

DOI: 10.16210/j.cnki.1007-7561.2021.05.003.en

RIANTONG S, JORG J J. Nutrition and applications of rice bran oil: a mini-overview[J]. Science and Technology of Cereals, Oils and Foods, 2021, 29(5): 26-29.

Nutrition and Applications of Rice Bran Oil: a Mini-overview

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Abstract: Rice bran oil is a healthy oil from many aspects. The oil has a balanced fatty acid profile comparing with many other vegetable oils. The key difference is the minor components or micronutrients or unsaponifiable matters contained in the oil that are very special and in larger percentages. The oil contains more than 1.5% oryzanol that gives nutritional and pharmaceutical functions from the studies so far. More studies are needed to demonstrate the wide functions in many aspects. The oil also contains large percentage of phytosterols which received huge amount of studies for nutritional applications. Furthermore, the oil contains tocopherols and tocotrienols, in which for the later particularly it gives many special functions including prevention of breast cancers for example. When the oil is properly processed and used in foods, those functions are more and more demonstrated in nutritional or biological studies. Thus the oil in food and pharmaceutical applications is in exploring both in academic studies and industrial practice. In this work, an overview of such progress is given.

Key words: rice bran oil; oryzanol; phytosterol; tocotrienol; food applications; pharmaceutical applications

Chinese Library Classification Number: TS201.4

Documentary Identification Code: A Article ID: 1007-7561(2021)05-0026-05

Published time on CNKI: 2021-08-25 09:10:02

Published address on CNKI: <https://kns.cnki.net/kcms/detail/11.3863.TS.20210824.1251.004.html>

1. INTRODUCTION

Rice bran oil (RBO) is a popular cooking oil in Japan since around 100 years ago along with India. Nowadays, it is rapidly gaining acceptance in other Asian countries like China, Thailand, Vietnam, Korea and Nepal. In these countries, RBO is perceived as a “healthy oil”, which is supported by several organizations around the world including the World Health Organization (WHO), the Chinese Cereals and Oils Association (CCOA), the National Institute of Nutrition (NIN) in India, and the

Japanese Oil Chemists’ Society (JOCS).

The nutritional value of RBO comes from the fatty acid composition as well as from the phytochemicals that are contained in the oil. The health benefits are mainly attributable to the balanced fatty acid (FA) composition of RBO, which contains approximately 22% saturated (SFA), 41% monounsaturated (MUFA) and 37% polyunsaturated fatty acids (PUFA) and are in line with the FA ratio promoted by the above-mentioned organizations. SFA are composed of mainly palmitic, with small amount of stearic and myristic acid. The main MUFA is oleic acid and most of PUFA is represented by the ω -6 PUFA linoleic acid. However, ω -3 PUFA can only be found in small amounts as linolenic acid in RBO^[1].

In addition to the valuable ratio of FA, RBO

Received Date: 2021-06-19

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encompasses several phytochemicals in its non-saponifiable fraction that are thought to have beneficial health effects. A unique and important micronutrient is γ -oryzanol, which is present at a concentration of around 1.5% in physical refined RBO. First thought to be just a single substance, it was later discovered that γ -oryzanol consists of a mixture of several ferulic acid esters of triterpene alcohols and phytosterols^[2].

Equally important are the vitamin E derivatives tocopherols and tocotrienols. Unusual for a vegetable oil, RBO has a higher concentration of tocotrienols ($\approx 0.07\%$), mainly present as γ -tocotrienols, than tocopherols ($\approx 0.04\%$). Indeed, RBO has the highest concentration of tocotrienols in edible oils after palm oil. Other valuable micronutrients are unbound phytosterols like γ -sitosterol, campesterol and stigmasterol along with squalene.

2. HEALTH BENEFITS OF RICE BRAN OIL

RBO has been examined in numerous studies in animals and humans for potential health benefits. One of the most studied subjects is the effect of RBO on lipid metabolism. Several randomized controlled clinical trials (RCT) have been conducted and a recent meta-analysis containing 11 RCTs found that RBO intake can reduce LDL-cholesterol by 6.91 mg/dl and total cholesterol by 12.65 mg/dl on average^[3]. Triglyceride levels were also reduced; however, the effect did not reach significance.

