Austin Journal of Nutrition & Metabolism

Open Access

Austin Publishing Group

Review Article

Bioactive Phytochemicals from Cereals: A Source of Superfoods

Punia H[1]*, Tokas J[1] and Malik A[2]
[1]Department of Biochemistry, College of Basic Sciences & Humanities, CCS Haryana Agricultural University, Haryana, India
[2]Department of Seed Science & Technology, College of Agriculture, CCS Haryana Agricultural University, Haryana, India
***Corresponding author:** Himani Punia, Department of Biochemistry, College of Basic Sciences & Humanities, CCS Haryana Agricultural University, Hisar-125 004, Haryana, India

Received: October 11, 2021; **Accepted:** November 03, 2021; **Published:** November 10, 2021

Abstract

Whole-grain cereals have received considerable attention in the last several decades due to the unique blend of bioactive components like phytochemicals and antioxidants. However, phytochemicals and antioxidants in whole grains have not received as much attention as in fruits and vegetables, although the increased consumption of whole grains and whole-grain products has been associated with a reduced risk of several developing chronic diseases. These unique bioactive compounds in whole grains are proposed to be responsible for the health benefits of whole-grain consumption.

Keywords: Cereals; Grains; Human health; Phenolic; Phytochemicals; Nutrition

Introduction

Cereals can be defined as a grain or edible seed of the grass family. Cereals are grown for their highly nutritious edible seed, which is often referred to as a grain. The significant cereals consumed worldwide are wheat, rice, maize, barley, oats, rye, millet, and sorghum [1]. Apart from being an essential part of the diet, these cereals are rich in various health-promoting components. Cereals are stapled foods providing significant sources of carbohydrates, proteins, B vitamins, and minerals for the world's population [2]. Cereals contain a range of substances that may have health-promoting effects; these substances are often referred to as "phytochemicals" or "plant bioactive substances" [3].

Bioactive compounds are extra nutritional elements that typically occur in small quantities in foods. These substances are beneficial to human health but are not essential for the human body [4,5]. Most whole-grains bioactive compounds are present in cereal grains' bran/germ fraction (Figure 1). Epidemiological studies have shown that regular consumption of whole grains and whole-grain products is associated with reduced risks of various types of chronic diseases such as cardiovascular diseases, type 2 diabetes, and some cancers [6]. These health benefits are achieved through multifactorial physiological mechanisms, including antioxidant activity, mediation of hormones, enhancement of immune system and facilitation of substance transit through the digestive tract, butyric acid production in the colon, and absorption and dilution of substances in the gut. Whole grains or foods made from whole grains contain all the essential parts, the bran, the endosperm, and rarely germ, in contrast to the refined grains, in which the bran and the germ of the grains are removed during the milling process [7].

Whole-grain cereals and foods have been the focus of significant scientific, governmental and commercial interest during the past ten years. The outer layer of grain has been shown to contain much higher bioactive compounds such as phenolic compounds, phytosterols, tools, and carotenoids than the inner parts. The phenolic compounds of whole grains, including lignans, alkylresorcinols, and phenolic acids, are metabolized and absorbed in humans and are among the major compounds inducing physiological changes underlying the protective effects [8]. However, components in the whole-grain responsible for these effects on the protection of health and homeostasis and their mechanism of action are not fully understood.

Bioactive Compounds Present in Wholegrain Cereals

Whole grains contain unique bioactive compounds that complement those in fruits and vegetables when consumed together. Whole grain cereals' major bioactive compounds are phenolic compounds, phytosterols, dietary fibers (mainly beta-glucan), lignans, phytic acid, γ-oryzanols, avenanthramides, cinnamic acid, ferulic acid, inositols, and betaine [9]. Some bioactive compounds are specific to certain cereals; γ-oryzanol in rice, avenanthramide, saponins in oats, beta-glucans in oats and barley, and alkylresorcinol in the rye, although these are also present in other cereals like wheat but relatively in fewer amounts. The essential bioactive compounds in whole-grain cereals are discussed under:

Phenolic compounds

Phenolic compounds possess one or more aromatic rings with one or more hydroxyl groups. They are generally categorized as phenolic acids, flavonoids, stilbenes, coumarins; phenolics are the products of secondary metabolism in plants, providing essential functions in the reproduction and growth of the plant, acting as defense mechanisms against pathogens and parasites, also contributing to the color of the plant. In addition to their role in plants, phenolic compounds in our diet provide health benefits associated with cancer in which reactive oxygen species, i.e., superoxide anion, hydroxyl radicals, and peroxyl radicals, are involved [10]. It is emerging that polyphenols may have a far more critical effect in vivo, such as enhancing endothelial function, cellular signaling, and anti-inflammatory properties to reduce the risk of chronic diseases.

