Beta-glucan and its effect on lipid metabolism

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BACKGROUND. The beta-glucan (BG) of oats is effective at reducing blood cholesterol and this has been recognised by the European Food Safety Authority (EFSA)[1]. This effect is related to viscosity, molecular weight (MW) and solubility of BG[2]. However, further processing of the BG in foods can reduce its efficacy, and so a recommended intake of BG of at least 3 g/day requires large quantities (>100g) of minimally processed cereals such as oats and barley to be consumed daily. Despite the clear health benefits of BG, the mechanisms involved are still not well understood. The aim of the current project was to determine some of the key mechanisms of BG action on lipid digestion and how the processing of foods containing BG modulate lipid metabolism. A multidisciplinary approach involving a range of *in vitro* biochemical and biophysical methods were used to address this important area of nutrition.

MATERIALS

Pure polymers

Guar gum: Positive control

BG1: High MW BG

BG2: Medium MW BG

Oat materials

Flakes

Flour

BG32: bran-enriched flour

METHODS

Characterisation

- Nutritional composition
  - → Protein, lipid, moisture and ash
  - → Starch
  - → Non-starch polysaccharides
- MW (weight-average) by SEC-MALS
- Rheological behaviour

Kinetics of BG release

- Incubation of oat materials at 37°C in 20 mM sodium phosphate buffer
- Materials:
  - → BG32, flour and flakes
  - → Raw and cooked (hydrothermal processing)
- BG starting concentration: 0.5 %
- Time points: 0 to 72h

Digestibility experiments

- *In vitro* duodenal digestion using gas chromatography:
  - **Pure polymers** or **Oat materials** (0.5 and 0.8%)
  - **Sunflower emulsion** (d_{32} ≈ 2 µm)
  - Bovine **bile salt** solution (~10 mM)
  - **NaCl** (150 mM) and $CaCl_2$ (10 mM) solutions
  - **Lipase** from pancreatin (40 U/mg of powder)
- Time points: 0, 2, 5, 10, 15, 30 and 60 min

COMPOSITION OF THE MATERIALS

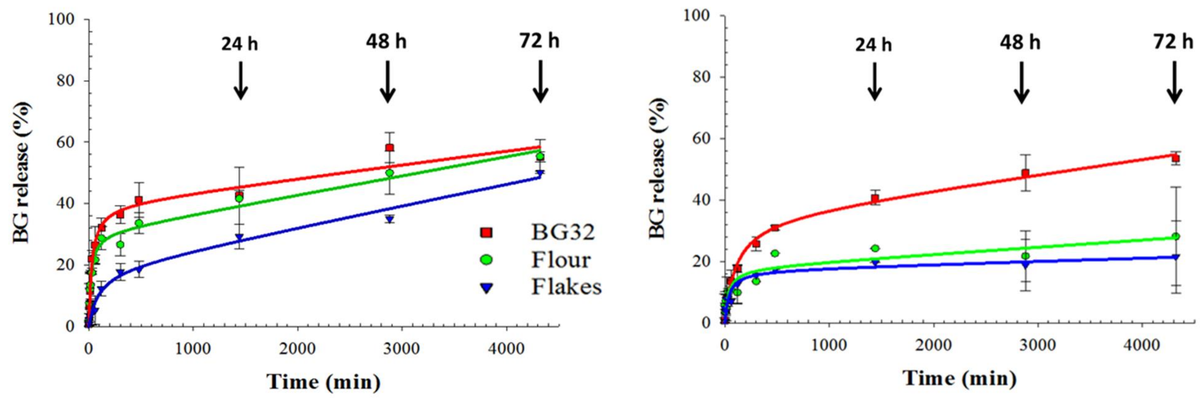
Pure polymers and oat materials

	Guar gum	BG1	BG2	BG32	Oat flake Oat flour
Protein (N x 5.7) (%)	4.4 ± 0.5	-	-	18.9 ± 0.6	11.5 ± 0.2
Crude lipid (%)	1.0 ± 0.3	-	-	3.5 ± 0.5	9.6 ± 0.3
Starch (%)	0.8 ± 0.1	4.2 ± 0.2	2.2 ± 0.4	7.5 ± 0.1	60.3 ± 1.2
Non-starch polysaccharides (%)	81.2 ± 1.7	76.9 ± 1.6	74.6 ± 0.1	47.6 ± 0.3	6.8 ± 0.1
Cellulose (%)	-	0.8 ± 0.0	0.7 ± 0.3	2.4 ± 1.0	0.6 ± 0.1
Arabinoxylan (%)	-	6.1 ± 0.1	1.5 ± 0.1	12.8 ± 0.0	1.8 ± 0.0
Beta-glucan (%)	-	82.8 ± 0.6	87.6 ± 02.1	34.8 ± 0.5	4.5 ± 0.3
Galactomannan (%)	78.2 ± 1.4	-	-	-	-
Moisture (%)	11.3 ± 0.1	9.8 ± 0.5	14.3 ± 0.4	8.3 ± 0.8	10.4 ± 0.1
Ash (%)	0.6 ± 0.0	1.7 ± 0.1	2.8 ± 0.0	3.0 ± 0.0	1.7 ± 0.0
Molecular weight (x 10^{-3} g/mol)	**2490**	**1020**	**650**	**1082**	**1118**

- Oat flakes and flour contained ~4.5% of BG and BG32 34.8%
- The starch content differed greatly between the purified BG and the oat materials
- The average BG MW from BG1, BG32 and the oats were of similar range.

