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The Action of Digestive Enzymes on the Soluble Dietary Fiber Fraction of Thermally Processed Wheat

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Abstract

Thermal treatment can modify the physicochemical properties of dietary fiber (DF). The study was conducted to evaluate the effect of thermal processing on soluble DF fraction of wheat samples subjected to *in vitro* gastric and intestinal digestion. Samples were treated by heating in a forced air oven at 150ºC for 5, 10 and 15 minutes, and by exposing to radiations in a microwaves oven for 30, 60 and 90 seconds. The effect of digestive enzymes action on the soluble DF fraction was evidenced by the variation in the dynamic viscosity (DV) of the supernatant collected after gastric and intestinal incubation. Regardless of the heat treatment, DV increased during processing and during digestion. Maximum DV values were observed at 240 minutes of intestinal digestion, after 90 seconds exposure to microwaves.

Keywords: wheat, dietary fiber, digestion, dynamic viscosity

1. Introduction

Dietary fibers (DF) are ubiquitous components of plant foods, and include various chemical and morphological structure materials resistant to the action of human food enzymes, but which can be digested by intestinal microflora. The source of dietary fiber includes vegetables, wheat and most other grains. Foods rich in soluble fiber are also fruits, oats, barley and beans.

The beneficial effects of dietary fiber have been known since antiquity, but have become more clearly understood only between the 1950s and 1970s [1,2,3].

DF include many different substances; except lignin, all are carbohydrates in nature. From a chemical point of view, the fiber was defined as "non-starch polysaccharide (NSP)" [4]. NSP include cellulose and non-cellulose polysaccharide (NCP) [5].

The latter includes: pectin and hemicellulose (structural polysaccharides); fructans, glucofructans, mannans and galactomannans (storage polysaccharides); gums and mucilages (isolated polysaccharides), containing a mixture of pentoses, hexoses and uronic acids.

Through its different physicochemical properties, DF intake influences several metabolic processes, including nutrient absorption, carbohydrates and fats metabolism, and sterols metabolism.

Consuming adequate amounts of DF can improve gastrointestinal health, and reduce susceptibility to diseases such as diverticular diseases, heart diseases, cancer and diabetes. Increased DF consumption has also been associated with increased satiety and weight loss. Fiber-rich foods, due to their consistency, encourage mastication and stimulate secretion of digestive juices.

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In cereal grains with high concentrations of DF, water-soluble arabinoxylans and β-glucans are responsible for increased intestinal viscosity and low digestibility of starch, fats and proteins. Arabinoxylans represent approximately 8.8 g/kg of wheat endosperm cell wall polysaccharides, one third to half of which is water soluble [6,7].

Most food processes are mainly based on heating for a certain period of time [8-10]. Thermal processing of plant tissues alters the physico-chemical properties of the plant cell wall and changes DF solubility, which changes the dynamic viscosity of the water extract (DV).

The study was conducted to evaluate the effect of thermal processing on the soluble DF fraction of wheat samples subjected to *in vitro* gastric and intestinal digestion.

2. Materials and Methods

Samples of wheat, graded at 500 μm, were treated by heating in a forced air oven (Froilabo AC60) at 150°C for 5, 10 and 15 minutes, or by exposure to radiation in a microwave oven (Vortex WD800D-823, 800 W and 2450 Hz) for 30, 60 and 90 seconds.

The thermal processed whole meal samples were digested *in vitro*. Digestion was performed according to the method of Boisen *et al*. [11] with some modifications [12].

The experiments were carried out with the two-step pepsin-pancreatin procedure which involves sample incubation with pepsin at pH 2 (gastric digestion), followed by the incubation with pancreatin at pH 6.8 (intestinal digestion) [13].

