Comparative Study on Water Extract Viscosity of Unprocessed and Processed Cereals

Adrian Caprita, Rodica Caprita

Abstract—**Cereals and cereal by-products are the main dietary sources of carbohydrates for humans and animals. The most common dietary fibers (DF) in cereals are non-starch polysaccharides (NSP). Arabinoxylans and β-glucans are the two most important water-extractable dietary fiber polysaccharides in cereal food products. The structure and molecular weight distributions of these polymers determine their physical properties like viscosity, extractability, solubility and gelling behavior, as well as nutritional properties. Production of cereal foods include processing such as extrusion, flaking, milling and bread making which may have great effects on DF, especially on their molecular weight distributions. Experiments were conducted on some cereals to investigate the water extract viscosity (WEV), the correlation between WEV and NSP, and the influence of processing on the soluble fraction of DF, evidenced by the viscosity of aqueous extracts. The comparison between WEV and the soluble, insoluble and total NSP values, revealed that the WEV are high positively correlated (r = 0.9707) with the soluble NSP content and decrease in the following order: oats>barley>wheat> triticale>corn>rice. Processed cereals have much higher WEV than the unprocessed grains. Viscosities of aqueous extracts vary with fiber content. The flaking process increased the soluble fiber content in wheat, barley and oats, and subsequently the water extract viscosity was also increased. Results revealed a high positive correlation (r = 0.9268) between WEV and DF content of processed wheat, barley and oats. WEV of processed wheat, barley and oats are not correlated with the total carbohydrates content.**

Index Terms—**cereals, dietary fiber, non-starch polysaccharides, water extract viscosity**

I. Introduction

The American Association of Cereal Chemists adopted the following definition for dietary fiber (DF): "Dietary fiber is 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. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plants substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation" [1].

Nondigestible plant carbohydrates in foods are usually a mixture of polysaccharides that are integral components of the plant cell wall or intercellular structure. Fractions of plant foods are considered DF if the plant cells and their three-dimensional interrelationships remain largely intact [2]. Another distinguishing feature of DF sources is that they contain other macronutrients (e.g., digestible carbohydrate and protein) normally found in foods.

Dietary fiber polysaccharides are generally composed of ten different monosaccharides; arabinose, xylose, glucose, mannose, galactose, fucose, rhamnose, galaturonic acid, glucuronic acid and 4-O-methyl-glucuronic acid linked together to form different types of polymers.

Resistant starch that is naturally occurring and inherent in a food, or created during normal processing of a food, as is the case for flaked cereal, would be categorized as DF. Examples of oligosaccharides that fall under the category of DF are those that are normally constituents of a DF source, such as raffinose, stachyose, and verbascose in legumes, and the low molecular weight fructans in foods.

The types of plant material that are included within the definitions of DF may be divided into two forms, based on their water solubility:

- Insoluble dietary fiber (IDF) which includes celluloses, some hemicelluloses and lignin;
- Soluble dietary fiber (SDF) which includes β-glucans, pectins, gums, mucilages and some hemicelluloses (composed of a variety of heteropolysaccharides including arabinoxylans).

Dietary fiber is thought to have a wide-ranging influence on human health, including gastrointestinal benefits and reducing the risk of chronic disease.

Literature data suggest that the addition of fiber sources that are viscous can be more beneficial for various health reasons, particularly on the reduction of blood glucose and cholesterol levels and diminished uptakes of fatty acids and other nutrients [3]-[8]. Fiber sources that are slowly, incompletely, or essentially not fermented in the large intestine provide bulk and therefore optimize laxation [9], [10]. The degree of thickening when exposed to fluids depends on the chemical composition and concentration of the polysaccharides [11].

Cereals and cereal by-products are the main dietary sources of carbohydrates for humans and animals. The most common dietary fiber polysaccharides in cereals are non-starch polysaccharides (NSP) which include cellulose, β-glucans and arabinoxylans. Arabinoxylans and β-glucans are the two most important water-extractable dietary fiber polysaccharides in cereal food products. The structure and molecular weight distributions of these polymers determine their physical properties like viscosity, extractability,

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solubility and gelling behavior, as well as nutritional properties. Production of cereal foods include processing such as extrusion, flaking, milling and bread making which may have great effects on the dietary fiber polysaccharides, especially on their molecular weight distributions.

Experiments were conducted on some cereals to investigate the water extract viscosity (WEV), the correlation between WEV and NSP, and the influence of processing on the soluble fraction of dietary fiber, evidenced by the viscosity of aqueous extracts.

II. EXPERIMENTAL

Samples of cereals and commercial foods (processed cereals) were analyzed for the water extract viscosity.

The raw and processed cereals were milled by a laboratory grinder to pass through a 500 μm sieve. The extracts were obtained at a ratio of flour to water of 1:2, by shaking the mixture at 150 rpm and 40°C for 60 minutes, 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. Following the centrifugation, an aliquot of 0.5 mL supernatant was removed and immediately assayed for dynamic viscosity. Viscosity measurements were carried out at 25°C using a Wells Brookfield Cone/Plate Digital Viscometer, Model DVIII Cone CP-40. All results were expressed in cP and calculated also as values relative to that of water.

