JAP&T
TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2012, *18* (4), 296-298

*Journal of Agroalimentary Processes and Technologies*

# Water-Retention Capacity after *in Vitro* Digestion of Ground Wheat, Barley and Corn

**Adrian Căpriţă*, Rodica Căpriţă, Iuliana Creţescu**

*Banat's University of Agricultural Sciences and Veterinary Medicine from Timişoara, 300645-Timişoara, Calea Aradului 119, Romani*

**Received: 20 September 2012; Accepted: 17 November 2012**

***Abstract***

The present study evaluated in vitro water-retention properties of three cereal grains: wheat, barley and corn. All samples were submitted to an in vitro digestion that consisted of a two step enzymatic procedure: an initial simulation of the gastric digestion by pepsin, followed by a pancreatin digestion which simulated small intestine digestion. The obtained results indicate the dependence of water-retention capacity on the type of grain and on the type of digestion. The highest value was obtained for barley after intestinal digestion and the lowest was obtained for corn after intestinal digestion. Small differences were observed between values obtained after gastric and intestinal digestion.

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

## 1. Introduction

Dietary fiber is a ubiquitous component of plant foods and includes materials of diverse chemical and morphological structure, resistant to the action of human alimentary enzymes [1].

Dietary fiber behaves within the gastrointestinal tract as a polymer matrix with variable physicochemical properties including susceptibility to bacterial fermentation, water-retention capacity, cation-exchange, and adsorptive functions [2]. These properties determine physiological actions of fiber and are dependent on the physical and chemical composition of the fiber. Fiber swells within the aqueous medium of the intestinal lumen taking up water and small molecules [3].

Water-retention capacity (WRC), a physical property of fiber, has been related to human colonic digesta passage [4-6]. The water associated with fiber is an important consideration when investigating the effects of fiber in the diet. Such water will influence the metabolic activity of fiber along the gut.

High WRC has been associated to reduction in the gelatinisation of starch, which is relevant to human nutrition, where the degree of starch gelatinisation can affect the postprandial sugar availability in foods [7].

The water-retention capacity of dietary fiber has important physiological effects in both the upper and lower intestine. Hydration of fiber occurs by adsorption to the surface of the macromolecules and by entrapment within the interstices of the fibrous or gel matrix [2].

Because of their ability to swell within the aqueous medium, dietary fibers can trap water and nutrients, especially water-soluble ones, such as sugars. WRC increases with particle size, due to the greater number of pores and voids in the sponge-like matrix. The WRC of fiber is a measure of the ability of a fiber source to immobilize water within its matrix. Water-retention capacity (WRC) of dietary fiber is usually considered as the amount of water held in association with fiber or non-starch

* Corresponding author: *e-mail:* adi.caprita@gmail.com

polysaccharides (NSPs) either as trapped water or bound water, and is a function of the source of fiber and method of measurement [6,8].

The results of studies on the chemical composition, the structure, and WRC of some fiber concentrates suggest that WRC depends mostly on the fiber structure than on the chemical composition [6,9,10]. McConnell et al. [4] highlighted the relationship between WRC value and the dietary fiber content, by observing the highest value of WRC in bran.

By an *in vitro* determination of the hydration or physicochemical properties of dietary fiber (such as water retention capacity), the *in vivo* physiological effects of dietary fiber can be predicted [11,12].

The objective of our experiment was to determine WCR of ground wheat, barley and corn after in vitro gastric (G) and intestinal (I) digestion.

## 2. Materials and methods

For the gastric digestion, a sample of 4 g air-dried material, ground to pass a 0.5 mm screen, was weighed with an accuracy of 0.1 mg into a 50 mL plastic centrifuge tube.

To each sample were added 13 mL of phosphate buffer (0.l M, pH 6.0), 0.4 mL HCl 2M, and 4 mL freshly prepared 4% pepsin solution (P7012 Sigma-Aldrich; ≥ 2,500 units/mg of protein, from porcine gastric mucosa). In order to prevent bacterial growth, 0.5 mL of a chloramphenicol solution (0.5 g chloramphenicol, Sigma C-0378, per 100 ml ethanol) was added.

The tubes closed with stoppers were placed in a shaking water bath (LabTech LSB-015S) at 37°C, r = 120 rpm. The gastric digestion was monitored at different incubation times: 30, 60, 90, and 120 minutes. Samples were then centrifuged at 5000g for 10 minutes with a Hettich 320R centrifuge.

For the intestinal digestion, after 120 minutes gastric digestion of the sample, 2 ml phosphate buffer (0.2 M, pH 6.8), 2 ml of 0.6 N NaOH (to adjust pH to 6.8), and 2 ml 2% pancreatin (Sigma P7545) were added to the mixture.

The tubes were incubated in the water bath with shaking at 120 rpm at 37°C for 240 minutes.

All samples for *in vitro* analysis were done in duplicate.

*Determination of water retention capacity:*WRC of all the samples was evaluated in duplicate after G and I digestion [13]. To perform the analyses, samples were incubated following the *in vitro* methods described above and the evaluation was made in separate tubes for G and I incubation, the latter including both G and I incubation. 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 is expressed as gram 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 (Tables 1, 2, 3 and Figure 2) indicate the dependence of WRC on the type of grain and on the type of digestion. The highest value was obtained for barley after intestinal digestion (1.026 g/g DM) and the lowest was obtained for corn after intestinal digestion (0.832 g/g DM). Small differences were observed between values obtained after gastric and intestinal digestion.

