

Review

Palm oil and rice bran oil: Current status and future prospects

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The continued demand for edible oils by the ever increasing population makes it pertinent to explore new sources. In this direction, two new edible oils namely palm oil and rice bran oil have been subjected to nutritional and toxicological evaluations of their chemicals constituents. An attempt has been made in this article to assess the acceptability of the two oils based on the various investigations that have been carried out so far.

Key words: Palm oil, rice bran oil, anti-oxidants, cholesterol fatty acids, phospholipids, tocopherols, oryzanol, cardiovascular diseases.

INTRODUCTION

Vegetable oils are the main source of dietary fat for almost all sections of the Indian population and there is a continued growing demand from both caterers and consumers. Although the Indian population has a penchant for a variety of deep fried products, there is also a greater awareness of the problems such as atherosclerosis caused by saturated fats. Thus, in view of the present health scenario, there is a tendency to replace traditional fats like ghee and coconut oil with other healthier options. Due to the ever-increasing demand for edible fats, several oils and fats are being examined, so as to find a fat that is suitable to the Indian consumer. During the course of identifying new sources of oil, it is necessary to consider its potential to meet both the consumers' tastes as a cooking medium and the essential fatty acid requirements. It is also necessary to know the atherogenic potential, in view of the fact that consumption of saturated fats might lead to cardiovascular disease.

Among the oils under consideration, palm oil and rice bran oil offer great scope in India, as they are widely preferred by the vanaspathi industries and also by the Indian consumer. The oil palm gives higher yields in comparison with other oil yielding species. Rice bran oil also offers high potential, as India has high rice production in the world second only to China. Thus, there is an urgent need to evaluate both palm oil and rice bran oil under Indian dietary conditions in order to contribute to the nutritional and health risks that may follow the consumption of these fats in large amounts.

Many studies have been conducted in relation to nutritional status of these edible oils. A large amount of information on the ability of these oils to lower cholesterol levels, scavenge free radicals, cause mutagenicity and other effects. However, there is no paucity of data on: a) the effect of feeding them at very high level; b) their protective effect on cardiovascular diseases; c) the effect of consumption of the fried oil; d) changes in the fatty acid composition on heating; and e) their effect on the fatty acid composition of plasma, erythrocytes, and other tissues. Many trials have been conducted utilizing heated palm oil and heated rice bran oil, in both short term and long term experimental studies.

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Abbreviations: RPO, Red palm oil; CRPO, chemically refined palm oil; RBD, refined, bleached and deodorized; PRPO, physically refined palm oil; HDL, high density lipoprotein; FER, feed efficiency ratio; FFA, free fatty acid; LDP-c, low density lipoprotein cholesterol; VLDL-c, very low density lipoprotein cholesterol.

PALM OIL

The oil-palm tree (*Elaeis guineensis*) originates from the

west coast of Africa, where it (oil) has been used since very early times (P.O.R.I.M, 1988). The oil palm is cultivated widely in East Africa, South America, Indonesia and Malaysia. In India, oil palms are now being grown in several states (ICAR, 1988). A total area of 5,75,000 ha has been identified as suitable for oil-palm cultivation in India. The states of Andhra and Karnataka alone grow oil-palm over an area of 2,50,000 ha.

