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RICE BRAN OIL- UNIQUE GIFT OF NATURE: A REVIEW

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ABSTRACT

Rice bran oil (RBO) is popular in several countries such as Japan, India, Korea, China and Indonesia as a cooking oil. It has been shown that RBO is an excellent cooking and salad oil due to its high smoke point and delicate flavor. The nutritional qualities and health effects of rice bran oil are also established. RBO is rich in unsaponifiable fraction, which contains the micronutrients like vitamin E complexes, gamma oryzanol, phytosterols, polyphenols and squalene. It is high in antioxidants namely oryzanol, tocotrienol, tocopherol and squalene with some amount of omega 3 fats. WHO, NIN and ICMR have recommended a near equal ratio of SFA(27-33%); MUFA(33-40%); PUFA(27-33%) in a healthy oil. Rice Bran oil is closest to this recommendation having SFA (24%); MUFA (42%); PUFA (34%). Therefore, in recent years, research interest has been growing in RBO processing to obtain good quality oil with low refining loss.

Key words: Edible oil, Fatty acids, *Oryza sativa*, Rice bran oil

Rice oil, also called rice bran oil, has been used extensively in Asian countries such as India, Japan, Korea, China, Taiwan, Thailand, Indonesia and Pakistan (Kahlon, 1992; Orthoefer and Atlanta, 1994). Rice is the staple diet for majority of Indians and India is the largest producer of rice in the world next to only to China. Rice (*Oryza sativa* L.) like other cereals contains only a small amount of oil (2-3%). However, when paddy is milled, the germ and bran layers separate from the endosperm and form the milling residue which is commonly known as "Bran". It is this bran which constitutes about 5% of the paddy which is enriched in oil to the extent of 4-30% (Table 1). Bran from parboiled paddy gains more oil than the bran from fresh paddy. The oil extracted from the bran has high free fatty acids content. The structure of the rice kernel is given in Fig. 1.

TABLE 1: Oil content of bran from different mills.

Mill type	Grade	Oil content %
Huller	Raw	4-6
	Parboiled	4-6
Sheller	Raw	12-15
	Parboiled	15-20
Modern	Raw	15-20
	Parboiled	25-30

Source: FAOSTAT, 1998

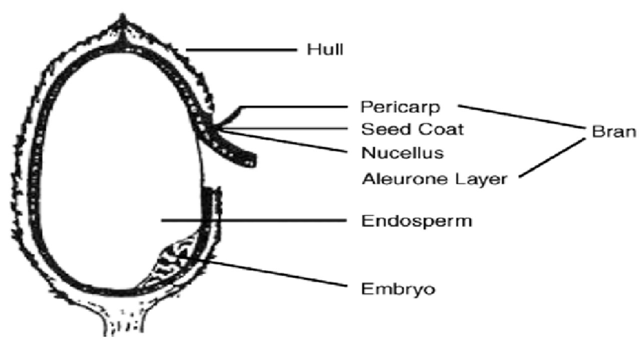

FIG. 1: Structure of rice kernel.

Currently the industry is producing about 9 lakh tonnes of rice bran oil out of which 6.8 lakh tonnes is of edible grade and 2.2 lakh tonnes is non edible grade. Rice bran oil contains a high proportion of mono-saturated fatty acids (40-50%) and poly-unsaturated acids (29-42%). A very low content of linolenic acid ensures good shelf life (Krishna, 2001). The fatty acid composition of the common vegetable oils is compared with that of rice bran oil (Table 2). The rice bran oil is almost similar in fatty acid composition to that of groundnut oil and ranks fifth in production among the major edible oils produced in the country (Orthoefer and Hui, 1996). The rice bran oil is with ideal SF/MUF/PUFA ratio as

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TABLE 2: Fatty acid profile of some common vegetable oils and rice bran oil.

Fatty Acid	Vegetable Oil				Cereal Bran Oil	
	Soybean	Groundnut	Sunflower	Mustard	Rice Bran	Corn gram
Myristic	0-1	0-1	0	0	0.4-1.0	0.17
Palmitic	7-11	6-9	3-6	2-8	18	8.12
Stearic	2-6	3-6	1-3	7-15	1-3	2-5
Oleic	15-33	53-71	14-33	3-35	45	14-49
Linoleic	43-56	13-27	44-75	10-30	37	34-62
Linolenic	2-10	-	-	5-26	0.5-1.0	-
Arachidic	0-2	2-4	0-4	-	-	-
Beheric	-	0-2	-	-	0-2	-

Source: Orthoefer and Hui, (1996)

compared to other edible oils (Table 3) and is closer to the guidelines set up by WHO.

