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EMERGING HEALTH BENEFITS OF RICE BRAN - A REVIEW

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Abstract:

Rice bran is the outer layer of rice kernel and is a byproduct of rice milling which constitutes 8% of whole rice grain. It contains various nutrients like protein, carbohydrates, fats, dietary fiber, various vitamins and minerals. It has a unique blend of various phytochemicals like γ-oryzanol, tocopherol, tocotrienol, phytosterol etc., which possess several properties. These compounds also act as antioxidants against free radicals. Besides this, it has some antinutrients like lipase, phytate, trypsin inhibitors etc. The effective utilization of rice bran can only be done by deactivating these antinutritional factors especially lipase which develops rancidity in rice bran. Various methods are used to stabilize rice bran and improve its quality and potential role in treating life threatening disorders. It can play an important role in lowering serum cholesterol, hypertension, alleviate postmenopausal syndrome, improve insulin sensitivity, reduce the skin related problems and growth of cancerous cells. Rice bran oil and wax are the products of rice bran in which rice bran oil is more important as it is the concentrated source of γ-oryzanol and other antioxidants. The different food products made by incorporating processed rice bran helps in improving nutrient content, textural property and also increased shelf life of the product.

Key Words: Rice Bran, γ-oryzanol, Tocols, Lipase & Heat Treatment

1. Introduction:

Rice is the most common staple food which is consumed by half of the World's human population. It is the third highest agricultural commodity with the worldwide production after sugarcane and maize [1]. Asia, Africa and America are the prominent rice producing continents.

Table 1: Scientific Classification of Rice Bran (http://plants.usda.gov/java/ClassificationServlet?source=displayandclassid=ORYZA)

Kingdom	Plantae (Plants)
Subkingdom	Tracheobionta (Vascular Plants)
Superdivision	Spermatophyta (Seed Plants)
Division	Magnoliophyta (Flowering Plants
Class	Liliopsida (Monocotyledons)
Subclass	Commelinidae
Order	Cyperales
Family	Poaceae (Grass)
Genus	*Oryza*
Species	*Sativa*

Oryza sativa is the botanical name of rice plant. Rice endosperm (70%) is obtained as a major product while rice husk (20%), rice bran (8%) and rice germ (2%) are

obtained as byproduct of rice milling industry which is obtained from the seed of the grass species of the *Oryza sativa* (Asian Rice) or *Oryza glaberrima* (African Rice) [2, 3, 4].

Rice is grown as annual plant, besides it can also sustain as a perennial in tropical areas. It produces a ratoon crop for upto 30 years. The plant of rice grow tall upto 1-1.8 m (3.3-5.9 ft) which is more depend on the variety of soil and its fertility. The leaves of rice plant are slender 50-100 cm (12-20 inch) long and 2-2.5 cm (0.79-0.98 inch) wide. The flowers are small wind-pollinated which produced in a branched arching to pendulous inflorescence 30-50 cm (12-20 inch) long. The seed of edible part is a grain which is 5-12 mm (0.20-0.47 inch) long and 2-3 mm (0.079-0.118 inch) thick. High temperature above 20°C but not more than 35-40°C is required for rice cultivation. After harvesting, the amount of solar radiation received during 45 days determines final crop output [5].

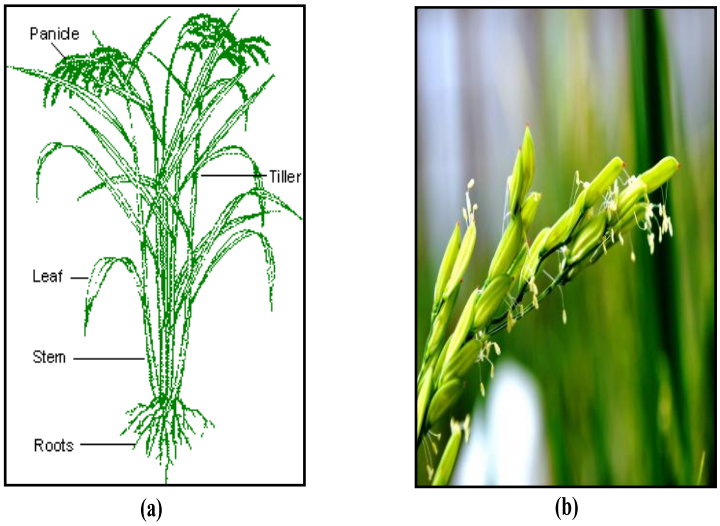


Figure 1: (a) Rice Plant (b) Panicle of Rice
(a)http://www.fao.org/ag/icons/plant.gif
(b)http://botany.org/Awards/ContestImages/CA12-021_1080.jpg