The oil palm plant starts bearing fruits about 5 years after planting, reaches its peak production 5 years later and continues to yield for another 20 years. The fruit consists of a leathery exocarp, a fleshy mesocarp and a hard shell called endocarp. The endocarp contains a creamy endosperm (Cottrell, 1991). Palm oil obtained from the mesocarp of the oil-palm fruit. The oil is extracted from the mesocarp of the oil-palm fruit by a series of unit operations involving; (1) sterilization of palm fruits for arresting the lipase enzyme present; (2) stripping for separating the fruits from the bunch; (3) screw pressing; (4) separation of the oil and its clarification. The palm kernel oil is obtained from another set of unit operations. These operations are seed separation, shell cracking, shell separation, kernel crushing, and screw pressing and solvent extraction. The oil obtained by the above method is called crude palm oil and red palm oil because of its intense orange color. The red palm oil is an unrefined, unbleached version and extremely rich in carotenoids. The total carotenoids content of red palm oil is said to vary from 500-1600 ppm (Wong et al., 1988). α -Carotene (29%), β -carotene (62%), γ -carotene (4%), Xanthophylls and Lycopene (2%) which contribute to the red color. RPO is the only vegetable oil that contains carotenoids of which 62-70% is beta-carotene. Beta-carotene is the most common precursor of vitamin A, which is important for maintaining the skin and mucous membranes in good condition, as well as in promoting good vision, bone growth and reproduction. Another aspect of the RPO is the phospholipid content. The phospholipid content of crude palm oil varies with the season and to a lesser extent with the mill operation. Red palm oil contains 3.2-4.5 ppm iron. Recent studies indicate that beta-carotene acts as an anticarcinogen, (Sylvester et al., 1986), and produce a hypocholesterolemic effect (Shaish et al., 1995) in conjunction with other favourable factors. In fact, 1 g of RPO contains 430-760 IU of vitamin A. However, there are hardly any reports to show the extent of change in carotenoid contents in red palm oil (RPO) kept for a long time under storage.

RPO also contains about 1.5% of unsaponifiable matter, which includes sterols, tocopherols (tocopherol and tocotrienols) and the carotenes. During the process of refining, most of the carotenes are lost, thereby increasing the cost of the oil. In view of this, attempts are now being made to make use of the red palm oil as a source of vitamin A to meet the needs of Indian population particularly children, to prevent vitamin A deficiency.

The technology for retaining most of the β -carotene in RPO has been developed (Rajam et al., 2005; Manorama and Rukmini, 1992). The unsaponifiable fraction of the RPO also contains, Tocopherol (20%), tocotrienols (25%) α -tocotrienols (45%) and γ -tocotrienols (10%). In palm oil, the later compounds vary from 600-1200 ppm. The tocopherols are not only good antioxidant; they are also physiologically active as vitamin E. In addition to tocopherols, one finds in palm oil tocotrienols which constitute two – thirds of the total tocopherols that are present (Cottrell, 1991). Tocopherols and tocotrienols are known to scavenge free radicals (Packer, 1992), protect against oxidative injury (Serbinova et al., 1992), reduce platelet aggregation (Qureshi et al., 1991), and protect against atherogenesis (Hasselwander et al., 2002) and cancer.

In India 90% of the palm oil produced is used for edible purposes. To meet the growing demand for oil, India also imports RBD (Refined, Bleached and Deodorized) oil. The RBD palm oil has a pale yellow color like other refined oils and is semisolid at room temperature; it has a good shelf life (Cottrell, 1991). Under normal conditions, palm oil is usually a semi-solid, in the tropics, but at colder temperatures it is a solid fat. The solid consistency makes the palm oil less acceptable as cooking oil in cold countries. The process of fractionation by cooling leads to the formation of high-melting triglycerides (palm stearin) leaving behind low-melting glycerides (palm olein). Palm olein is therefore the liquid fraction of palm oil. There is also a difference in fatty acid composition of palm olein and palm stearin (Table 1); palm stearin is characterized by a low P/S ratio, and is more saturated than palm olein.

In countries like Japan, refined palm oil is further refined through treatment with phosphoric acid, followed by de-acidification with alkali, bleaching and deodorization, before being available commercially. Such refined palm oil is called chemically refined palm oil (CRPO). The CRPO has a lower free fatty acid content than the physically refined palm oil (PRPO) (Miyazawa et al., 1994). The quantity of palm oil refined by these two methods is commonly judged by chemical and physical criteria (Swoboda, 1985; Williams and Padley, 1985). The physically refined and chemically refined palm oil has certain physico-chemical properties which are absent in imported oil (Table 2). CRPO does not seem to be nutritionally superior to the physically refined palm oil, as both these oils produce similar rates of growth in rats. However, chemical refining does not reduce the free fatty acids to lower levels than physical refining (Duff, 1991; Young et al., 1986).

