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Mini Review

Rice bran: a potential of main ingredient in healthy beverage

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Abstract

This review of literature provides an overview on the composition data of rice (*Oryza sativa* L.), rice bran (RB) and its application in food products. Rice is a major source of nourishment for consumption, especially in Asia. Rice plants produce rice brans and hulls that have been reported to health promoting effects in animals and human. RB is an underutilized milling by-product of rough rice and has high nutritional value. Bran composts importance nutrients including: soluble and non-soluble fibers, vitamins, minerals, lipids and proteins. Various studies have been reported that RB is a good source of bioactive compounds such as γ-oryzanol, tocopherols, and tocotrienols which provide health beneficial and antioxidant activity. Furthermore, the RB could act as antibiotic activity and anti-cholesterol as well. Nowadays, the beverages made from cereal are very popular and their trend continued increasing. Some materials such as rice and RB can be used to produce healthy drink that could be as an alternative aspect. Therefore, the interesting in nutritionals value has a potential for healthy beverage production like a functional drink.

Introduction

Rice (*Oriza sativa* L.) is a major cereal crop in the developing world in terms of total world production (672×10^6 tonnes) equivalent to that of wheat (FAO/UN, 2012). In Asia and the Pacific (seventeen countries), North and South America (nine countries), and eight countries in Africa, rice is an annual plant which can be grown under board ranged of topographical conditions. It will provide a great yield under environmental abundance, especially river basin area due to rice is considered semi-aquatic grass plant (Yoshida, 1981). The major rice production from statistical data was found in Asia (Major producers: China, India, Indonesia, Bangladesh, Vietnam and Myanmar) which producing alone more than 75 percent (506×10^6 tonnes) of rice world production (FAO/UN, 2012). Besides that, the regular rice consumptions can be processed into various products as well, for example: rice flour, rice noodle, used as ingredient in baked products and producing the alternative healthy beverage etc. During the milling process, rough rice is milled to produce polished edible grain and removal of brownish layer. This process generates agricultural waste as a by-product (rice bran and rice hull) (Friedman, 2013).

Rice bran (RB) is identified as a by-product from agricultural waste. Nowadays, it has been widely studied and applied in food industry due to high nutritional promoting (especially, protein, lipid, vitamins and minerals) and rich of major source in phytochemical compounds. The interesting of rice bran nutritional qualities has attracted it as a valuable food material. Furthermore, RB presents some good properties for human health such as antioxidant, antibiotic as well as anti-cholesterol. Currently, RB has been used for animal feed, rice bran oil extraction, wax production, and used as a food ingredients (Watchararuji *et al*., 2008). These products are resulted from stabilized rice bran extraction which is utilizable for human food; currently, it is certainly used for baked products, energy bars, and protein fortification of powdered drink formulations (Mitchell, 2009). There are several countries that are more consider to increasing the value of RB by developing the whole RB for many food products. One product is made from whole RB to be healthy beverage which interesting thing because it can be alternative of beverage market for health concern consumers. Today, the demanding of functional food products are influenced by healthy drink market which is growing rapidly. As a result, the functional beverage seems to be a part of world population.

Healthy beverage or functional drink is very popular for consumption. Moreover, trends of people

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for consuming these products are increasing. Some people are willing to spend more money to buy this product due to they are believe that this product can prevent risk diseased and provides a good health. Healthy drinks made from that have been launched into the market nowadays. Nevertheless, the health product obtained from whole RB have no reported and launched into the market. The main point of this review article is to consolidate and integrate on the composition data of rice (rice processing, rice and its related products), rice bran and applications of rice bran for a potential source of main ingredient in healthy beverage.