Current public health recommendations to reduce the risk of coronary heart disease in the UK suggest including oats and oat-based products as part of a healthy diet. The most common phenolic compounds found in whole-grain cereals are phenolic acids and

Citation: Punia H, Tokas J and Malik A. Bioactive Phytochemicals from Cereals: A Source of Superfoods. Austin J Nutr Metab. 2021; 8(4): 1114.

flavonoids.

Phenolic acid: Phenolic acids are derivatives of benzoic and cinnamic acids and are present in all cereals. The phenolic acids reported in grains occur in both free and bound forms. Sorghum and millet have the widest variety of phenolic acids. Free phenolic acids are found in the outer layer of the pericarp. The primary phenolic acids in cereals are ferulic acids and p- coumaric acid. Ferulic acid is the most abundant hydroxycinnamic acid found in cereal grains. Wheat bran is a good source of ferulic acid. The ferulic acid content of the wheat grain is near about 0.8-2 g/kg dry weight basis, which may represent 90% of total polyphenols. It has antioxidant properties to combat destructive free radicals and astringency that deters consumption by insects and animals [11,12]. Coumaric acids are hydroxyl derivatives of cinnamic acid. p-Coumaric acid is present in the lowest amount in the center of the grain kernel and increasing amount towards the outer layers. Coumaric acids are suggested to have an antioxidant effect, and researches have shown that there is a free radical scavenging property in p- coumaric acids. It also has been recommended to have anti-tumor activity against human malignant tumors. It induces cytostasis and inhibits the malignant properties of human tumor cells in vitro [13].

Flavonoids

Flavonoids are compounds with a C6-C3-C6 skeleton that consists of two aromatic rings joined by a three-carbon link. More than 5000 flavonoids have been identified in nature. Sorghum has the widest varieties of flavonoids reported. Cereals have only small quantities of flavonoids, except that barley contains measurable amounts of catechin and procyanidins [14]. Flavonoids have antioxidant, anticancer, anti-allergic, anti-inflammatory, anticarcinogenic, and gastroprotective properties.

Lignans

Lignans are polyphenolic bioactive compounds present in many plant foods, including flax seeds and whole grains like corn, oats, wheat, and rye. Mammalian lignans have potent antioxidant activity and weak estrogenic activity that may account for their biological effects and health benefits. They make them unique and helpful in promoting health and combating various chronic diseases. Mammalian lignans inhibit colon cancer cell growth and also induce cell cycle arrest and apoptosis in vitro. Lower cancer rates have also been associated with a high dietary intake of lignans.

Carotenoids

Carotenoids are the most widespread pigment in nature, with yellow, orange, and red colors. They have also received substantial attention because of their role as pro-vitamins and antioxidants. More than 600 different carotenoids have been identified, which occur in plants, microorganisms, and animals [15]. Carotenoids commonly found in whole-grain cereals are lutein, zeaxanthin, beta-cryptoxanthin, beta carotene, and alpha-carotene. Lutein is the carotenoid present in the highest concentration in wheat, followed by zeaxanthin and then beta-cryptoxanthin. Rice bran contains both lutein and zeaxanthin, which improves eyesight. Cereals are the source of carotenoids. Maize is the best source with about 11 μg/kg on a dry weight basis. Carotenoids are more evenly distributed within the grain, with significant quantities within endosperm, in contrast to other micronutrients such as minerals, trace elements, and polyphenols. Carotenoids perform essential functions in plants. They provide color in whole-grain flour.

Phytic acid

Phytic acid is a bioactive compound that is also known as Inositol Hexaphosphate (IP6). Almost all mammalian cells contain IP6 and its lower phosphorylated forms (IP1-5). It may account for more than 70% of the total kernel phosphorus. Phytic acid is mainly located in the bran fraction of whole-grain cereals, especially within the aleurone layer. In corn, IP6 is primarily found in the germ. Phytic acid from whole-grain cereals has long been nutritionally harmful since it chelates minerals such as Zn, Fe, Ca, and Mg, thus limiting their intestinal bioavailability.

Phytosterols

Cereal products are recognized as significant plant sterol sources than vegetables. Plant sterols are one of the bioactive components currently being actively studied. The most important natural source of plant sterols in human diets are oils and portions of margarine. They have decreased serum cholesterol levels in several studies, and they may also be beneficial in preventing colon cancer.