Rice bran oil is extensively used in Japan, Korea, China, Taiwan and Thailand as an edible oil. Despite being a leader in rice production, India has not fully exploited its potential to produce and use edible grade RBO (Rajam *et al.*, 2005). The National Institute of Nutrition (NIN) following a comprehensive and systematic protocol of the WHO/ Food safety.

The highly nutritious oil contains excellent combination of nutraceuticals, vitamins, minor components which are very useful in maintaining healthy heart and related blood vessels as well as attains lowering of bad cholesterol and increasing of good cholesterol (HDL).

Nutrient composition of Rice Bran Oil (RBO)

The chemical composition of RBO is very close to that of groundnut oil. Both the oils contain about 35% linoleic acid. In addition, linolenic acid (2.2%) is present in rice bran oil. RBO has high unsaponifiable fraction (4.2%), which is higher than the level recommended by the Central Committee of Food Standards (Gingras, 2002). However, the unsaponifiable fraction of RBO is rich in minor constituents such as phtyo sterols (1.8%), (gamma) oryzanol (1.6%) and total tocopherol (81.3 mg/ 100g). Oryzanol is a mixture of ferulic acid esters of triterpene alcohols such as cycloartanol (106 mg/ 100 g), cycloartanol (482 mg/100 g) and 24-methylene cycloartanol (494 mg/100 gm). Tocopherols and tocotrienols which are present in high concentrations (550 ppm), provide oxidative stability to RBO and improve its shelf life. As compared to other edible oils, RBO has higher content of squalene (320 mg/100g), which is beneficial in maintaining the tone of skin (Randall *et al.*, 1985) The unsaponifiable matter of the oil also has been shown to reduce serum cholesterol in

TABLE 3: Rice bran oil with "ideal" SFA/MUFA/PUFA ratio as compared to other edible oils.

Oil	Fatty Acid % Wt		
	Saturated (SFA)	Monosaturated (MUFA)	Polyunsaturated (PUFA)
Mustard/Rapeseed	6	67	27
Cotton seed	28	22	50
Sunflower	12	21	67
Safflower	10	15	75
Soybean	16	24	60
Palm	51	39	10
Olive	14	77	9
Canola	6	58	36
Corn	13	20	62
Coconut	92	6	2
Palm kernel	86	12	2
Groundnut	20	50	30
Rice bran	24	42	34
Recommended by WHO	28.6	40	28.6

Source: Orthoefer and Hui, (1996)

experimental animals. The sterol composition of unsaponifiable matter is same as that found in other edible oils but for a higher content in rice bran oil (2.2).

The beneficial effects of these unsaponifiable matter components are well known. Tocopherols and toco-trienols act as potent antioxidants and anti-cancer agents while squalene has been shown to have antioxidant, antidermatitic and anti-tuberculosis properties. The sterols are known to reduce cholesterol in the blood in experimental animals. CFTRI work has shown the individual cholesterol lowering effect of refined rice bran oil and or oryzanol in experimental animals.

The work carried out at the National Institute of Nutrition, Hyderabad has also demonstrated the antidermatitic and cholesterol reducing properties in rats and human beings respectively. The unsaponifiable matter of rice bran oil at 2 and 4 % in a diet of 10% in a diet of 1% fat diet had produced lowering of cholesterol levels. A diet of 10% refined rice bran oil of 4.1% unsaponifiable matter in three generations studies in rats has not shown any toxicological effects and the effect was same as that for groundnut oil fed rats (DeGuzman, 2003). The studies in Japan by Suzuki and Oshima on human beings have shown that blending of rice bran oil with sunflower oil (7:3) reduced cholesterol to a great extent. The oil extracted from two different rice varieties *viz.*, Indica and Japonica showed more or less similarity in the fatty acid composition (Table 4). The indica varieties showing high amount of palmatic acid as compared to japonica varieties while large variation was found in oleic acid of japonica varieties over indica type. It is clear that 95% of the oil is more or less similar in composition to Japanese rice bran oil (Table 5). The limit of unsaponifiable matter fixed for RBO produced in Japan as in Table 6 indicates that the value may be as high as 5.0% for frying purposes (Seetharamaiah and Prabhakar, (1986).