Rice production

Rice (*Oryza sativa* L.) is a major of dietary foods (about 60% of world's population) and identified as important group of cereal crops in the world, especially for people in Asia as well as outside Asia. However, around ninety percent of rice production is obtained and consumed in Asia (Wayne and James, 1994). Rice is rich genetic diversity, with thousands of varieties grown throughout the world. Almost the cultivated rice belongs to the species *Oryza sativa* and *Oryza Glaberrima*., while *Oryza Sativa*., is the distinguished species, and another one species is cultivated only in Africa (Rohman *et al*., 2014). Rice is a predominant staple food due to it provides the high nutritionals and promoting the daily energy (calories) for many companion animals and humans, especially in part of carbohydrate (4 Kcal) (Ryan, 2011; Rohman *et al*., 2014). Moreover, it was reported that rice provides dietary energy around 20 percent of the world, while wheat and maize promotes 19 and 5 percent, respectively. Naturally, non-milled state rice has different colors, including brown, red, purple and even black. The variety of rice colors is valuable for health properties. Moreover, the unmilled rice has a higher nutrient content than milled or polished white rice. Currently being compiled statistics of rice production and cereal grains production in the world widely. Even though the yield of rice production presented the high amount value, but domestic manufacturers produced the highest agricultural cereal crops in the world which was achieved by 7 countries of East and South Asia including; China, India, Indonesia, Bangladesh, Vietnam, Thailand, and Philippines, respectively. Moreover, they provided for rate of rice prices in producer countries from 2006–2010 as well as the world rice production, consumption, and stocks ranged from 2010-2014 (FAO/UN, 2012).

Although the rice plant can grow under good environmental conditions, rather *O. sativa* may grow more than once per year. Similarly to other plants that associated with *Oryzeae* species. Rice plant can be grown not only in the deep water areas (up to 5 meter) but also on dry land, which can call as semi-aquatic annual grass plants. Nemoto *et al*. (1995) noted that rice can be cultivated in temperate and tropical areas as well as in cool and warm regions. Different environmental is considered as important factors to develop rice plant, such as day length, temperature, humidity, planting density and nutrition (Wayne and James, 1994). Nevertheless, a partially of the rice plant adaptability can explains its importance to food cereals crop production (Kent and Evers, 1994).

Rice milling process

Milling processes is one of the method with the objective is to remove the bran, hull, and germ with minimum endosperm breakage (Owens, 2001) from rice seed which untill get the milled rice (polished white rice). Generally, the rice grain consists of an outer protective covering as hull (husk), and kernel (brown, cargo, dehulled or dehusked rice). It has been identified one rice seed has approximately/around 20% pericarp, 2%, tegmen (seed coat), aleurone layer (5%), endosperm (89–94%) and embryo (2–3%) (Delcour and Hoseney, 2010). According to Elke and Emanuele, (2013) noted that the milling step composes pre-cleaning/destoning, husking, paddy separation, whitening (bran removal), polishing, grading, and milling. Each milling step has different function. However, all of steps influent to milled rice quality (Elke and Emanuele, 2013). During the process, milling may also eliminates various vital vitamins and minerals. According to rice milling processes, RB is an underutilized milling "by-product" of rough rice and has high nutritional value. Generally, RB was extracted to rice bran oil for cooking because of its chemical components promoting in good human healthy and also produce animal feeding (Friedman, 2013). However, using the whole RB (without isolating into a single component) has not been reported. Herein, using the whole RB for fully utilization is very interesting, especially in terms of beverage production, cosmetic manufacture and pharmaceutical. Furthermore, the milling also generates several types of rice. The best rice possess broken kernels as less than 3/4 of the lengthy of whole kernels generally. Normally, natural unmilled state rice found in many different colors (brown, red, purple and black). Each color provides different nutritional values. Moreover, they also promoting in health benefit. Some studies supported that different type rice consumption represents various cultures, rice forms as an integral part of culinary tradition.

Different cultures have differed inclination regarding the color, taste, texture, and stickiness of the rice varieties that they consume. For instance, South Asia and the Middle East are mostly consuming dry flaky rice; Japan, Taiwan, Korea, and northern China (moist sticky rice); and red rice in parts of southern India.

