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Functional properties of beta glucans from barley

Key external stakeholders:

Food manufacturers; bakeries; food ingredients companies.

Practical implications for stakeholders:

- Barley fractions are feasible functional ingredients that can be used in the formulation of yeast breads of a high baking, sensory and nutritional quality.
- Barley middlings, considered a by-product or waste stream, contains high levels of beta glucan and were successfully used to produce viable bread products that may have potential for commercialisation.

Past studies have shown barley to be an excellent source of dietary fibre and beta glucan, a polysaccharide that when consumed regularly has important health benefits including reducing the risk of heart disease. This project studied a variety of barley cultivars and evaluated their use as low cost, high beta glucan-containing functional ingredients. Optimisation of milling procedures generated a range of milled barley fractions that were then blended with wheat flours and used in bread formulations which were evaluated for their rheological, textural and nutritive properties.

Main results:

- A range of new and nutritious barley fractions were isolated by optimising the milling process.
- Barley middlings were found to be an important source of beta glucan and can be used in the formulation of bread products.

Opportunity / Benefit:

The opportunity exists for bakers, ingredient companies and other relevant industry personnel to optimise milling conditions, formulate flour blends and develop functional bread products with enhanced levels of dietary fibre and beta glucan.

Collaborating Institutions:

University College Cork, Cork Institute of Technology, University College Dublin

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1. Project background:

Barley is primarily used in the brewing industry and for animal feed, with only approximately 2% utilised in food. In the past decade, however, interest in barley as a human food source has increased. The increased interest is a result of past studies which have shown barley to be an excellent source of soluble and insoluble dietary fibre and in particular, the polysaccharide (1→3)(1→4)-β-D-glucan (beta glucan). The beta glucan content in barley grains can range from 5-11%, significantly higher than that found in wheat and oats. Nutritional studies have shown a link between the regular consumption of beta glucan and a number of health benefits. These include a decrease in the risk of chronic heart disease by lowering blood cholesterol and an increased insulin response in diabetics. The research on beta glucan in oats and barley and their associated health benefits has lead the FDA to indicate that the regular consumption of beta glucan (3g per day) may lower the risk of heart disease.

This project involved a comprehensive study of a variety of barley cultivars. The milling properties and chemical characteristics (including beta glucan) of each milled fraction were determined. The potential of the barely cultivars for use as a low cost, high beta glucan-containing functional ingredient was examined using bread as a model system.

2. Questions addressed by the project:

- Isolating new and nutritious barley fractions by optimising the milling process.
- Generating milled fractions that could be used as novel, economical ingredients in functional foods.
- Using these fractions in blends with wheat flour to produce yeast breads of a high baking and sensory quality with enhanced nutritional properties.

3. The experimental studies:

The main experimental steps in this project involved roller milling, chemical characterisation, baking and rheology trials, microstructure elucidation, sensory analysis and nutritional profiling. Below is a brief description of the main methods which were used when assessing the fractions which were produced by the milling procedure.

Chemical characterization of each fraction: Total starch, amylose/amylopectin, starch pasting properties, total fibre, soluble and insoluble fibre, beta glucan, total protein and proteomic profiling, scanning electron microscopy.

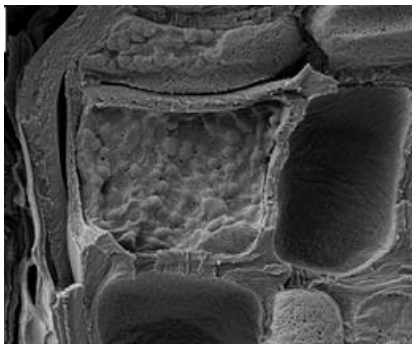
Analysis of the rheological and textural properties of doughs and breads containing specific levels of the milled fractions: Optimum dough development time, dough uniaxial extensional tests, dough fundamental oscillatory testing, loaf specific volume, texture profiling, digital image analysis, dietary fibre, beta glucan, quantitative sensory analysis.

4. Main results:

Chemical composition and microstructure of milled barley fractions:

Wholegrain barley, pearled barley (outer layers of the grain removed) and wheat were roller milled in a Bühler mill, each producing three fractions; endosperm (flour), middlings and bran. The middlings fraction is normally the by-product stream of milling. These fractions were compared and contrasted with one another and also with the milled wheat fractions. Barley endosperm had the highest total starch content in both wholegrain and pearled barley. Amylose-to-amylopectin ratios (Am:Ap) were higher in barley flours than in wheat flours. Wholegrain barley bran had significantly higher fibre contents than the pearled barley bran or wheat bran. The protein contents of the fractions of both barley types did not differ significantly. The endosperm had the lowest protein content, with the bran and middling fractions having double the protein content of the endosperm fraction.

