Review

NUTRITIONAL ROLE OF RICE BRAN IN CARDIOVASCULAR HEALTH

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ABSTRACT

Cardiovascular diseases are a major cause of death globally, including in Vietnam. In recent years, there has been a rise in younger people developing cardiovascular diseases due to unhealthy lifestyles and diets. The rice bran, a byproduct of rice milling, was traditionally used as animal feed. However, recent research has shown that rice bran contains valuable nutrients such as lipids (15-22%), carbohydrates (34.1-52.2%), fiber (7-14%), and protein (10-16%), as well as beneficial bioactive compounds like flavonoids, ferulic acid, policosanol, and feruloylated oligosaccharides. These components have demonstrated potential in preventing and managing cardiovascular diseases. This review presents the nutritional components of rice bran, available rice bran products on the market, and research on its impacts on cardiovascular health, suggesting its potential incorporation into food products to mitigate cardiovascular disease risk.

Keywords: *rice bran, chemical composition, cardiovascular diseases.*

I. INTRODUCTION

Cardiovascular diseases (CVDs) are a group of disorders of the heart and blood vessels. They include coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, and deep vein thrombosis and pulmonary embolism [1]. The World Health Organization reported that in 2019, CVDs accounted for 39.5% of deaths globally. In Vietnam, data from the Ministry of Health indicates a rising number of CVD cases over the years, with mortality rates increasing from 127.3 per 100,000 people in 2000 to 164.9 per 100,000 people in 2022 [2]. CVDs are the leading cause of death in Vietnam, accounting for approximately 200,000 deaths annually, or 33% of all fatalities (Vietnam Ministry of Health, 2023). These alarming statistics highlight the urgent need for effective interventions and public health strategies to prevent and manage CVDs in Vietnam [57]. Presently, cardiovascular diseases are not only the leading cause of death but also increasingly affect younger individuals, with myocardial infarctions occurring more frequently in people in their 30s and hypertension affecting 16.5% of those under 40 [3]. The rising incidence of cardiovascular diseases among younger populations can be attributed to unhealthy habits, lifestyles, and diets such as high consumption of animal fats, processed foods, and stimulants like alcohol and tobacco.

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Doi:10.56283/1859-0381/781

Submitted: August 30, 2024
Revised: December 2, 2024
Accepted: December 9, 2024
Published online: January 9, 2025

High-risk individuals often include those with overweight or obese, large waist circumference, and dyslipidemia, particularly smokers [3].

Preventing CVDs requires addressing major behavioral risk factors. The World Health Organization (WHO) recommends:

-Avoiding tobacco use: smoking is a major risk factor for CVD. Quitting smoking and avoiding exposure to second-hand smoke can significantly reduce the risk [58];

-Maintaining a healthy diet: consuming plenty of fruits, vegetables, whole grains, and nuts while limiting saturated fats, trans fats, salt, and sugar can help prevent CVD. WHO recommends eating at least 400 grams of fruits and vegetables per day and reducing salt intake to less than 5 grams per day [58];

-Engaging in regular physical activity: participating in at least 150 minutes of moderate-intensity physical activity per week is recommended to maintain cardiovascular health [58].

Rice bran (RB), a rice milling by-product, is a nutrient-rich cereal flour containing 15-22% lipids, 34.1-52.2% carbohydrates, 7-14% fiber, 6.6-9.9% ash, and 10-16% protein [4]. Additionally, rice bran contains both soluble and insoluble fibers, vitamins especially B vitamins and minerals [5]. The primary fats in rice bran are short-chain and unsaturated. Furthermore, its protein comprises nearly all essential amino acids required by the body, such as lysine, histidine, threonine, triptophan, valine, methionine, isoleucine, leucine, and phenylalanine [6].

Recently, rice bran has garnered interest for its numerous health benefits. Studies have shown that rice bran's benefits include protecting and preventing intestinal immune system disorders, improving bowel dysfunction, lowering blood lipid levels, controlling blood glucose levels, and guarding against certain cancers and cardiovascular diseases. Beyond improving bowel dysfunction, rice bran's role in disease prevention and protection is of significant research interest. Multiple studies indicate that rice bran can reduce CVD risk. This article aims to summarize the rice bran’s role in cardiovascular health and elucidate its components that lower cardiovascular disease risk.