Rice consumption

There are three categories of rice consumption in the world: direct food use, processed foods use and brewer's use. After hulling, the brown rice can be continued to other processes. It can be further in polishing rice to obtain white polished rice, and parboiled. Although, there are many studies about nutritive comparisons between polished and brown rice, and it was found high nutrition's value in brown more than polished rice (Roy *et al.*, 2008). On the other hand, some rices are unpopular consumption because of their color (generate to darker color) (Kiple and Ornelas, 2000). However, people not only consume plain rice, but also rice is applied for food products and beverages by using several technologies such as produce rice flour (Chiang and Yeh, 2002), bakery products (Matz, 1996; Sivaramakrishnan *et al.*, 2004; Renzetti and Arendt, 2009; Veluppillai *et al.*, 2010), cakes (Ji *et al.*, 2007), rice breakfast cereals (Yeh, 2004), rice crackers (Lu, 2004), noodles (Yeh, 2004), germinated brown rice (Chung *et al.*, 2012), infant foods (Mennella *et al.*, 2006; Meharg *et al.,* 2008; Ljung *et al*., 2011; Wang *et al*., 2012), canned and frozen rice (Azanza, 2003), rice snack, vinegar (Haruta *et al.*, 2006), even alcoholic rice beverages (Hardwick, 1995; Owens, 2001; Deori *et al*., 2007; Elke and Emanuele, 2013). From a technological aspect, production and processing conditions extremely effect to nutritional handling of the final rice products. Increasing the consumption of brown rice and germinated brown rice, both characterized by a higher content of healthy beneficial food components (Roy *et al.*, 2011), compared to the polished white rice, will significantly help to avoid malnutrition and other dietary and food-related diseases in the future. Meanwhile, the researcher has been efforted to use the rice flour application in food industry to substitute wheat flour due to amount of rice production that equivalent wheat harvest and it classifieds to gluten-free cereal. Considering, trend of people that allergenic wheat protein (gluten) are increasing. Therefore, rice is an alternative cereal grain can be a food ingredient or consuming instead wheat flour. According to rice milling processes, RB is an underutilized milling "by-product" of rough rice and has high nutritional value. Generally, rice bran oil is extracted from RB use for cooking because of its chemical components promoting for good health and also producing animal feed (Friedman, 2013). However, using the whole RB (without isolating into a single component) has not been reported.

Rice bran

Bran is an industrial residue of cereal from milling process. It consists of pericarp, aleurone and subaleurone fractions (Friedman, 2013). Generally, the bran contain much more importance nutrients including: soluble and non-soluble fibers, vitamins, minerals, lipids and proteins (Murtaugh *et al.*, 2003; Chronakis *et al*., 2004; Faccin *et al.*, 2009). RB (smooth and non-smooth) is a good source of bioactive phytochemicals such as γ-oryzanol, tocopherols, and tocotrienols; which have health beneficial properties and antioxidant activity (Watchararuji *et al*., 2008; Moongngarm *et al*., 2012). Faccin *et al*., (2009) noted that the amount of rice bran is more than 76 million tons annually, which is production of the five largest rice producers worldwide such as China, India, Indonesia, Bangladesh and Thailand. Currently, many researchers focus on by-products that obtained from agricultural harvesting. Due to they are needed to increase the value of agricultural by-products, RB is identified as one of greatly interested for researchers. Simultaneously, there are several studies have been reported about the using of RB for application in various products, particularly food ingredients. But the utilization of RB is needed to attract for demand consumption in the world as well.

Compositions of rice bran

Generally, rice bran is still having more importance nutrients though the milling process is applied. First, RB can classify to two types; full-fat rice bran (no fat removal) and defatted rice bran (fat removed). However, both types are closely promoting in high nutritional except fat content with presented in Table 1., The previous studies of Prakash (1996) reported about chemical composition of full-fat rice bran and defatted rice bran (% dry basis) that was composed of carbohydrate (43.5-54.3%), protein (14.1-18.2%), fat (1.6-20.9%), ash (12.8-15.3%), and fiber (8.4-10.5%). Da-Silva *et al.* (2006) summarized that the different contents of rice bran composition possible caused from different sources and cultivars. Moreover, its contain high in soluble and non-soluble fibers, vitamins as well as minerals. Meanwhile, there are comparisons of chemical compositions between rice bran obtained in different rice verities or color as well (Table 1). Rice bran has abundance source of protein which known as essential amino acid

Table 1. Chemical compositions in rice bran (% dry basis)

Rice bran (RB) types/Compositions	Protein	Fat	Carbohydrate	Ash	Fiber	References
RB1 (Full-fat)	12.0	13.7	25.4	12.1	14.4	Connor, 1976
RB2 (Defatted)	18.3	5.4	31.6	11.2	8.6	Luh *et al.*, 1991
RB3 (Khao dok mali 105)	13.66	18.80	40.63	10.65	12.48	Moongngarm *et al.*, 2012
RB4 (RD6 : Waxy rice and white in color)	12.07	16.96	42.54	10.78	11.77	Moongngarm *et al.*, 2012
RB5 (Black rice)	13.27	15.85	45.06	9.62	12.68	Moongngarm *et al.*, 2012
RB6 (Red rice)	12.93	17.32	41.23	11.41	12.11	Moongngarm *et al.*, 2012