Palm oil is widely used in domestic cooking and for the production of vanaspathi and margarine, for which purpose it is blended with other oil. It can easily substitute conventional vegetable oil, like peanut and coconut oils for domestic use, and make the latter available for other purposes. Moreover, the β -carotene present in the oil can also function as a natural color for margarines. Palm oil is also widely used in coffee whiteners, and in confectionery

Table 1. Physico-chemical properties of the palm oil.

Palm oil	Physically refined palm oil (PRPO)	Chemically refined palm oil (CRPO)
Iodine value (meq /kg)	50.4	50.2
Acid value (meq/kg)	0.7	0.1
Peroxide value (meq/kg)	4.9	0.9
Carbonyl value (meq/kg)	34.5	25.7

Source: Ramachandran (2001).

Table 2. Major components of crude red palm oil.

Components	ppm
Carotenoids	500-700
Tocopherols and Tocotrienols	600-1000
Sterols	329-530
Phospholipids	5-130
Triterpene alcohols	40-80
Methyl sterols	40-80
Squalene	14-15
Aliphatic alcohols	100-200
Aliphatic hydrocarbons	50

Source: Food and Nutrition Bulletin (1994).

as a substitute for cocoa butter.

Palm oil, and its fraction-palm olein and palm stearin – are gaining its importance in the food industry (Palm oil update, 1989). Palm stearin is used instead of beef tallow for the manufacture of margarines (Bhattacharyya et al., 1987), palm olein is used in the manufacture of vanaspathi, hydrogenated vegetable oil; moreover, it is being incorporated into confectionery, bakery products, ice creams, and coffee whiteners. In India, it is used as a substitute for cocoa butter, and thus helping in reduction of import of cocoa butter.

The major objection to the use of palm oil has been that it is a saturated fat. Some earlier studies (Anderson et al., 1976) indicated that palm oil could increase cholesterol levels, and thus considered worse than animal fat, mainly due to the growing concern over the relationship between atherosclerosis and high cholesterol levels. However, several years later studies by various workers, Hornstra (1987), Horlick and Craig (1957) and Gottenbos and Vles (1983) indicated that palm oil is hypocholesteremic, increases protective High density lipoprotein (HDL), and does not cause atherogenesis, in spite of its low P/S ratio (0.31) and low linoleic acid content (10%). Animal experiments have shown that Palm oil is similar to other oils in absorption, feed efficiency ratio (FER) and growth promotion (Baudet et al., 1984; Khan and Lim, 1988). Further, it prevents cholesterol accumulation in the liver of young and adult rats (Choi et al., 1993) even in the

liver of hyper cholesterolemic animals. In humans, it not only decreases cholesterol, (Hornstra, 1988) but also increases HDL and decreases apo-B, relative to the control diets (Sundaram et al., 1990) Subsequent studies by various workers have unequivocally demonstrated that palm oil though low in linoleate content, is not hypercholesterolemic because of: (a) the equal distribution of saturated and unsaturated fatty acids in it, and (b) the high content of oleic acid (18:1, n-9) which has been proved to reduce cholesterol levels (Khor and Tan, 1992; Mattson and Grundy, 1985; Rudel et al., 1991). The level of linoleate is just optimum in this fat, as higher levels are preferred due to the possible generation of free radicals and the oxidation unsaturated fatty acids, which can probably lead to various forms of cancer and tumor (Conte et al., 2004).

Recent studies by Japanese workers indicated that feeding palm oil alone induces a deficiency of n-3 fatty acids leading to the accumulation of eicosapentaenoic acid (EPA 22:5, n-6) (Rebhung et al., 1994). The increase in 22:5, n-6 is compensated by the decrease in docosahexaenoic acid (DHA: 22:6, n-3). It has been shown that, this could be prevented by feeding an optimum level of n-3 fatty acid containing vegetable oil like soybean oil (Miyazawa et al., 1994). It is obvious from the above studies that the nutritional qualities of fatty acids cannot be judged solely by their fatty acid composition.