***Table 1.*** WRC of ground wheat in gastric and intestinal digestion

| Specifi-cation | $W_1$ (g) | $W_0$ (g) | $W_2$ (g) | $W_3$ (g) | WRC (g/g) |
|---|---|---|---|---|---|
| G | 9.977 | 4.004 | 16.692 | 13.2471 | 0.860 |
| I | 10.022 | 4.002 | 17.085 | 13.1901 | 0.973 |

***Table 2.*** WRC of ground barley in gastric and intestinal digestion

| Specifi-cation | $W_1$ (g) | $W_0$ (g) | $W_2$ (g) | $W_3$ (g) | WRC (g/g) |
|---|---|---|---|---|---|
| G | 9.966 | 4.004 | 17.338 | 13.3429 | 0.998 |
| I | 9.980 | 4.002 | 17.340 | 13.2321 | 1.026 |

***Table 3.*** WRC of ground corn in gastric and intestinal digestion

| Specifi-cation | $W_1$ (g) | $W_0$ (g) | $W_2$ (g) | $W_3$ (g) | WRC (g/g) |
|---|---|---|---|---|---|
| G | 9.992 | 4.006 | 16.640 | 13.2780 | 0.839 |
| I | 9.986 | 4.002 | 16.680 | 13.3480 | 0.832 |

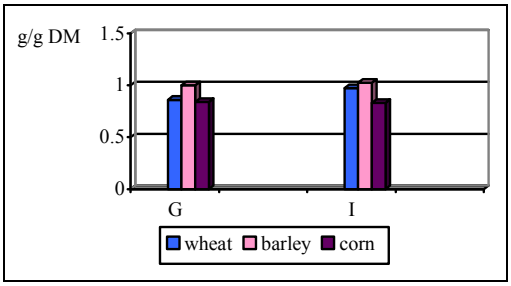


***Figure 1.*** WRC in gastric (G) and intestinal (I) digestion

## 4. Conclusion

The study on the action of digestive enzymes on some grain samples showed changes that occur in water retention capacity during gastric and intestinal. Water retention capacity depends on the type of grain, dietary fiber content and type of digestion.

The highest WRC value was obtained for the barley sample after intestinal digestion and the lowest was obtained for corn after intestinal digestion.

Small differences were observed between values obtained after gastric and intestinal digestion.

**Acknowledgements**
This work was supported by CNCSIS–UEFISCSU, project number 1055/2009 PNII – IDEI code 898/2008.

## References

1. Chawla, R.; Patil, G.R., Soluble dietary fiber, *Comprehensive Reviews in Food Science and Food Safety* **2010**, *9*(2), 178–196, doi: 10.1111/j.1541-4337.2009.00099.x
2. Kay, R.M., Dietary fiber, *Journal of Lipid Research* **1982**, *23*(2), 221-242
3. Eastwood, M.A.; Kay, R.M., An hypothesis for the action of dietary fiber along the gastrointestinal tract, *American Journal of Clinical Nutrition* **1979**, *32*, 364-367.
4. McConnell, A.A.; Eastwood, M.A.; Mitchell, W.D., Physical characteristics of vegetable foodstuffs that could influence bowel function, *Journal of the Science of Food and Agriculture* **1974**, *25*(12), 1457-1464.
5. Stephen, A.M.; Cummings, I.H., Water-retention by dietary fibre in vitro and its relationship to faecal output in man, *Gut* **1979**, *20*, 722-729.
6. Robertson, J.A.; Eastwood, M.A., An examination of factors which may affect the water holding capacity of dietary fibre, *British Journal of Nutrition* **1981**, *45*, 83-88.
7. Symons, L.J.; Brennan, C.S., 2004, The effect of barley β-glucan fiber fractions on starch gelatinization and pasting characteristics, *Journal of Food Science* **2004**, *69*(4), 257-261, doi: 10.1111/j.1365-2621.2004.tb06325.x
8. Robertson, J.A.; Eastwood, M.A., A method to measure the water-retention properties of dietary fibre using suction pressure, *British Journal of Nutrition* **1981**, *46*(2), 247-255.
9. Eliasson, A.-C.; Gudmundsson, M., Starch: physicochemical and functional aspects. In: *Carbohydrates in Food*, Eliasson, A.C. (Ed.), Marcel Dekker Inc., Lund, Sweden, 1996, pp. 431–504.
10. Guillon, F.; Champ, M., Structural and physical properties of dietary fibres, and consequences of processing on human physiology, *Food Research International* **2000**, *33*(3-4), 233–245, http://dx.doi.org/10.1016/S0963-9969(00)00038-7
11. Dreher, M.L. (1987). *Handbook of dietary fiber. An applied approach*, Marcel Dekker Inc., New York, 1987.
12. Robertson, J.A.; de Monredon, F.D.; Dysseler, P.; Guillon, F.; Amado, R.; Thibault, J.-F., Hydration properties of dietary fibre and resistant starch: An European collaborative study, *Lebensmittel-Wissenschaft und Technologie* **2000**, *33*(2), 72−77, http://dx.doi.org/10.1006/fstl.1999.0595
13. Anguita, M.; Gasa, J.; Martın-Orue, S.M.; Perez, J.F., Study of the effect of technological processes on starch hydrolysis, non-starch polysaccharides solubilization and physicochemical properties of different ingredients using a two-step *in vitro* system, *Animal Feed Science and Technology* **2006**, *129*(1-2), 99–115, http://dx.doi.org/10.1016/j.anifeedsci.2005.12.004