Table 2. Amount of amino acid in rice bran

Amino acids	Amount of amino acid (g/kg)				
	Houston *et al.*, 1969	Juliano, 1985	Wang *et al.*, 1999	Tang *et al.*, 2003	Faccin *et al.*, 2009
*Lysine**	4.81	5.5	4.7	5.4	10.10
*Histidine**	2.71	3.0	2.9	3.3	5.23
Arginine	8.28	9.0	8.9	10.2	12.42
Aspatic acid	9.09	10.5	8.0	11.2	14.19
*Threonine**	3.78	4.4	3.7	3.7	6.46
Serine	4.68	5.3	4.1	4.5	7.89
Glutamic acid	13.58	15.3	12.5	18.1	22.58
Proline	4.23	-	-	-	6.51
Glycine	5.47	6.1	5.4	6.2	9.46
Alanine	6.15	6.8	6.1	7.3	12.33
Cystine	2.32	2.6	1.6	-	1.23
*Valine**	6.00	5.7	6.3	7.0	8.94
*Methionine**	2.32	2.0	2.2	-	1.43
*Isoleucine**	3.94	3.0	3.9	4.5	6.98
*Leucine**	6.91	8.0	7.4	8.0	14.73
*Tyrosine**	3.13	3.7	3.3	3.7	5.96
*Phenylalanine**	4.43	5.1	4.6	5.1	9.54
Tryptophan	-	0.7	1.2	-	-
Asparagine	-	-	-	-	-
Glutamine	-	-	-	-	-

*Essential amino acid

(Sereewatthanawut *et al*., 2008). Amino acids (AA) are essential to the body, especially in part of muscle building and maintenance (Han *et al*., 2014). The AA can divide to two categories include: essential AA and non-essential AA. According to nutritional basic for essential AA, human bodies can synthesis by themself, while non-essential AA cannot be synthesis (need to obtain from foods). However, both of AAs are significant to human digestibility and absorbability. Nine amino acids were identified to essential amino acids in human nutrition (Table 2) including: lysine, methionine, threonine, tryptophan, histidine, leucine, isoleucine, valine, and phenylalanine (Friedman, 1996; Gropper *et al*., 2005; Han *et al*., 2014). There are several studies the nutritional value of proteins from different food sources. Fabian and Ju (2011) was combined associate with AA in rice bran quantity determination and reported to gram/kilogram of RB. On the other hand, fat content is the highest component that contained in rice bran. This composition had considered to rice bran oils extracted for food industrial. However, the high amount of fat in RB cause to rancidity and it leading to low quality characteristic (da-Silva *et al*., 2006). Several studied reported that the rancidity (hydrolytic and oxidative) in rice bran provided free fatty acid (FFA) and

Table 3. Fatty acids compositions in rice bran

Fatty acids*	Amount (%)			
	Faccin *et al.*, 2009	Bhatnagar *et al.*, 2014**	de-Campos *et al.*, 2007	Oliveira *et al.*, 2011
C14 (Miristic)	0.3	0.5	0.03	0.3
C16 (Palmitic)	20.3	23.8	3.16	17.0
C16 : 1, 17 (Palmitoleic)	0.2	-	-	0.2
C18 (Stearic)	2.0	1.2	0.43	2.1
C18 : 1 (Oleic)	43.7	41.6	7.79	38.8
C18 : 2 (Linoleic)	30.9	36.7	8.75	32.0
C18 : 3 (Linolenic)	1.5	2.5	0.52	1.3
C20 (Arachidic)	0.7	-	-	0.5
Others fatty acids	0.4	-	-	0.6
Saturated	23.7	-	3.62	20.2
Mono-unsaturated	43.9	-	7.81	-
Polyunsaturated	32.4	-	9.81	73.1

* Percentage of total fat.
** Commercial rice bran

Table 4. Bioactive phytochemical in rice bran (neutracutical)

Nutraceutical	Quantity		
	Friedman *et al.*, 2013*	Lai *et al.*, 2009**	Renuka Devi *et al.*, 2007*
Phytosterols	2,230-4,400	-	-
γ-oryzanols	2,200-3,000	1.6-9.8	7,832
Tocopherols, Tocotrienol	210-440	0.12-0.77	146
Polyphenols	305-309	2.55-15.7	5.5**
Squalene	4,000	-	-