II. METHODS

Research articles, short communications, and reviews from PubMed (https://pubmed.ncbi.nlm.nih.gov) and HINARI (https://hinari.summon.serialssolutions.com), encompassing experimental studies, clinical trials, and survey data, were selected.

Keywords used for the literature search were: rice bran, rice bran composition, rice bran protein, rice bran oil, rice bran and cardiovascular disease, rice bran and heart health.

III. NUTRITIONAL ROLE OF RICE BRAN IN CARDIO-VASCULAR HEALTH

3.1. Rice bran protein

Rice bran protein, although comprising 10-16% of rice bran, exhibits significantly nutritional and functional properties comparable to proteins in other grains. The protein fraction in rice bran includes albumin (37-40%), globulin (21-36%), prolamin (3-5%), and glutelin (22-36%) [6, 7].

Antihypertensive effects: rice bran protein and its hydrolysates have been found to exhibit antihypertensive properties. Peptides such as Tyr-Tyr and Tyr-Ser-Lys are reported to inhibit angiotensin-converting enzyme (ACE), contributing to blood pressure reduction [10, 55]. Thermolysin-digested rice bran (TRB), protease G6-digested rice bran, and trypsin-digested rice bran have also been shown to lower systolic blood pressure (SBP) in experimental models [51, 55]. Additionally, a clinical trial demonstrated that rice bran containing the novel peptide Leu-Arg-Ala significantly reduced SBP in hypertensive individuals without adverse effects [10].

Antidiabetic effects: peptides derived from rice bran protein can inhibit amylase, α-glucosidase, β-glucosidase, and dipeptidyl peptidase-IV (DPP-IV), suggesting potential benefits in managing blood glucose levels [52].

Cognitive improvement: rice-memolin, a pentapeptide derived from rice bran protein, has shown cognitive enhancement in animal studies. It promotes neurogenesis and the expression of neurotrophic factors in the hippocampus, which may aid in mitigating cognitive decline [51].

Antimicrobial properties: peptides from rice bran protein exhibit antimicrobial properties, potentially acting against various bacterial strains [52].

Enhancement of iron availability: peptides derived from rice bran protein improve iron bioavailability, enhancing nutritional outcomes [53].

3.2. Rice bran oil

For many years, health organizations have advocated and encouraged people to reduce their intake of saturated fat to lower the risk of coronary heart disease [14, 15]. The reason is that saturated fats can raise blood cholesterol levels more than polyunsaturated fats [16]. Rice bran oil (RBO) contains a high amount of monounsaturated fatty acids (42%) and polyunsaturated fatty acids (40%; 38% omega-6 fatty acids and 2% omega-3 fatty acids), with a low level of saturated fat (18%) [17]. Studies have reported that dietary supplementation with RBO can reduce total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG) while increasing high-density lipoprotein cholesterol (HDL-C) levels in the blood. Therefore, commercial RBO products offer potential health benefits for managing

hypercholesterolemia [18]. Research indicates that incorporating rice bran oil into daily diets reduces serum cholesterol levels and LDL cholesterol fractions. Rice bran oil may benefit heart disease patients, as a 1% cholesterol reduction can lower heart attack risk by 2% [19]. Additionally, the ratio of SFA: MUFA:PUFA in rice bran oil is close to the recommended 10:15:10 ratio by the American Heart Association for patients with cardiovascular conditions to prevent hypertension, atherosclerosis, and high cholesterol [20, 21]. Dietary adjustment is the most effective initial treatment for hyperlipidemia and atherosclerosis. A diet rich in cholesterol-lowering phytochemicals and antioxidants significantly reduces atherosclerotic lesion formation [22].