Rice bran is the outer covering of rice kernel and consists of pericarp, aleurone, subaluerone layer, seed coat, nucellus, part of the germ and small part of starchy endosperm [6, 7]. Rice bran is light in color, sweet in taste, moderately oily and has a slightly toasted nutty flavor [8].

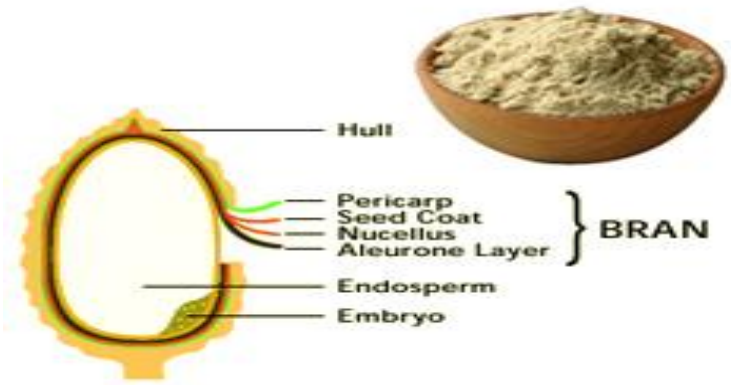


Figure 2: Structure of Rice Bran
(http://modinaturals.com/image/brands_img/modi-images_oiltank.jpg)

Oryza sativa has two major subspecies: the sticky short grained *japonica or sinica* variety and the nonsticky, long grained *indica* variety. *Japonica* varieties are usually

cultivated in dry fields, in temperate East Asia, upland areas of South East Asia and high elevations in South Asia, while indica varieties are mainly lowland rice grown mostly submerged, throughout tropical Asia.

In 2011, genetic evidence published in the Proceedings of the National Academy of Sciences of USA shows that all forms of Asian rice, *indica* and *japonica*, spring from a single domestication that occurred 8,200-13,500 years ago in China of the wild rice, *Oryza rupipogon* [9]. A 2012 study, through the map of rice genome variation indicate that the domestication of rice occurred in the Pearl River Valley region of China. Rice was spread to South and South East Asia from East Asia [10]. From Western Asia Rice was introduced to Europe and through European colonization to America. Based on archeological evidence Normile, 1997; David (1996) [11, 12] concluded that rice was first domesticated in the reign of the Yangtze River Valley in China.

2. Composition and Nutritive Value:

Rice bran contains appreciable amount of protein (11-17%), fat (12-22%), dietary fiber (6-14%) like β-glucan, pectin and gum; moisture (10-15%) and ash (8-17%). Also it is rich in vitamins including vitamin E, thiamine, niacin, and minerals like aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, zinc and sodium [8, 13, 14]. Its brighten prospects are the presence of antioxidants like tocopherol, tocotrienol, β-Sitosterol and γ-oryzanol for utilization of humans as functional ingredients to reduce the life threatening disorders [15, 16, 17]. Rice bran is rich in lipids and intense lipase activity in the presence of endogenous lipoxygenase causes rapid deterioration of these lipids by rancification [18]. The commercial use of rice bran requires enzymatic inactivation because of lipid susceptibility immediately after bran separation to avoid fatty acid liberation, allow its commercialization for human consumption and also to extend its shelf life.