Beta glucan concentrations were highest in the middlings fraction of the milled barley grains. This was the most surprising and unexpected result, as the middlings fraction is normally considered a by-product or waste stream for discarding. This set up the potential for further studies on the use of this milled fraction as a possible low-cost functional food ingredient.



The transverse section of a barley grain, captured by a scanning electron microscope at a magnification of 5000x, showing starch granules and fibrous cell walls.

Fundamental rheological and textural properties of doughs and breads produced from milled pearled barley flour:

In this study, doughs and breads were produced using pearled barley flour (PBF) in different ratios (30%, 50%, 70% and 100%) combined with wheat flour. A 100% wheat flour formulation was used as a control. Protein analysis revealed that increasing the amount of PBF in the formulation led to a significant decrease in the protein content of the formulation. Starch pasting properties were also affected by an increase in PBF concentrations in the breads. Extensional rheology revealed that increasing the PBF in the doughs led to the doughs rupturing at lower extensions and with a lower force. Bread volume between treatments was found to be significantly different, with an increase in PBF inclusion leading to smaller loaves. Texture profile analysis of the bread slices showed that breads containing higher ratios of PBF had a significantly harder and less cohesive crumb. However, low levels of PBF (≤50%) did not significantly effect loaf volume or crumb texture. An increase in the levels of total dietary fibre and beta glucan in the loaves was observed with increasing levels of PBF in the formulation, even at the lower levels of inclusion.

The utilisation of barley middlings to add value and health benefits to white breads:

In this study, flour blends, doughs and breads were produced using the middlings fraction of milled barley in different ratios (15%, 30%, 45% and 60%) combined with wheat flour. A 100% wheat flour formulation was used as a control. The protein content decreased significantly as levels of barley middlings (BM) inclusions increased, impinging on baking abilities of the doughs. Lab-on-a-chip electrophoresis showed a significant decrease in the detection of high molecular weight protein as the BM concentration of the formulations was increased. Starch pasting properties were significantly affected by the increased inclusion of the barley middlings into the formulation. Fundamental dough rheology of the samples also showed significant differences between the doughs, with doughs containing increased middlings showing increased firmness, decreased resistance to extension and decreased elasticity. Importantly, bread quality was not significantly affected by the addition of up to 30% BM. The loaf volume, sensory attributes and textural properties in particular, containing up to 30% BM were of a good quality, when compared to the wheat control. Total dietary fibre and beta glucan content of the breads increased significantly with the inclusion of BM.

Overall, it was found that breads containing up to 30% BM were viable products that may have the potential for commercialisation, however including BM into bread formulations is not without its difficulties. This appears mainly to be due to two factors linked to the addition of BM to the bread formula. Firstly, by increasing the BM content, in effect the gluten concentration of the overall mix is diluted, which in turn leads to a weaker structure that is less flexible than a standard wheat bread and so cannot proof as effectively. Secondly, the increased BM content leads to an increase in beta glucan content. Although the increased beta glucan content is desirable from a nutritional perspective, this in turn can lead to problems in gluten development. Beta glucan's high affinity to water leads to less water being available to be used in the gluten matrix and so as a result the gluten matrix will be less substantial and therefore less likely to produce a desirable bread. It is therefore important to strike a balance when trying to increase the level of beta glucan in a bread product so that the quality of this product is not compromised to a level that makes it no longer desirable to the consumer.

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5. Opportunity/Benefit:

Advice and technical assistance can be provided to bakers, ingredients companies and other relevant industry personnel on optimised milling conditions for barley, the formulation of flour blends and the production of breads with enhanced fibre and beta glucan levels. This support is available through consultancy and/or technical services through Teagasc's fee-paying service.

6. Dissemination:

Main publications:

Sullivan P, O'Flaherty J, Brunton N, Gee V, Arendt EK and Gallagher E (2010). Chemical composition and microstructure of milled barley fractions. European Food Research and Technology 230(4), 579-595.

Sullivan P, O'Flaherty J, Brunton N, Gee V, Arendt, EK. and Gallagher E (2010). Fundamental rheological and textural properties of doughs and breads produced from milled pearled barley flour. European Food Research and Technology 231(3), 441-453.

Sullivan P, O'Flaherty J, Brunton N, Gee V, Arendt, EK and Gallagher E (2011). The utilisation of barley middlings to add value and health benefits to white breads. Journal of Food Engineering, 105: 493–502.

Popular publications:

Gallagher, E. (2009). Better breads for better health. The Ashtown Food Innovator, (2): 3.
Sullivan, P. (2010). Better breads using barley. TResearch, 5 (1): 11.

Oral presentations relaying results were made at a number of scientific conferences and industry workshops over the course of the project, e.g. 7th European Young Cereal Scientists and Technologists Workshop (Luthuania), The International Association of Cereal Chemists Conference (Spain), Whole Grain Global Summit (UK)

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