Today, the use of rice bran oil as a cooking oil has become increasingly popular among consumers due to its anti-inflammatory, anti-dyslipidemic, and anti-thrombotic properties (Table 1). Rao and SUGASini [35] have demonstrated that the unsaponifiable fraction of rice bran oil significantly contributes to its anti-inflammatory activity. Inflammatory mediators such as ROS (O_2 and NO_2), eicosanoids (PGE2, TXB2, LTB4, and LTC4), cytokines (TNF-α and IL-6), and hydrolytic enzymes (collagenase, elastase, and hyaluronidase) were significantly reduced in isolated peritoneal macrophages from male Wistar rats fed crude rice bran oil containing saponifiable fractions [35]. Francisqueti and Minatel [35] investigated the therapeutic effects of γ-oryzanol derived from rice bran oil in preventing cardio-renal metabolic syndrome. Wistar rats fed a high-fat diet for 20 weeks, with or without γ-oryzanol supplementation, showed that the γ-oryzanol-supplemented diet prevented weight gain, increased blood triglycerides, and improved systolic and diastolic function [36].

In humans, testing the effects of supplementing diets with palm oil, rice bran oil, and coconut oil in subjects with normal blood lipid levels revealed an increased susceptibility to excessive chylomicron development (small fat particles that transport lipids to tissues) in response to meals rich in saturated fatty acids from palm oil, thereby raising the risk of atherosclerosis [37]. However, those consuming rice bran oil or coconut oil did not develop atherosclerosis risk factors [37]. In hyperlipidemic patients, a diet supplemented with rice bran oil has been shown to reduce body weight, body mass index, waist circumference, and hip circumference [38], as well as total cholesterol, LDL cholesterol, and the atherogenic index of total cholesterol/HDL cholesterol [38]. Kuriyan and Gopinath [39] also confirmed that rice bran oil significantly reduced total cholesterol and triglycerides in the plasma of hyperglycemic patients compared to common cooking oils like sunflower oil. Additionally, mixing rice bran oil with other cooking oils such as sesame oil [40, 41] or palm oil [42] also shows so.

From the information above, it is evident that rice bran contains components that can intervene and protect cardiovascular health. Further studies needs to be done *in vitro* and *in vivo* studies on the bioactive compounds of rice bran.

Table 1. *Cardioprotective roles of in vitro and in vivo bioactive compounds derived from rice bran.*

Compound/Source	Methods	Key Findings
Rice Bran Enzyme Extract [43–45, 47]	*In vivo* animal studies (ApoE–/– mice, Zucker rats, Wistar rats)	- Reduced serum lipids, atherosclerotic plaque development, hepatic steatosis, and inflammation - Improved endothelial function and increased antioxidant activity
Feruloylated Oligosaccharides [31]	*In vitro* culture (RAW264.7 cells)	- Increased IL-10; decreased TNF-α, IL-1β, IL-6, NO, and PGE2
Rice Bran Policosanol [32]	*In vivo* (Sprague-Dawley rats)	- Reduced platelet adhesion and cellular protein secretion
Resveratrol and Rice Bran Blend [46]	*In vivo* (Sprague-Dawley rats)	- Reduced infarct size, increased survival signaling, and enhanced anti-apoptotic protein activity
Bioactive Rice Bran Peptides [49]	*In vitro* (HUVECs)	- Reduced H2O2-induced cell death and oxidative stress
Hydrolyzed Rice Bran Protein [50–51]	*In vivo* (Sprague-Dawley rats, renovascular hypertension model)	- Improved endothelial function, reduced hypertension, hyperglycemia, and insulin resistance
Rice Bran Oil [52–54]	*In vivo* (Wistar rats, human studies)	- Reduced inflammatory mediators, improved lipid profiles, and decreased atherosclerosis risk - Lowered LDL, triglycerides, and C-reactive protein levels
Rice Bran Blends [40–42]	*In vivo* (human studies, hypertensive and hyperlipidemic participants)	- Lowered LDL, total cholesterol, triglycerides; improved HDL levels

3.3. Biologically active compounds

Atherosclerosis is one of the most significant conditions in CVDs, characterized by the accumulation of plaques on arterial walls. This leads to the hardening and narrowing of arteries, impairing blood circulation [23, 24]. The underlying cause of atherosclerosis involves the dysfunction of endothelial cells that line the inner surface of blood vessels [25], which is triggered by free radicals, adhesive molecules (reactive nitrogen species, reactive oxygen species), inflammatory factors, and thrombosis-promoting agents [26].

