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MINI REVIEW

Effects of barley on post-prandial glycemic response

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ABSTRACT

Barley contains very high levels of dietary fibre and β-glucan relative to other cereal grains, offering potential as a postprandial glycemic response lowering agent for the growing number of individuals looking to manage blood glucose levels. Although research is generally supportive of the postprandial glycemic response (PPGR) lowering effect of β-glucan, there are still gaps in our understanding of 1) the precise mechanism by which β-glucan lowers blood glucose, and 2) how the PPGR after barley consumption may be influenced by factors that may alter β-glucan molecular weight and/or viscosity.

Keywords: *Barely, b-glucan, blood glucose, postprandial, diabetes, obesity*

Barley and glycemic control

Type 2 diabetes is a growing epidemic and is often associated with a high risk of cardiovascular disease[1]; therefore, management of blood glucose levels is very crucial in preventing diabetes and associated ailments such as damage to kidneys, eyes, nerves, heart and blood vessels.[2] In this scenario, low glycemic foods are getting tremendous attention among diabetic and healthy people as health professionals are now recommending to replace high glycemic foods with low glycemic foods to improve glycemic control and to prevent future diabetic complications.[3]

Several epidemiological and acute feeding studies have established the fact that high dietary fibre intake is associated with lower cardiovascular disease risk and improvement in fasting and postprandial glycemic response (PPGR).[4-6] Specifically, oat and barley derived β-glucan, a viscous soluble fibre, has been well reported for its health effects, including its ability to reduce PPGR in a wide variety of food matrices.[7, 8] Among these cereal sources, barley typically has the highest β-glucan content. Barley is one of the oldest cultivated cereal grains in the world. In North America barley is generally used for livestock feed and malting. In some parts of the world, such as Tibet and Morocco, barley is consumed routinely in large amounts.[9]

Barley's nutritional profile makes it an ideal vehicle in providing optimal nutrition to the growing population. Whole barley grain contains about 65–68% starch, 10–17% protein, 4–9% β-glucan, 2–3% free lipids and 1.5–2.5% minerals.[10-11] The total dietary fibre content ranges from 11 to 34%, of which the soluble fibre content is between 3 and 20%. In addition to high-fibre levels, barley is also a great source of bioactives such as proanthocyanidins, catechins and phenolic acids.[10-12]

The European Food Safety Authority (EFSA) has recently sanctioned a health claim for oats or barley derived β-glucan due to its favourable effect on improving PPGR. Based on this EFSA claim, 4 g of β-glucan for each 30 g of available carbohydrates should be consumed per meal to achieve a physiologically relevant effect. A systematic review by Tosh et al. also demonstrated that 3 g β-glucan per meal is sufficient to achieve significant lowering of PPGR if it is consumed as intact cooked or fermented grains; 4 g β-glucan per meal if the food is processed.[8] Moreover, in a recent human study conducted in our laboratory, tortillas containing barley β-glucan doses of 4.5 g, 7.8 g and 11.6 g per 50 g of available carbohydrate all showed a 20% reduction in glucose response compared to the glucose control, and the maximum reduction was observed with tortillas containing the highest amount of β-glucan.[13]

Proposed mechanism of action

Despite the large number of human and animal feeding trials showing the favourable effects of barley β-glucan on glycemic response, the precise physiological mechanism of action by which barley β-glucan reduces glycemic response has not been well elucidated. In general, barley β-glucans are very high molecular weight polysaccharides which possess high viscosity. Consequently, consumption of this viscous fibre tends to increase the viscosity of the entire meal bolus in the stomach, which prevents or delays the

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action of digestive enzymes on food and food components.[14-16] This might also result in delayed gastric emptying. In addition, increased viscosity has been shown to inhibit intestinal glucose absorption. *In vivo* studies and several *in vitro* digestion experiments have validated this notion that β-glucan can slow down the rate of starch digestion.[17-19] Furthermore, being a soluble dietary fibre, β-glucan can undergo fermentation in the large intestine by the gut microbiota to produce short-chain fatty acids (SCFA) including acetate, propionate and butyrate. Reduced glucose absorption due to gut viscosity might be responsible for the acute effects of β-glucan whereas the SCFA generated through colonic fermentation might be mediating the postprandial glucose effects at subsequent meals.[20-22]

Potential factors affecting the glycemic response to barley

It is hypothesized that the beneficial effects on glycemic control from consumption of barley β–glucan can be attributed to its rheological properties, or viscosity, in the gut. [17, 23] The viscosity of β–glucan is primarily determined by its concentration (amount in solution) and molecular weight or size. Accordingly, factors that can influence the physicochemical properties of barley β–glucan such as cultivar, chemical composition, processing, and food form will have significant impact on its glycemic response.[24, 25] Although much of the research on human glycemic response to β–glucan has been done using oats, evidence for barley β–glucan and glycemic response lowering is emerging. In our laboratory experiments, applying heat-moisture treatments to barley (boiling, autoclaving, pressure cooking or micronization) has resulted in significantly higher β–glucan viscosity, which is likely due to the inactivation of endogenous β–glucanases.[26]

Methods used to measure viscosity vary from one study to the next, indicating a need to have a standardized method to measure β-glucan viscosity for health claim substantiation. Furthermore, since the two main contributors to the viscosity of β-glucan are concentration and molecular weight, it is also helpful to measure the extractability (solubility) of β-glucan in the food product being tested as it can be affected by processing. In addition, molecular weight distribution of the solubilized β-glucan is a key factor in mediating the health outcomes.[27]

Ames et al.[28], in their effort to design test foods for clinical trials and to meet the requirements of a health claim, noted that there is a need to characterize the range of effects that processing has on the physicochemical properties of β-glucan in various food matrices. It is also very important to establish standardized food processing and preparation methodologies to create β-glucan containing food products and formulations with a defined and reproducible food matrix and validate realistic molecular weight and viscosity ranges for treatment effects.

Concluding remarks

Although the magnitude of reduction in glycemic response to barley varies depending on the study, overall there is an adequate amount of scientific evidence to support the favorable effect of barley on PPGR lowering. Yet, despite all the clinical evidence, a health claim for PPGR would be needed to accelerate the market demand for food grade barley in Canada, and help those who want to limit the rise in blood sugar after a meal choose products to meet their goals. There are several research gaps that need to be filled before a health claim submission to Health Canada can be successful: 1) test foods in proper serving sizes; 2) measurement of both the glucose and insulin response; 3) inclusion of a reference product that matches treatments in total fibre, macronutrients, and energy; 4) dose response studies. In addition, a meta-analysis to quantify the overall PPGR lowering effect of barley β-glucan and a well-designed human study investigating the long term benefits of barley β-glucan consumption in the diabetic population are also highly recommended.

Conflict of interest

Dr. Nancy Ames reported receiving funding from the Alberta Barley Commission, PepsiCo and Western Grains Research Foundation through Agriculture and Agri-Food Canada Funding programs. Also, Dr. Nancy Ames serves as a Scientific Advisory Board Member for the Quaker Oats Centre of Excellence and is a Scientific Advisor to the Healthy Grains Institute. Joanne Storsley declares that she has no conflicts of interest.

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