Crude palm oil contains a variety of minor components, which play a major role in lowering cholesterol levels, and providing protection against tumor development (Goh et al., 1994; Engelberts et al., 1993). Technologies are being developed to retain the β -carotene in palm oil. The β -carotenes present in the crude palm oil are being exploited as a source of vitamin A, particularly in countries where the vitamin A deficiency is wide spread (Gopalan et al., 1992). β -Carotene of palm oil has a protective effect against cancer (Sundaram et al., 1989). It contracts any arterial thrombosis tendency and aggregation of platelets due to the presence of tocopherols and tocotrienols. It also protects against X-ray include damage in bone marrow cells and prevents peroxidation of skin lipids (Rand et al., 1988).

Crude palm oil did not prove toxic to rats, and did not alter their reproductive performance, when fed at low levels for several generations (Manorama et al., 1993). No deleterious effects were observed when high protein diets, containing 10% of heated palm oil, were fed to rats for a short duration (Okuy and Oke, 1986). Palm oil has also been found to be non-toxic, antimutagenic and anticarcinogenic (Azuine et al., 1992). Thus, the above studies indicate that palm oil is safe for human consumption at low levels. If the cost of palm oil is maintained at a reasonable price, one could ensure a higher level of consumption, among poor income groups and thus reduce calorie and vitamin A deficiencies. It could also help in preventing atherosclerosis, and also increase the intake of beneficial components like β -carotene, tocopherols and tocotrienols.

Further studies need to be carried out on blending (Hariharan et al., 1996) oils, with the following objectives:

a) to increase n-3 fatty acids; b) to evaluate the simultaneous increase of saturated fatty acids like palmitic (16:0) acid; and c) its effect of blending on linoleic acid levels. By blending of oil, it should become possible to favorably shift the n-6 /n-3 ratio close to the recommended levels (Ghafoorunissa, 1994). Palm oil as such does not contain any trans-fatty acids. However, further elaborate investigations are needed to see whether heating of palm oil leads to the formation of trans- isomers.

RICE BRAN OIL

Rice is produced in very large quantities in nine countries of South-east Asia. Considerable amounts are also produced in the USA, Europe and Latin America. China is the largest rice producing country followed by India. Rice bran is a byproduct of rice processing industry and upon extraction yields rice bran oil. The oil content of rice bran varies in each variety, and depends to an even greater extent on the processes and conditions obtained during rice milling. Rice bran, as such, has 15 to 25% of oil associated with it. The total world production of about

4000 million tons of paddy may yield about 6-7 million tons of edible grade oil. Modern techniques of recovery would yield oil and other by-products of better quality than the old technologies, still being used in India, China and other Asian countries.

Rice bran oil is comparatively new oil, recently introduced in the consumer market. It is used in the manufacture of vanaspathi and for culinary purposes. Rice bran oil shows great promise for extensive use in India, due to the presence of several factors like γ -oryzanol, which are known to protect from cardiovascular diseases. Multiple generation studies are being conducted to evaluate its nutritional quality, mutagenicity and protective effect against certain types of cancer.

There are a number of factors that influence the quality of rice bran oil. Immediate extraction and processing are considered as of prime importance, as delayed extraction can lead to problems, such as color changes and deterioration of organoleptic quality and flavours. Moreover, rice bran quality is also influenced by the presence of an active lipase, which hydrolyses the triglyceride to fatty acids and glycerol. The rate of hydrolysis is so high that the free fatty acid (FFA) content in the oil may rise by 10-20% within a day and up to 70% in a month, imparting a dark colour to the oil. The composition of oil is known to vary with respect of phospholipids, glycolipids and non-glyceride components such as waxes, sterols, oryzanols (ferulic acid esters) tocopherols, hydrocarbons, besides pigments and odour components (Sharma and Rukmini, 1987).

