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Mini Review

Nutraceutical potential of rice and wheat antioxidants and their impacts on health

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Abstract
Antioxidants are substances involved in the prevention of cellular damage caused by free radicals which set the common pathway for cancer, aging, and a variety of chronic and inflammatory diseases. They play many important roles such as free radical scavenger, reducing agent and antioxidant defense enzyme system activator. Rice and wheat are two very commonly consumed cereal grain that contain several antioxidative compounds and are shown to be beneficial for a wide range of medical conditions. The objectives of this article are twofold. Firstly, we described the various antioxidant compounds present in rice and wheat and provided evidences on their beneficial effects on health such as reduction of oxidative stress, prevention of cancer, diabetes and cardiovascular diseases. Then the final part critically discusses the various aspects of the use of rice and wheat as nutraceutical and functional food. In this paper, we extensively studied the antioxidant chemistry of the cereal grains, factors affecting their content, bioavailability, their various health aspects and rationale for commercial production. In conclusion we proposed that rice and wheat bran contain several phenolic compounds function as antioxidants which can be used as cheap sources of nutraceutical and functional food applications.

INTRODUCTION

The plants of Gramineae family are well known for their containing various phytochemicals that function as antioxidants such as ferulic acid, caffeic acid, gallic acid, para-cumaric acid and flavonoids. Rice (*Oryza* spp) is the staple crop in many countries across the globe and is the second most important crop next to wheat in terms of cultivation area in the world. About 40% of the World's population consumes rice as a major source of calorie [1]. Wheat (*Triticum* spp) is the most widely grown crop in the world and provides 20% of the daily protein and of the food calories for 4.5 billion people. It is the second most important food crop in the developing world after rice [2]. Their huge-scale global consumption has served as a great tool to study combating micronutrient malnutrition and there are numerous researches on improving their nutritional content by biofortification using genetic recombinant technology. There is also a growing concern among nutritionists and food scientists regarding the antioxidant capacity and phenolic profile of some whole grains specially that of rice and wheat. The bran portion is believed to be the nutritional storehouse of the rice grain and the antioxidative and disease-preventative phytonutrients of rice and wheat bran are now being considered a potential source of cheap nutraceuticals. Nutritionally, bran fractions produced by milling are rich in fiber, minerals, vitamin B6, thiamine, folate and vitamin E and some phyto-chemicals, in particular antioxidants such as phenolic compounds [3]. However recent experiments on rice and wheat bran have generated much hope due to their

potential as being safe and inexpensive sources of natural antioxidants. Several important nutraceutical compounds, such as tocotrienols, tocopherols, and oryzanols, can be extracted from rice bran, a by-product of milling [4]. Milling industry disposals exert various adverse effects on nature all over the world, but the fact that the disposals contain such parts of the grain which are rich in phytochemicals, has been overlooked, whether due to lack of sufficient infrastructure or commercial exploitation. Several clinical studies have demonstrated that the antioxidants in cereal grains function as main factors for their observed efficacy in reducing the incidence of chronic diseases like coronary heart disease and some cancers. Therefore large scale extraction of antioxidants from these inexpensive and readily available sources can become very beneficial from both, environmental and public health viewpoint.

ANTIOXIDANTS OF WHEAT AND RICE

Rice is a good source of various biologically active compounds including phenolic antioxidants. In general, rice kernel is composed of bran, germ and endosperm. Due to the abundance of some bioactive compounds, rice bran, the outer layer of brown rice, has experienced a lot of studies in recent years [5-7]. Common antioxidative compounds identified in rice include phenolic compounds, tocopherols, tocotrienols and gamma-oryzanol [8]. The phenolic compounds have been found as a major active component for antioxidation [8-11]. Among these; tocopherols, tocotrienols (α, β, γ and δ homologs) and γ-oryzanol has received the most research attention [12]. Other compounds identified include sinapic acid, protocatechuic acid [13, 14], chlorogenic acid, hydroxybenzoic acid [14], vanillic acid, syringic acid [15], caffeic acid [13, 14] and gallic acid [14], tricin (flavone) [13] and the esters 6'-O-(E)-feruloylsucrose and 6'-O-(E)-sinapoylsucrose [14, 16]. The aleurone layer of rice grain contains some pigments composed of mixture of anthocyanin compounds, which belong to the family of flavonoids [5]. For pigmented rice, the main substance of phenolic compounds has been reported as anthocyanins [8, 17, 18]. Since these compounds are localized mainly in the external layers of the grain, milling procedures significantly reduces the concentration in the final polished grain. Rice bran contains between 70 and 90 percent of the phenolic acids in light brown pericarp rice grains [14], and approximately 85% of the anthocyanins in the rice grains with black pericarp [19], with little variation depending on the cultivar and the compounds considered. The germination process also affects the phenolic compounds in grains [16] which is probably caused the metabolism of phenolic compounds. Rice bran is a rich source of steryl ferulate esters, commonly referred to as oryzanols [13].