TABLE 4: Fatty acid composition of oil of Indica and Japonica types of brown rice.

Fatty Acid	Fatty acid content (%)	
	Indica type (Indian varieties)	Japonica type (Japanese varieties)
Myristic	0.2-0.4	0.2-0.4
Palmitic	16-18	14.9-16.7
Palmitoleic	0.2-0.3	0.2-0.3
Stearic	1.6-2.2	1.6-2.1
Oleic	40-46	40.9-49.5
Linoleic	28.8-35.6	28.5-36.7
Linolenic	1.1-1.8	1.2-1.5
Arachidic	0.8-1.1	0.7-0.9
Gadoleic	0.5-0.7	0.6-0.9
Behenic	0.4-1.0	0.4-0.5
Lignoceric	0.6-1.0	0.7-1.1

Source: Orthoefer and Hui, (1996)

Sterols: Plant sterols such as stigma sterol, beta sitosterol and campesterol have been reported to have cholesterol lowering activity (Table 7). The esters of phytosterols with long chain fatty acids and free sterols both are effective.

Nicolosi studied the effect of feeding a semipurified diet containing 0.1% cholesterol and varying amounts of rice bran oil (0 to 34.3% of dietary energy) to mini adult male cynomolgus monkeys, Serum cholesterol and LDL cholesterol decreased with the increase in amount of RBO (maximal decrease about 10%). The effect could not be explained by the fatty acid composition of RBO, oryzanol (0.02 g/100 g oil) or tocotrienols. The phytosterol content was 2.5 g/100 g oil and is suggested to be the factor contributing to lower cholesterol. However, this could not be substantiated with rice bran oil sterol concentrate (which primarily was oryzanol concentrate). The structure, composition of the phtyosterols (oryzanol constituents) and the dosage seems to be important to have a desirable hypocholesterolemic effect (Lloyd, 2000).

Tocopherol/Tocotrienols: Vitamin E refers to alpha-tocopherol and related compounds showing similar biological activity. The structures of the four tocopherols and three tocotrienolas are given below. Rice bran oil contains 45-137 mg/100 g of tocopherols and tocotrienols of which about 57% is the latter. A typical break-up is as follows:

Tocopherols have been isolated from rice bran oil by molecular distillation and treatment with anion exchange resins. The tocopherol concentrate thus obtained is mixed with hardened soya oil to

TABLE 5: Composition of crude rice bran oil.

Constituents	% in oil
Saponifiable lipids	95.0
UnSaponifiable lipids	4.2

Source: Orthoefer and Hui, (1996)

TABLE 6: Categories of rice bran oil marketed in Japan.

Category	Grade	Maximum (%) unsaponifiable Matter	Usage	Cloud point
A	1	0.5 %	Salad oil mayonnaise	Below 0°C
B	2	2.0 %	Cooking and Frying Purpose	3 to 40°C
C	3	5.0 %	Cooking and Frying Purpose	Unwinterised
D	4	Above 5 %	Dark brown oil for industrial use	Unwinterised

Source: FAOSTAT, (1998)

give 40% tocopherol containing food additives. Partial concentration of the tocopherols is achieved by reacting the deodorizer distillate from rice bran oil which is rich in fatty acids, with calcium hydroxide or sodium carbonate in the presence of a suitable solvent and concentrating the filtrate. An enrichment procedure for tocotrienols involves treatment of the methyl esters of the residues from physical refining of rice bran oil with anion exchange resin to remove any free fatty acid followed by chromatography on C-18 alkyl bound silica gel. Tocotrienols rice fractions have also been islolated from rice bran oil methyl esters by elution with ethanol from an Amberlite LG 400 column (Qureshi *et al.*, 2002).

Alpha-tocopherol and the related compounds have a powerful antioxidant activity in vitro. It is believed that this antioxidant activity is central to the beneficial effect of vitamin E in biological system in alleviating a multiplicity of deficiency syndromes. The reported beneficial effect of vitamin E compounds are for antisterility, treatment of nutritional myopathy, increased immune function, control of cardiovascular, cancer and aging. There is an opportunity in utilising the antioxidant properties of tocopherols/tocotrienols/ oryzanol in food and cosmetic applications.

