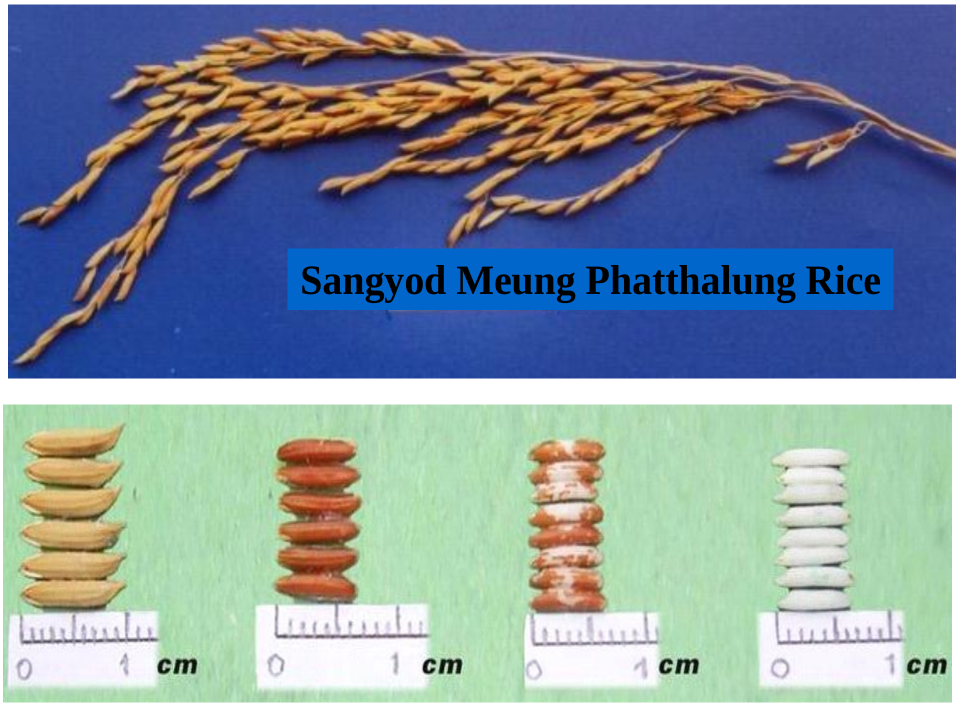
Chapter 2

Literature Reviews

1. Sangyod Rice

Thailand has many varieties of rice-more than 5,900 varieties have been reported (Banchuen *et al*., 2009). Sangyod rice is an indigenous pigmented rice of Southern Thailand. It was originally grown around the Songkhla Lake area. Most Sangyod rice is grown in Phatthalung province. Sangyod rice has played an important role in the economy of Southern Thailand. It is the principal rice cultivar in Southern Thailand and has become a popular and high priced rice in the functional food market in Thailand since the year 2008. Sangyod rice is a non-glutinous variety, a local early lowland rice, which is light-sensitive and grown in the annual planting season. Sangyod has excellent taste and color characteristics. It is a small long, slender grain, dark red pericarp, soft and aromatic cooked rice, as well as very delicious and nutritional (Department of Intellectual Property, 2006). Traditionally, southern people plant Sangyod rice for special purposes, such as a special festival or special guests, including patients and elders. Analysis of the nutrient values found that Sangyod rice has high nutritional value namely iron, vitamin B and niacin (Department of Health, 2004). Sangyod rice is a nutraceutical food because it contains high contents of antioxidants such as vitamin E, gamma oryzanol and anthocyanins. These compounds are effective free radical scavengers with anti-inflammatory and anti-cancer activities. The increasing rate in incidences of chronic diseases such as cancer and cardiovascular disease is alarming and reactive cell-damaging free radicals are implicated in these diseases. This is a major reason for the heightened interest in antioxidants that are found in Sangyod rice. The production of Sangyod rice in Southern Thailand is approximately 10,000-12,000 tons per year. About 400-500 tons of Sangyod rice bran (SRB) and 500-600 tons of broken rice are the by-product from rice mill factories. Most of Sangyod rice bran and broken rice are sold for animal feed with very low value. Our research group has been successful in value-adding the broken Sangyod rice. We produced brown rice flour and its application in many products such as rice ice cream, bakery products, beverages and Asian tradition sweet rice-based products.



