REVIEW

PHYTOSTEROLS IN RICE BRAN AND USAGE OF RICE BRAN IN FOOD INDUSTRY

Özgül Özdestan, Tuğçe Erol, Burcu Acar

Department of Food Engineering, Faculty of Engineering, Ege University, Bornova-Izmir, Turkey,
e-mail: ozgul.ozdestan@ege.edu.tr

Abstract

Phytosterols are very important for daily diet that can not be synthesized by human body. Main sources of phytosterols are vegetable oils, seeds, legumes and cereals. Phytosterols prevent cholesterol absorption therefore lower total and LDL cholesterol level in blood. Also plant sterols might protect against certain types of cancer such as colon, breast and prostate. Rice bran is the best source of total lipids and phytosterols based on raw material. Rice bran oil contains very high concentrations of cycloartenol and 2.4-methylenecycloartanol, which made up over 40% of the total phytosterols. Rice brain contains 12–22% oil, 11–17% protein, 6–14% fiber, 10–15% moisture, and 8–17% ash. Also, It is rich in vitamins, including vitamin E, thiamine, niacin, and minerals like aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, sodium, and zinc. Furthermore, presence of antioxidants like tocopherols, tocotrienols, and γ-oryzanol also brighten prospects of rice bran utilization for humans as functional ingredient to reduce the life threatening disorders. To improve quality and nutrition of food product, rice bran can be evaluated as a potential food ingredient. It has been used in food as full-fat, defatted bran, bran oil, and protein concentrates. Rice bran is used by the food industry in the production of baked foods, snacks, crackers, breads, cereals, pastries, pancakes, noodles, muffins, biscuits. In this review, phytosterols found in rice bran which impacts on human health and the usage of rice bran in food industry are discussed in general terms.

Keywords: bioactive compound, cereals, phytosterol, rice bran.

Introduction

Phytosterols (including plant sterols and stanols) can not be synthesized by humans, and all plant sterols and stanols in the human body therefore originate from the diet. The class of sterols known as phytosterols is found mainly in plant cell walls and membranes. Sitosterol, campesterol, and stigmasterol were the major phytosterols in the lipid extracts. Phytosterols have hypocholesterolemic effects (Jong et al., 2003; Jiang and Wang, 2005). They are known to have several bio-active qualities with possible implications for human health (Normen et al., 2002). The difference of phytosterols which are a group of triterpens from cholesterols is the presence of a double bond within ethyl or methyl groups and within the side chains of them. Phytosterols can be found either in the free form and the esterified form. Phytosterols are classified either as -sterols or -stanols; according to the presence of the double bond within the position Δ5 (Bayrakçı, 2013).

Rice bran is the best source of phytosterols based on raw material. Rice bran, a part of the rice kernel that contains pericarp, aleurone, and subaleurone fractions, is a by-product of rice milling. It is estimated that the world annual production of rice bran amounts to 76 million tons. Rice brans, oils, and hulls contain a large number of bioactive compounds, with pigmented brans containing many more bioactive compounds than do white brans (Friedman, 2013).

Because of the increasing interest in relationship between health and food, results increasement of formulation studies about functional products. For this reason, stabilized rice bran or its components have been used as ingredients in various food matrices such as bread (Hu et al., 2009), cookies (Bhanger et al., 2008), pizza (de Delahaye et al., 2005), beverages (Faccin et al., 2009; Jeličić et al., 2008), tuna oil (Chotimarkorn et al., 2008). Rice bran is also used in meat emulsions and batter mixes industrially. In this study we will present brief overviews of phytosterols and selected recent studies on enrichment of some food products with rice bran.

Phytosterols and Chemical Structure

Phytostanols are a fully-saturated subgroup of phytosterols (contain no double bonds). Phytostanols occur in trace levels in many plant species and they occur in high levels in tissues of only in a few cereal species. Phytosterols can be converted to phytostanols by chemical hydrogenation. More than 200 different types of phytosterols have been reported in plant species. In addition to the free form, phytosterols occur as four types of "conjugates," in which the 3β-OH group is esterified to a fatty acid or a hydroxycinnamic acid, or glycosylated with a hexose (usually glucose) or a 6-fatty-acyl hexose (Moreau et al., 2002). The structures of sitosterol, sitostanol, campesterol and campestanol are shown in Fig. 1 (Gilbert et al., 2005).