* Reported as ppm. Unit
** g/kg Unit

enzymatic reaction activity (lipase and lipoxygenase) (Ramezanzadeh *et al.*, 1999a; Ramezanzadeh *et al.*, 1999b; da-Silva *et al.*, 2006). Free fatty acid constituent in RB that provides to heath benefit was determined by many researchers as showed in Table 3. Furthermore, Ramezanzadeh *et al.* (1999a, b) noted that oxidative and hydrolytic rancidity of rice bran could be prevented by microwave heating, packing in vacuum condition in zipper-top bags and storing at 4-5°C (around 16 weeks). In addition da-Silva *et al.* (2006) studied about prevention of hydrolytic rancidity in rice bran. They found out that thermal processing by tray drier/oven (approximately 20 min at 12°C) cloud be prevented the rancid odor in rice bran. Anyway, vacuum packaging as well as storing at 4-5°C after thermal processes is also significant procedure to extend the shelf-life of RB.

Bioactive compounds in rice bran

Phytochemicals are defined as the bioactive compounds in plant (non-nutrient) those can be found in fruits, vegetables, cereal grain, whole grains, and other plants (Liu, 2004; Zhang *et al.*, 2010). These substance act as a secondary metabolites to against any environmental dangerous. Among of carotenoids, phenolics, alkaloids, nitrogen-containing compounds, and organosulfur groups were classified as biological active compounds. Normally, the whole cereal grain phytochemicals include with carotenoids, phenolics, and vitamin E. Majority of phenolics have a high potential leading to antioxidant activity in human body. This compound is able to against free radicals those may cause to increase oxidative stress as well as damage large biological molecules (lipids, proteins, and DNA) (Lui, 2007). Rice bran obtained from different varieties of colored rice is a good source of bioactive phytochemicals

Table 5. Application of rice bran in various products

Products of rice bran	Rice bran usage	References
Rice bran oils	Use to consumption due to it is promoted in low level of cholesterol resulting in good health.	Friedman, 2013 Rigo *et al.*, 2014 Kaewboonnum *et al.*, 2008
Wax	Use as a food coating material such as chocolate and fruits.	Friedman, 2013
Supplement food	Use the extracted bioactive compounds such a Gamma-oryzanol, Lecithin and vitamin E from rice bran to produce supplement foods.	Shih, 2003 Friedman, 2013
Infant food	Rice bran smooth as a food ingredients mixing with normal infant food for increasing the nutritional value.	Shih, 2003
Animal feed	Rice bran non-smooth was application	Friedman, 2013
Cosmetic products	Use the rice bran oils extracted as an ingredient in lotion production because of it contain high amount of Gamma-oryzanol and vitamin E leading to good skin.	Lerma-García *et al.*, 2009 Friedman, 2013
Bread ingredient	Use the smooth rice bran	Jiamyangyuen *et al.*, 2005
Cereal breakfast, Supplement food plus high protein and beverage	Use the smooth rice bran	Shih, 2003
Ingredient in meat product (meatball and sausage)	Use the smooth rice bran	Prakash, 1996
Organic rice bran beverage with flavor	Use the smooth rice bran to produce the soft beverage (chocolate and strawberry flavor)	Faccin *et al.*, 2009
Dairy product (yogurt and yogurt drink)	Use some pigment (black color from black rice) in rice bran for application in yogurt products.	Nontasan *et al.*, 2012 Gao *et al.*, 2008 Li *et al.*, 2012

(Watchararuji *et al*., 2008; Moongngarm *et al.*, 2012). There are various studies about bioactive compounds in varieties of RB even antioxidant activity of several pigmented RB (Iqbal *et al.*, 2005; Laokuldilok *et al*., 2010). The major biological active compounds (nutraceutical) found in RB is shown in Table 4. Indeed, the compositions of rice bran varies is depends on source of bran, the milling processes, and the stabilization techniques (Iqbal *et al*., 2005). However, these compounds are sensitive and can be easily destroyed by thermal processing, especially high temperature (Xu and Chang, 2011; Kim *et al*., 2011; Thanonkaew *et al.,* 2012). Phytosterols (2,230-4,400 ppm.) and γ-oryzanols (2,200-3,000 ppm) (Table 4) are influence to bioactivity of itself as results in well healthy due to it promoted in higher content than other phytochemicals (Friedman *et al*., 2013). These substances are useful for nutraceuticals technology, however it depends on the bioavailability and utilization. In 2004, Patel and Naik noted that Japan contributes 2% for total production of paddy or bran in the world, it is a promising producer of nutraceuticals and other high value products from the derivatives of paddy or bran. According to Ling *et al.* (2001 and 2002) have done for using feeding bran fraction from colored rice varieties to improve the antioxidant in rabbit's blood, and the results showed significant reduction in atherosclerotic plaque. Beside, other bioactive compounds such as polyphenols, vitamin E (Tocopherols, Tocotrienol), and squalene also considered in health effect but they are provide different functions (Nagendra *et al.*, 2011). Consequently, the interesting in nutritional value and bioactive phytochemicals in RB, today in part of manufacture have been utilized RB to apply for several food products due to its health benefit. Moreover, several studies attempted to evaluate RB as potential main food ingredients designed or substitute to improve the quality and nutrition of the final product. Therefore; the application of rice bran in various products was summarized in Table 5.