Grain **Brown rice** **Partial polished rice** **Polished rice**

Figure 2.1 Sangyod rice

2. Rice bran

Rice bran is the outer layer of the brown rice kernel which is removed while milling brown rice to white. The bran is primarily comprised of pericarp, aleurone and subaleurone layers of kernel, and typically includes the embryo or germ and small amounts of starchy endosperm. Several studies have reported that rice bran is an excellent source of nutrients and bioactive compounds including oil, proteins, vitamins, dietary fibers, tocopherols, tocotrienols and gamma oryzanol (Loypimai *et al*., 2009; Chotimarkorn *et al*., 2008; Zigoneanu *et al*., 2008). Interest in rice bran oil has been growing because of the health and nutritional aspects as well as its wide application as an industrial oil. Rice bran and its main components have demonstrated that their properties improve the plasma lipid pattern of rodents, rabbits, non-human primates and humans, reducing total plasma cholesterol and triglyceride concentration and increasing high density lipoprotein cholesterol levels (Cicero and Derosa, 2005; Xu *et al*., 2001). Among rice varieties, the most commonly consumed rice have whitish kernels, though there are also several varieties with a colored testa (black, purple, or red), visible after removing the husk that covers the caryopsis. Varieties with white kernels were selected in the past, presumably because of their preferred appearance, whereas red (reddish-brown) caryopses are mainly found in wild rice species. Farming and consumption of colored varieties is limited in Western countries, but in some growing areas of Asia, traditional varieties with pigmented caryopsis are particularly valued in local markets (Finocchiaro *et al*., 2007). Ahuja *et al*. (2008) reported that red and black rice are considered more nutritious, have been found to be rich in iron (Fe), zinc (Zn), and minerals, and possess antioxidant properties. These also reduced atherosclerotic plaque by 50% more than white rice in rabbits. The antioxidant and scavenging activity of red rice is higher than that of black and white rice.

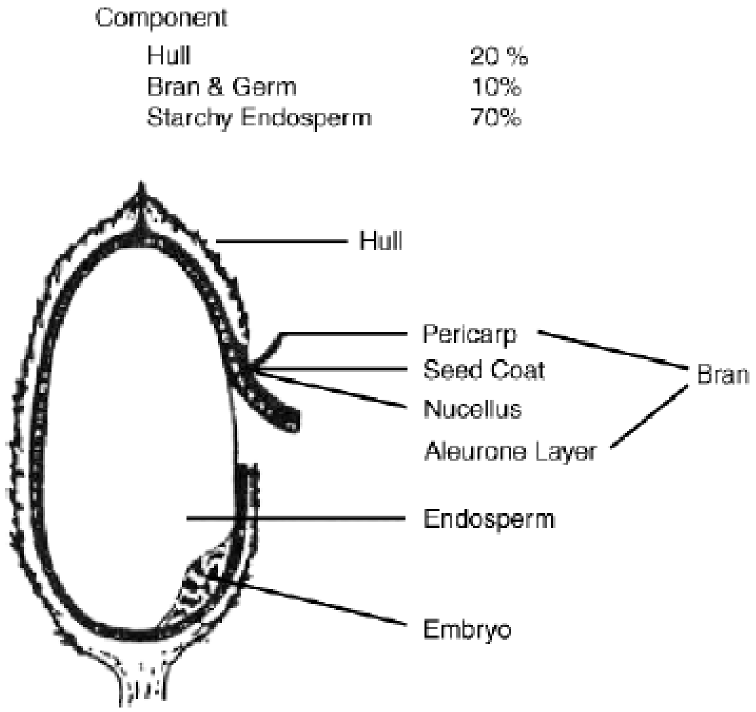


Figure 2.2 Composition of rice bran

Source: Orthoefer (2005)

3. Rice bran oil

Rice bran is the source of rice bran oil. 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. Earlier methods to recover the oil used hydraulic pressing. In a Japanese system for pressing, the raw bran is cleaned by sifting 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. 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. Countercurrent 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. Flake size is larger if expanded at 120 °C, but the flakes are fragile and easily broken. Flakes with high moisture content were more resistant to breakage. Final bran moisture was about 6%.