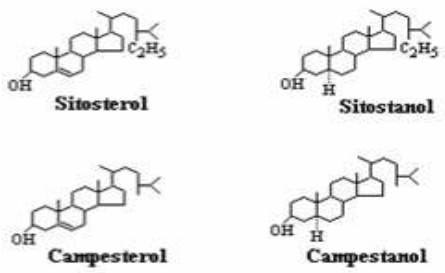

Figure 1. Chemical structures of some phytosterols (Gilbert et al., 2005)

Heath Effects and Resources of Phytosterols

Phytostanol; reducing blood cholesterol levels, as well as their other beneficial health effects, have been known for many years (Quilez et al., 2003). It was recognized in the 1950s that plant sterols lower serum concentrations of cholesterol (Pollak, 1953). Plant sterols might also protect against certain types of cancer such as colon, breast and prostate (Rao, Koratkar, 1997; Awad and Fink, 2000). Phytosterols can be found at widely varying concentrations in the fat-soluble fractions of seed, root stems, branches, leaves and blossoms. They are constituents of both edible and ornamental plants, including herbs, shrubs and trees. As natural constituents of the human diet, phytosterols are naturally found in all food items of plant origin, principally oils, but also pulses and dried fruits. Their content is highest in edible oils, seeds and nuts. The total contents are very variable and range from nearly 8 g kg^{-1} in corn oil to 0.5 g kg^{-1} in palm oil, with intermediate levels being found in commonly used oils. Tall oil contains a higher proportion of plant stanols than do vegetable oils. Phytosterols are of products based on vegetable oils. The refining process cited leads to a significant reduction in phytosterols in vegetable oils and it would therefore be very interesting to develop industrial methods which minimize these losses (Taşan et al., 2006). Main sources of phytosterols are wheat bran, wheat germ, durum wheat, rice bran, vegetables oils, seed and legumes (Clifton, 2002; Jiang, Wang, 2005). Germ and bran fraction of cereals, especially rice bran and wheat germ which have high level of oil, are known as best source of phytosterols. Rice bran contains %22.2 of phytosterol (Taşan et al., 2006). The dietary intake of phytosterols among and within different human population varies greatly, depending on the type and amount of plant foods eaten. Although cooking oils, margarine and peanut butter are the main sources of phytosterols in the diet, phytosterols are also consumed in seed, nuts, cereals and legumes (Clifton, 2002). The consumption of phytosterols can range between 170 mg per day in populations eating a Western diet and 360 mg per day in diets rich in vegetable products (Vries et al., 1997). The dietary intake of plant stanols is usually only about 50 mg/day unless the diet is supplement with tall oil, which is derived from conifers and is rich in sitostanol (Gilbert et al., 2005). The normal dietary intake of plant stanols is much less than that of plant sterols.

Rice Bran

Rice is one of the most important staple foods for a large part of human population. Global rice production is 645 million tons and this huge amount of production results large amount of rice by products (Kubglomsong, Threerakulkait, 2014; Al-Okbi et al., 2014). Rice bran is the major by-product generated during the milling processing (Kubglomsong, Threerakulkait, 2014). Brown rice is resulted from dehusking of raw rice and brown rice is covered by bran layers which namely, pericarp, testa and aleurone layers. Bran is obtained by de-branning or polishing process and constitutes 5–10% of brown rice. It's mainly composed of protein, fiber, oil, vitamins, minerals and starch which come from endosperm during polishing (Al-Okbi et al., 2014). It is also a good source of antioxidants such as polyphenols, tocopherols, tocotrienols and gamma-oryzanol which help in preventing the oxidative damage of body tissues and DNA. Many studies reported that rice bran has cholesterol lowering properties, cardiovascular health benefits and anti-tumor activity (Tuncel et al., 2014a). Table 1 shows the bioactive compounds of rice bran (Friedman, 2013). Jiang and Wang (2005) have studied to determine amount of phytosterols in some cereal by- product (rice bran, wheat bran, wheat germ, oat bran, oat germ, durum wheat, corn fine fiber).

Table 1

Bioactive compounds of rice bran (Friedman, 2013)

Phenolic and cinnamic acids	Anthocyanis, flavonoids	Steroial compounds	Polymeric carbohydrates
Caffeic acids	anthocyanin monomers, dimers, andpolymers	acylated steryl glucosides	arabinoxylan
Coumaric acid	apigenin	cycloartenol ferulate	glucans
Cathecins	cyanidin glucoside	campesterol ferulate	hemicellulose
Ferulic acid	cyanidin rutinoside	24-methylenecycloartenol ferulate	
Gallic acid	epicatechins		
Hyroxybenzoic acid			
Methoxycinnamic acid	eriodtyol	γ-oryzanol	
Sinopic acid	hermnetins	β-sitosterol ferulate	
Syringic acid	hesperetin	tocopherols	
Vanillic acid	isorhamnetins, luteolin, peanidin glucoside, tricin	tocotrienol	

For this purpose total lipid of this products are extracted and sterol profiles of these extracts were analyzed by gas chromatography. Rice bran is reported as the most lipid-rich material, with 22.2% total lipid extracted on a dry weight basis. In terms of raw material, the highest phytosterol content is also obtained from rice bran with 4.5 mg/g bran. Sitosterol, campesterol and stigmasterol are determined as major phytosterols in samples however different from these components, it is indicated that rice bran oil contains very high concentrations of cycloartenol and 24-methylenecycloartanol.