On the other hand, there was no benefit on HDL-cholesterol from the inclusion of RBO in the diet. It is thought that the favorable FA ratio mentioned above plays a significant role in the hypocholesterolemic effect of RBO. However, this is only part of the truth. Clinical studies in nonhuman primates and humans has shown that RBO has a higher cholesterol-lowering effect than blend of oils with a very similar FA composition^[4-5]. The authors of these studies concluded that the phytochemicals in RBO are also responsible for the hypocholesterolemic effect. This is not surprising since several of the micronutrients present in RBO have already been implicated with cholesterol reducing properties. For example, phytosterols, which are abundant in RBO, compete with cholesterol absorption in the intestine, hence, lowering cholesterol concentration in the blood^[6]. In addition, tocotrienols can lower cholesterol level by inhibiting the HMG-CoA reductase enzyme, the

rate-limiting step in the de-novo synthesis of cholesterol^[7].

Beside the hypocholesterolemic effect, RBO and the micronutrients contained in it have been associated with numerous other health benefits. Many studies on γ -oryzanol and tocotrienols have shown anti-oxidative, neuroprotective, anti-atherosclerotic, anti-carcinogenic, anti-diabetic, anti-ulcerogenic and immune modulatory effects of these micronutrients^[7-8] which would make RBO an important dietary tool to attenuate the burden of the most common diseases in humans. However, although these results are very promising and mechanistic pathways have been discovered, most of the studies have been done in preclinical settings and additional research is certainly needed to further uncover the benefits of using RBO in our diet.

Interestingly, recent studies have revealed that tocotrienols may also have anti-aging properties by hindering the accumulation of senescent cells that are believed to play a major role in aging. Proposed mechanisms are the delaying of senescence by reducing ROS production, the inhibition of mTOR and NF pathways driving the senescence-associated secretory phenotype (SASP) responsible for inflammation and as a possible senolytic agent inducing selective death of senescent cells^[9].

In summary, RBO is regarded as a “healthy oil” due to its favorable FA ratio and several valuable micronutrients contained in the oil. The hypocholesterolemic effect of RBO is well established and numerous other studies with RBO and its micronutrients have demonstrated various other health benefits. However, most of these studies are either preclinical or preliminary. Therefore, well-designed RCTs are urgently needed to further confirm these health benefits in humans.

3. FOOD APPLICATIONS

As demonstrated above, RBO is one of the most nutritious oil and has been shown to have potentially beneficial effects to human health based on its favorable fatty acid composition and its unique rich source of commercially-important bioactive phytochemicals and antioxidants, such as γ -oryzanol, tocotrienols, tocopherol, phospholipids or lecithin, phytosterols, squalene, and ferulic acids. Due to those valuable compounds and its antioxidant capacity, RBO has been reported to have some biological activities, such as decreasing the level of low density lipoprotein, lowering cholesterol,

reducing blood pressure, and preventing colorectal cancer^[10]. In addition, RBO has a good fatty acid composition balance which makes it more stable under frying conditions and a longer shelf-life than other common vegetable oils^[11]. Hence, it has inevitably opened up new dimensions in nutritional, pharmaceutical and cosmetic applications^[12-13] apart from traditionally used as cooking and salad oil.

For food applications, RBO is a suitable oil for making margarine and shortening due to its high smoke point and its mild flavor^[14]. However, for shortening, butter and margarine production, trans-fatty acids (TFAs) are usually formed during the hydrogenation process. TFAs have been reported as a contributor to vascular diseases and cancers. To overcome the presence of TFAs from hydrogenation process, chemical or enzymatic interesterification process or blending of the oil are practically adopted.

Blending of vegetable oils is mainly due to improve their thermal stability, oxidative stability, nutritional benefits and to get the desired properties required. RBO can be commercially blended with less stable oil to delay deterioration and increase the stability of the blended oils and fried products. For example, RBO, virgin olive oil and sesame oil were blended with less stable oils^[15]; RBO was fortified in sunflower, groundnut and mustard oil, and palm olein^[16]; RBO was mixed with soybean oil^[17]. In this application, the optimal mixture ratio of RBO to other oils must be investigated to meet both physicochemical and organoleptic properties of the blended oil and fried products. RBO is used in water-in-oil (W/O) emulsions for industrially production of margarine, butter, spreads, and shortenings. However, the emulsions were highly unstable to phase separation which could be completely inhibited by replacement of 30%~45% of RBO with rice bran stearin^[18].

