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Review Article

ROLE OF RICE BRAN IN PHARMACEUTICAL INDUSTRY AND ITS APPLICATION

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ABSTRACT

Rice bran, a byproduct of rice milling, has gained significant attention in the pharmaceutical industry due to its rich nutrient profile and bioactive components. It contains essential fatty acids, vitamins, minerals, and a variety of phytochemicals, including antioxidants, flavonoids, and phenolic compounds. These components contribute to its potential therapeutic properties, such as anti-inflammatory, antidiabetic, anticancer, and cardioprotective effects. The versatility of rice bran makes it an excellent candidate for developing novel drug delivery systems, including nanoparticles, microcapsules, and hydrogels. Additionally, rice bran oil, extracted from the bran, is used as a carrier in pharmaceutical formulations due to its stability and biocompatibility. This review explores the various applications of rice bran in the pharmaceutical industry, highlighting its role in enhancing drug efficacy, improving bioavailability, and contributing to sustainable pharmaceutical practices.

Keywords: Rice Bran, Pharmaceutical Industry, Bioactive Components, Drug Delivery Systems

INTRODUCTION

Rice (*Oryza sativa* L.) is a major of dietary foods (about 60% of world's population) and identified as important group of cereal crops in the world, especially for people in Asia as well as outside Asia (Wayne and James, 1994). Rice is rich genetic diversity, with thousands of varieties grown throughout the world.The major rice production from statistical data was found in Asia (Major producers: China, India, Indonesia, Bangladesh, Vietnam and Myanmar) which producing alone more than 75 percent (506×106 tonnes) of rice world production (FAO, 2012). Besides that, the regular rice consumptions can be processed into various products as well, for example: rice flour, rice noodle, used as ingredient in baked products and producing the alternative healthy beverage etc. During the milling process, rough rice is milled to produce polished edible grain and removal of brownish layer. This process generates agricultural waste as a by-product (rice bran and rice hull) (Friedman, 2013).

Rice bran (RB) is identified as a by-product from agricultural waste. RB presents some good properties for human health such as antioxidant, antibiotic as well as anti-cholesterol. Currently, RB has been used for animal feed, rice bran oil extraction, wax production, and used as a food ingredients (Watchararuji *et al*., 2008). There are several countries that are more consider to increasing the value of RB by developing the whole RB for many food products. One product is made from whole RB to be healthy beverage which interesting thing because it can be alternative of beverage market for health concern consumers.

Rice bran

The whitening or pearling process applied to brown rice produces bran, a finely pulverized material composed of the pericarp, aleurone, crushed germ, and some fragments of the endosperm (Saunders, 1985). The final composition and the chemical and physical proprieties of rice bran change on the basis of the rice variety, the growing conditions, but also on the type and type of milling system. Rice bran is considered a healthy food, due to its high concentration of nutraceutical compounds. Rice bran in fact contains about 60% of all the nutrients of the entire rice grain (Begum *et al*., 2015). It incorporates around 11–17% of proteins, 12–22% of oil, 6–14% of fiber, 10–15% of moisture, and 8–17% of ash, and it is rich in micronutrients, such as vitamins, and in minerals, such as aluminum, calcium, chlorine, iron, magnesium, and manganese. It contains high nutritional value proteins that are abundant in essential amino acids. Rice bran is a source of dietary fiber, and the lipidic fraction is rich in polyunsaturated fatty acids and contains significant quantities of bioactive and antioxidant compounds, such as γ-oryzanol, tocotrienol, and tocopherols (Sharif *et al*., 2014).

Despite all of these attractive properties of rice bran, millions of tons of this by-product are wasted every year or employed as low-quality animal feeds (Dubey *et al*., 2019). This incredible waste of high-grade food is due to the instability of rice bran, and its tendency to become rancid because of its natural lipase enzyme that catalyzes the hydrolysis of oil into glycerol and free fatty acids (Saunders, 1985). The use of rice bran is only possible after a stabilization process to deactivate the lipase; such a step limits the rancidity and helps to maintain the quality of rice bran during storage. Several techniques exist and have been studied for bran stabilization: these include parboiling, chemical methods, stove toasting methods, ohmic heating techniques, retained moisture heating, added moisture heating, dry heating under atmospheric pressure, extrusion cooking, microwave heating, and infrared heating. Many researchers agree that the most effective of the aforementioned methods is microwave heating, an inexpensive and fast method that generates a product with a low range of free fatty acid that remains stable over time (Jiang, 2019). After stabilization, rice bran can be employed directly or can be subjected to other processes in order to obtain high-value products for food, nutraceutical or pharmaceutical industry applications. One of the most popular and commercialized products derived from the processing of rice bran is rice bran oil.