Health benefit

Antioxidative activity in relation to compositions

The antioxidative activities of each component in RB are important for the beneficial properties. The antioxidants are known to deactivate the natural by-products that received oxidative metabolism, is mostly known as free radicals (Patel and Naik, 2004; Higash *et al.*, 2004). The minor components in RB (γ-oryzanols, phytosterols and other phytosterol) are examined to free radicals scavenging (Wang *et al*., 2002). Xu *et al.* (2001) evinced that γ-oryzanols showed high antioxidant capacities as indicated by the γ-oryzanols was generating to four times equivalent with vitamin E components (α-tocopherol, β-tocopherol, α-tocotrienol and β-tocotrienol) for oxidative mechanisms inhibition. Furthermore, they concluded and suggested that all factors cloud be used to produce and develop for food ingredients, especially nutraceuticals food from the appropriate chemical process and biological function of RB (Xu *et al*., 2001; Patel and Naik, 2004). The different types of grain is promoted in different types of bran as well. The USDA National Small Grains Collection (NSGC) classifies rice bran into seven colour classes: white, light-brown, speckled brown, brown, red, variable purple, and purple. The most important groups of phytochemicals found in whole grains can be classified as phenolics, carotenoids, vitamin E, lignans, β-glucan and inulin. Among the cereal grains, rice contains greater levels of particular phenolic acids that are not present in significant quantities in fruits and vegetables. These compounds are present in different fractions from milling the grains (Ti *et al.*, 2014). Moreover, the bound phenolics are the major form found in rice bran, which is lost during the milling process. In 2010, Zhang *et al.*, examined phenolic profiles and antioxidative activities of black rice bran (12 varieties). The average values of black rice bran for free phenolics (2086 to 7043 mg gallic acid equivalent/100 g DW), bound phenolics (221.2 to 382.7 mg gallic acid equivalent/100 g DW), and total phenolics content (221.2 to 382.7 mg gallic acid equivalent/100 g DW) were effective greater than those of white bran (8, 1.5, and 6 times, respectively). Briefly, total flavonoid contents (3596 to 12448 mg of catechins equivalent/100 g DW), total anthocyanin (1231 to 5101 mg of cyaidin-3-glucoside equivalent/100 g DW) and cyanidin-3-glucoside, cyanidin-3-rutinoside, and peonidin-3-glucoside of black brans ranged (in mg/100 g DW) from 736.6 to 2557, 22.70 to 96.62, and 100.7 to 534.2, respectively. Moreover, they presented the total antioxidant activity of black rice bran was 537.5 to 1876 μmol gallic acid equivalent/g DW). The total antioxidant activity correlated to the content of all bioactive compounds mentioned above. As a result, the health potential of rice bran depends on type of rice bran and also depends on bound phenolic acids of each grain. The different amount of bioactive compound that presented in each colored brans that mentioned, this discrepancy may be due to the use of different solvents for extracting the phytochemical compounds (Min *et al.*, 2012). In addition, Ajitha *et al.* (2012), found that tricin isolated from rice bran showed a strong effective component with free radical scavenging. However, the studies related with antioxidative properties of RB have been widely reported, which presented similar results as described by Nam *et al.* (2005); Nam *et al.* (2006); Laokuldilok *et al.* (2011); Tabaraki and Nateghi (2011); Chen *et al.* (2012); Jun *et al.* (2012); Chiou *et al.* (2013). These results showed that the phenolic compounds are mainly fuction for antioxidant activity, Therefore, these aspects it seem to be the black RB is consideration for functional ingredient and natural colorant for food and pharmaceutical uses.

