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Perspectives of cell-wall degrading enzymes in cereal polishing

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ABSTRACT

Diet and chances of chronic disease are highly linked together. Cereals are a basic element of the human diet and studies have demonstrated that intake of whole cereal grains is associated with reducing the risk of cancer, cardiovascular disease, obesity and diabetes. Bioactive molecules residing in the grains are attributed for such positive impact on health. Most of the bioactive molecules of cereal residues in their bran portion and hence their bioavailabilities are governed by the processing step. It is well accepted that grain processing followed by polishing has negative impacts on nutritional properties of cereal. Use of cell wall degrading enzymes for mobilization of bioactive molecules in bran layer of grain is opening up a new avenue for grain enrichment. Therefore, the present review focuses on the role of cell wall degrading enzymes in cereal grains processing for making nutrient rich products more palatable and acceptable among consumers.

Contents

1. Cereals: Introduction

Cereals are a member of the grass family "Poaceae or Gramineae". The grains of cultivated grass apart from source of energy are now emphasized for their cumulative and significant health promoting effects. The intake of grains provides the body with bioactive components well known for their physiological effects. Cereals are consumed either as cooked whole grains after dehusking and polishing or as flour. Table 1 shows the

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Table 1.
Composition of some selected cereals.

Cereals	Ash (%)	Protein (%)	Oil (%)	Crude fiber (%)	Carbohydrates (%)
Wheat	2.7	12.1	1.7	1.9	69.4
Rice	0.6	6.8	0.5	0.2	78.2
Maize	1.5	11.1	3.6	2.7	66.2
Dry beans	3.8	25.4	1.5	1.4	69.3
Peas	2.6	24.1	13.0	0.8	60.3

composition of some selected cereals (Gopalan, Sastri, & Balasubramanian, 1981; Kurien, Murty, Desikachar, & Subrahmanyan, 1964; Uebersax & Ruengsakulrach, 1988).

Cereal cultivation covers the major portion of agricultural production. The world's production of projected total grains (wheat and coarse grains) in 2015 was 2530 million tonnes while the utilization has been 2528 million tonnes (FAO, 2015). The intensification of agricultural system has converted cereal production to be the most important economic food product worldwide. Generally, in most parts of the world cereal-based diets are adopted as caloric and protein source. Wheat, maize, rice, barley, sorghum, oats, rye, and millet are highly acceptable cereal grains which provide 56% of the food energy and 50% of the protein (Cordain, 1999). Inclusion of cereal grains in the diet provides bioactive compounds to the body.

The edible portion of cereal grasses (gramineae) are the “caryopsis” single seeded fruits commonly called grains. These grains have three components, i.e. endosperm and germ formed by fertilization whereas the third part is bran which includes the pericarp and seed coat. Endosperm, the largest morphological component in all cereals, is of prime importance. Starchy endosperm and aleurone layer, the two portions of the endosperm are rich source of energy, protein, lipid, vitamins and minerals. Germ, which is formed by fusion of male and female gamete, is nutritionally rich in unsaturated fat, vitamin E, protein, minerals and vitamin B. The bran possesses valuable components like fibers, vitamins, phytochemicals etc. Because of high nutritional value, the whole cereal grain consumption is associated with health promoting effect. However, the major problem is the accessibility of digestive enzymes to starchy material of endosperm primarily due to kernel structures. The outer protective layer (pericarp) restricts digestive enzyme access, and as a result whole cereal grains are poorly digested. A solution for this problem is separation of endosperm from remaining grain component. The cereal processing industry has devised a new step of refining/ milling which enhances the overall performance of cereal grains. Some technical problems associated with mechanical milling of cereals are high cost, loss of several nutrients (loss of fibers, vitamins, phenolic compounds etc) and breakage of grains (due to fracture of endosperm) during milling process (Singh, Das, Bal, & Banerjee, 2013).

A better alternative to milling process involves biotechnological approach which involves biocatalysts for the degradation of bran layers to meet the consumer demand of healthy food. The use of enzymes for degradation of biopolymer present in bran is gradually becoming more popular as it is efficient than chemical and mechanical processes. The present article provides about the role of several carbohydrate cleaving enzymes on polishing of cereals.