γ-oryzanol is a component of rice-bran oil. Its content in whole-

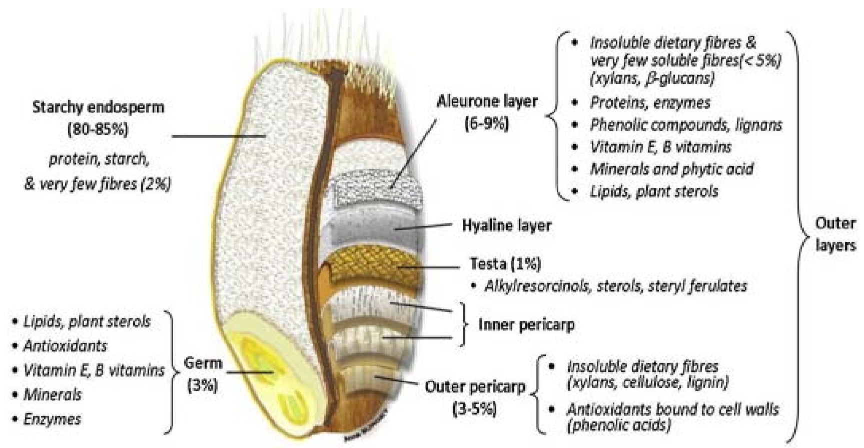

Figure 1: Histological structure of whole grain.

grain rice is 18-63mg/100g dry weight. Its concentration in rice-bran is 185-421 mg/100g, depending on the rice variety, milling time and stabilization process, and extraction methods. γ-oryzanol has antioxidant activity, and it has been demonstrated both in vitro and in vivo. It is associated with decreasing plasma cholesterol. It is also associated with reducing cholesterol absorption and decreasing platelet aggregation.

Beta-glucan

β-glucan are polysaccharides found principally in the cell walls of the aleurone layer and endosperm in barley and oat kernels. They are more concentrated in the endosperm in barley, while in oats, they are concentrated in the aleurone layer. The most considerable amounts of β-glucan are found in barley (3-11%) and oats (3-7%), with lesser amounts reported in the rye (1-2%) and wheat (<1%) [16]. only trace amounts have been reported in corn, sorghum, rice, and other cereals of importance as food. Oat-based breakfast cereals have also gained considerable attention in recent years as they are rich β-glucan, which has been considered a bioactive component and has been promoted as a means of reducing serum and plasma cholesterol levels.

Importance of Bound Bioactive Compounds in the Prevention of Colon Cancer

Most of the bioactive antioxidant compounds in grain are bound and can survive gastrointestinal digestion to reach the colon intact, providing an antioxidant environment. These bioactive antioxidant compounds are in insoluble form and bound to cell wall materials [17]. Since cell wall materials are difficult to digest, they survive upper gastrointestinal digestion and finally reach the colon. In the colon, the fiber is fermented, and some of the bioactive compounds which have antioxidant activity are released. Only 0.5% - 5% of the ferulic acid is absorbed within the small intestine, mainly the soluble fraction. This typical whole-grain wheat phenolic acid would probably exert a major action in protecting the colon from cancer [18]. Thus, bound antioxidant phenolic acids might act along the whole length of the digestive tract by trapping oxidative compounds.

Conclusion and Future Perspective

Cereal and cereal products remain a staple component of diets around the world. They make a substantial contribution to the intake of carbohydrates, protein, fiber, and vitamin E, some of the B vitamins, sodium, selenium, magnesium, and zinc. They also play an essential role in promoting good health, beyond merely the provision of nutrients; there is much evidence to suggest that regular consumption of cereal products, specifically whole grains, may have a role in the prevention of chronic diseases as diabetes and colon cancer. These health benefits provided by whole-grain cereals are due to bioactive compounds in the whole compounds that contribute to health.

Identifying and quantifying cereal bioactive compounds will help us select grains with increased levels of these health-promoting compounds. Research is also needed to determine their bioavailability, metabolism, and health contribution in humans. The mechanisms involved are complex, so more information is required on the mechanisms involved to prepare solid and convincing arguments for increased consumption of whole-grain cereal products by the people, provide better information about their health benefits, and develop new health claims in the future. Further studies are needed to explore this new area of research using the most recent genomic and transcriptomic techniques. This new approach will further investigate how complex antioxidant-rich foods such as cereal and cereal products can modify general metabolism, and metabolic pathways are affected by antioxidants. This will provide new information on the health benefits of whole-grain cereals.