Antibiotic activity

Nowadays, the researcher indicated for rice bran was extracted by five different extraction techniques (referred to rice bran extracts) can inhibit microbial growth cause to abnormal symptoms. Mostly microorganisms is important factor that effecting to diarrheal disease, for example *Vibrio cholerae, Vibrio vulnificus, Salmonella* spp., *Shigella* spp., *Escherichia coli*, and *Staphylococcus aureus* (Kondo *et al.*, 2011). The minimum inhibitory concentration at 0.976 mg/ml of rice bran extracted was most effective versus *V. cholerae* strain O139. Thus, it seems to rice bran extracts might contribute to the treatment of diarrheal disease. Ghoneum and Agrawal (2011); Ghoneum *et al.* (2013) noted that modified arabinoxylan RB at 1 μg/mL enhanced the phagocytosis by neutrophils of *E. coli* pathogenic bacteria *in vitro* study, while its not affect to bacteria growth (31 strains) in phagocyte cells. In addition, Friedman *et al.* (2013) summarized about RB against the HIV cell and presented that not only for bacteria inhibition, but the rice bran extracts also promoted against to viruses cell (HIV). However, there are no more report involved of rice bran extracts act as antibiotic properties published. Consequently, the bran formulations are also effective against antibiotic-resistant pathogens merits and it considering to further study.

Anticholesterol properties

Generally, rice bran oils have hypocholesterolemic influence resulting from selective decrease of Low Density Lipoprotein (LDL) cholesterol. In 2011, some studies reported on cholesterols level and amount of linolenic acid in RB were -17 and 36%, respectively. When compared with other sources like a soybean (+3 and 50.2) and corn (-15 and 43.0), RB shown good properties (Nagendra *et al.*, 2011). This effect was far greater than the predicted values. However, this side effect associated with bioactive compounds in rice bran oils extracted. Phytosterols have been purpose to cholesterol reduction since the 1950s (Nagendra *et al.*, 2011). Due to the structure of phytosterols was found closely with cholesterols structure, influent to bioavailability competition in human absorption system. Most studies focused on the β-sitosterol and sitostanol performance for reducing LDL and circulating cholesterol levels. These results explained about these agents may be hypolipidemic in mild hypercholesterolemia by altering the lipid metabolism, for instance acetyl Co-A carboxylase and malic acid activities reduction in liver organ. Nevertheless, the γ-oryzanol was also found to have similar hypocholesterolemic effects (Ling and Jones, 1995; Kahlon *et al.*, 1992). According to Berger *et al.* (2005) noted, after 4 weeks for experiments, the content of γ-oryzanol at low as well as high that containing in rice bran oils was reduced total plasma cholesterol (6.3%), LDL-C (10.5%), and LDL-C/HDL-C ratio (18.9%). Besides, several studies (Nicolosi et al., 1991; Kahlon *et al.*, 1996; Nakamura, 1996) were related with cholesterol reduced which they mentioned that the unsaponifiables present in the rice bran were shown to significantly reduce liver cholesterol levels. The lowing cholesterols influenced for coronary heart disease (CHD). Some studies reported that the dietary fiber consumption from cereals grain can reduce the risk of CHD partially, reducing blood pressure, lowering blood cholesterol levels and improving insulin sensitivity (Truswell, 2002; Whelton *et al.*, 2005; Mellen *et al.*, 2008; Martinette *et al.*, 2008). Reena and Lokesh (2007) studied in rats for rice bran oil feeding that contain unsaturated fatty acids mixed with coconut oils. They found that after 60 days of feeding, it reduced the atherogenic potentials of saturated fatty acid present in coconut oil. Moreover, related studies in rats are described by Purushothama *et al.*, (1995); Chopra and Sambaiah, (2009); Jung *et al.*, (2007). Therefore, phytochemical compounds in RB and its extracted considered act as anticholesterol properties in human body.

Healthy beverage

Trends of healthy beverage

The beverage industry is a sub-sector or identify to the second group of food industry, in terms of value added (Guimarães *et al.*, 2012). Globally, the healthy drinks are one of the most widely consumed and profitable beverages (Piorkowski and McClements, 2014). Due to the most people concern in their health and they believed in healthy beverage are related to reduce the risk of disease, for instance cancer, cardiovascular disease as well as anti-aging (Siró *et al.*, 2008). Considering in the last decades, a demand of field food consumption has been changed leading to operator for food industry was activated and developed of themselves. Healthy drink is one alternative product that very interesting, and it can identify to "functional food" categories (Siró *et al.*, 2008).