Chloesterol lowering effect of RBO

Studies in humans: The hypolipidemic action of RBO was investigated in 21 subjects with high total cholesterol (> 225 mg/dl) or high triglycerides (> 190 mg/dl). The subjects were randomly divided into experimental and control groups. Twelve subjects, who constituted experimental group, were instructed to use RBO in place of their usual cooking oil, which they were using earlier. The remaining nine, served as controls, were allowed to continue the use of their habitual edible oil. There was a significant reduction in total cholesterol and triglyceride levels 15 and 30 days after the use of RBO. However, in control subjects there were no changes in serum lipids (Sugano and Tsuji, 1997).

TABLE 7: Sterol composition of rice bran oil.

Composition	Source 1 (%)	Source 2 (%)
Beta sitosterol	0.885	1.7
Campesterol	0.506	0.66
Strigmasterol	0.271	0.25
Total	1.800	3.20

Source: http://www.californiariceoil.com/nutrition.htm

The hypocholesterolemic effect of RBO was also reported from Japan. RBO has been shown to have greater serum cholesterol lowering effect than corn, safflower or sunflower oil. In addition, RBO in combination with safflower oil (70:30 ratio) has been shown to substantially lower high total cholesterol to normal levels within seven days. Experimental rats after feeding blend of RBO with safflower or sunflower oils (70: 30 ratio) for 28 days showed similar results. It is suggested that high linolenic acid content of safflower oil, in combination with micronutrients of RBO unsaponifiable fraction, act synergistically to lower total cholesterol levels (Wilson *et al.*, 2000). In view of this RBO could be considered as suitable edible oil for patients with hyperlipidema. RBO increases levels of good cholesterol (HDL) and decrease bad cholesterol (LCD). Hypocholesterolemic activity of RBO in comparison with other edible oils is presented in Table 8.

TABLE 8: Hypocholesterolemic activity of various edible oils.

Edible oil	Linoleic acid (%)	Cholesterol level
Safflower	77.1	-16
Sunflower	61.4	-12
Cotton seed	58.0	0
Soybean	50.2	+ 3
Sesame	45.9	+ 2
Corn	43.0	-15
Rice bran	36.0	-17
Groundnut	35.0	+ 5

Source: http://www.californiariceoil.com/nutrition.htm

Safety evaluation of RBO

Antimutagenic properties: There is a definite association between fat intake and occurrence of certain types of colon and breast cancer. Since RBO is an unconventional oil, its mutagenic potential was assessed by Ames mutagenicity assay, using *Salmonella typhimurium* strains of TA 98 TA 100 with or without metabolic activation. However, no mutagenic activity was observed either with or without metabolic activation. High temperatures are known to produce mutagens in deep fried foods as well as in edible oils. Four different snack foods, prepared in RBO, were therefore evaluated for the presence of mutagents by Ames mutagenicity assay. Similar presentations in GNO were taken as control. Food deep-fried in RBO showed that the oil is less absorbed or consumed in fried foods when compared with foods fried in GNO. In addition, neither RBO nor the foods fried in it had any mutagenic effects in the bacterial screening system. The organoleptic studies of the foods fried in RBO also revealed good acceptability of these products (Bhattacharyya *et al.*, 1986).

Rice bran to Rice bran oil: Rice bran is the source of rice bran oil (Barber *et al.*, 1980). Various commercial efforts to extract the oil have been made over the past 50 years. Initially, use of the oil in traditional foods was targeted. More recent efforts have emphasized the nutritional benefits of rice bran oil. Rice bran oil with low free fatty acid content can be extracted with hexane from extrusion stabilized bran. The process flow is shown in Fig. 2. Nonstabilized bran, although having a high free fatty acid, can also be used for production of oil. With nonstabilized bran, the extraction is similar to that of extracting a fine powder. Pre-processing of the bran through an extruder, expander, or expeller may be used to form either a flake or pellet that results in improved solvent flow through an extraction bed (Prabhakar and Venkatesh, 1986). Flaked bran with only 7–12% passing a 25 mesh screen gave a percolation through a 60-cm bed of 563–620 L/m2/ min. The oil extraction rate was rapid, with 96% of the oil being removed in 5 minutes and only 0.7% residual oil remaining after 1 hour of extraction.