The level of antioxidant components vary substantially among the different fractions of wheat grain. In general, bran tissues are the main site where the phenolic compounds are concentrated. Wheat kernel is composed of bran, germ, and endosperm. Main antioxidant components of wheat are phenolic acids, flavonoids, tocopherol, tocotrienol, terpenes, carotenoids, phytates and phenolics [20]. Wheat phenolic acids include ferulic, vanillic, syringic, sinapic, caffeic and p-coumaric acids which have been demonstrated to be a source of nutritional antioxidants [20-22]. Ferulic acid and lutein are the predominant phenolic acid and carotenoid found in whole wheat respectively. The antioxidant activities of whole wheat and milling fractions have been studied widely by food scientists [23, 24]. However, wheat and wheat based products differ in their phenolic acid content and composition. Aleurone is a single cell layer occupying the inner site of the bran and outermost cell layer of the endosperm which contains phenolic acid and ferulic acid in particular. It contains most of the minerals and phenolic antioxidants of the wheat grain. The aleurone layer is therefore the fraction with the highest antioxidant activity, followed by the bran [20].

Health benefits of rice and wheat antioxidants

Antioxidants are the essential nutrients that help protect human body against the free radicals. Stabilized rice bran has over 100 antioxidants and co-factors which means it contains a wide range of nutrients required for natural health maintenance. Antioxidants also play a role in the body's cell protection system and help to boost immune system and cardiovascular function. Phytonutrients in rice and wheat bran possessing antioxidant and other reported beneficial physiological properties include: ferulic acid, its esterified derivative (γ-oryzanol), and unsaponifiable components such as tocopherol (vitamin E) and tocotrienol (as a form of vitamin E) [25]. The nutrients in rice and wheat have known potential for reducing the risk of coronary heart disease, reducing tumor incidence, cancer risk, lowering blood pressure, reduces the rate of cholesterol and fat absorption, delaying gastrointestinal emptying and providing gastrointestinal health. Thus diet with the regular inclusion of cereals can contribute much to health promotion and disease prevention [26]. Studies have shown that nutraceutical combination (red yeast rice, berberine and policosanols) improves aortic stiffness in low-moderate risk hypercholesterolemic patients [27]. In patients with mild cholesterol elevations, treatment with a nutraceutical combination (red yeast rice, berberine and policosanols) reduce cholesterol and allows more than 65% patients with mild hypercholesterolemia to reach the recommended

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LDL cholesterol target. Recently, combined therapy with red yeast rice, berberine and policosanols, administred at the same dosage used in the present study, reduced cholesterol levels and improved endothelial function in hypercholesterolemic patients [28].

Supplementation of black rice pigment fraction improves antioxidant and anti-inflammatory status in patients with coronary heart disease [29]. Phenolic antioxidants of rice have the potential to reduce the risk of disease, such as inhibiting platelet aggregation [22], reducing the risk of coronary heart disease and cancer [20], and preventing oxidative damage of lipid and low-density lipoproteins [23]. Most of the antioxidant compounds in rice bran are bound to fiber thus survive gastrointestinal digestion and remain intact in colon, where they provide an antioxidant environment [24]. Digestion increases the solubility and activity of bound phenolic compounds which is believed to be the reason why whole-grain consumption may help prevent colon cancer, the second most common type of cancer among North Americans. Wheat grains are a source of phytochemicals with potential health benefits. But such benefits are fully exploited if whole-wheat products are consumed. That's why the consumption of whole wheat grain is commonly suggested by dietitians. Several studies have shown that wheat phytochemicals possess strong antioxidant properties and play a protective role against diseases like cancer, diabetes and cardiovascular diseases. Whole grain consumption reduces the risk of chronic diseases such as cardiovascular disease, cancer, diabetes and obesity. Wheat germ Vitamin E is a powerful antioxidant and helps to maintain skin health. It also improves immunity and has anti-aging properties and can prevent cancer. It can help control blood LDL, cholesterol and triglycerides and thus promote cardiovascular health. Wheat phenolic acids are involved in scavenging of few free radicals including peroxyl, hydroxyl, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid (ABTS•) and di-(phenyl)-(2,4,6-trinitrophenyl)iminoazanium (DPPH•). Besides that, wheat phenolic acids also protect cellular proteins from oxidative modification and thus preventing the adverse effects of such processes. Whole wheat cereals contain high amount of nutrients such as dietary fiber, resistant starch, vitamins, minerals and microconstituents, which not only take part in construction of body tissues but also help to reduce a risk of the some diseases such as coronary cardiovascular disease, colon cancer [30] and diabetes [31]. Whole grain consumption has been consistently associated with reduced risk of developing chronic diseases, including cardiovascular disease [32, 33], type II diabetes [34], obesity [35] and cancer [36, 37]. Tocotrienols, as a lipophilic antioxidant, have shown peculiar physiological potential including antitumor properties in mammary cancer [38, 39] by reducing serum cholesterol effects [40] and anti-inflammation [41]. Previous studies have reported that intake of a tocotrienol-rich fraction of rice bran lowers serum total and LDL-cholesterol concentrations in hypercholesterolemic person [40, 42].