The initial interest in rice bran oil resulted from work with the stabilized rice bran. Rice bran was shown to be equivalent in serum cholesterol reduction to oat bran in hamster trials. Two clinical studies showed rice bran reduced serum low-density lipoprotein (LDL) cholesterol in humans. Defatted bran was less effective in lowering cholesterol than full fat bran. The cholesterol-lowering activity was concentrated in the unsaponifiable fraction of rice bran oil. Oryzanol was found to contribute to the hypocholesterolemic activity of rice. The increasing rate in incidences of chronic diseases such as cancer and cardiovascular disease is alarming and reactive cell-damaging free radicals are implicated in these diseases. This is a major reason for the heightened interest in antioxidants that are found in rice bran oil (RBO). RBO is an interesting natural antioxidant and very popular as a cooking oil in several countries. Recently, RBO has had many applications in different industries. Its unique properties make it a very appealing oil for food, cosmetic and pharmaceutical industries. It is rich in vitamin E complex, tocopherols, tocotrienols, phytosterols, polyphenols, and squalene and contains a potent antioxidant known as gamma oryzanol (Vieno *et al*., 2000; Juliano *et al*., 2005; van Hoed *et al*., 2006). RBO contains high levels of vitamin E that have been reported to have hypocholesterolemic, anticancer, and neuroprotective properties (Sen *et al*., 2007). Recently, it has been shown that gamma oryzanol from RBO can regulate antioxidant and stress genes in rats (Ismail *et al*., 2010).

Gamma-oryzanol is an extract from RBO that has high anti-oxidant activity. It is a mixture of sterol esters of ferulic acid and triterpene alcohols. The chemical structure serves as an important anti-oxidation effect caused by part of ferulic acid similar to cholesterol that effected on blood glucose levels and serum lipid parameters. It also protects the skin from Ultra-violet radiation and increase moisture to the skin as well (Vorarat *et al*., 2010). Consequently, there is increasing interest in incorporating RBO into a wide variety of health products in order to benefit from its desirable functional and nutritional characteristics.

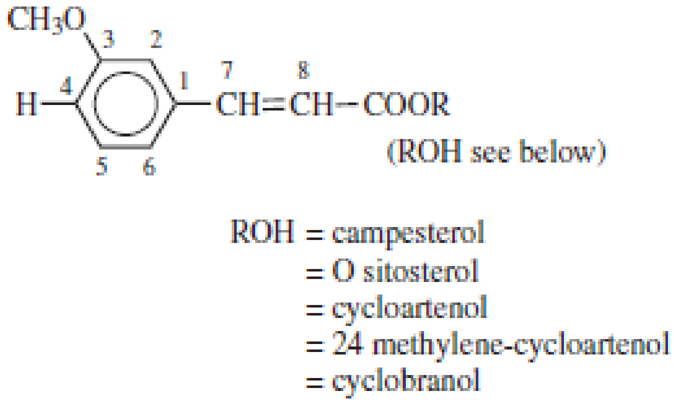
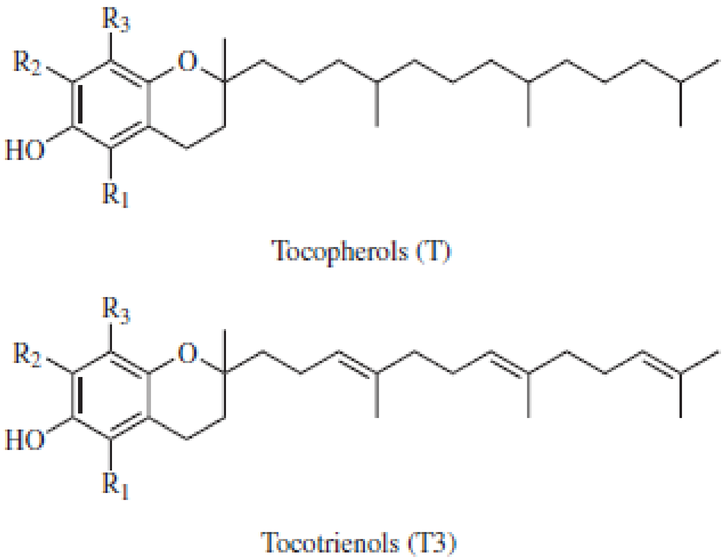


Figure 2.3 Structure of Oryzanol

Source: Orthoefer (2005)



	R_1	R_2	R_3
α-T(3)	CH_3	CH_3	CH_3
β-T(3)	H_3	H	CH_3
γ-T(3)	H	CH_3	CH_3
δ-T(3)	H	H	CH_3

Figure 2.4 Structure of tocopherol and tocotrienol

Source: Orthoefer (2005)