Each wheat sample was incubated for 120 minutes in a shaking water bath (LabTech LSB-015S) at 37°C, r = 120 rpm with 0.l M phosphate buffer, HCl 2M, and freshly prepared 4% pepsin solution. Bacterial growth was prevented by adding chloramphenicol solution. For the intestinal digestion 0.2 M phosphate buffer, 0.6 N NaOH, and l 2% pancreatin were added, and the samples were incubated in the shaking water bath at 120 rpm at 37°C for 240 minutes and monitored at different incubation times: 60, 120, and 240 minutes. All samples for *in vitro* analysis were done in duplicate.

The dynamic viscosity was determined using a cone/plate viscometer (Brookfield Model DVIII Cone CP-40) at 100 rpm and 25°C [14]. All results were calculated in cP and expressed as values relative to that of water.

3. Results and Discussions

The gastrointestinal tract, especially the large intestine, is the main area of action of DF [15]. The physiological effects of DF depend on the type (partially fermentable or highly fermentable), the amount of fiber consumed, the composition of the whole fiber-containing meal, and the individual physiological profile of the subject consuming the meal. The major physiological effects of DF come from interactions with the colon content during fermentation.

Food processing affects the carbohydrate and micronutrient content and bioavailability in various ways, with either desirable or adverse effects on the nutritional value [10]. Processes involving heat treatment can affect DF, an increased temperature leading to breakage of the weak links between the polysaccharide chains. Also, the glycosidic linkages in DF can be broken. These changes are important from an analytical, functional and nutritional point of view.

The effect of digestive enzymes action on the soluble DF fraction was evidenced by the variation in DV of the supernatant collected after gastric and intestinal incubation. The experimental data revealed that thermal processing increased the extract viscosities, which are correlated with the proportion of soluble DF in wheat, suggesting a redistribution of the total DF content from insoluble to soluble components.

Thermal treatment can increase the solubility of food fibers, and consequently increase intestinal viscosity and decrease digestibility of nutrients. Thermal treatment significantly reduced the insoluble fraction of food fibers in wheat. Wheat samples subjected to heat treatment in an oven at 150° C, prior to *in vitro* intestinal digestion, revealed higher viscosity values than the unprocessed samples (W) (Figures 1, 2, and 3).

Higher viscosity values for microwave treatment compared to oven heating were obtained (Figures 4, 5, and 6).

Regardless of the mode of thermal treatment, the viscosity increased with processing time and with intestinal digestion. Maximum viscosity values were observed at 240 minutes of intestinal digestion, with wheat exposed for 90 seconds at microwaves.

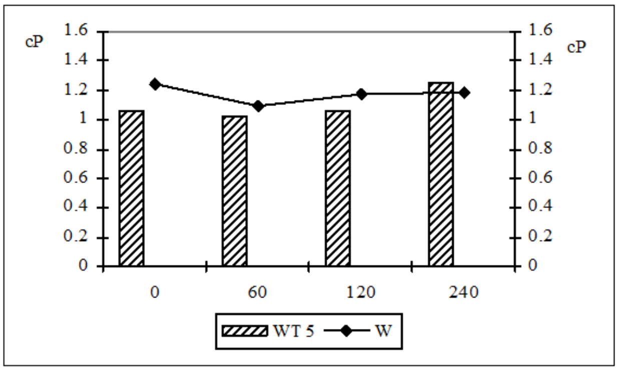

Figure 1. Variation of DV with digestion time of wheat samples heated for 5 minutes at 150ºC

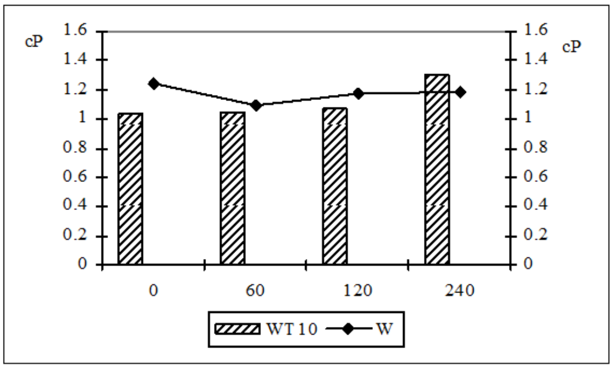

Figure 2. Variation of DV with digestion time of wheat samples heated for 10 minutes at 150ºC