Potential of rice and wheat bran as sources of nutraceutical

In recent years, nutraceuticals have attracted much interest as possible therapies for many chronic diseases such as lowering plasma cholesterol in patients with marginally high hypercholesterolemia. Considering the vast worldwide production of rice and wheat, the bran and its oil rank among the most important sources of nutraceutical components is available in the world today. In the United States, rice bran is most commonly used in animal feed or as a food ingredient due to its high nutritional content [43]. The antioxidative effects of rice and wheat bran arise from their various phytonutrients such as phenolic acid and alkylresorcinols (*e.g.* 5-alkylresorcinols in rice). Studies have suggested that the majority of bioactive compounds such as phytochemicals (including phenolic acid and alkylresorcinols) are not found in cereal grains but instead in the germ/bran fractions. In wholegrain wheat flour, the bran fraction contains around 83% of total phenolic content [44]. Rice bran contains more than 67% of the total nutrition of rice, and accounts for 10% of the brown rice kernel. Consequently, the bran fraction has higher antioxidant activity than other milled fractions [45]. Researchers have also shown that it is the aleurone layer of wheat bran that consistently has the highest antioxidant capacity among wheat fractions and that ferulic acid in particular which accounts for up to 60% of this antioxidant capacity [46]. Bran is the by-product of the milling process that has potential as a rich source of valuable health-promoting compounds and with the aid of modern technology it can be more efficiently exploited at commercial scale to produce nutraceutical and functional food. Several enzymes render the bran rancid within few hours of milling which necessitates the removal of it from the rice kernel, totaling 60 million metric tons worldwide of a wasted resource each year**.**

NutraCea (Scottsdale, AZ), a US based rice research institute and a world leader in rice bran stabilizing technology, has successfully stabilized rice bran without adding chemicals, or degrading its nutritional profile. These remarkable advancements in food technology have enabled the conversion of rice bran into an economically viable food, virtually revolutionizing modern nutrition, with potentially huge implications for people's health and well-being.

CONCLUSION

Despite the fact that the concentrations of phenolic compounds in rice and wheat bran and are not high compared to many other natural food, they still serve as readily available, inexpensive and natural sources of these compounds because of their wide utilizetion and thus can be exploited to develop physiologically functional foods. Two most commonly used synthetic antioxidants namely butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) which are commonly used in processed food to improve shelf-life and prevent oxidative rancidity. Controversies about the safety of these synthetic antioxidants urge the task of looking for safer and natural antioxidants. Thus from a food safety and nutritional point of view natural antioxidant compounds are of great importance. This paper gives evidences from previous studies that the intake of food rich in natural antioxidants such as cereal grain polyphenols and flavonoids have beneficial effects on many degenerative diseases such as cancer, cardiovascular disease and diabetes. There is a growing interest among food scientists to identify and isolate antioxidative compounds from natural sources which will be both safe for consumption and inexpensive. The commercial rice-milling process leads to products with low-value fractions, such as husk and bran. Eventhough rice husks are inedible, they can be used for the extraction of the desired antioxidants and thus should get greater research attention as an economical and natural antioxidant source. However, rice husks offer the valuable nutritional advantage as they contain an antioxidant defense system to protect the rice seed from oxidative stress. Therefore they assume a great significance because of their acceptability, non-toxicity and availability in large quantities. Rice bran is one of the most abundant co-product in the rice milling industry which could be exploited as a good commercial source of natural antioxidants like oryzanols, tocopherols, tocotrienols, ferulic acid, p-coumaric acid, gallic acid, caffeic acid and polycosanols. The extracts from bran can be used as substitute of synthetic antioxidants for food products, stabilization of fats, frying oils [33], stabilization of functional foods such as low-heat whole milk powder. Defatted wheat germ is another good option for obtaining natural antioxidants and can be used to formulate nutraceutical with potential applications to minimize the effect of oxidative stress. Thus the sustainable use of these cereal grains may open a new horizon in nutraceutical industry.

COMPETING INTERESTS

The authors declare that no conflict of interest exists.

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