

## Rheological Properties of Cooked Oat Bran

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### ABSTRACT

Oat bran is an ingredient in many functional foods, due to the beneficial physiological effects of  $\beta$ -glucan, which has the ability to lower serum cholesterol and reduce postprandial glucose and insulin levels. Oat bran is prepared by milling oats and separating the fibre-rich seed coat from the endosperm. However, the separation between bran and endosperm is not as clear cut as in wheat and thus there is considerable variation in the composition of oat bran from different sources. The aim of this study was to describe the roles of starch and  $\beta$ -glucan on the rheological properties of oat bran slurries.

Dry-milled oat bran samples with varying levels of  $\beta$ -glucan were obtained and were finely ground to minimize variation in particle size. Slurries (2 g dry matter / 25 ml water) were prepared in a Rapid Visco Analyser, using the standard profile. This provided a continuous measure of viscosity during cooking. The viscosity and rheological properties were also measured using a Haake RS600 RheoStress and Texture Analyser Ta-XT2i. Changes during refrigerated storage were also measured.

### INTRODUCTION

The soluble fibre of oats is widely recognised as offering health benefits, and this has led to a market for oat bran. The physiological response of soluble fibres has been related to increased viscosity in the small intestine<sup>1</sup>. Mainly in response to the FDA approved health claim,  $\beta$ -(1 $\rightarrow$ 3)(1 $\rightarrow$ 4)-D-glucan is used as an indicator of soluble fibre content. The viscosity of a soluble fibre solution, such as

$\beta$ -glucan, depends on concentration, molecular weight, physical state, and chemical structure of the polymer. The chemical structure of oat  $\beta$ -glucan polymer is a linear unbranched polysaccharide composed of (30%) beta- (1 $\rightarrow$ 3) linked cellotriosyl and cellotetraosyl units and (70%)  $\beta$ -(1 $\rightarrow$ 4) linked D-glycopyranosyl units. At low concentration  $\beta$ -glucan solution behaves like a Newtonian solution. Above a specific concentrations,  $\beta$ -glucan forms viscous and pseudoplastic solutions. Large oat  $\beta$ -glucan molecules start to entangle at concentration level around 0.2% and  $\beta$ -glucan solution shows a pseudoplastic behaviour. Pseudoplastic behaviour increases with concentration and molecular weight of  $\beta$ -glucan<sup>2</sup>.

Unlike wheat bran, oat bran does not separate cleanly from the starch rich endosperm and its composition varies considerably. Oat bran is generally also heat stabilised, to prevent rancidity, which also inactivates other endogenous cereal enzymes<sup>3</sup>.

When oat bran is cooked in water starch gelatinises. Beta-glucan is also capable of binding enormous amounts of water. The structure of cooked oat bran is important to the sensory quality of food products as well as in food process engineering.

There have been some studies on the roles of starch, beta-glucan and protein on the viscosity<sup>4, 5</sup>. These have relied on enzymes to remove a component from the system, however most enzymes have side activities that may distort the results.

The rheological properties of cooked oat bran are complex. Gelatinized starch readily forms a gel, whereas beta-glucan generally

forms a viscous solutions<sup>2</sup>. From the perspective of product acceptability, the viscosity of the product at serving temperature and its “spoonability” are important.

The aim of this study was to investigate the effect of adding oat starch to oat bran on the viscosity during cooking and on the rheological properties of cooked oat bran slurries.

### MATERIALS AND METHODS

Oat bran with a high (21.3% d.m.) beta-glucan content and oat starch were kindly supplied by FinnCereal Ltd (Vantaa, Finland). Preliminary tests suggested that a dry matter content of 2 g / 25 ml water gave samples that could be suitable for porridge type food applications and were in the measuring range of the equipment.

Samples were cooked in a Rapid ViscoAnalyser (RVA) using the Standard 1 profile (Table 1). This allowed cooking and mixing conditions to be precisely controlled and had the added benefit of allowing changes in viscosity during cooking to be followed. This profile was modified to study the effect of cooking conditions. Following cooking the samples were covered with Parafilm (Neenah, WI) and stored for two days in a refrigerator.

Table 1. Standard 1 profile for RVA

Time (hh:mm:ss)	Type	Value
00:00:00	Temp	50°C
00:00:00	Speed	960 rpm
00:00:10	Speed	160 rpm
00:01:00	Temp	50°C
00:04:42	Temp	95°C
00:07:12	Temp	95°C
00:11:00	Temp	50°C

Idle temperature: 50±1°C

End of test: 13 min

The flow behaviour of the oat soluble fibre beta-glucan was studied by steady shear measurement using cone and plate sensors (2°, 35mm) at 30°C.