III. RESULTS AND DISCUSSION

The dynamic viscosities (DV) and the relative viscosities (RV) of aqueous extracts obtained from some cereals are presented in Table I. Relative viscosities of wheat water extracts ranged from 1.70 to 2.40 cP. Relative viscosities of barley water extracts ranged from 2.51 to 2.85 cP.

TABLE I
DYNAMIC AND RELATIVE VISCOSITIES OF AQUEOUS EXTRACTS OBTAINED FROM SOME CEREALS

Sample	Specification	DV (cP)	RV (cP)
W_1	Wheat	2.16	2.40
W_2	Wheat	1.98	2.20
W_3	Wheat	1.70	1.90
W_4	Wheat	1.59	1.77
W_5	Wheat	1.53	1.70
B_1	Barley	2.56	2.85
B_2	Barley	2.46	2.74
B_3	Barley	2.46	2.73
B_4	Barley	2.37	2.64
B_5	Barley	2.26	2.51
C	Corn	1.10	1.22
T	Triticale	1.66	1.85
O	Oats	2.57	2.85
R	Rice	0.99	1.10

Because of the variation in NSP contents [12], there is a considerable variation in WEV among wheat and barley cultivars (Fig. 1).

When comparing the WEV with the soluble, insoluble and total NSP values [13], we observed that the WEV values are high positively correlated with the soluble NSP content (r = 0.9707) and decrease in the following order: oats>barley> wheat>triticale>corn>rice (Fig. 2 and Fig. 3).

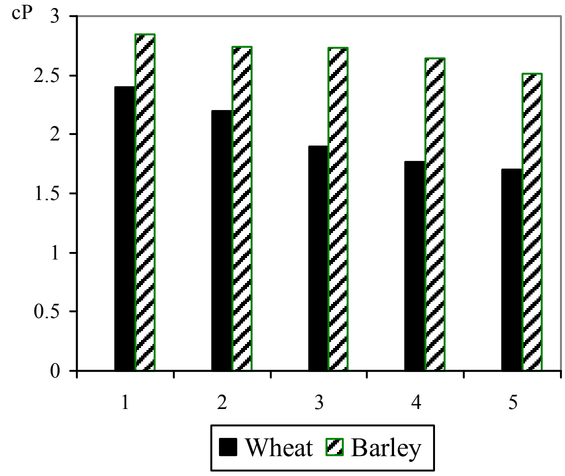

Fig. 1. WEV of 5 different species of wheat and barley.

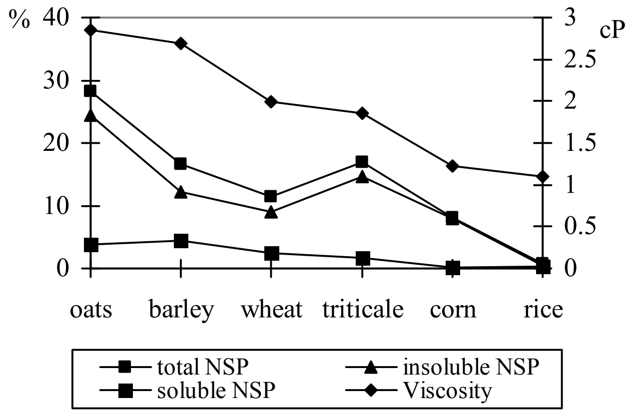

Fig. 2. Soluble, insoluble, total NSP and WEV of some cereals.

Total carbohydrates (TC), dietary fiber (DF) content, dynamic and relative viscosities of aqueous extracts obtained from some commercial food products made from cereal grains are presented in Table II.

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TABLE II
TOTAL CARBOHYDRATES, DIETARY FIBER CONTENT, DYNAMIC AND RELATIVE VISCOSITIES OF PROCESSED CEREALS

Samples	Specification	TC (%)	DF (%)	DV (cP)	RV (cP)
WF1	Wheat flakes	59.6	0.5	2.08	2.60
WF2	Wheat flakes	77	4	5.54	6.92
OF1	Oats flakes	58	6.8	6.96	8.70
OF2	Oats flakes	62.5	9	12.00	15
OF3	Oats flakes	63.3	5.4	8.34	10.42
BF	Barley flakes	71	10	9.83	12.28
CF	Corn flakes	83,3	3	2.44	3.05
C	Corn meal	75.1	0	0.86	1.07
S	Semolina	73.6	2.1	1.48	1.85
B	Biscuit	78	0.5	1.62	2.02
PR	Preboiled rice	79.8	0.5	0.96	1.20

Experimental data show that processed cereals have much higher WEV than the unprocessed grains. WEV vary with fiber content (Fig. 4).

