# Effects of Processing on the Functionality of Cereal Polysaccharides

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Cereal polysaccharides, which can be divided into starch and nonstarch polysaccharides, are an important source of energy and dietary fiber in the human diet. From an energy perspective, it is well known that starch is poorly digested in its native form. Thermal treatment is required to induce changes (gelatinization) in the native starch granule structure that render starch molecules more accessible for digestion by enzymes. However, the increasing occurrence of type 2 diabetes, which is due, in part, to consumption of high levels of rapidly digestible, refined starches, has led to increased demand for low glycemic index (GI) foods.

The role of cereal fibers in the prevention of many chronic diseases is well established in the literature (a summary of the most recent published papers is presented by the Oldways Whole Grains Council online at https://wholegrainscouncil.org/whole-grains-101/health-studies-health-benefits/what-are-health-benefits), which has led to dietary recommendations that call for increased intake of whole grain products or products rich in cereal fibers. In response, food manufacturers are tailoring processing conditions to develop food structures that deliver the desired physiological functionality (e.g., high fiber, low GI, cholesterol lowering effects, etc.) while maintaining good sensory properties. This article highlights the influence of common cereal processing operations, such as milling, fermentation, baking, and extrusion, on the predominant functional cereal polysaccharides: arabinoxylan and β-glucan.

## Milling and Fractionation

Dry milling and fractionation generally results in flour fractions that are enriched with different components of cereal polysaccharides. The mechanical forces experienced during dry milling and fractionation have a minimal effect on cereal fiber properties (e.g., molar mass, solubility, etc.), and the process does not induce enzymatic activity that can degrade the fiber. Djurle et al. (7) found that other than an improvement in extractability there was no difference in the molar mass distribution of arabinoxylans in kernels or flour. Improved extractability of fiber due to degradation of the native grain macro structure and reduced particle size is important for subsequent processing and physiological functionality of cereal polysaccharides.

The combination of different ingredients, including water and lipids, during cereal processing can result in degradation of cereal fiber due to enzymatic and microbial activity, depending on the conditions encountered. Rakha et al. (13) studied the fate of arabinoxylans and β-glucan during the making of porridge using whole grain rye. The study showed arabinoxylans were more stable than β-glucan. This can be attributed to the simpler structure of β-glucan compared with arabinoxylans, which makes β-glucan readily accessible to digestion by β-glucanases. Extensive enzymatic degradation of β-glucan is expected, therefore, in processes involving long incubation times (e.g., during proofing in breadmaking). Shortening proofing, omitting fermentation, or incorporating barley flour after fermentation of wheat dough to obtain a final bread product with high molar mass β-glucan has been suggested. Furthermore, coarsely ground flour or intact flakes that limit enzyme access during breadmaking can be used to obtain high molar mass β-glucan in the final product (2,14). Kilning of oats, the primary aim of which is to inactivate lipases, results in inactivation of endogenous β-glucanases as well (1). Consequently, the degradation of kilned oat β-glucan is mainly due to the activity of β-glucanases from other ingredients, such as wheat flour.

## Fermentation

Fermentation, either during bread baking or sourdough fermentation, has a significant influence on fiber properties. Lactic acid bacteria fermentation of whole grain flour or bran increases solubilization of arabinoxylans, decreases the molecular weight of arabinoxylans, and/or induces formation of prebiotic arabinoxylan-oligosaccharides (6,10). These effects can be achieved using fermentation alone or specific enzyme hydrolysis. Cereal β-glucan is very easily degraded during short yeast fermentation (3,14,17) and even more intensively degraded during sourdough fermentation (15).

## Thermal Treatment

Baking, extrusion, steaming, and boiling are the common thermal treatment processes utilized in cereal processing. Cereal fibers are generally heat stable, but their stability can be altered depending on processing conditions, such as low pH or the presences of oxidants such as ascorbic acid, which heighten the susceptibility of cereal fibers to nonenzymatic degradation during thermal treatment (5,8,9,11,12,16). Baking typically has minimal effects on the molar mass distribution of arabinoxylans and β-glucan (2,14). Therefore, in bakery products the main changes in cereal fiber quality occur during mixing, proofing, or sourdough production.