Table 2: Nutritional Composition of Rice Bran [19, 20, 21]

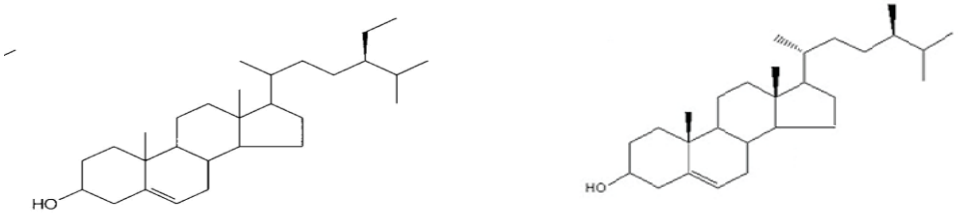
Proximate Composition of Rice Bran			
Energy Content	399-476 Kcal	Available Carbohydrate	34-62 g
Crude Fat	15.0-19.7 g	Crude Ash	6.6-9.9 g
Amino Acid Composition of Rice Bran (g)			
Crude Protein g N*5.95	11.3-14.9	Histidine	2.7-3.3
Isoleucine	2.7-4.1	Leucine	6.9-7.6
Lycine+ Cysteine	4.8-5.4	Phenylalanine	7.7-8.0
Methionine+Tyrosine	4.2-4.8	Threonine	3.8-4.2
Tryptophan	0.6-1.2	Valine	4.9-6.0
Vitamins and Minerals Contents of Rice Bran (mg)			
Thiamine	1.20-2.40	Riboflavin	0.18-0.43
Niacin	26.7-49.9	α-Tocopherol	2.60-13.3
Calcium	30-120	Phosphorus	1.1-2.5 g
Zinc	4.3-25.8	Iron	8.6-43.0

Rice bran also contains phytochemicals with promising health benefits [22]. A major rice bran fraction contains 12-13 % oil and highly unsaponiable components (4.3%) [23]. Following are the some important antioxidants and phytochemicals in rice bran:

➢**Antioxidants:** The antioxidants at cellular and molecular levels are known to deactivate the natural byproducts of the oxidative metabolism that are popularly known

as free radicals [24, 25, 26]. The components of rice bran that is γ-Oryzanol, tocols and other phytosterol conjugates are examined to have antioxidant property against the free radicals. Rice bran polysaccharides exhibited good potential for reducing power, chelating ferrous ions, and scavenging effects of 2,2-azino-bis(3-ethylbenzthiazoline-6-sulphonate), 1,1-diphenyl-2-picrylhydrazyl (DPPH), and hydrogen peroxide [27].

➢**Phytosterols:** These are the chemical compounds which are synthesized by plants including sterols and stanols. Phytosterols cannot be synthesized by human being hence supplied through the diet. The class sterols known as phytosterols are found mainly in cell walls and membranes. The major phytosterols in the lipid extracts of rice bran are Sitosterol, Campesterol and Stigmasterol. These have hypocholesterolemic effects [28, 29]. They are known to have several bio-active qualities with possible implications for human health [30].



β-Sitosterol Campesterol

Figure 3: Chemical Structure of Sitosterol and Campesterol [31]

➢**Tocols:** Tocols (tocotrienol and tocopherol) are natural antioxidants that may benefits human health. Tocols are also known as Vitamin E. They exits as lipid-soluble compounds and are unevenly distributed with in the grain (α-tocotrienol primarily in the endosperm, whereas α-tocopherol in the germ). The α-tocotrienol (5, 7, 8-trimethyltocotrienol), γ-tocotrienol (7, 8-dimethyltocotrienol) and δ-tocotrienol (8-methyltocotrienol) are the major forms of tocotrienol whereas α-tocopherol (5, 7, 8-trimethyltocol), γ-tocopherol (7, 8-dimethyltocol) and δ-tocopherol (8-methyltocol) are the major forms of tocopherol [32]. Their biological activity results from their ability to donate phenolic hydrogen atoms to free radicals, thus breaking destructive chain reaction. Other beneficial therapeutic properties of tocols include the ability to reduce serum cholesterol concentration and to inhibit the growth of certain cancer cells.