Industrial processing of rice bran, in order to obtain phytochemical-rich fractions

γ-Oryzanol is an important value-added co-product of rice bran processing. Therefore, research to improve the recovery of γoryzanol and other phytochemicals in order to obtain fractions enriched in a particular compound or group of compounds, has been conducted. Within this concern, particular attention has been paid to brown rice milling and Rice bran oil extraction and refining by either physical or chemical techniques. Relatively novel procedures involve the use of SC-CO_2, subcritical water and enzymes (Lerma *et al*., 2009).

Health benefits of rice bran

Natural products obtained from plants have been used as a prominent source of prophylactic agents for the prevention and treatment of diseases in humans and animals. Nutraceuticals including phytochemicals are perceived as offering some of the greatest opportunities for improving human health. Phytochemicals of dietary and non-dietary origin have been the focus of researchers in the recent past because of their potential to counter various diseases. Rice bran contains phytochemicals with promising health benefits.Rice bran oil rich in natural antioxidants may play a role in reducing the risk of chronic diseases (Suman *et al*., 2020).

Uses of rice bran

Rice bran has several unique properties that render its suitability for niche markets like nutraceutical and pharmaceutical industry. One such feature is the presence of significant levels of minor-elements such as oryzanol, tocotrienol and phytosterols that have a large nutraceutical application. They are used in the development of value-added healthy products. Gamma oryzanol has been found to have higher antioxidant action in comparison with tocopherol. Gamma oryzanol comprises of ferulic acid esters of sterols and triterpene alcohols. The ferulic acid esters are campesterol, stigmasterol, and beta-cytosterol and the triterpene alcohols are cycloartenol, cycloartanol, 24- methylenecycloartanol and cyclobranol (Bucci *et al*., 2002; Piironen *et al*., 2000). Due to its antioxidant action, it is drawing immense interest in research world as a food additive. It has been cited as ‘oxidation inhibitor’ in the ‘food additive list’ (Hu *et al*., 1996).

Composition of rice bran

Rice bran is the rice grain's outer covering, produced by the rice milling process. It has a rich composition of different phytochemical compounds. These phytochemicals include various phenolic compounds, vitamins, flavonoids, steroidal compounds, and polymeric carbohydrates. Due to these phytochemicals, rice bran has high economic importance (Friedman, 2013). However, a large portion of the population is still not aware of the benefits of rice bran. Rice bran also produces various products like bran oil, medicines, and animal food. The primary use of rice bran is the production of bran oil. Rice bran oil is expected to have about 23% saturated fatty acids, 44% oleic, and 30% linoleic acid (Latha and Nasirullah, 2014).

Phenolic compounds in rice bran: Phenolic compounds are considered secondary metabolites and consist of one or more aromatic rings having at least hydroxyl groups. These phenolic compounds play different vital roles in various metabolic pathways. These are included in the antioxidant pathways to neutralize oxidative stress conditions. Apart from antioxidative, these are also involved in anticarcinogenic, anti- inflammatory, and antimutagenic activities, which elucidated the importance of phenolic compounds in disease prevention or cure (Roleira *et al*., 2018).

Flavonoid compounds in rice bran: Flavonoids are the secondary metabolites found naturally in plants. It is considered a group of substances with variable phenolic structures. These compounds are known for their beneficial role in human health. These have a wide range of applications in various industries like nutraceutical, pharmaceutical,

medicinal, and cosmetics (Panche *et al*., 2016). Rice bran is considered a rich source of several flavonoid compounds, which enhances the therapeutic significance of rice bran. Common flavonoid compounds in rice bran are catechin, myricetin, quercetin, apigenin, and luteolin (Ghasemzadeh *et al*., 2018).

Phytoactive compounds in rice bran: Steroidal compounds are a critical class of natural products involved in different physiological processes. Steroidal compounds generally have a distinct structure of four carbon rings called steroid nucleus. The addition of diverse chemical groups to this steroid nucleus at different positions leads to synthesizing various steroidal compounds (Benveniste, 1986; Yokota, 1997). These steroidal compounds regulate distinct physiological processes because of which they are used in different industries like medicine, pharmaceutical, and agrochemicals (Patel and Savjani, 2015).