Commonly, rice bran oils having an FFA content of 15-40% are produced. Commercial rice bran oil varies in FFA depending on the quality of rice bran from which the oil has been extracted. The refining of high FFA oil has been accomplished by different methods such as physical refining (Rao, 1983), Bhattacharya et al. (1987) using simple solvents like hexane, or with mixtures of two solvents like hexane and ethyl alcohol, or of ethyl alcohol and isopropanol. Rice bran oil is more difficult to refine using methods like alkali or heat treatment, due to the presence of tightly associated wax. Hence, the oil has to be dewaxed and degummed before being neutralized. De-waxing is done by treating with hexane or other solvents and removing the separated wax by filtration or centrifugation. Thereafter, the oil has to be degummed. The earliest method employed for degummed of rice bran oil involved the use of 0.1 M phosphoric acid (Bhattacharya and Bhattacharya, 1985) of 85% strength, in the form of a 10% aqueous solution, at 60% for 30 min. The degummed oil may be de-waxed again by treatment with 0.2% calcium chloride, in the form of 10% aqueous solution, at 15°C for 4 h (Bhattacharyya and Bhattacharyya, 1983). Current commercial practices involve de-waxing and degumming by adding phosphoric or citric acids followed by filtration or settling. Alternatively, steam is passed into the oil at a temperature of 80-100°C, which separates the gum by flocculation (mutual

Table 3. Characteristics of crude and refined Bran oil.

Characteristic	Crude Bran oil	Refined Bran oil
Free fatty acids (%)	30	0.1
Unsaponifiable matter (%)	4	2.0
Refractive Index	1.46-1.47	1.46-1.47
Specific gravity	0.91-0.92	0.91-0.92
Iodine value	85-105	90-105
Saponification value	175-195	180-195
Acid value	80.0	0.5
Flash point Pensky martens	90	250

Source: Ramachandran (2001).

adhesion and floating). Subsequently the oil is de-acidified by steam distillation to remove the free fatty acids, or also by physical refining e.g., distillation or miscellar refining. Efforts have also been made to deacidify rice bran oil by re-esterification using a chemical catalyst (Bhattacharyya and Bhattacharyya, 1987). The oil obtained is then bleached, using activated carbon, and the deodorized to get pure rice bran oil. The unsaponifiable fraction obtained during refining contains vitamin E, tocopherols and oryzanol, all of which have various pharmaceutical properties. The refined rice bran oil thus produced has a characteristic colour and the characteristics as listed in Table 3.

The total availability of rice bran oil in India is about 6 million tons (Usha and Premi, 2011). The present production of rice bran oil is about 400,000 tons of which only 50% is of edible grade, 50% of the total available rice bran oil is left unutilized due to various reasons. About 40% of rice milling capacity in India is provided by obsolete huller type mills (Seth and Mehta, 1987). Thus, if hullers are eliminated from commercial rice milling, and replaced at least 1-2 million tones of additional bran would become available for extraction. The other major problem affecting the quality of bran is the presence of a powerful lipase (Guptha, 1989). Several methods have been developed to stabilize the rice bran by de-activating this enzyme (Desikachar, 1974; Maharaj, 1982). A newer bran stabilization technique—viz., the low-cost acid stabilization technique could obviate problems arising from presence of non-oil impurities like wax, unsaponified matter, color pigments in bran handling (Gopalakrishna, 2002). These impurities restrict the use of rice bran oil in the manufacture of vanaspathi. Most of the vanaspathi manufactures in India do not use more than 20-30% of rice bran oil for vanaspathi manufacturing, mainly due to the high content of color and unsaponifiable compounds in the final product. In 1994-95, about 150,000 tons of rice bran oil was used for vanaspathi manufacture.