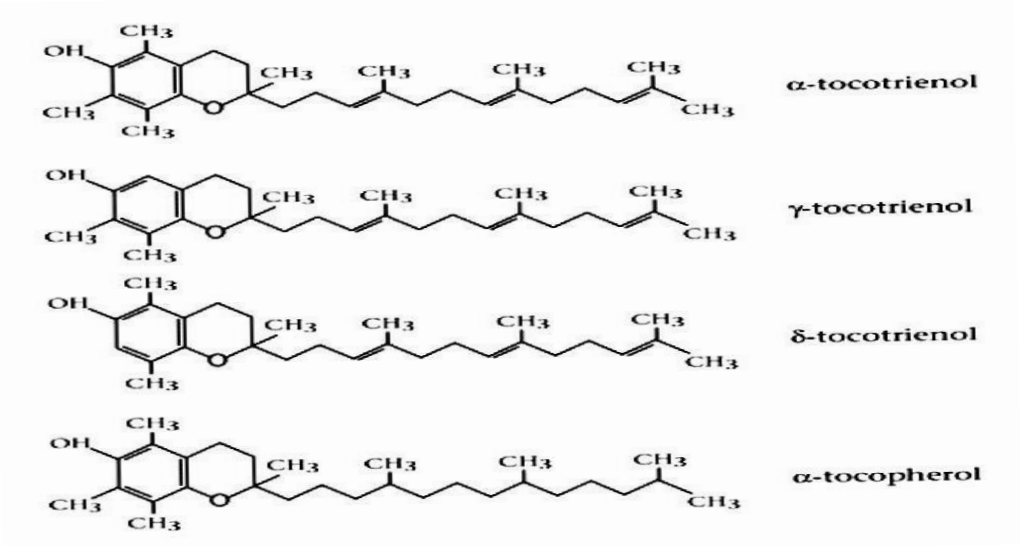
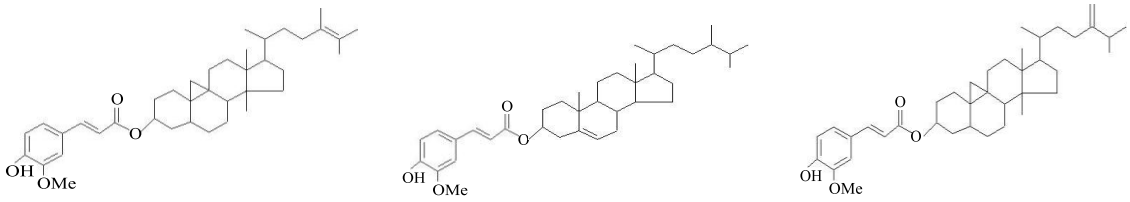


Figure 4: Chemical Structure of different forms of Tocotrienols and α-Tocopherol [33]

➢**Gamma Oryzanol:** It is the mixture of ferulate (4-hydroxy-3-methoxy cinnamic acid), esters of sterols and triterpene alcohol [34]. The three major components of γ-Oryzanol that account for 80% are cycloartenyl ferulate, 24-methylenecycloartanyl ferulate and campesteryl ferulate [35]. The molecular formula of γ-Oryzanol is $C_{40}H_{58}O_4$.



Cycloartenyl ferulate | 24-methylenecycloartanyl ferulate | Campesteryl ferulate

Figure 5: Chemical Structure of Components of γ-Oryzanol [35]

3. Antinutritional Factors:

These are the natural or synthetic compounds that interfere with absorption or utilization of nutrients. Following are the some antinutritional factors present in rice bran:

➢**Lipases:** These are the enzymes that are primarily responsible for the hydrolysis of triglycerides into glycerol and fatty acids. Rice bran contains several types of lipases which results in significant increase of the free fatty acids (FFA) by hydrolyzing the oil. Rapid increase in the free fatty acid (FFA) occurs within hrs and reaches 7-8% within 24 hrs, followed by about 56% increase per day [36]. The enzyme has active upto 40°C and activity declined sharply to 65% at 60°C and then gradually decreased [37].

➢**Trypsin Inhibitors:** These are also endogenous enzymes which can form stable complex with proteolytic pancreatic enzymes that is trypsin and chemotrypsin. Due to complex formation, the activity of these enzymes decreases. Rice bran contains trypsin inhibitor [38, 39].

➢**Haemagglutinin-Lectin:** These are toxic globulin protein present in the rice bran and agglutinate mammalian red blood cells [40]. Similarly, lectin is a glycoprotein and is present in germ portion. The lectin also contains a large number of glycine and cystine residues [41]. The haemagglutinin, rice bran lectin, is capable of binding to specific carbohydrate receptor sites in intestinal wall thereby lowering the nutrient absorption [42].