Earlier methods to recover the oil used hydraulic pressing (Juliano, 1985). In a Japanese system for pressing, the raw bran is cleaned by sifting

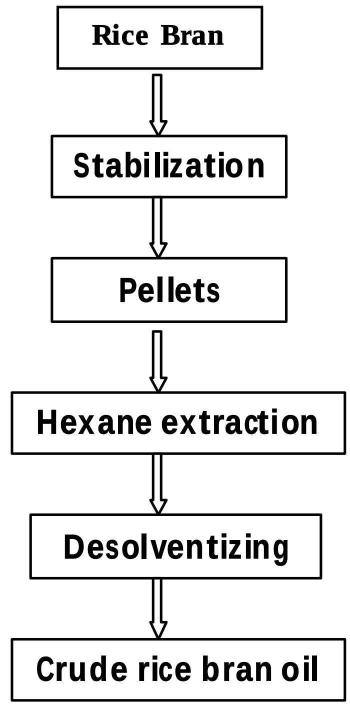

FIG. 2: Process for rice oil production.

and air classification to remove whole and broken grains and hulls, and, in some instances, to recover rice germ. The bran is then steam cooked, dried, prepressed, and finally expeller pressed (Seetharamaiah and Prabhakar, 1986). Hexane extraction may be batch, battery, or continuous type. All three systems were recently operating in Japan. Continuous systems operate in Brazil, Burma, Egypt, India, Mexico, Taiwan, Thailand, and the United States. The bran in the most efficient systems is stabilized, pelletized, and, if required, dried. After the pretreated bran is placed in the extractor, hexane is pumped in and allowed to percolate through the bran to extract the oil. Counter current extraction is used. The miscella (solvent plus oil) is passed through filters to remove the bran fines before evaporation for solvent and crude oil recovery. The production of fines from expander stabilized bran depends on stabilization condition (Rukmini and Raghuram, 1991). Flake size is larger if expanded at 120^0C, but the flakes are fragile and easily broken. Flakes with high moisture content were more resistant to breakage. Final bran moisture was about 6%. Pelletizing of the bran improves percolation and minimizes fines in the miscella. Pellets are 6–8 mm in diameter. Moistening during palletizing reduces the fines problem. Parboiled bran does not produce the hard pellets found for raw bran possibly because of protein denaturation during parboiling (Aizono, 1976). Binding of the fines in the pellet is assisted by starch gelatinization during heating of the bran. Parboiled bran also presents problems with sticking to dryer surfaces resulting in self-ignition in the dryer. Prior mixing with raw bran alleviates the problem.

The X-M process combines solvent extraction and milling of the rice. Brown rice is pre-treated with warm rice oil (0.5%) for 2–3 hours to soften the bran (Kahlon, 1992). The rice is then milled in the presence of a rice oil miscella. The solvent slurry is then removed from the rice and the rice oil is recovered. Advantages are that stabilization is not required and the resultant oil had a minimum FFA level. This process is no longer used. Extraction of rice bran oil by supercritical fluid has been investigated. Minor reductions in oil yield may occur. The oil yield with supercritical CO_2 is 17.98%, with CO_2–ethanol 18.23%, and with hexane 20.21%. (Ghosh and Bandyopadhyay, 2005).

Status of rice bran oil in other countries

• RBO is extensively used as “Premium Edible oil” in Japan, Korea, China, Taiwan and Thailand.

• In Japan, rice bran oil is more popularly known as a “Heart Oil”.

• In recent years, US scientists have also shown a tremendous interest in the cholesterol lowering properties of rice bran oil

• In Western countries rice bran oil has acquired the status of “Health Food”.

CONCLUSION

In today’s “Health is Wealth” scenario, this wonderful “Heart friendly” cooking oil should be promoted as “Health oil” in India with the help of Government and other associated agencies. Television, electronic media and press should form the core of the activity as regards advertisements. Family physicians, dieticians and health experts should be motivated to create a “Awareness of RBO” along with easy availability of oil in every village level in pouches for better health of our people in the national interest.

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