KINETICS OF BG RELEASE FROM BG32, OAT FLOUR AND FLAKES

RAW oat materials | **COOKED oat materials**

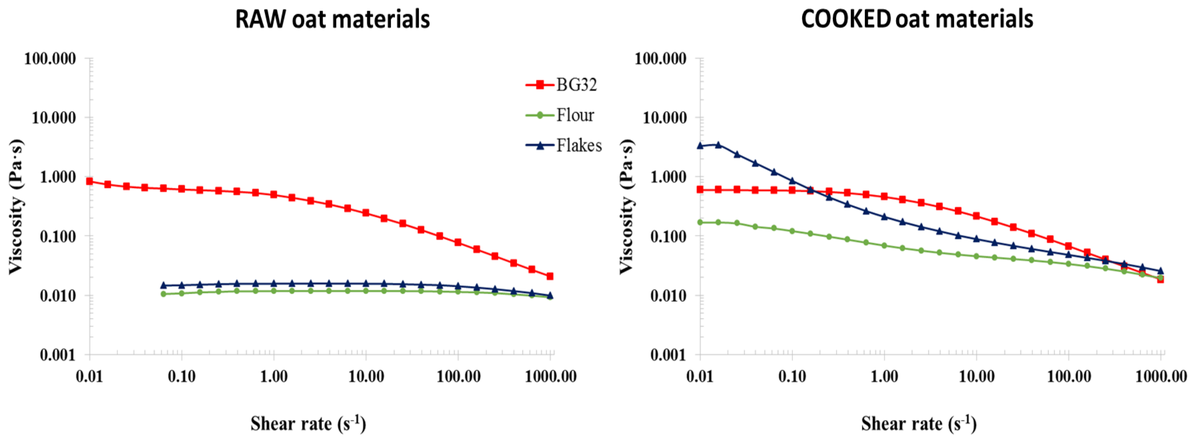


- BG release was not complete (~50-57%) even after prolonged incubation time
- The kinetics of BG solubility varied between the raw flakes and the two raw flours
- Cooking had a marked effect on BG release in the flour and flakes samples.

RHEOLOGICAL MEASUREMENTS

BG release solutions after 72 h of incubation

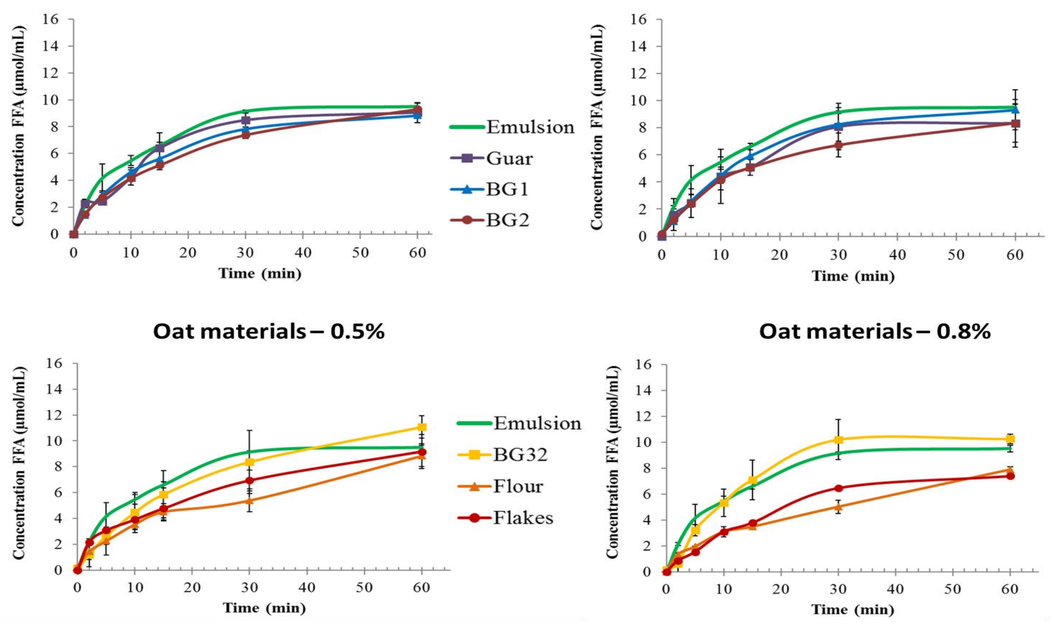
RAW oat materials | **COOKED oat materials**



- Despite similar BG content, a different flow behaviour was observed for BG32 compared with the oat flour and flakes
- The rheological profiles (shear-thinning behaviour) of raw and cooked BG32 were similar, except for a slight upward deviation at low shear rate for the raw sample
- Over the shear rate range, cooked flour and flakes displayed higher viscosity levels than the raw samples, which showed Newtonian behaviour.

DIGESTIBILITY EXPERIMENTS

Pure polymers – 0.5% | **Pure polymers – 0.8%**



- Pure polymers only slightly decreased the rate and extent of lipolysis
- Flour and flakes markedly reduced lipolysis, especially at high BG concentration.

CONCLUSIONS AND INDUSTRIAL IMPACT

This work showed that only about half of the BG content of oat materials is released during incubation. The kinetics of BG solubility and the flow behaviour varied depending on the structure and degree of processing of the oat materials. Complex sources of BG appeared to have a greater impact on lipolysis in our model emulsion system, suggesting that some additional components, other than BG, may also interfere with the lipolysis process.

The results of this study highlight the importance of considering the structure and properties of foods, and not just the nutrient content. These findings also provide information on potential sources of BG for the design of food products with optimal health effect.

References:

[1] EFSA-NDA (2011). *EFSA Journal* **9:** 2471-2484.

[2] Wang Q, Ellis RP (2014). *Br J Nutr* **112**: S4-S13.

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