➢**Phytates:** Phytates (1, 2, 3, 4, 5, 6-hexaphosphate of myoinositol) occur in discrete regions of cereals grains and account for 85% of the total phosphorus content of grains. They reduce the bioavailability and digestibility of nutrients by forming complexes with minerals, protein, digestive enzymes and amino acids mainly lysine, methionine, arginine and histidine [43, 44].

4. Shelf Life and Stabilization of Rice Bran:

The shelf life of rice bran is less than a week. The stability and shelf life of rice bran is one of the primary factors in establishing the value of the product [45]. Rice bran has a shorter life span compared to refined white rice due to its increase in free fatty lipids during storage [46]. If proper packaging and storage recommendations are followed, white rice can be stored for decades, compared to only about 1 year for the bran fraction. Rice bran is abundant in oil content (15–20%), which makes it easily susceptible to rancidity. During the milling process, the oil and lipase in the bran come into mutual contact, resulting in the rapid hydrolysis of the triglycerides of the oil into glycerol and FFA. Such bran with higher amounts of free fatty acid (FFA) is unpalatable. The methods employed to stabilize the bran (prevention of rancidity by lipase action) are based on reducing the moisture content, or altering the temperature or pH to

destroy the activity of lipase [47]. These include processes involving heat treatment, cold storage or low temperature storage [47], chemical treatment, control of relative humidity during storage and simultaneous milling and extraction and microwave heating [48, 49]. Hydrochloric acid treatment has been successfully used to stabilize rice bran [47]. When rice bran is subjected to a short-term, high-temperature treatment immediately after milling, the lipase activity is destroyed, thereby stabilizing the bran [50]. The effective utilization of rice bran is possible only by deactivating the lipase enzyme responsible for the hydrolytic degradation of rice bran constituents [51]. Stabilization is an effective treatment turning rice milling by-products like rice bran into valuable dietary constituents. These have resulted in emergence of rice bran as an important by-product of rice milling. These are:

➢**Heat Treatment:** It is effective and resultant product could be stored at refrigerated temperature upto 16 weeks without imparting antinutritional effects and allied quality attributes [33, 49].

➢**Microwave Heating:** In rice bran, dipolar water molecules are excited by the electromagnetic waves and are made to spin. The resultant enhanced kinetic energy, alongwith friction, produces heat that results in the even distribution of heat having deleterious effects on lipase activity [36, 52].

➢**Extrusion Cooking:** Extrusion cooking has been found to produce stable rice bran by holding at 125-130 ºC for few seconds, then at 97-99 ºC for 3 min prior to cooling [50]. Heating in the presence of moisture is more effective for permanently denaturing lipases [36].

➢**Ohmic Heating:** Ohmic heating or Joule heating is a food processing method in which an alternating electrical current is passed through a food sample. Ohmic heating is distinguished from other electrical heating method by the presence of electrodes contained in the food; the frequency and the waveform of the electric field impose between the electrodes. The efficiency of ohmic heating (OMH) is dependent on the conductive nature of the food to be processed [53].

5. Health Benefits of Rice Bran:

Rice bran is highly nutritious as it has wide variety of antioxidants like oryzanol, tocopherol, tocotrienol, phytosterol and also contains other important nutrients. Due to all these properties that render its suitability for the production of value added products in neutraceuticals and pharmaceutical industry [54]. Other health benefits of rice bran in the health of humans are:

➢**Coronary Heart Disease (CHD):** It is the coronary artery disease in which oxygen rich blood is not supplied to the heart muscle due to the blockage of artery by a gradual formation of fatty steaks within their walls called plaque. The consumption of dietary fiber that is present in rice bran have shown to reduce the risk of coronary Heart Disease (CHD) mortality by lowering blood pressure, lowering blood cholesterol levels and by improving insulin sensitivity [55, 56]. The regulation of plasma cholesterol levels is done by liver; hence liver cholesterol levels also provide a measure of the influence of diet on cholesterol metabolism. In hamsters, diet containing 10% total dietary fiber (TDF) from rice bran or a 5:5 total dietary fiber (TDF) combination of rice bran and a 13-glucan-enriched (19% total 3-glucans) barley fraction in diets containing 0.25% cholesterol significantly lowered the cholesterol [57]. 24 mildly hypocholesterolemic men consuming 60 g/d of rice bran diet containing 11.8 g dietary fiber in a four-week study had 49% (non-significant) reduction in low density lipoprotein-cholesterol (LDL-C) and apolipoprotein-B (apo-B), in their high density lipoprotein-cholesterol/plasma cholesterol (HDL-C/PC) ratio, there was a significant difference and no change in

