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Rice bran: Nutritional values and its emerging potential for development of functional food—A review

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ABSTRACT

Rice bran is a by-product of rice milling industry and constitutes around 10% of the total weight of rough rice. It is primarily composed of aleurone, pericarp, subaleurone layer and germ. Rice bran is a rich source of vitamins, minerals, essential fatty acids, dietary fiber and other sterols. There is a widespread scientific agreement on various health benefits associated with consumption of dietary fiber. Consumer attitude towards health foods is promising and the scope of functional foods is growing in the world markets; rice bran is finding increased applications in food, nutraceutical and pharmaceutical industries. However, potential applications of rice bran in food industry are limited by its instability owing to rancidity caused by exposure of oil to lipases during milling. Various methods of stabilization have been carried out, paving way for supplementation of rice bran in numerous food preparations. Considering the importance of rice bran, this review aims to focus on the functionalities of rice bran, its health benefits and potential applications in food industry.

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1. Introduction

Rice (*Oryza sativa* L.) is an important cereal crop and a staple food for more than half of the world's population (Wani et al., 2012). Its importance to the world population's dietary requirements is evident from the presence of rice in the diet of a quarter of world's population. The global rice production in year 2010 stood at 696324394 t (FAOSTAT, 2012) and India ranks second amongst the top rice growing counties in the world. Rice is an important energy source with versatile functional properties. There is a need for the rice grains to undergo several processing steps before being consumed as food. Rice processing involves various steps like cleaning, hulling and post hulling processing (whitening, polishing and grading). Processing of rice produces

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several streams of materials such as husk, milled rice, and bran. Milling of paddy yields 70% of rice (endosperm) as the major product and byproducts consisting of 20% husk, 8% bran and 2% germ (Van Hoed et al., 2006).

Rice bran, a by-product of rice milling, is obtained from outer layer of the brown (husked) rice kernel during milling. Of the total weight of rough rice, bran constitutes around 10% (Hu, Wells, Shin, & Godber, 1996). Each year 90% of the rice bran produced in the world is utilized cheaply as a feed stock for cattle and poultry and the remainder is used for extraction of rice bran oil (Schramm, Alicia, Hua, Xu, & Lima, 2007; Zullaikah, Melwita, & Ju, 2009). Rice bran has very short shelf life owing to high fat content and potent enzyme lipase which degrades the oil, making bran rancid and inedible. Stabilization of rice bran by various means is carried out to enhance the stability of rice bran by inactivation of enzyme lipase, for possible applications in food industries. Rice bran is rich in antioxidant compounds like polyphenols, vitamin E, tocotrienols and carotenoids that help prevent the oxidative damage to DNA and other body tissues (Jariwalla, 2001).

Rice bran is finding enormous applications in food industries for increasing the nutritional quality of processed foods. Rice bran being high in dietary fiber and in view of its therapeutic potential, its addition can contribute to the development of value-added foods or functional foods that currently are in high demand. Supplementation of rice bran has been successfully carried in various foods like bread, cakes, noodles, pasta, and ice creams without significantly affecting the functional and textural properties. This review describes the functionalities and health benefits of rice bran. Supplementation of rice bran in various foods is also discussed.

2. Rice bran and its composition

Rice contains 80% carbohydrates, 7–8% proteins, 3% fat and 3% fiber (Juliano, 1985) and rice grain contains 5% bran, of which 12–18.5% is oil (Saikia & Deka, 2011). Rice bran is a mixture of bran (brown layer) and germ which is produced as a by-product during the milling process in the production of white rice from brown rice. It is a good source of proteins, minerals, fatty acids and dietary fiber (Mccaskill & Zhang, 1999). Rice bran representing 5–8% of the total grain contains minerals including iron, phosphorus and magnesium, 11% and 13% crude protein, approximately 11.5% of fibers and good amount of oil because it may contain 20% of its weight in oil (Oliveira et al., 2011). Chemical properties of rice bran and rice bran fiber are summarized in Table 1.