References

1. Punia H, Tokas J, Bhadu S, Mohanty AK, Rawat P, Malik A, et al. Proteome dynamics and transcriptome profiling in sorghum [*Sorghum bicolor* (L.) Moench] under salt stress. 3 Biotech. 2020; 10: 412.
2. Punia H, Tokas J, Malik A, Satpal, Sangwan S. Characterization of phenolic compounds and antioxidant activity in sorghum [*Sorghum bicolor* (L.) Moench] grains. Cereal Res Commun. 2021; 49: 343-353.
3. Punia H, Tokas J, Malik A, Singh S, Phogat DS, Bhuker A, et al. Discerning morpho-physiological and quality traits contributing to salinity tolerance acquisition in sorghum [*Sorghum bicolor* (L.) Moench]. South African J Bot. 2021; 140: 409-418.
4. Tokas J, Punia H, Malik A, Sangwan S, Devi S, Malik S. Growth performance, nutritional status, forage yield and photosynthetic use efficiency of sorghum [*Sorghum bicolor* (L.) Moench] under salt stress. Range Manag Agrofor. 2021; 42: 59-70.
5. Malik A, Mor VS, Tokas J, Punia H, Malik S, Malik K, et al. Biostimulant-Treated Seedlings under Sustainable Agriculture: A Global Perspective Facing Climate Change. Agronomy. 2020; 11: 14.
6. Swaminathan S, Dehghan M, Raj JM, Thomas T, Rangarajan S, Jenkins D, et al. Associations of cereal grains intake with cardiovascular disease and mortality across 21 countries in Prospective Urban Rural Epidemiology study: prospective cohort study. bmj. 2021; 372. m4948.
7. Develaraja S, Reddy A, Yadav M, Jain S, Yadav H. Whole grains in amelioration of metabolic derangements. J Nutr Heal food Sci. 2016; 4: 1-11.
8. Punia H, Madan S, Malik A, Sethi SK. Stability Analysis for Quality Attributes in Durum Wheat (Triticum Durum L.) Genotypes. Bangladesh J Bot. 2019; 48: 967-972.
9. Ho FK, Gray SR, Welsh P, Petermann-Rocha F, Foster H, Waddell H, et al. Associations of fat and carbohydrate intake with cardiovascular disease and mortality: prospective cohort study of UK Biobank participants. bmj. 2020; 368. m688.
10. Tsafrakidou P, Michaelidou A-M, G Biliaderis C. Fermented cereal-based products: Nutritional aspects, possible impact on gut microbiota and health implications. Foods. 2020; 9: 734.
11. Punia H, Malik A. Plantibodies: A New Approach for Immunomodulation in Human Health. Biomed J. 2018; 1: 2.
12. Punia H, Tokas J, Malik A, Sangwan S, Baloda S, Singh N, et al. Identification and detection of bioactive peptides in milk and dairy products: Remarks about agro-foods. Molecules. 2020; 25: 3328.
13. Chaves-López C, Rossi C, Maggio F, Paparella A, Serio A. Changes occurring in spontaneous maize fermentation: An overview. Fermentation. 2020; 6: 36.
14. Riaz Q, Ács K, Bekes F, Eastwood RF, Farahnaky A, Majzoobi M, et al. Fructan contents in Australian wheat varieties released over the last 150 years. Cereal Res Commun. 2019; 47: 669-677.
15. Bationo F, Humblot C, Songre-Ouattara LT, Hama-Ba F, Le Merrer M, Chapron M, et al. Total folate in West African cereal-based fermented foods: Bioaccessibility and influence of processing. J Food Compos Anal. 2020; 85: 103309.
16. Antognoni F, Mandrioli R, Potente G, Saa DLT, Gianotti A. Changes in carotenoids, phenolic acids and antioxidant capacity in bread wheat doughs fermented with different lactic acid bacteria strains. Food Chem. 2019; 292: 211-216.
17. Adebo OA, Gabriela Medina-Meza I. Impact of fermentation on the phenolic

compounds and antioxidant activity of whole cereal grains: A mini-review. Molecules. 2020; 25: 927.

18. Wang J, Bai J, Fan M, Li T, Li Y, Qian H, et al. Cereal-derived arabinoxylans: Structural features and structure-activity correlations. Trends Food Sci Technol. 2020; 96: 157-165.