In a study that determined the antioxidant activity of different variety of two bran, three different extraction solvent (methanol, ethanol and ethyl acetate) were used shows that antioxidant pyhtocompounds from rice bran with methanol produces a significantly greater yield than ethanol and ethyl acetate. Presence of tocotrienols or synergistic effect of tocopherols and tocotrienols are reported as a reason of the strong antioxidant activity (Arab et al., 2011).

Rice bran contains 12–22% oil by weight (Sharif et al., 2014). Crude rice bran oil is rich in unsaturated linoleic and oleic fatty acids and bioactive compounds such as γ-oryzanol, phytosterols, tocopherols, and tocotrienols (Friedman, 2014). In addition to nutritious components and health benefits of rice bran oil, some properties such as good stability, appealing flavour and long fry life, provides the rice bran oil in shortening (Liang et al., 2014).

In spite of being an excellent nutrient source, raw rice bran is not suitable for human consumption because of rancidity problem. This problem mainly occurred by lipases and inactivation of the deteriorative enzymes is called stabilization. The employed stabilization approaches are extrusion, micro wave treatment, ohmic heating, dry heat treatment, gamma radiation, parboiling, toasting etc. (Tuncel et al., 2014b).

To evaluate rice bran as potential food ingredients and improve quality and nutrition, several studies were attempted. Especially most of the studies are available which are related to improve flour formulation of bread. Sekhan et al. (1997) prepared leavened pan bread with addition full fat and defatted rice bran flour at 5, 10 and 15%. Reduction in loaf volume and decreasing in overall acceptability of bread are recorded. In similar study, Lima et al. (2002) used full fat and defatted rice bran to evaluated functional behaviour of bread. Results showed that bread hardness, gumminess and chewiness increase depending on level of rice bran. Cohesiveness and springiness were not affected significantly. In another study, infrared stabilized rice bran is supplemented to white wheat, wheat bran and whole grain breads at levels of 2.5, 5.0 and 10.0 % by Tuncel et al. (2014a). For all types of breads, resilience and cohesiveness showed a significant decreasing trend with the inclusion of stabilized rice bran and a strong correlation was observed between these textural attributes. Crude fat and ash content of all bread types were increased with the inclusion of stabilized rice bran. It is observed that significant and gradual increase in insoluble, and thereby total dietary fiber content of pan breads. The same researchers also evaluated the effects of rice bran addition on the content of B vitamins, minerals and phytic acid content of breads. In all type breads, mineral, phytic acid and vitamin B content is significantly increased especially niacin. It is recorded that the antinutritive content of phytic acid should be taken into account (Tuncel et al., 2014b).

In production of corn flakes and tortilla chips, gelatinized corn flour was supplemented with rice bran from 10 to 30%. It was observed that the maximum breakdown viscosity and color quality was affected and sensory parameters decreased. Percentage of protein increased depending on the level of rice bran (Al-Okbi, 2014).

De delahaye et al. (2005) used stabilized rice bran flour in order to enrich wheat flour as a source of dietary fiber, in the preparation of frozen pizza and they also evaluated physical, chemical rheological and sensorial characteristics of the pizzas during the storage period of 2 months at -18 °C. It is observed that increasing the stabilized rice bran content results increase crude fat, ash and dietary fiber content of pizza dough. It is reported that the farinographic curves of pizza dough shows the development time, water absorption and stability decreased, while mixing tolerance index and departure time is not affected by enrichment level.

Conclusion

Phytosterols are defined as plant sterols which have important bioactive properties for human health. Because of lowering cholesterol level in blood, antibacterial, antifungal and antiulcer effects, phytosterols are being used in pharmaceutical and food industry. Rice bran as a by product of milling industry is a good source of phytosterols and also generally used as animal feed. Considering the amount of rice production in the world, the amount of by products will also be high level. In order to adding value to by product and producing healthy food, usage of rice bran is available. Due to nutritional profile, functional characteristics, apparent hipoallergenicity, it has many applications in a diet. In addition to them, using with different bioactive compounds might be able to provide multifunctional foods.

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