1. INTRODUCTION

Rice Bran Oil is a unique vegetable oil produced from the outer brown layer of rice which is removed in the form of rice bran during the polishing process of the rice milling industry. Besides having an almost ideally balanced fatty acid profile, it is rich in natural antioxidants. A number of scientific studies conducted in India & abroad have well documented the better cholesterol lowering properties of rice bran oil as compared to other conventional vegetable oils. All these studies have attributed these properties of the oil to the presence of unique nutraceuticals in this oil known as oryzanol & tocotrienols. Rice bran oil is the world’s healthiest edible oil, containing vitamins, antioxidants and nutrients. It is not just delicate and flavourful; but also helps to lower cholesterol, fight diseases, enhance the immune system, and fight free radicals. It contains highest amount of all natural vitamin-E and contains unique component oryzanol which is linked with increase in good cholesterol and lowering down the bad cholesterol and triglycerides. Rice Bran Oil is extensively used in Japan, Korea, China, Taiwan and Thailand as premium edible oil. It is the conventional & the most favourite cooking medium of the Japanese and is popularly known as "Heart Oil" in Japan. It has acquired the status of a "Functional Food" or a "Health Food" in Western Countries.

India is the second largest producer of rice in the world next to China, having potential to produce about 13.04 lakh MT of Rice Bran Oil per annum. India produces 140 Million MT of paddy and 93 Million MT of rice. Currently, the industry is processing about 44 lakh MT of Rice Bran producing about 8.30 lakh MT of Rice Bran Oil per annum, out of which 8.0 lakh MT are of edible grade and the balance 0.30 lakh MT is of non edible grade (SEA, India, 2010-11). The production of rice bran oil in India is shown in appendix (Table 1). India has substantial reserves of non-traditional oil seeds and oil-bearing materials. At present, merely half of this potential is realized; yet India is the largest producer of rice bran
oil in the world. Edible rice bran oil in India is still not very popular among the consumers. Typically rice bran accounts for 7–8% of the rice produced and the recovery of rice bran oil from rice bran is usually 15 - 16.5% in the country.

Bran is a hard outer layer of grain as shown in Fig. 1. Rice bran oil content ranges from 12-25% depending upon the quality of the bran. Chemical refining of rice bran oil generally results in losses considerably higher than those encountered in other vegetable oils due to the presence of larger amounts of free fatty acids and non-triacylglycerol constituents. Among the non conventional oils, rice bran oil and cottonseed oil are the most important.

Fig. 1 Structure of Rice with different layers

RBO has the ideal ratio of saturated, monounsaturated and poly-unsaturated fatty acids and is the closest to World Health Organization recommendation. The tocotrienol present in RBO has anti-thrombolic and anti-Cancer properties and good for skin. It contains squalene which improves skin tone and delays wrinkle formation. It has 4 hydroxy 3 methoxy cinnamic acid which stimulates hormonal secretion and rejuvenates health. Rice bran oil is a superior salad, cooking, and frying oil which leaves no lingering after taste. The high smoke point prevents fatty acid breakdown at high temperatures. Its light viscosity, allows less oil to be absorbed in cooking, reducing overall calories. It mixes better in salad dressings and improves the taste of baked goods.
The quality characteristic of properly refined rice bran oil is shown in appendix (Table 2). Appearance of rice bran oil ranges from cloudy to clear depending on the degree of dewaxing and winterization processes applied. Rice bran oil (RBO) has a good balance between oleic and linoleic acid, with a low linolenic acid content. Another interesting feature of RBO is its high unsaponifiable matter content compared to other oils. It contains the unique antioxidant gamma-oryzanol, which is mostly absent in other oils (Mezouari and Eichner, 2007).

The typical composition of crude rice bran oil is 81.3-84.3% triglycerides, 2-3% diglycerides, 5-6% monoglycerides, 2-3% free fatty acids, 0.3% waxes, 0.8% glyco-lipids, 1.6% phospholipids, 4% unsaponifiables. The wax content of rice bran oil can be somewhat variable, depending upon cultivar and processing parameters. The phospholipids in rice bran oil predominantly include phosphatidylcholine, phosphatidylethanolamine and phosphatidylglycerol. Various sterols constitute the principal portion of the unsaponifiable fraction of nutraceutical interest. In recent years, many studies have been conducted in the area of utilization of these minor components as co-products of rice bran oil processing (http://www.ricebranoil.info/why/index.html).

High content of natural antioxidants present in rice bran oil, impart higher oxidative stability and a longer shelf life as compared to other edible oils. The oxidative stability of refined rice bran oil has been found to be five times more than the groundnut oil. Although the polyunsaturated fatty acid content of rice bran oil is much lower than the other conventional oils, but it has higher cholesterol reduction power than even the polyunsaturated fatty acid rich oils. The fatty acid composition of rice bran oil as compared to other edible oils is shown in appendix (Table 3), whereas the proportion of saturated, mono saturated and poly unsaturated is given in Table 4.
Oryzanol is a powerful antioxidant only found in rice bran oil. It is more active than Vitamin E in fighting free radicals. Oryzanol is effective in lowering cholesterol levels in the blood, reducing liver cholesterol synthesis and treating menopausal disorders. Crude rice bran oil contains about 1.5% or more gamma-oryzanol, a group of ferulate esters of triterpene alcohols and phytosterols. Studies have shown several physiological effects related to gamma-oryzanol and rice bran oil components. These include its ability to reduce plasma cholesterol, reduce cholesterol absorption and decrease early atherosclerosis (Rong et al., 1997), inhibit platelet aggregation (Seetharamaiah et al., 1990), and increase fecal bile acid excretion (Seetharamaiah and Chandrasekhara, 1989). Oryzanol has also been used to treat nerve imbalance and disorders of menopause (Nakayama et al., 1987).