Polymeric carbohydrates: Carbohydrates are the primary energy source for our body and are found in nearly all food products like fruits, grains, vegetables, milk, and so forth. Rice bran also contains carbohydrates in polymeric form. (Choi *et al*., 2011) reported that rice bran contains approximately 17.92 g of digestible carbohydrates per 100 g. Common polymeric carbohydrates in rice bran are hemicellulose, glucans, and arabinoxylan (Friedman, 2013).

Fundamental medicinal properties of rice bran

Anticancerous activity: Anticancerous activity generally represents the potential of any given substance to prevent or inhibit cancer. Rice bran extract and fermented rice bran have been reported to show anticancerous activity and prevent cancer through the regulation of different pathways: reducing inflammatory reactions, improving the chemoprotective effect, promoting cell cycle arrest, and cell apoptosis (Yu *et al*., 2019).

Anti-inflammatory activity:

Anti-inflammatories are substances that inhibit cell swelling or inflammation, and this activity is known as anti-inflammatory activity. Rice bran is composed of various phytoactive compounds that show anti-inflammatory activities (Sapwarobol *et al*., 2021). It has been found that the addition of rice bran extract to the diet could enhance the inflammation system in obese objects (Haldar *et al*., 2020; Ito *et al*., 2015). The potent anti-inflammatory activity of γ-oryzanol-rich rice bran extracts. They further suggested that γ-oryzanol could show anti-inflammatory activity via inhibiting the NO production in RAW 264.7 mouse macrophage cell line (Chalermpong *et al*., 2012).

Antidiabetic properties:

Broadly, the property of a compound to lower the abnormal sugar level in the blood is called an antidiabetic property. Rice bran is composed of various phytoactive compounds, which show antidiabetic properties (Sivamaruthi *et al*., 2018).

Antihypertensive property:

Hypertension is an abnormal condition in which blood pressure rises more than normal. Prolonged hypertension can lead to heart failure or damage to the kidney, brain, eyes, and so forth (Winters and William 2024). Rice bran oil can be used as an antihypertensive substance due to the presence of various phenolic compounds and antioxidant fatty acids (Punia *et al*., 2021).

Cholesterol-lowering activity:

Hyperlipoidemia or hypercholesterolemia is a chronic abnormality characterized by a high level of blood lipids. Clinical index values such as triglyceride, total cholesterol, and high and low-density lipoprotein (LDL) cholesterol are used to diagnose hyperlipoidemia. Rice bran protein and rice bran protein hydrolysate have been found to be effective in decreasing cholesterol levels (Yu *et al*., 2022). In vitro assay and reported that rice bran protein inhibits the micellar solubility of cholesterol through binding to the bile acids (Wang *et al*., 2015). It is also elaborated that the hydrophobic portion of rice bran protein hydrolyzed with trypsin, papain, neutrase, and alcalase possess an inhibitory activity on the micellar cholesterol (Zhang *et al*., 2012).

Immunomodulatory Activity:

The rice bran water-soluble polysaccharide fractions showed similar or higher anti-complementary activity potency compared to water-soluble polysaccharides isolated from *Angelica acutiloba* and *Glycyrrhiza uralensis,* which have been proven to have better immunomodulatory effects (Yamagishi *et al*., 2003). Similarly, also showed that rice hull polysaccharides (RHPS) exert immunomodulatory effects by enhancing the levels of natural antibodies (IgG, IgM, and IgA), cytotoxicity of splenic natural killer cells (NK cells), phagocytosis by macrophages, and induction of cytokines (IL-2, IFN-γ) (Yang *et al*., 2015).

Antioxidant property:

The antioxidants at cellular and molecular levels are known to deactivate the natural by-products of the oxidative metabolism that are popularly known as free radicals (Patel and Naik, 2004). The minor components of the rice bran i.e. gamma oryzanol, phytosterols and other phytosterol conjugates are examined to have antioxidant property against the free radicals (Kochhar, 2000). All these factors can be used to develop nutraceuticals and other food ingredients from the chemically suitable and biologically functional compounds of the rice bran that are known to have antioxidant properties (Fukushi, 1966).

Products of Rice Bran

Rice Bran Wax: Wax is an ester of long chain carboxylic acid and a long chain alcohol. During rice bran oil (RBO) extraction a certain amount of wax is obtained by the dewaxing step of refining process and the amount varies with conditions of extraction like source and history of rice bran, solvent used and extraction temperature. Rice bran wax (RBW) can be distinguished as hard wax (38.5%) and soft wax (11.2%). The potential applications of rice bran wax (RBW) can be realized in pharmaceutical, food, cosmetic, polymer and leather industries (Buffa, 1976; Ito, 2003).