The structure of the cooked oat bran was characterised using a Texture Analyser TA-XT2i with a modified back extrusion test for yoghurt. A 2 cm diameter Perspex cylinder probe and the RVA canister, which was 37mm in diameter, were used instead of the back extrusion rig.

### RESULTS AND DISCUSSION

To determine the roles of starch and soluble fibre in increasing the viscosity, the sample was diluted with oat starch so that the total dry solids remained constant. Final viscosity initially decreased with starch addition, but then increased (Fig. 1).

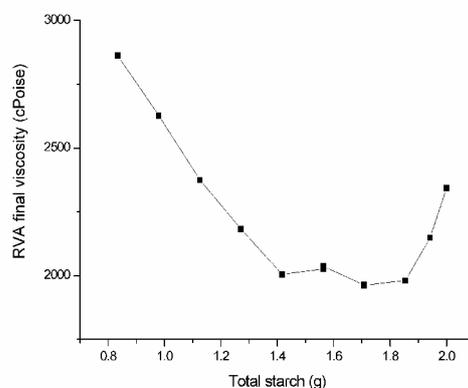


Figure 1. Effect on RVA final viscosity (50°C) of adding starch to oat bran, total solids was maintained at 2.0 g

Addition of starch to oat bran resulted in an increased firmness and reduced cohesiveness. Taken together with the results shown in Figure 1, this suggests that soluble fibre is largely responsible for the cohesive structure of cooked oat bran and starch has a greater effect on firmness.

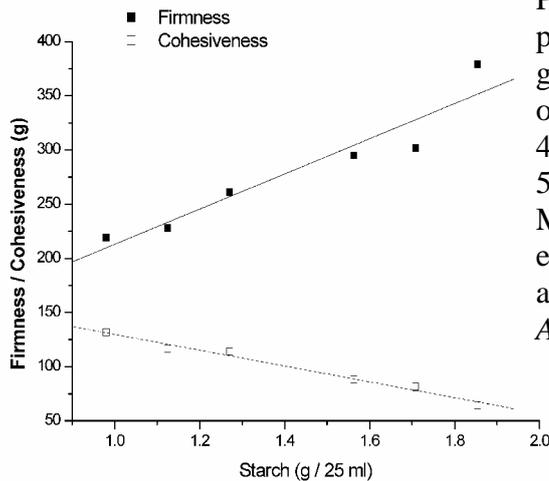


Figure 2. Effect of adding starch to oat bran on firmness and cohesiveness, determined using back extrusion at 10°C

P. J. (2003), "Rheological and molecular properties of water soluble (1,3)(1,4)- $\beta$ -D-glucans from high- $\beta$ -glucan and traditional oat lines", *Carbohydrate Polymers*, **52**, 439-447

5. Zhou, M., Robards K., Glennie-Holmes, M. and Helliwell, S. (2000), "Effects of enzyme treatment and processing on pasting and thermal properties of oats" *J. Sci. Food Agric.* **80**, 1486-1494.

## CONCLUSIONS

Both starch and beta-glucan were shown to have contributed to the viscosity of cooked oat bran. The effects on hot and cold viscosity were different. In cold products, high beta-glucan oat bran was cohesive. Addition of starch increased the firmness, but reduced cohesiveness.

## REFERENCES

1. Ripsin, C.M., Keenan, J.M., Jacobs, D.R., Elmer, P.J., Welch, R.R., Van Horn, L., Liu, K., Turnbull, W.H., Thye, F.W., Kestin, M., Hegsted, M., Davidson, D.M., Davidson, M.H., Dugan, L.D., Demark-Wahnefried, W., and Beling, S. (1992), "Oat products and lipid lowering: a meta-analysis", *J.A.M.A.*, **267**, 3317-3325.
2. Doublier, J.L. and Wood, P.J. (1995), "Rheological properties of aqueous solutions of (1 $\rightarrow$ 3),(1 $\rightarrow$ 4)- $\beta$ -D-glucan from oats (*Avena sativa* L.)", *Cereal Chem.*, **72**, 335-340.
3. Kaarlehto, T. and Salovaara, H. (2000). "Effect of kiln drying on falling number of oats", *Cereal Chem.*, **77**, 177-180.
4. Colleoni-Sirghie, M., Kovalenko, I. V., Briggs, J. L., Fulton, B. and White,