Rice bran oil is the only readily available oil, other than palm, that contains significant levels (approximately 500 ppm) of tocotrienols (Eitenmiller, 1997). These occur in at least four known forms and are similar to the tocopherols in chemical structure. They belong to the vitamin E family and are powerful natural antioxidants (Tomeo et al., 1995). The protective benefits of dietary antioxidants in the prevention of cardiovascular disease and some forms of cancer have been widely publicized (Eitenmiller, 1997; Nesaretnam et al., 1995). Both types of Vitamin E are natural antioxidants that help in fighting free radicals, a major cause of cancer. Tocotrienol is believed to vastly outperform tocopherol in fighting free radicals and in preventing oxidation; it also helps lower cholesterol levels in the blood.

RBO is widely used in pharmaceutical, food and chemical industries due to its unique properties and high medicinal value. It is ideal oil for margarine and shortening. The flavour gives the good palatability and the desired prime form crystal provides smooth plasticity and spreading qualities. Rice bran oil is also refined by neutralisation with alkali, with or without bleaching with fuller's or activated earth and/or activated carbon no other chemical agents
being used. The edible grade bran oil is coloured leaf-green and is quite similar in
composition and taste to groundnut oil. The flow sheet for the production of rice bran oil is
shown in appendix (Fig. 1).

The processing of rice bran to yield crude bran oil involves: preparation of rice bran
for extraction, solvent extraction, distillation of miscella, slipping of the oil and separation of
oil from water in the post-dissolventiser tank. Preparation of rice bran involves reduction of
moisture content from 12% to 6% in an expeller by steam jacketing. The treatment besides
reducing the moisture content of bran, increases particle size and imparts a hardening effect
to bran particles for better extractability, better filtration time and reduction of fines problem.
The pre-treated bran after being turned to flakes is fed to extraction column. The extraction
can be either batch or continuous. The bran flakes is seated on the false bottom provided in
the extractor with coir mat as filter element. After maintaining a vacuum of 25” Hg in the
extractor, solvent normally hexane is drawn into the extractor which is a counter current
multistage type and the extraction is carried out in hot condition, since it helps in quick and
efficient extraction, the oil which gets dissolved in the solvent is withdrawn from the bottom
as concentrated miscella. The solvent retained with the bran is recovered finally and
reused. The distillation of concentrated miscella is carried out at a temperature of about 75-
80° C, when more volatile component, hexane vaporises leaving behind the oil. The vapours
of the solvent are condensed and reused. The oil with 4% solvent is taken from the bottom to
a stripping column. The crude oil with about 4% solvent is fed to the stripping column, which
has block of gravels placed on a perforated plate as a packed column. The oil is stripped off
the solvent by open steam injecting and the solvent vapours recovered are reused after
condensation. The oil along with the condensed steam is taken by gravity into a tank called
post-dissolventiser. In the post-dissolventiser, the oil along with condensed steam from
stripping column is kept for 2 to 3 hours, when water gets separated and the oil is taken to the
oil tank where the oil is given salt wash to separate the sludge, gums etc. in the oil. This is the
crude rice bran oil, which can be used for manufacture of soap, emulsifiers, fatty acid, plasticisers, cosmetics and tocopherol (vitamin E) etc.

**Refining of crude rice bran oil for edible purposes**

Rice bran oil is, in general not only high in acid value in crude state but contains a considerable amount of wax, unsaponifiable matter and minute ingredients as well as a large amount of colouring matter difficult to bleach, and therefore it is said to be the most difficult oil among all vegetable oils, to refine. The various steps involved in the refining are:

**Degumming:** This step is essential to remove gums and mucilage present in the vegetable oils which are complex mixtures. The normal method of degumming involves the use of small quantities of concentrated phosphoric acid or sulphuric acid at moderate temperatures followed by filtration or settling. Alternately, direct steam injection may be carried out until the temperature reaches 80-100° C by which time sufficient steam will have condensed to achieve hydration and flocculation of the colloidal gum materials, which are then removed by centrifugation. Different degumming processes are available for crude rice bran oil. Enzymatic degumming is the best process already available today for reducing the phosphorous content of crude RBO below 5 ppm (Chakrabarti & Rao, 2004). It converts non-hydratable lecithin (gums) to water soluble lysolecithin, which is separated by centrifugation.

**Dewaxing:** It is preferable to remove wax from crude oil at the first stage of refining process, otherwise yield and quality of edible oil will decrease. Among various methods available for dewaxing, continuous wax method is preferred. The yield rate of dewaxed oil is 90-93% and that of the crude wax is approximately 5-8%.