India is one of the largest producers of rice, and thus has a high potential to produce rice bran oil. The rice bran contains 15-20% of oil by weight (4.2%) which is rich in constituents such as phytosterols, triterpene

alcohols, tocopherols, tocotrienols (Sharma and Rukmini, 1987). It also has a highly hypocholesteremic compound, viz., γ -oryzanol (1.6%), which is a mixture of ferulic acid esters of sterols and triterpene alcohols, for example, cycloartanol, 106 mg/dl; cycloartenol, 482 mg/dl and 24-methylene cycloartanol, 494 mg/dl (Itoh et al., 1973). The tocotrienols and tocopherols act as antioxidants, and thus provide oxidative stability to the fat (Lea, 1960). The triglyceride fatty acid composition is similar to that of other oils with a high concentration of linoleic acid (35-38%) and α -linolenic acid ranging from 1.8-2.4%. Besides, it has also some squalene, which is beneficial for the skin. As against this, the commercially obtained oil varies in FFA content depending on the quality of rice bran from which it has been extracted. The FFA content of refined oil varies from 2-5%, whereas crude oils with high FFA content ranging from 15-40% are also produced. This is due to the presence of a lipase in the bran, which should normally be inactivated before extraction of oil. Some methods have already been developed to inactivate the enzyme (Gopalakrishna, 2002). The oil thus produced, is clear in colour and is widely used as a cooking medium in Japan, Korea, China, and to some extent in India and South-East Asian countries.

NUTRITIONAL AND TOXICOLOGICAL STUDIES ON RICE BRAN OIL

Several studies have indicated that consumption of rice bran oil has no adverse effect with respect to absorption, utilization and growth promotion in rats (Sharma and Rukmini, 1986; Seetharamaiah and Chandrasekhara, 1989a). Similar results were obtained with hamsters (Kahlon et al., 1992) and also in non-human primates. In the latter, the total cholesterol, LDL-c and apo B levels were also reduced (Nicolosi et al., 1991). Besides multigeneration studies have been completed in rats that were fed rice bran oil at 10% level to evaluate the toxicological effect (Rukmini, 1980) and reproductive performance, vis-à-vis peanut oil, as judged by the percentages of consumption, birth weight, litter size,

weaning weight and pre-weaning mortality. Further, no mutagenic and teratogenic effects were observed and so its safety for human consumption could be established, using the food safety protocol of the WHO/Food Safety Council (WHO Report, 1987; SCFSC, 1978).

Further studies with rice bran oil were conducted to evaluate its hypocholesteremic effect in a diet containing added cholesterol (Rukmini and Raghuram, 1991). The results were evaluated and rice bran oil was found to be highly hypocholesteremic (Sharma and Rukmini, 1986; Purushothama et al., 1995). Notable reduction in total cholesterol, low density lipoprotein cholesterol and very low density lipoprotein cholesterol, reduction of liver cholesterol and triglyceride levels and fecal excretion of sterols were observed. These observations suggest that RBO increases the turnover of cholesterol (Seetharamaiah and Chandrasekhara, 1989b). Substitution of varying amounts of rice bran oil in place of palm, peanut and coconut oil also resulted in significant reduction of total cholesterol and triglyceride concentration in humans (Raghuram et al., 1989; Raghuram and Rukmini, 1995). Cholesterol lowering effect was observed also in monkeys fed a diet with rice bran oil (Nicolosi et al., 1991). In studies on humans, significant reduction was observed in plasma cholesterol, when replaced with RBO in hyperlipidaemic patients (Lichtenstein et al., 1994). In all the cases, the diet was able to induce hypocholesteremia, resulting from a selective decrease of LDL-c fraction. Besides, the hypocholesteremic effect of RBO was greater than what could be predicted from fatty acid composition. This discrepancy might be explained by the relatively high concentration of unsaponifiable compounds- including plant sterols, oryzanol and tocotrienols- in rice bran oil, when compared to other vegetable oils.