Rice Bran Oil: Rice bran oil is the oil extracted from the hard outer brown layer of rice after chaff (rice husk). Rice bran oil is unique among edible oils due to its rich source of commercially and nutritionally important phytoceuticals such as oryzanol, lecithin, tocopherols and tocotrienols. The mechanism of the hypocholesterolemic effect of rice bran oil (RBO) and β-oryzanol is through decreasing cholesterol absorption in the intestines and increasing fecal cholesterol excretion (Seetharamaiah and Chandrasekhara, 1989).

Application

Rice bran resources are abundant, cheap, and easy to obtain. The development of rice bran polysaccharides is one of the most effective methods of deep processing and utilization of rice bran resources. Rice bran polysaccharides are beneficial for health and can be used in medicine, health products, beverages, food, and in other fields.

Industry Field

Rice bran is rich in nutritional value and contains a high level of protein. It is often used as a supplementary energy source for animal feed in livestock and poultry farming. Surprisingly, rice bran polysaccharides have a larger role in the feed industry (Chen *et al*., 2023). Polysaccharide-rich fermented rice bran extract (FBE) could improve broiler growth performance, increase bone strength, and improve immunity (Zheng *et al*., 2017). They also studied the complementary effect of FBE on piglets' intestinal health and growth, and reported that adding FBE to the diet improved growth by reducing the occurrence of diarrhea, as well as by reducing oxidative stress in the small intestine. Additionally, rice bran polysaccharides could be used as fermentation liquids and emulsifiers in the industry. Huang et al. demonstrated that modification of whey protein isolate solution (WPI) with rice bran polysaccharides enhanced the synergistic effect of both components and optimized the functional properties of WPI, such as emulsification, heat resistance, and acid resistance, thus resulting in efficient and stable new emulsifiers (Huang *et al*., 2022).

Medical Field

In addition, it is worth mentioning that the pharmacological activities of rice bran polysaccharides have been patented (Liu *et al*., 2019; Xie *et al*., 2021). For instance, patent "CN109879980 Preparation method for rice bran polysaccharide metal complex, and antioxidant" and patent "CN111718971 Rice bran polysaccharide with lipid-lowering activity and preparation method of rice bran polysaccharide" showed the antioxidant and hypolipidemic therapeutic effects of rice bran polysaccharides (Liu *et al*., 2018). Rice bran polysaccharides can also be used in the field of drug-carrying systems (Huang *et al*., 2020). Interestingly, rice bran polysaccharides primarily exert their medicinal effects in the form of oral tablets, oral liquids, injections, and soluble powders (Hong, 2017; Niu *et al*., 2015).

Table 1: Formulation made from rice bran and its results

Formulation	Result of formulation	References
Cosmetic products	Cosmetic products are rich in antioxidants, stable, and free from heavy metals and microbial contamination.	(Chaiyasut *et al*., 2018)
Oil mask	Successfully prepared rice bran oil mask formulations from chitosan blended with different polymer and usage of rice bran oil mask formulation with good viscosity.	(Suksaeree *et al*., 2014)
Cream	Antioxidant cream formulation of white rice bran extract showed good physical properties evaluation results.	(Suhery *et al*., 2023)

Rice Bran Oil (RBO) microcapsules	The optimum condition of RBO microcapsules are 40:50:10 (RBO: Sodium alginate:emulgator).	(Nashihah *et al*., 2018)
Peel-off Gel Mask	The physical properties of the most well during 8 weeks of storage and highest antioxidant activity than the other formulas with percent inhibition 88.81%	(Suhery and Anggraini, 2016)

CONCLUSION

Rice bran holds immense potential in the pharmaceutical industry due to its diverse bioactive components and multifunctional properties. The rich composition of essential fatty acids, vitamins, minerals, and phytochemicals endows rice bran with various therapeutic benefits, including anti-inflammatory, antidiabetic, anticancer, and cardioprotective effects. These properties make it a valuable resource for developing innovative drug delivery systems such as nanoparticles, microcapsules, and hydrogels, which can enhance drug efficacy and bioavailability. Moreover, rice bran oil serves as a stable and biocompatible carrier in pharmaceutical formulations, further extending its utility. The incorporation of rice bran and its derivatives into pharmaceutical applications not only improves the therapeutic outcomes but also supports sustainable practices by utilizing a byproduct of rice milling.

DECLARATION OF INTEREST

The authors declare no conflicts of interests. The authors alone are responsible for the content and writing of this article.

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