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L.V. Kaprelyants, Dr., Prof.; T.O. Velichko, Ph.D., Assoc. Prof.; L.G. Pozhitkova, Ph.D.
Odesa National University of Technology, Ukraine

BIOPROCESSING OF CEREAL PRODUCTS BY ENZYMES AND PROBIOTIC MICROORGANISMS

Cereal grains have gained global recognition as a significant source of carbohydrates and dietary energy, as well as providing protein, fiber, vitamins, and trace minerals. However, a considerable portion of grains is milled to produce refined flour, resulting in the removal of the bran. It is worth noting that a substantial amount of dietary fiber, along with certain minerals and vitamins, is predominantly found in the outer layers of the grain [1]. In the context of wheat composition, the bran fractions also contain phytochemicals, such as anthocyanins, which are known for their potential health benefits.

Wheat is one of the major cereals in terms of global production, consumption, and trade, and is composed of three parts: the epidermis, endosperm, and germ. Wheat bran (WB), the outer layer of wheat, contains approximately 17 % (w/w) protein, 4 % fat, 18 % starch, 40 % insoluble fiber, and 3 % soluble dietary fiber. Lipids in WB have been reported to exhibit cholesterol-reducing activity, whereas protein hydrolysates have antioxidant and immunomodulatory properties. The dietary fibers of WB contain xylan, arabinoxylan, cellulose, and lignin, which may inhibit cardiovascular disease, obesity, diabetes, colitis, and colon cancer through fermentation by the gut microbiota. Dietary WB fermented by *Lactobacillus acidophilus* is additionally supplemented with probiotic cultures and, together with the components of WB and associated metabolites, likely has beneficial effects on the health of the host [2].

Based on the studied data, we hypothesized that WB hydrolytic enzymes (xylanases, cellulases, pectinases, proteases) combined with fermentation by probiotic microorganisms can serve as dietary products or matrices acting as carriers for probiotics. Fermentation of cereals with probiotics, particularly lactic acid bacteria (LAB), is a valuable process for enhancing the nutritional value and functionality of cereals, leading to the production of probiotic and prebiotic foods. This process involves the breakdown of complex carbohydrates and proteins by LAB, resulting in the production of organic acids, vitamins, and other beneficial compounds.

The scientific definition of a prebiotic is “a substrate that is selectively utilized by host microorganisms, conferring a health benefit.” Often, prebiotics are types of soluble fiber that humans cannot digest but instead serve as ‘food’ for beneficial microbes that reside in the colon or elsewhere in the body.

Fibers or dietary fibers (DF) are non-digestible plant-derived carbohydrates comprising at least three units of individual sugars. Most DF from WB can be either soluble or insoluble. Depending on local regulations, if fiber is isolated from whole plants or synthesized from sugars, demonstration of physiological benefits is required to label it as ‘fiber’ on a food product. The recommended daily intake of DF is 28 g/d based on a 2000 kcal/d diet.

Most people do not get enough fiber in their diets. Increasing fiber-rich foods and prebiotic-containing foods or supplements can help promote gut health and benefit the gut microbiota. Many current prebiotics are a type of soluble DF.

The term ‘prebiotic’ is seldom used on product labels; instead, consumers should look for ingredients such as galactooligosaccharides (GOS), fructo-oligosaccharides (FOS), oligofructose (OF), xylo-oligosaccharides (XOS), chicory fiber, or inulin. Consuming at least 5 grams of prebiotics daily is recommended for improved gut health.

Thus, DF can act as prebiotics by providing nourishment for beneficial gut bacteria, leading to a healthier gut microbiota. Not all dietary fibers are prebiotics, but those that are,

such as inulin and fructans, are selectively fermented by specific gut bacteria, promoting their growth and activity. This fermentation process produces beneficial metabolites such as short-chain fatty acids (SCFAs) that positively impact host health. Prebiotic DF are specific, microbiota-shaping compounds that function as a carbon source for the growth of beneficial taxa, thereby delivering a selective change that confers health benefits to the host.

Prebiotics and probiotics may be taken simultaneously. When a product delivers both, it is called a synbiotic. Although theoretically a probiotic could be paired with a prebiotic to improve its function, few studies have demonstrated such synergy. The specific combination of prebiotic and probiotic must be carefully researched to ensure consumption of health-benefiting live microorganisms along with the exact substrates they need to grow.

Fermentation can improve the bioavailability of nutrients such as minerals and proteins by reducing anti-nutritional factors like phytic acid in WB. It can also increase the levels of certain amino acids, such as tryptophan, lysine, and methionine. Fermented WB serve as excellent vehicles for delivering probiotics to the gut, potentially offering benefits for gut health and overall well-being. Fermented WB also enhance the flavor, aroma, and texture of cereals, making them more palatable and appealing to consumers.

Common probiotics used in fermented WB include various *Lactobacillus* species, *Bifidobacterium* species, and others such as *Leuconostoc* and *Saccharomyces*. The key factor in the successful use of wheat bran in food applications is the application of co-bioprocessing technologies, including enzymatic treatment and fermentation with selected microorganisms. In the effort toward a more efficient food chain, biotechnological approaches for the valorization of cereal side streams can provide valuable support. Wheat bran can serve as a nutritious and cost-effective raw material for the production of food and further enhance the nutritional impact of functional foods.

Based on the studied data, we have developed biotechnological processes for the utilization of secondary grain processing products, including hydrolytic splitting by enzymatic preparations followed by fermentation with *Lactobacillus acidophilus* and *Bifidobacterium bifidum*. This biotechnological approach positively influences bran microstructure, causing partial degradation of cell walls and increasing the solubility of arabinoxylans, which are highly effective prebiotic carbohydrates. Such an approach enables the production of food products with therapeutic and prophylactic properties.

This line of research has wide practical significance for the development of functional and prophylactic food products across different sectors of the food industry, such as meat, dairy, and bakery. In essence, probiotic fermentation of cereals offers a way to create healthier and more functional foods by harnessing the beneficial metabolic activities of probiotic microorganisms and the inherent nutritional qualities of cereals.

References

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