Additionally, the interaction between the endothelium, leukocytes, and inflammatory mediators such as ICAM-1, VCAM-1, IL-1β, and IL-6 can contribute to the development of atherosclerosis [27, 28, 29].

Researchers have identified several bioactive compounds in rice bran that can reduce thrombus formation and vascular inflammation through their antioxidant activities. These include acylated stryl glucoside [30], flavonoids [31], ferulic acid [32], and policosanol [33], as well as components in plasma like leukocytes and platelets [34]. By scavenging free radicals and exhibiting antioxidant properties, these bioactive compounds in rice bran help reduce and prevent the onset of cardiovascular disease.

In a study on rice metabolism, researchers found bioactive flavonoids and their isomers, such as tricin and tricin 7-O-rutinoside, as well as tricin 7-O-β-D-glucopyranoside, predominantly concentrated in rice leaves and bran [31]. Additionally, rice bran contains tricin 4'-O-(erythron–β–guaiacyglyceryl) ether and isoscoparin 2"-O-(-(E)-feruloyl) glucopyranoside, which can inhibit excessive nitric oxide (NO) production by macrophages and scavenge the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical [32]. Feruloylated oligosaccharides (conjugates of ferulic acid) extracted from rice bran have also been recognized for their ability to inhibit atherosclerotic agents such as TNF-α, IL-1β, IL-6, and NO, and to stimulate IL-10 production in lipopolysaccharide (LPS)-stimulated macrophages (RAW264.7) in a dose-dependent manner (0.1–100 μg/mL) [32]. Furthermore, in the context of vascular inflammation, the production of prostaglandin E2 (PGE2) can be inhibited by feruloylated oligosaccharides from rice bran (100 μg/mL) [32]. Policosanol extracted from rice bran wax has demonstrated anti-thrombotic activity [33]. Mice pretreated with varying concentrations (125–1000 μg/mL) of policosanol extract showed a dose-dependent reduction in platelet aggregation with collagen and secreted cellular proteins [33].

3.4 Effects of rice bran and its products on cardiovascular disease in humans

Cardiovascular disease (CVD) is a leading cause of death globally, with dietary interventions playing a critical role in its prevention and management. Rice bran (RB), a byproduct of rice milling, is rich in bioactive compounds and has gained attention for its potential health benefits, particularly in cardiovascular health [38, 39]. Rice bran contains essential nutrients, including lipids, proteins, fibers, and bioactive components such as γ-oryzanol, tocopherols, tocotrienols, and unsaturated fatty acids [55, 56]. These compounds exhibit antioxidant, anti-inflammatory, and cholesterol-lowering properties, making RB a promising functional food for cardiovascular disease management [36, 56].

Lipid profile improvement: research indicates that rice bran oil (RBO) can significantly reduce total cholesterol, LDL-C, and triglycerides while increasing HDL-C. Zavoshy et al. (2012) demonstrated that dietary supplementation with RBO improved lipid profiles in hyperlipidemic patients, reducing the risk of atherosclerosis and coronary artery disease [38]. Similarly, Kuriyan et al. (2005) found that daily

consumption of RBO for eight weeks led to substantial improvements in lipid profiles among overweight individuals [39].

Blood pressure regulation: peptides derived from rice bran have been shown to exhibit antihypertensive properties. Ogawa et al. (2019) conducted a randomized controlled trial demonstrating that participants consuming processed RB experienced significant reductions in systolic blood pressure compared to those receiving a placebo [55]. This suggests the potential of RB peptides, such as Leu-Arg-Ala, as natural ACE inhibitors [55, 10].

Anti-inflammatory and antioxidant: effects Rice bran oil contains γ-oryzanol and other unsaponifiable fractions that reduce inflammatory markers such as TNF-α and IL-6. Rao and Sugasini (2016) showed that these components decreased oxidative stress and inflammation in animal models [56]. Human studies have also highlighted the role of RBO in improving oxidative stress markers, contributing to vascular health [36, 56].

Prevention of atherosclerosis: francisqueti et al. (2023) studied the effects of γ-oryzanol supplementation on endothelial function and LDL oxidation. Their findings suggest that regular consumption of RBO can prevent atherosclerosis by reducing oxidative damage and improving vascular endothelial health [36].