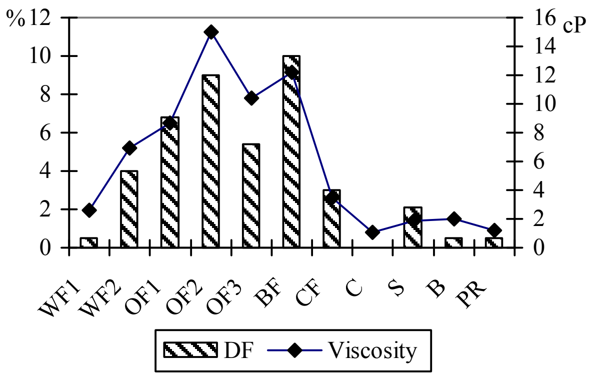

Fig. 4. WEV and DF content of processed cereals.

The flaking process increased the soluble fiber content in wheat, barley and oats, and subsequently WEV was also increased. Processing increases the solubility of β-glucans in oats and barley [14], so that WEV increased 5.26 times in oats and 4.56 times in barley. Corn meal fiber was unaffected by processing under the same conditions as the other foods (Fig. 5).

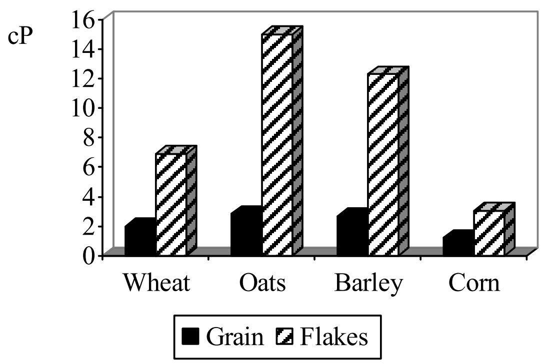

Fig. 5. WEV of wheat, oats, barley and corn grains, and flakes.

Results revealed a high positive correlation (r = 0.9268) between WEV and DF content of processed wheat, barley and oats (Fig. 6).

During processing occurs formation of new fiber components, *eg* resistant starch, or products of the Maillard reaction [15].

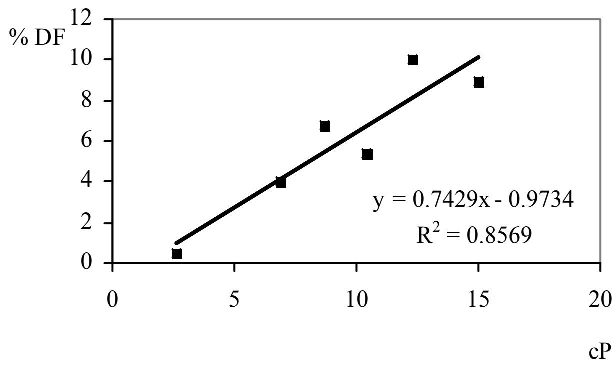

Fig. 6. Correlation between WEV and DF content in processed wheat, barley and oats.

The increase in the level of DF in cereal flakes is related to increasing content of resistant starch, due to the process temperature. Processing leads to increased degradation of the molecular mass of non-starch polysaccharides. This caused a notable reduction in the content of insoluble dietary fiber fraction and an increase in that of the soluble fiber fraction. Consequently, the determined extract viscosity is increased.

WEV of processed wheat, barley and oats are not correlated with the total carbohydrates content (Fig. 7). Flaked cereals have total fiber values comparable to those of unprocessed cereals, but a redistribution of insoluble to soluble fiber occurred.

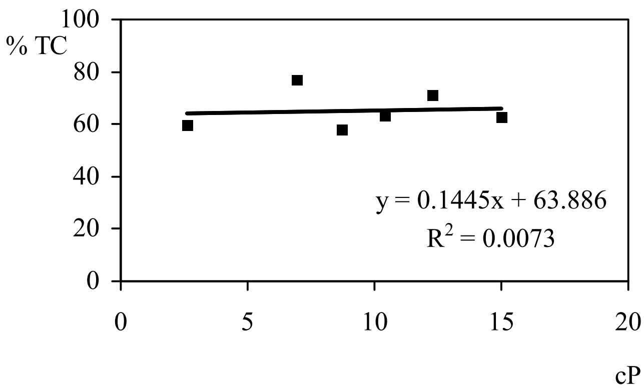

Fig. 7. Correlation between WEV and total carbohydrates content in processed wheat, barley and oats.

IV. CONCLUSIONS

When comparing the WEV with the soluble, insoluble and total NSP values, the obtained results show that the WEV values are high positively correlated with the soluble NSP content (r = 0.9707) and decrease in the following order: oats>barley>wheat>triticale>corn>rice.

Processed cereals have much higher WEV than the unprocessed grains. Viscosities of aqueous extracts vary with fiber content.

Processing increased the viscosity of aqueous extracts of wheat, barley and oats. Corn meal fiber was unaffected by processing under the same conditions as the other foods.

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