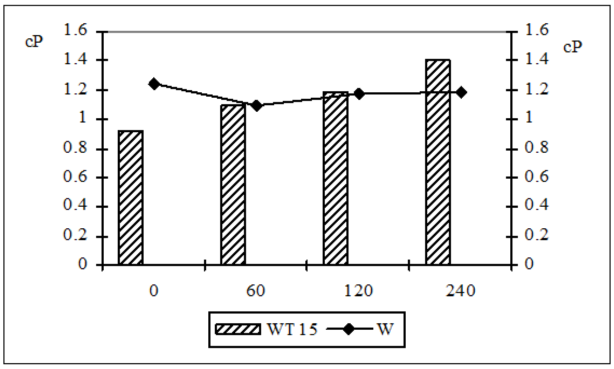

Figure 3. Variation of DV with digestion time of wheat samples heated for 15 minutes at 150ºC

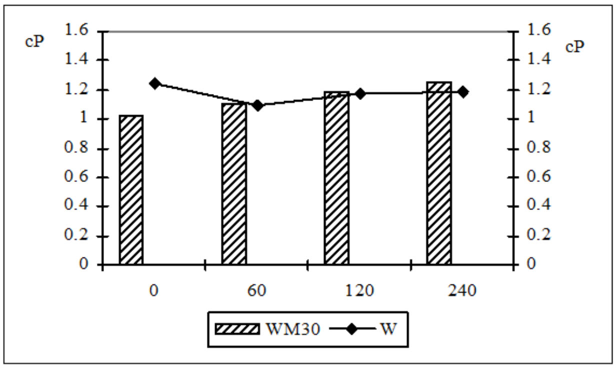

Figure 4. Variation of DV with digestion time of wheat samples heated for 30 seconds in microwave oven

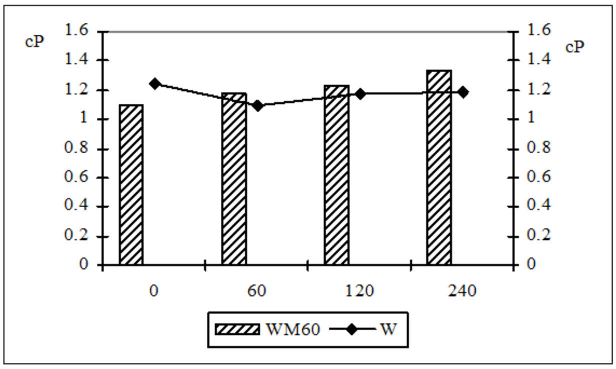

Figure 5. Variation of DV with digestion time of wheat samples heated for 60 seconds in microwave oven

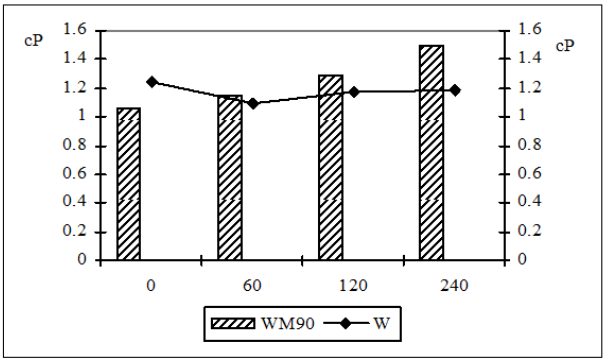

Figure 6. Variation of DV with digestion time of wheat samples heated for 90 seconds in microwave oven

4. Conclusions

Dynamic viscosity of wheat samples increased during thermal processing, and during *in vitro* digestion.

Dynamic viscosity of wheat samples was influenced by the type and lasting of heat treatment. Higher values were obtained for microwave treatment compared to oven heating.

Maximum values were observed at 240 minutes of intestinal digestion, for samples exposed to microwaves for 90 seconds.

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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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