plasma cholesterol (PC) in comparison to those consuming wheat bran [58]. In hyperlipidemic patients who were given 300 mg/d γ-oryzanol for three months, reported a significant effects of γ-oryzanol in lowering of cholesterol [59]. The unsaponifiable components present in rice bran oil contribute to the cholesterol-lowering properties in rice bran [60, 61]. It includes phytosterols, tocopherols, tocotrienols and triterpene alcohols, as important hypocholesterolemic agents.

➢**Diabetes Mellitus:** The fiber in rice bran has a laxative effect with increase fecal output and stool frequencies. The postprandial blood glucose in normal and diabetic patients can be reduced by soluble fibers. It acts like a sponge and absorbs water in the intestine, mixes the food into gel and thereby slows down the rate of digestion and absorption [62]. The fiber comprised of relatively low proportions of soluble fiber (7-13 %) and the rest is insoluble fiber in rice bran [63]. The nutraceuticals developed from the soluble and fiber fractions of rice bran control both type I and type II Diabetes Mellitus [64]. The blood glucose, total cholesterol and triglycerides can be decreased by rice bran [64, 65]. Lipoic acid is also present in rice bran which is endowed with antioxidant and antilipogenic properties which have application in the prevention of diabetic neuropathy, retinopathy and treatment of Parkinson's and Alzheimer's disease. Lipoic acid interacts with antioxidant vitamins-ascorbic acid and vitamin E and helps in conserving them.

➢**Colorectal Cancer:** Phytosterol has shown to inhibit tumors induced by chemicals in animals. The production of coprostanol and other neutral sterols and bile acids by colonic micro-flora from dietary cholesterol, have been established as factors in colon carcinogenesis [66]. The results showed that the intake of dietary fiber was inversely related to the occurrence of colorectal cancer. The highest protective effect was shown at the left side of the colon where as the least protective effect was at rectum. The value of the adjusted relative risk for the highest versus lowest quintile of dietary fiber was 0.58 (0.41-0.85). The bran fraction of rice is composed of phytochemicals and nutrients with known cancer-fighting and immune-enhancing properties [67]. The process of fermenting rice bran with bacterial or fungal agents can beneficially alter the bioactivity [68-71]. For example, fermenting rice bran with Saccharomyces boulardii induced an increase in the amount of ferulic acid released and reduced lymphoma cell viability compared with non-fermented rice bran [71]. Many plant phenols, such as ferulic acid, are often biologically unavailable after intake, and fermentation helps improve the efficacy of the antioxidant activities [72]. The potential chemopreventive agents in the bran are ferulic acid, tricin, β-sitosterol, γ-oryzanol, tocotrienols/tocopherols, and phytic acid [73]. The anticancer effects of the rice bran are mediated through the ability of these agents to induce apoptosis, inhibit cell proliferation, and alter cell cycle progression in malignant cells. These protect against tissue damage through the scavenging of free radicals and the blocking of chronic inflammatory responses. These have also been shown to activate anticancer immune responses as well as affecting the colonic tumor microenvironment in favor of enhanced colorectal cancer chemoprevention. Rice bran inhibits the growth of human colon cancer cells [67], and rice bran consumption reduces the number of intestinal adenomas in APCMin mice, an animal model of human familial adenomatous polyposis (FAP) [74]. Finally, Dimethylhydrazine (DMH) and axoxymethane (AOM) induced preneoplastic lesions are inhibited by rice bran-derived sphingolipids in the colons of rats [75, 76]. Several phenolic compounds have been recognized in the ethyl acetate extracts of rice bran, such as caffeic acid, cycloartenyl ferulate, ferulic acid, methoxycinnamic acid, p-coumaric acid, protocatechuic acid, sinapic acid, tricin and vanillic acid.