2. Composition of cereals and associated health benefits

The major constituents of cereal are carbohydrate biopolymers. Cereal polysaccharides are comprised of a diverse group of carbohydrates and can be categorized based upon their storage (i.e.

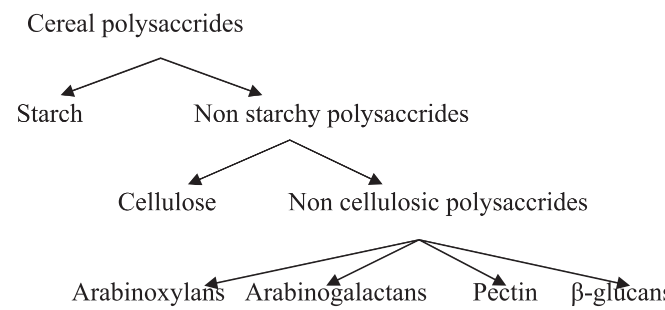

Fig. 1. The major constituents of cereal are carbohydrate biopolymers.

starch) or structural (i.e. cellulose) feature. Further classification can be done on their nature, i.e. starchy or a non-starch polysaccharide. Cereals are well known for their dietary fiber which is provided by the non-cellulosic polysaccharides (Fig. 1). Munck (1981) reported that kernel husk, the outer shell of cereal grains is composed of almost entirely of lignin with few hemicelluloses and cellulose fibers. The bran portions of kernel also consist of a hydrophobic polymer, lignin while the rest of the carbohydrate organization is similar to husk. The germ part of grain is rich in protein and fat. Endosperm of cereals usually contains, in addition to starch, various other polysaccharides. The aleurone layer of endospermic tissue is composed mainly of arabinoxylan and β-glucan (Burton & Fincher, 2014) while the starchy endosperm tissue cell walls enclose starch granules within in a protein matrix.

One of the major bioactive compounds of cereals is dietary fiber which includes cellulose, lignin, pectin, hemicelluloses, gums and mucilages confined mostly to the cell wall (Vitaglione et al., 2008). Cereal consumption in the western countries contributes about 50% of dietary fiber (DF) intake (Belderok, 2000; Lambo et al., 2005). Grains such as wheat, maize, rice, barley, sorghum, oats and rye are known for their fiber content (Table 1). Dietary fibers are known for reducing the chances of many disorders including cardiovascular diseases, colon cancer and diabetes (Plaami, 1997; Lattimer & Haub, 2010). The health promoting quality associated with the whole grain is especially credited to the content of dietary fiber in the bran layer (He et al., 2010; Zanovec et al., 2010). Munter et al. (2007) have related the association of bran and germ consumption with the reduced probability of the risk of type 2 diabetes. Total dietary fiber (TDF) in cereals can be divided in two groups depending upon their solubility in water.

2.1. *Soluble dietary fiber (SDF)*

Water soluble fiber in cereals includes 35% of arabinoxylan and the soluble portion of β-glucan (MacDougall & Selvendran, 2001). These fibers form a viscous solution in the intestine and are easily fermented by the colonic organisms. Cross-linking of polysaccharides with ferulic acid is a significant factor influencing fiber solubility (Bunzel et al., 2001) and fermentability of cereal fibers (Kroon, 1997; Wang et al., 2004).

Health promoting activities of SDF include the lowering of serum cholesterol and stabilization of blood sugar level, thus reducing the chances of diabetes and atherosclerosis (Devi, Vijayabharathi, Sathyabama, Malleshi, & Priyadarisini, 2014; Manthey, Hareland, & Huseby, 1999; Marlett, 1994; Plaami, 1997).

2.2. *Insoluble dietary fiber (IDF)*

IDF in cereals includes insoluble hemicelluloses, celluloses, pectin and lignin (Elleuch et al., 2011; Kays & Barton, 2002). IDF has a high water absorbing capacity enabling rapid movement of