Composition of rice bran varies with the rice type, climatic conditions and rice processing methods (Grist, 1985). Chemical profiles of rice bran also differ with respect to rice variety. Rice bran, a valuable byproduct contains a large quantity of essential nutrients such as minerals, vitamins, fiber, amino acids and antioxidants (Younas, Bhatti, Ahmed, & Randhawa, 2011). Rice bran is potentially a valuable source of natural antioxidants such as tocopherols, tocotrienol and oryzanol (Godber & Wells, 1994). Full fat rice bran contains 18–22% oil including an array of bio-active phytochemicals such as oryzanols, phytosterols, tocotrienols, squalene, polycosanols, phytic acid, ferulic acid, and inositol hexaphosphate to mention a few (Ardiansyah et al., 2006; Khatoon & Gopalakrishna, 2004; Osawa, 1999). Tocols and oryzanols are the main antioxidants present in the rice bran with oryzanols having 10 times higher antioxidant activity than tocopherols, while tocotrienols have 40–60 times greater antioxidant power than tocopherols (Abdel-Aal & Hucl, 1999). The proportion of these phytochemicals varies with the type of rice cultivar (Iqbal, Bhanger, & Anwar, 2005). Chemical characteristics and functional properties of dietary fiber obtained from rice bran are presented in Table 2.

3. Stabilization of rice bran

Although being an excellent nutrient source, rice bran is not suitable for human consumption due to the rancidity caused by presence of lipases. While removing bran layers from the endosperm during milling, the individual cells are disrupted and lipase enzymes come into contact with fat causing hydrolysis to free fatty acids (FFA) and glycerol (Malekian et al., 2000). Additionally, various antinutritional factors present in rice bran limit its use as a food ingredient. The factors include trypsin inhibitors, heamagglutinin–lectin and phytates (Younas et al., 2011). However, stabilization, an enzyme inactivation process, is widely employed to extend the shelf life of rice bran, enabling incorporation of rice bran back into our diet.

Studies have shown that all undesirable factors except phytates present in bran are proteinicious in nature, therefore, mild acid and alkali treatment and thermal cooking can denature these proteins (Jiaxun, 2001). Different techniques are employed for rice bran stabilization (Table 3). A simple chemical method for stabilization of rice bran has been reported by Prabhakar and Venkatesh (1986). The process is based on the principle that lipase activity is low at low pH, using hydrochloric acid the pH can be lowered from 6.9 to 4.0. This simple method can be used for stabilization and takes less than 4 min for a batch of 15 kg. Younas et al. (2011) reported acid treatment and heat treatment for the stabilization of rice bran for development of cookies. Ajmal, Butt, Sharif, Nasir and Nadeem (2006) reported that steaming at a temperature of 93–104 °C for 5–10 min can effectively inactivate the residual lipase activity. Autoclaving by using a commercial retort at 120 °C for 20 min and par boiling by soaking for 2 h and steaming for 20 min followed by drying, are also effective methods for the stabilization of rice bran and help retain its nutritional contents (Rosniyana, Hashifah, & Shariffah, 2009).

Table 2
Chemical characteristics and functional properties of dietary fiber obtained from rice bran. (Adapted from: Fadaei and Salehifar (2012).)

Chemical characteristics	Value	Functional properties	Value
Protein (%)	2.53	Water binding capacity (WBC)	8.00 (ml/g)
Ash (%)	19.17	Oil binding capacity (OBC)	3.50 (ml/g)
Moisture (%)	1.27		

Table 1
Chemical properties of rice bran and rice bran fiber. (Adapted and modified from Choi et al. (2011).)

Parameters	Moisture (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)	Digestible carbohydrates (g/100 g)	Dietary fiber (g/100 g)	pH	*L*	*a*	*b*
Rice bran	12.12 ± 0.25	12.32 ± 0.24	20.31 ± 0.92	8.73 ± 0.08	17.92 ± 0.26	28.60 ± 0.32	6.85 ± 0.10	68.85 ± 0.18	3.49 ± 0.05	18.07 ± 0.081).
Rice bran fiber	11.73 ± 0.32	21.91 ± 0.43	4.31 ± 0.43	7.42 ± 0.24	1.38 ± 0.18b	53.25 ± 0.79	7.07 ± 0.04	66.10 ± 0.20	4.73 ± 0.04	16.06 ± 0.06