➢**Anti-Aging:** The oryzanol, a protective agent against UV light induced lipid peroxidation and hence can be used as a potent sunscreen agent. Oryzanol can impede the progress of melanin pigmentation by intercepting the ultraviolet rays at the skin's surface and hindering its (ultraviolet rays) transmission. In gamma oryzanol, the ferulic acid and its esters stimulate hair growth and prevent skin ageing [77]. Approximately 500 ppm of tocotrienol is resent in rice bran [78]. Tocotrienols when applied to the skin penetrate and get absorbed rapidly. Majorly they get accumulated at the strata corneum of the skin and act as the first line of defense with their antioxidant property. They stabilize the free radicals generated in the skin when exposed to oxidative rays. They protect the skin against ultraviolet (UV) induced skin damage and skin ageing and thus help in skin repaid. Therefore, rice bran oil is widely used in hair conditioners, skincare and sunscreen products.

➢**Osteoporosis and Post-menopausal Syndromes:** The occurrence of osteoporosis is usually related to menopause and reduced production of estrogen [79]. Type I, or postmenopausal osteoporosis, commonly occurs in women about 15-20 years after menopause. The disease is usually accompanied by an increased loss of trabecular bone which leads to a high incidence of low trauma fractures [80]. A study conducted on Ovariectomized rats (who typically lose substantial bone mineral density after the ovariectomy) were used as a model for postmenopausal osteoporosis. It was found that the addition of a 7% oryzanol rice bran oil (RBO) concentrate to the diets of ovariectomized rats resulted in less bone loss at several bone sites than control rats [81]. Clinical trials involving menopausal women and women who had their ovaries surgically removed, have revealed that 67-85 percent of women treated with gamma-oryzanol have experienced a significant reduction in menopausal symptoms [82]. At menopause the pituitary gland secretes excess amount of Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH). A study in Japan has reported that Supplementation with Oryzanol reduces the over- secretion of these hormones [83].

➢**Other Uses:** The *ortho*, *meta* and *para* dicholorobenzenes have been employed as insecticides for a number of years. Among these the *para*- isomer has been used on a very large scale against insects and moths infesting clothes, hides, furs and museum specimens. Remarkably, rice bran was found to be an effective adsorbant of *para*-dicholorobenzene in a broad pH range of 1-12. The adsorption reaction was Freundlich type. This property of rice bran was attributed to the uptake by the intracellular particles called spherosomes [84, 85, 86].

6. 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 [87]. 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 [88, 89].

➢**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 [90].

7. Different Value Added Food Products By Incorporating the Rice Bran:

The various properties of rice bran like nutritional and functional are suitable for baked products, namely cookies, muffins, breads, crackers, pastries and pancakes [91]. The supplementation of rice bran into the wheat flour further increased the protein, lysine and dietary fiber contents in bread and cookies. Rice bran fractions can be used to produce acceptable low fat, high fiber bakery products [92]. The color, flavor, protein extractability and solubility of bran, as well as other properties, such as water and fat absorption, emulsifying and foaming capacity, have demonstrated improvements that further enlighten us on the potential use of bran in foods [93].