Mechanisms of cardioprotective effects cholesterol reduction: γ-Oryzanol and unsaturated fatty acids inhibit cholesterol absorption and enhance bile acid excretion [38, 36].

Antioxidant properties: Tocopherols and tocotrienols neutralize free radicals, reducing oxidative stress on endothelial cells [36, 56].

Anti-inflammatory effects: RB bioactives suppress pro-inflammatory cytokines and promote an anti-inflammatory state [10, 56].

Blood pressure modulation: RB peptides act as ACE inhibitors, promoting vasodilation and reducing hypertension [55, 10].

Rice bran and its derivatives, particularly RBO, offer significant potential in improving cardiovascular health.

Their ability to improve lipid profiles, reduce oxidative stress, and lower blood pressure suggests that rice bran-based interventions can be an effective dietary approach for preventing and managing CVD. Further long-term clinical trials are warranted to confirm these benefits and refine the application of rice bran in functional foods [10, 36].

IV. DISCUSSION

The role of rice bran (RB) and its derivatives in cardiovascular health has been increasingly recognized in recent years. Bioactive components of RB, such as γ-oryzanol, tocopherols, tocotrienols, and unsaturated fatty acids, have demonstrated significant cardioprotective effects through lipid modulation, antioxidant properties, and anti-inflammatory mechanisms [38, 39, 55]. These compounds collectively address critical risk factors for cardiovascular disease (CVD).

Clinical studies have confirmed that RB and its products can effectively reduce LDL-C levels, increase HDL-C levels, lower blood pressure, and mitigate vascular inflammation [38, 55]. For instance, randomized controlled trials have demonstrated the lipid-lowering effects of rice bran oil (RBO) and the antihypertensive effects of RB-derived peptides, particularly in individuals with metabolic syndrome or hyperlipidemia [36, 39].

Despite these promising findings, several challenges and research gaps remain. Most studies to date have focused on short- to medium-term interventions, leaving the long-term effects of RB consumption on CVD outcomes unclear. Additionally, further research is needed to explore the specific mechanisms of action of RB bioactives in diverse populations and to establish optimal dosing regimens. Potential side effects of prolonged RB supplementation also warrant investigation [10, 56].

As one of the world's largest rice producers, Vietnam generates a substantial amount of rice bran as a byproduct of rice milling. This underutilized resource offers a unique opportunity to develop functional food products aimed at improving public health and reducing the burden of CVD [10]. To fully leverage this potential, Vietnam should:

* *Promote research and development*: Increased investment in scientific research to better understand the health benefits of RB, particularly its effects on local populations, is essential [10, 56].

* *Enhance processing technologies*: Developing advanced methods to stabilize RB and extract its bioactive components efficiently can increase its shelf life and nutritional value [36].

* *Create consumer awareness:* Public education campaigns highlighting the health benefits of RB and its derivatives can encourage greater consumption and use in everyday diets [10, 55].

* *Develop functional foods:* Encouraging the food industry to incorporate RB into commonly consumed products, such as cooking oils, snacks, and beverages, can make RB-based interventions more accessible [10, 36].

The widespread availability of rice bran in Vietnam represents a significant opportunity for advancing public health through dietary interventions. By promoting RB-based innovations, Vietnam can address the growing prevalence of CVD while establishing itself as a leader in the development of health-focused food products. However, this requires coordinated efforts from researchers, policymakers, and industry stakeholders [10].

VI. CONCLUSION

Rice bran (RB) and its derivatives, including rice bran oil and rice bran protein, have demonstrated significant potential in preventing and managing cardiovascular diseases. The bioactive compounds in RB, such as γ-oryzanol, tocopherols, tocotrienols, and unsaturated fatty acids, play crucial roles in improving lipid profiles, reducing

oxidative stress, and mitigating vascular inflammation.

Incorporating RB as a functional food can effectively reduce the risk of cardiovascular diseases and support a heart-healthy diet. However, to fully realize its benefits, further investments in research, development of advanced processing technologies, and public awareness campaigns are essential.

With its abundant rice production, Vietnam has the opportunity to become a leader in developing innovative health-focused food products based on rice bran. This approach could significantly improve public health while addressing the burden of cardiovascular diseases.

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