4. Stabilization of rice bran

Rice is the main staple food in Thailand and many countries in Asia. It is also the main export product of Thailand. About 20 million tons per year of rice are produced in Thailand, which produces about 1.6 million tons of rice bran (USDA Foreign Agricultural Services, 2010). However, only a small portion of rice bran is processed into edible oil. Rancidity of lipids in RBO is a major problem for utilization of rice bran. The high lipid content and a potent enzymes result in drastic quality reduction of rice bran. Storage of rice bran, especially at room temperature, for extended periods leads to degradation of triglycerides in the oil and ultimately to the formation of off-flavors and odors. Rice bran contains active enzymes. Germ and outer layers of the caryopsis have higher enzyme activities. Particular lipase, but also lipoxygenase and peroxidase, are probably most important commercially because they effect the keeping quality and shelf life of rice bran (Orthoefer, 2005). Ramarathnam *et al*., (1989) also reported that lipid peroxidation by lipases and lipoxygenases is thought to be the primary cause for bran degradation. Two main changes, oxidative rancidity and hydrolytic rancidity affect the quality of RBO. Oxidative rancidity is caused by the oxidation of the double bonds of the fatty acids while hydrolytic rancidity is caused by the removal of fatty acids from the glycerol molecule. The potent enzymes in rice bran are the key to control the reaction. The hydrolysis reaction turns triglycerides into glycerol and free fatty acids, which occurs soon after rice milling and is caused by the presence of lipase enzymes as catalyst. These free fatty acids produced by the hydrolysis reaction are harmful compounds which make RBO unsuitable for edible use. To prevent rice bran from becoming rancid, it must undergo a stabilization process or extraction of oil soon after the milling process, which are two effective methods for lipase enzyme inactivation and prohibition of rancidity of RBO (Ju & Vali, 2005). However, extraction of oil soon after the milling process is not practical for the commercial scale because of the distance and transportation of bran to the factory. Recently, various stabilization methods, applied to protect RBO degradation, have been reported such as microwave heating (Lakkakula *et al*., 2004: Zigoneanu *et al*., 2008), ohmic heating (Ramezanzadeh *et al*., 2000; Loypimai *et al*., 2009), steaming (Juliano, 1985), extrusion (Zhu and Yao, 2006), refrigeration and pH lowering (Amarasinghe *et al*., 2009). Heat treatment is the most common method to stabilize rice bran. High temperatures above 120 ºC denature the enzyme responsible for lipid degradation in RBO without destroying the nutritional value of the rice bran. Orthoefer (2005) reported that extrusion (dry heat) cookers have been ideal for stabilization because excess moisture is not added, eliminating the need for drying. The heating of the bran occurs through conversion of mechanical energy of the screw drive to heat the bran. Temperatures used for stabilization vary from 100° to 140° C. The bran is kept hot for 3–5 minutes after extrusion to ensure lipase inactivation. The hot bran is then cooled using ambient air. Dry extrusion was found more suitable for stabilizing bran to be used as a food ingredient. The success of stabilization of rice bran and its oil depends on temperature, duration of heat treatment, moisture content of treatment medium, pH, and other parameters (Orthoefer, 2005).

5. Cold pressing process

Cold pressing process of vegetable oil is becoming an interesting substitute for solvent extraction because of consumers' desire for natural and safe food products. Over the last few years, increased interest in cold-pressed plant oils has been observed as these oils have better nutritive properties than those after refining. Cold pressing is simple, ecological friendly and does not require much energy. The cold pressing method has successfully produced virgin olive oil, avocado oil, and hempseed oil (Moreau and Kamal-Elddin, 2008). Cold-pressed oils may retain higher levels of natural antioxidants that may be removed during the refining steps of a conventional oil processing procedure, and exhibit acceptable shelf stability and improved safety without added synthetic antioxidants. In addition, cold pressing involves no organic solvent, which results in a product that is chemically contaminant free (Singer *et al*., 2008). Recently, mechanical pressing (cold pressing) of RBO has been used in small and medium factories for producing commercial RBO in Thailand. Becouse mechanical pressing oil extraction is technically less expensive and less labor-intensive than the extraction solvent method. The safety and simplicity of the whole process is advantageous over the more efficient solvent extraction equipment. Furthermore, materials pressed out generally have better preserved native properties; end products are free of chemicals and it is a safer process. The cold-pressing procedure involves neither heat nor chemical treatments, and it is becoming an interesting substitute for conventional practices because of consumers' desire for natural and safe food products. Developing economical methods to stabilize rice bran and extract RBO are important for the small and medium size rice bran oil factory. An economical and efficient method of stabilization is required for obtaining best results. Stabilization of rice bran with domestic heating methods could be a high potential method to pretreatment of rice bran for mechanical pressing. However, there is not much information in the literature about the application of different domestic heating methods for stabilization of rice bran and its effect on extraction yield, quality, phytochemical content and antioxidant activities of cold-pressed RBO (*Oryza saltiva* L.) In this experiment, hot air heating, roasting, steaming and microwaving were applied for stabilization of rice bran for using in the cold pressing process. Therefore, the aim of the present study was to investigate the impact of domestic heating on mechanical extraction yield, quality and antioxidant properties of cold-pressed RBO.

