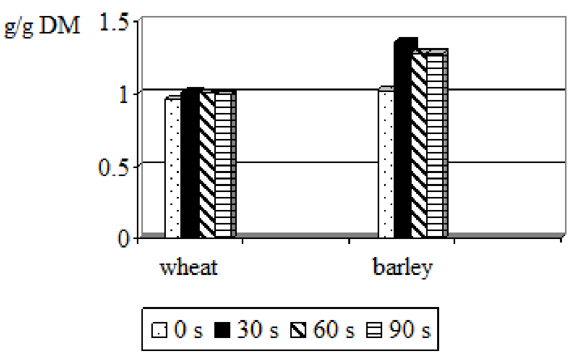

Figure 1. WRC of wheat and barley exposed to microwave radiations

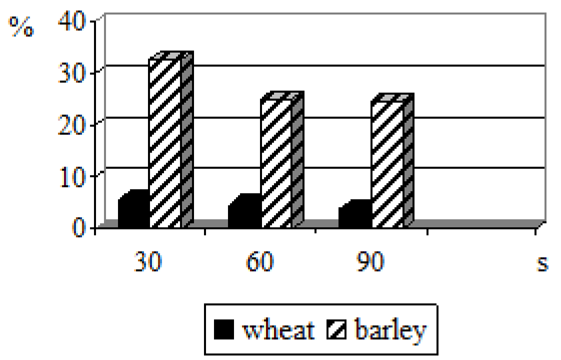

Figure 2. WRC of wheat and barley exposed to microwave radiations as percentage of WRC of raw wheat and barley

4. Conclusions

The present study revealed higher values of WRC of barley exposed to microwave radiations and submitted to *in vitro* simulated digestion, compared with samples of unprocessed cereals.

Changes during exposure to microwave radiation such as protein denaturation, starch gelatinization, and swelling of the crude fiber, could all contribute to the increased WRC.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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