Functional foods are foods or dietary components that may provide a health benefit beyond basic nutrition. Biologically active components in functional foods impart health benefits or desirable physiological effects. It may improve the general conditions of the body (e.g. pre- and probiotics), also decrease the risk of some diseases such as cholesterol-lowering products, and could even be used for curing some illnesses (Roberfroid, 2000; Maynard and Franklin, 2003). In this regard, functional foods play an outstanding role and trend on such food since 1998 till present is continued increase. Siro *et al*. (2008) and Roberfroid (2000) noted that the increasing demand on such foods can be explained by the increasing cost of healthcare, the steady increase in life expectancy, and the desire of older people for improved quality of their later years. Although, these supplement food are found in the global market, but mainly fortify with various plant bioactive extracts. On the other hand, cereal grain is considered interesting for food ingredient, especially rice and rice bran can be claimed as a gluten-free. Only a few papers associated with RB beverage production and its properties have been reported. Furthermore, high nutrition in RB and the demand for functional food products drive the researchers try to develops whole RB related products. The beverage production from, rice bran to be functional drinks is one of the alternative interesting aspects to added-value. Moreover, there are many technologies for enhanced exploitation of the health-promoting potential of cereals such as dry milling, exploration of wet enzyme-based fractionation processes as well as fermentation that descripted by Delcour *et al.* (2012). Therefore, these cereals could be considering for healthy drinks production and investigation their properties in part of cereal plants based beverage.

Cereal beverage

Currently, cereals are increased usage and application in food beverage, for instance wheat and barley used for beer production (Depraetere *et al.*, 2004; Lu and Li, 2006; Mejlholm and Martens, 2006), maize can be used to make mahewu in Zimbabwe and to make a variety of maize beers (Okagbue, 1995), oats (whole oat flakes) for hot cereals in USA, UK and Northern Europe (Webster, 1996), oat fortified in yogurt drink (Bekers *et al.*, 2001) and also for alcoholic beverage production

(Meussdoerffer and Zarnkow, 2009) such as Sake in Japan (Japanese rice wine) (Kamara *et al*., 2009), due to their health beneficial properties. The related studies about cereal beverage has been reported and descripted elshwere (Potter *et al*., 2007; Gao *et al.*, 2008; Kreisz *et al*., 2008). However, for rice bran have been a few reported as cereal beverage production. In 2009, Faccin *et al*., utilized whole RB for organic rice bran beverage production (with chocolate and strawberry flavors) and studied in chemical, rheological and sensorial properties of the product. They found that this beverage promoted good nutritive values, partially fatty acid and amino acid contents. Furthermore, this product is acceptable from panelist's evaluation. Another one factor that must be concerned for in pasteurization rice bran beverage is viscosity during stored under refrigeration. Pasteurized rice bran beverage showed the Newtonian behavior and relation to the effect of thermal processing on its rheological properties. Meanwhile, Issara and Rawdkuen, 2014 reported the same way for nutritive values except sensorial properties. This study used RB:water (1:5, 1:10 and 1:15) to produce the rice bran milk and characterize its properties compared with commercial soymilk. The results found out that the ratio at 1:15 was closely with soymilk in terms of physico-chemical properties, total polyphenol content as well as the DPPH radical scavenging activity. High amount of water added to produce rice bran milk lowered the phenolic content and biological activity. Moreover, sensory profile evaluation found that only color attribute was close to the commercial soymilk, while big differences were observed in the attributes of appearance, taste, flavor, sweetness, and overall liking. Besides, the authors concluded that RB can be use as a new alternative cereal plant-based beverage production for health concern consumer. These findings could be used as preliminary result for further development of organic RBM to meet consumer quality requirements. However, RB is not as popular for consumption or process into beverages. Therefore, this product have not yet become a commercial available and have not been lunched in the market. So, it requires more studies on further development storage stability and others to meet the consumer desirability.

Conclusion

In summary, rice bran is identifying as by-product from milling process. The results of the review studies show that rice bran might contribute to the prevention and therapy of several chronic human diseases, including allergy, cancer, infections, and cardiovascular disease, due to their bioactive compounds. Moreover, it also promoted in high nutritional values. Considering in trends of health food and beverage, the market of both products is growth rapidly due to demand of consumption. However, the interesting in nutritional value, RB canbe used to produce the cereal healthy beverage for alternative functional drink. Therefore, rice bran could be considered for food ingredients as well as a main ingredient in healthy beverage production. Consequently, it is one of the alternative interesting aspects to added-value of rice bran.

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