RBO can be used to produce high quality emulsion filled gel (EFG) or fat replacer^[14] to substitute or mimic the properties of fats in foods. However, volume fraction of the emulsion droplets, the size and spatial distribution of emulsion droplets, homogeneity of fat distribution, and on the interaction between the gel matrix and the emulsion droplets, strongly affected the rheological properties and the breakdown behavior of EFG^[19]. Hence, suitable conditions for application in each product are needed in order to obtain the effective and functional EFG.

It was reported that RBO bears a distasteful

flavor and strong odor^[20] which could limit its application. These undesirable characteristics may be improved by preparing the RBO as oil-in-water (O/W) emulsions. The emulsions are easy and low cost in terms of production and provide better sensory properties, i.e. without an oily mouthfeel, unpalatable taste and unpleasant odor^[21]. The RBO O/W emulsions are applied in a variety of products such as foods, paints, cosmetics and pharmaceutical products. However, as emulsions are thermodynamically unstable systems, hence, emulsifiers are necessary to produce emulsions that are kinetically stable under specific environmental conditions (pH, temperature, storage time). The pectin-zein complexes could be used to improve the physical stability of O/W emulsions, especially the formulations with a high fraction of oil^[22].

4. PHARMACEUTICAL APPLICATIONS

For pharmaceutical applications, RBO and a blend of RBO with other oils or some biological active compounds have been widely used in pharmaceutical and medical purposes. Physically refined γ -oryzanol-rich RBO is blended with cold pressed, un-refined, antioxidants and lignan-rich sesame oil (80:20) and used to control hyperglycemia and improve the lipid profile in type 2 diabetes mellitus patients^[23].

Medium chain fatty acids such as capric acid (C10:0) and caprylic acid (C8:0) were successfully incorporated into RBO by enzymatic modification to improve the health benefits of RBO in increasing levels of high-density lipoproteins^[24]. A blend of RBO and safflower oil (7:3) affected serum and liver lipid levels in rats^[25] and has a significant hypocholesterolemic effect in healthy young women^[26]. RBO and sunflower oil blend (80:20 ratio with 5 000 ppm oryzanol) could be considered beneficial for patients with lipid abnormalities and normolipidemic people by maintaining normal levels of lipids^[27].

RBO was used to isolate for tocotrienols-rich fraction and used for effective hypocholesterolemic action together with its antioxidant function in hyperlipidemic rats^[28]. In addition, a tocotrienol-rich fraction isolated from RBO suppressed chemically induced hepatocarcinogenesis^[29]. RBO has its role of antioxidant and anti-inflammatory agent^[30-32]. Some studies report the development of pharmaceutical dosage forms containing RBO for topical use as sunscreen^[33] and for the treatment of skin disorders^[34].

In this context, RBO was developed into pharmaceutical dosage forms or a semisolid formulation (hydrogel) containing RBO- loaded lipid-core nanocapsules^[35], which is suitable for the therapeutic systems, mainly due to the ability to control the release of drugs and to improve drug stability^[36]. The beneficial effects of nanoencapsulation are to improve the protective properties of RBO on skin damage caused by UVB exposure^[35].

RBO has been reported to have hypolipidemic, antiatherogenic, antidiabetic properties^[37], cancer chemopreventive properties^[29] and prevent colon carcinogenesis^[38]. Due to hypolipidemic effects of vegetable oils, substitution of RBO or canola oil for sunflower oil could attenuate lipid disorders in type 2 diabetes women^[39]. RBO was successfully extracted and purified for oryzanol^[40-41]. In addition, cycloartenyl ferulate and 24-methylene cycloartenyl ferulate were also separated from RBO for pharmaceutical and medicinal applications owing to their anti-inflammation activity^[42] exhibited greater

potency in anti-tumor activity^[43], cytotoxicity in MCF-7 human breast cancer cells^[44], and inhibiting a purified human immunodeficiency virus type 1 reverse transcriptase^[45].

As a summary, RBO is highly nutritional and functional from a few aspects of the compositions in terms of FA profile and micronutrients. It is highly rare that the oil contains so much oryzanol as well as phytosterols and tocopherols besides squalene and other minor components. These provide both nutritional food applications and pharmaceutical possibilities. The oil shows good behavior in frying of foods in terms of stability, sensory properties of the fried foods, etc. besides nutritional concerns. There are also pharmaceutical products in the market from RBO or its formulations. It is a unique healthy oil from nature and its wider applications are waiting for further exploring.

REFERENCES

See in its Chinese version P24-P25.