**Neutralisation:** The purpose of this process is to remove fatty acid from dewaxed oil. In this process, the oil is treated with alkali such as caustic soda, which acts upon free fatty acid in
the oil to form soap. The neutralisation is done generally either by a batch operation or by a continuous operation. The neutralisation is generally adopted during the chemical refining process.

**Bleaching:** Bleaching is generally carried out either by a batch or continuous method, under either normal atmospheric pressure or vacuum. The conventional earth bleaching will readily give oils with Lovibond colours of 2-3- red units, an acceptable level for high grade cooking oil and salad oils.

**Deodorization:** The final stage in processing for cooking oil involves the removal of oxidative breakdown products which cause undesirable odours and tastes. Deodorisation of rice bran oil can be carried out in the normal manner by heating the oil to temperatures 200-250° C under high vacuum, stripping out the undesirable volatiles, in a current of dry steam. Any free fatty acids, peroxides and certain proportion of natural tocopherol antioxidants are also removed.

In India, Rice Bran Oil is the most important oil among the non-conventional oils in terms of its potential to augment the availability of oils. Full realization of its potential would help in reducing the gap between demand and supply of indigenous edible oils in the Indian market.

**Table: 1. Edible Oil Demand Projection**

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<th>2004</th>
<th>2010</th>
<th>2015</th>
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<tr>
<td>Total Demand (Million Tonnes)</td>
<td>10.9</td>
<td>15.6</td>
<td>21.3</td>
</tr>
<tr>
<td>Total Area under Oilseeds (Million Hectares)</td>
<td>23.4</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Yield (Tonnes/hectare)</td>
<td>1.07</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Production of Oilseeds (Million tonnes)</td>
<td>25.1</td>
<td>33.6</td>
<td>44.8</td>
</tr>
<tr>
<td>Domestic supply of edible oils (Million tonnes)</td>
<td>7</td>
<td>10.1</td>
<td>13.4</td>
</tr>
<tr>
<td>Total edible oil imports - (Million tonnes)</td>
<td>4.3</td>
<td>5.9</td>
<td>8.3</td>
</tr>
<tr>
<td>Imports as share of demand</td>
<td>39.40%</td>
<td>38.10%</td>
<td>39.50%</td>
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As the demand for the edible oil is increasing (Table 1), the exploration and popularization of newer fats/oils is of much significance. Besides this, blending of different oil may be counted as one of the option to solve the problem of increasing demand. In Indian scenario, as the demand of oil is increasing, the importance of blended oil cannot be denied. Blended oils have been proved to be cost effective, nutritionally better, more thermally stable, than the individual oil. Future may see the vast role of blended oil to have the equilibrium between supply and demand (Sharma, 2003). Probably, these factors may have resulted the popularization and commercialization of blended oils in Indian market.

Blended oils are gaining popularity worldwide due to advantages they offer such as improved thermal stability, oxidative stability, nutritional benefits (Sharma et al., 1996a; Frankel and Huang, 1994) and an ability to tailor the desired properties. Most importantly, they are cheaper alternatives or substitutes to pure vegetable oils. A comparison of the absorption of oil by chick pea (Cicer arrietium) dal fried in groundnut, cottonseed, rapeseed and their blends has shown that the absorption of cottonseed oil is minimal. Lower peroxide values were reported in stored food items which were fried in rapeseed-cottonseed blends compared to those fried in groundnut-cottonseed and groundnut-rapeseed oil blends (Mehta et al., 1986). The blends of 50% palm kernel olein with 50% coconut oil were suitable, if crude oils with a coconut flavour were desired (Lee and Timms, 1988). A blend of marine and vegetable oils (1:3) has been used for frying, baking or for the preparation of margarines without the development of a fishy odour (Freeman et al., 1988). The pattern of oil uptake constituents during the frying of dehydrated potato chips has been reported (Sharma et al., 1996 b). Premavalli et al., (1998) investigated the storage and thermal stabilities of refined cottonseed oil-mustard seed oil blends (80:20). Comparative studies on physical properties of vegetables oils and their blends after frying indicated a minimization in peroxide value using blended oils (Susheelamma et al., 2002). Commercialization has been started in this respect.
and a few oil blends have already been permitted. This trend is likely to increase in the near future therefore; thorough investigations aimed at studying the frying behavior of various types of blended oils are the most urgently needed.

RBO is commercially available in the market from the different processing methodology. There are still unexplored areas like storage stability of RBO and RBO based blended oil and the quantification of RBO in the blended oil. Moreover, the frying characteristics of the foods consisting of different ranges of moisture content and the effect of microwave cooking are the aspects, required immediate attention. The proposed work was therefore aimed to explore the following objectives:

- Enzymatic degumming of crude rice bran oil.
- Effect of packaging materials on the storage stability of physically refined rice bran oil and its blends.
- Quantification of rice bran oil in the blended oils.
- Thermal oxidation of rice bran oil during oven test and microwave heating.
- Effect of frying conditions on the physic-chemical properties of rice bran oil and its blended oil.