- A traditional Cuban bakery product, Torticas de Moron, was made by replacing the wheat flour by parboiled rice bran at 0, 20, 25 or 30%. In the rice Torticas, protein, fat, crude fiber and ash were higher than the control. It was further observed that 25% replacement of flour with rice bran resulted in a product with acceptable sensory properties, chemical composition and shelf life [94].
- The functional properties of full fat and defatted rice bran were explored by blending rice bran in wheat flour at 5, 10 or 15% to prepare leavened pan bread. Addition of any of the defatted and full fat rice bran was associated with reduction in loaf volume and a decrease in overall acceptability of the bread. Breads containing upto 10% of either type of rice bran was still considered acceptable [95].
- The full fat and defatted rice bran were blended in wheat flour at 5, 10 or 15% to prepare cookies. There was improvement in spread of cookies with the addition of full fat rice bran. In contrast, decrease in spread after supplementation of defatted rice bran. Cookies supplemented with either type of rice bran were acceptable upto 10% supplementation level [95]. In another study, cookies were successfully prepared from stabilized rice bran at levels of 20% [96]. In a similar study, stabilized full-fat rice bran upto 20% level and un-stabilized full fat or stabilized defatted rice bran upto 10% was found suitable in various food products [97]. Dry heat and extrusion stabilized rice bran was supplemented in wheat flour at 5-20% levels for the preparation of cookies [98].
- Rice bran protein concentrate (RBPC) from defatted rice bran was incorporated at 5, 10 and 15 per cent levels in biscuits. The physicochemical, fracture strength (texture analyzer) and sensory attributes (nine-point hedonic scale) were analyzed in biscuits to assess their acceptability. The formulation of the protein enriched biscuits by utilizing rice bran protein concentrate with enhanced nutritional value especially for malnourished and undernourished people [99].
- Rice bran was incorporated at 20 percent level in the wheat chapattis. The nutritive value, sensory evaluation, glycemic index (GI) and glycemic load (GL) were evaluated. Total 20 subjects, 16 males and 4 females were selected with average age and BMI of 56.55 ± 6.37 and 26 ± 3.68 respectively. Overall acceptability scores were in acceptable range for controlled chapatti (8.99) and rice bran based chapatti (8.08). The GI of rice bran based chapatti (68.34 ± 11.49) was significantly lower ($P \leq 0.01$) than controlled chapatti (83.92±9.63). The peak blood glucose was found between 60-90 minutes of reference and both type of chapattis, however the mean blood glucose concentration was found lowest for rice bran chapatti [100].
- Ten standard Indian subcontinent breakfast/dinner recipes namely chapati, mixed vegetable chapati, wheat dosa, wheat rava idli, adai, rava adai, ragi adai, rice vermicelli, ragi vermicelli and kolukattai were chosen and the replacement of the cereals and pulses in standard recipes by rice bran at 25, 30 and 35 per cent replacing the cereals and pulses in the standard recipe. The acceptability trials were carried out using 20

semi trained panel members. The results revealed that the recipes with 25 per cent incorporation of rice bran had a good acceptability in par with standard recipe [101].

➢Biscuit and bread are the products which were developed. The processed rice bran was incorporated at 5 to 15% levels. Functional properties for both the products were analyzed. Sensory scores of the products revealed that biscuits were best accepted at SRB 10% and PRB 10% and bread was best accepted at SRB 5% and PRB 10% respectively [102].

➢The fiber in rice bran has been reported to contain high amounts of functional proteins and fats along with antioxidants, vitamins and trace minerals, in addition to being a concentrated source of fiber. The presence of these nutrients allows rice bran fiber to be used as both nutritional and functional ingredient. Chicken coated with stabilized rice bran fiber tend to absorb less fat during frying while the small amount of fat found naturally in rice bran fiber can act as a carrier for flavors [103]. Later, stabilized rice bran was incorporated at 5, 10 and 20% in chutney powder. Addition of the rice bran had more affect on color and the least on texture with intermediate effects on aroma, taste and overall acceptability [104].

8. Conclusion:

Rice bran is an emergence in the field of nutrition. It is widely available as rice is a staple food of half of the world's population. Stabilization is an effective treatment to deactivate the lipase enzyme for effective utilization of rice bran. The nutrients in rice bran has known potential role in reducing the risk of coronary heart disease by controlling blood LDL, cholesterol and triglycerides, lowering blood pressure, reducing the rate of cholesterol and fat absorption, reducing tumor incidence, cancer risk, delaying gastrointestinal emptying and providing gastrointestinal health. Rice bran also serves as a natural source of phytosterols, which provide blood-sugar control, prostate health and cholesterol metabolism. Rice bran is naturally lactose-free, gluten-free and hypoallergenic, making it a tolerable health product for a variety of tastes. The fiber content in rice bran plays an important role in weight control by promoting a feeling of fullness without over-eating and it is effective in preventing heart attacks, intestinal disorders, and various cancers. Rice bran oil is an important product of rice bran as it is a rich source of various antioxidants like γ-oryzanol, tocols, etc.

9. References:

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