Figure 2.5 Cold pressing process of rice bran oil in Southern Thailand

6. Nanoemulsions

Nanoemulsions are obtained when the size of an emulsion globule reaches approximately 20-500 nm. The small droplet size can resist the physical destabilisation caused by gravitational separation, flocculation and/or coalescence. It also avoids the creaming process because the droplet's Brownian motion is enough to overcome the gravitational separation force. The size and polydispersity of nanoemulsions can affect properties such as particle stability, rheology, appearance, colour, texture and shelf life (Bernardi *et al*., 2011). Emulsion-based delivery systems have shown to be particularly suitable for encapsulating lipophilic components (McClements, 2010a, 2010b; McClements *et al*., 2007). These systems can be fabricated entirely from natural food-grade ingredients using relatively simple processing operations, such as blending and homogenization. The composition and microstructure of emulsions can be controlled to create desirable functional attributes, such as protection against chemical degradation, ease of handling, and ease of dispersion in products. Increased consumption of these bioactive lipids may reduce the incidences of human diseases, such as heart disease, hypertension, diabetes, and cancer (Gogus and Smith, 2010; Lopez- Huertas, 2010). The availability of new delivery systems for bioactive lipids could therefore have major benefits in improving public health, as well as in reducing the economic costs associated with chronic diseases. In these systems, it is important that the oil droplets remain both physically and chemically stable throughout the shelf life of the product. The relatively high levels of functional and nutraceutical components present within cold-pressed-RBO may mean that it behaves differently in emulsions than other edible oils. The presence of minor components within edible oils can impact emulsion performance, due to their ability to impact the physical or chemical stability of these systems (Khan and Shahidi 2000; McClements 2005; Arima *et al*., 2009). In many food applications, oils are present in the form of lipid droplets dispersed within an aqueous medium (oil-in-water emulsions), rather than as bulk oils (Dickinson 2002; McClements 2005). In these systems, it is important that the oil droplets remain both physically and chemically stable throughout the shelf life of the product. The relatively high levels of functional and nutraceutical components present within RBO may mean that it behaves differently in emulsions than other edible oils.

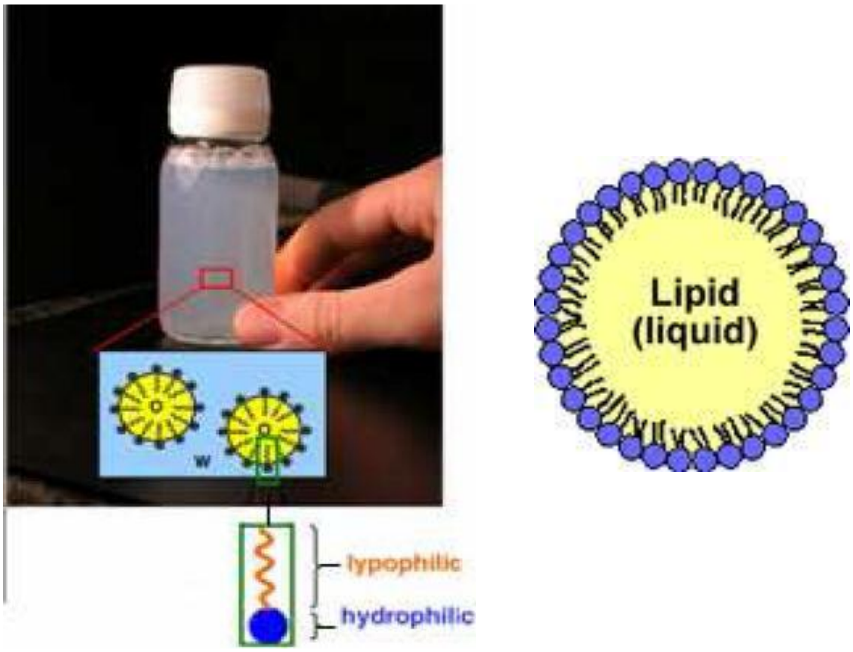


Figure 2.6 Oil in water nanoenulsion