Various workers have shown that the unsaponifiable fraction in rice bran oil has γ -oryzanol (Scavariello and Arellano, 1998). It has been suggested that these compounds can act as regulatory agents, which control cholesterol biosynthesis by regulating certain key enzymes (Rong et al., 1997). Oryzanol is a mixture of ferulic acid esters of tripenoids alcohol. Apart from its hypocholesterolemic activity, oryzanol also promotes growth in animals and maintains the estrous cycle in rats (Shojiro and Shvetzu, 1980; Shimomura et al., 1980). Feeding diets containing oryzanol at 0.5% level, for about 7 weeks, reduces the total cholesterol, triglycerides and LDL-c, respectively (Seetharamaiah and Chandrashekhara, 1998) and protects against platelet aggregation (Seetharamaiah et al., 1990). Besides, it also reduces triglyceride levels in rats having fructose induced hypertriglyceridaemia in rats (Seetharamaiah and Chandrashekhara, 1988). Further, it possesses a potential antioxidant effect, and protects against lipid peroxides.

Several evidences suggest that cycloartenol, a triterpene alcohol is observed, and accumulates in liver (Kiribuchi et al., 1983). Since its structure is similar to

cholesterol, this compound competes for the cholesterol binding sites and thereby causes metabolism and excretion of cholesterol as bile salts and pigments. Besides, tocotrienols are also reported to inhibit the HMG CoA reductase activity of the biosynthetic pathway of cholesterol (Qureshi et al., 2002; Hirose et al., 1991; Sugano and Tsuji, 1997). Furthermore, triterpene also inhibits esterase activity leading to slow hydrolysis of cholesterol esters which leads delay in absorption of cholesterol.

It has been demonstrated that rice bran oil (both heated and unheated) possesses anti- and non- mutagenic activity (Polasa and Rukmini, 1987). Oils heated in a domestic kitchen are normally non heat abused. However in a restaurant where the oil is heated for a prolonged period in the presence of oxygen and moisture: consequently, its mutagenic potential may increase. Thus, rice bran oil is highly protective against hypercholesteremia, hyperlipidemia and coronary heart disease. Moreover, the PUFA/SFA ratio and linoleic/ α -linolenic ratio of RBO is nearly similar when compared with the recommendations of the world health organization (WHO Report, 1990). Hence, its use has been recommended in moderate amounts.

Since RBO has several (Sugano et al., 1999) advantages and health protecting effects, necessary steps should be taken to enhance its production and consumption. Further studies are required to evaluate the blending (Sunitha et al., 1997) with other oils to increase the production and thereby make large quantities of this non-conventional oil available for human consumption (Sugana and Tsuji, 1996). Further studies should be oriented toward the formulation of infant foods containing palm oil and rice bran oil, - in order to utilize the beneficial advantages they can confer, not only by decreasing cholesterol levels, - but also as good sources of vitamin A and oryzanol, respectively.

FUTURE PROSPECTS

Studies indicate that palm oil is safe for human consumption. If the cost of palm oil is reduced, one could ensure a higher level of consumption, among poor income groups and thus reduce calorie and Vitamin A deficiencies. Further studies need to be done on blending of oils (Hariharan et al., 1996), with the following objectives: a) to increase n-3 fatty acids; (b) to evaluate the simultaneous increase of saturated acids like palmitic (16:0) acid; and (c) effect of blending on linoleic acid levels.- By blending of oils, it should become possible to favorably shift the n-6/n-3 ratio close to the recommended levels (Ghafoorunissa, 1994), palm oil as such does not contain any trans fatty acids. However, further elaborate investigations are needed to see whether heating of palm oil leads to the formation of trans isomers, given the low rate of oil consumption by the

Indian population, on increase in palm oil consumption is unlikely to have any adverse effect; on the other hand, it could help to prevent atherosclerosis, and also increase the intake of beneficial components like β -carotene, tocopherols and tocotrienols.

Rice bran oil also has several advantages (Sugano et al., 1999), and health protecting effects. Necessary steps should be taken to enhance its production and to popularize its consumption. Further studies are required to evaluate the blending with other oils (Sunitha et al., 1997) to increase the production, and there by make large quantities of this non-conventional oil available for human consumption (Sugana and Tsuji, 1996).

This knowledge would be useful in recommending various ways of using these oils in food industry, as well as in house holds.

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