## Extrusion

Extrusion, in which a combination of high heat, high pressure, and shear forces are utilized, affects the extractability, solubility, and molar mass distribution of cereal fibers. Extruded bran has been shown to have a higher solubility and swelling capacity and an increase in apparent viscosity compared with nonextruded bran (4,7,18). These changes result from the disruption of cross-linking between cereal polysaccharides, disag-

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gregation, and/or thermal degradation of the polysaccharides. In addition to variation in extrusion conditions and raw material characteristics, the simultaneous occurrence of these changes (e.g., matrix disruption, disaggregation, thermal degradation) may explain the varying results obtained in extrusion studies (4).

## Conclusions

Cereal processing can have a profound influence on the functional properties of cereal polysaccharides. However, effects are fiber dependent and can be tailored using optimized processing conditions. Alterations in the nutritional properties of fibers are likely to be dependent on processing-induced changes in these polysaccharides, and a more in-depth understanding is required to create or maintain polysaccharide properties that provide both nutritional and technological functionality. A more detailed evaluation of the effects of processing on cereal fiber is currently being reviewed by members of the Health Grain Forum and will be published in 2018.

Cereal processing has a significant influence on the quality of grain polysaccharides and is very likely to alter the physiological functionality of grains processed using different methods. However, the exact impact of processing on human responses to grain polysaccharides is not well understood or studied. An example is the degradation of β-glucan during processing, which influences its viscosity-forming ability and may reduce the cholesterol-lowering properties of β-glucan. On the other hand, low molar mass glucans can have prebiotic effects on gut microbiota, providing health-promoting properties that have not yet been identified.

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**Kati Katina,** Ph.D., is an associate professor at the University of Helsinki. She has been working in cereal science for 20 years, and her special research interest is fermentation-induced changes in the nutritional and technological quality of wheat- and rye-based ingredients and bakery products. Her research has focused especially on fermentation-induced changes in high-fiber and whole grain-rich raw materials and products. Kati is chair of the Healthgrain Forum, which is actively promoting use of whole grain and cereal fiber-rich raw materials. Recently, her group has focused on understanding and modifying the functionality of protein-rich grains and fractions, such as wheat bran and faba bean. Her research group is also actively collaborating in Africa to promote safe and sustainable use of local grains with tailored bioprocessing technologies.

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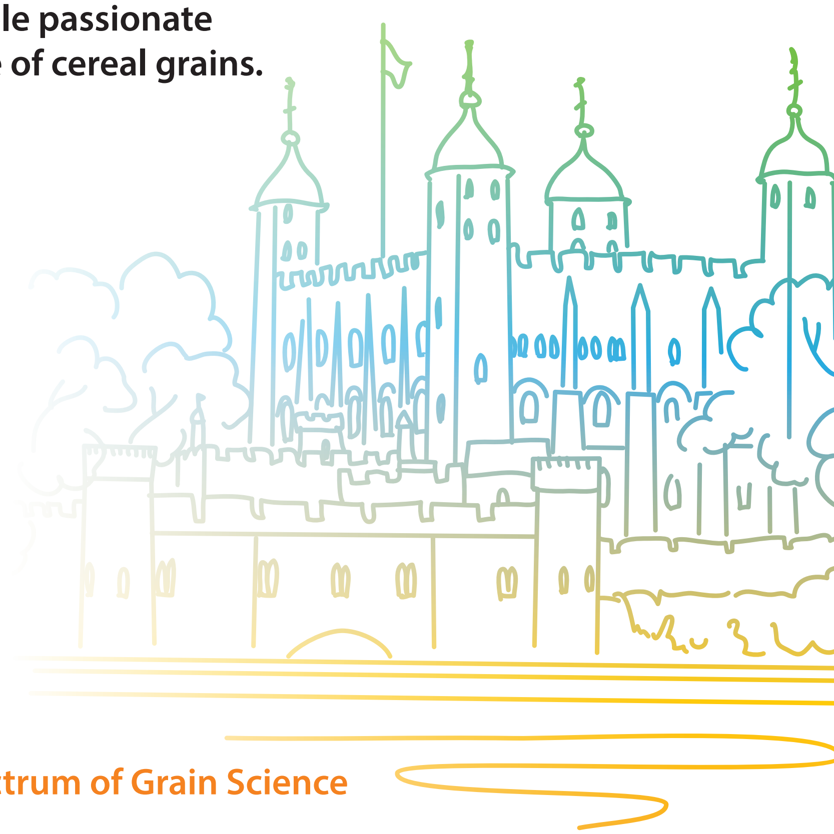

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