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Valorization of Fermented Rice Water (*Oryza sativa* L.) in Food Industry: A Review

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ABSTRACT

Rice (*Oryza sativa*) is an important staple food in Malaysia and gaining popularity in recent years due to its widespread availability and versatility to make various kind of dishes. The rice is often washed by rinsing, soaking, or boiling prior to any subsequent cooking procedure yielding suspension of dissolved starch that has a milky and slurry texture. The rice water is enriched with carbohydrate, protein, minerals and vitamin that leach out of the rice during the process. It is commonly used for other purposes in cosmetic and agriculture industry. Nevertheless, the disposal of rice water remains high as it often discarded by household and industries thus its utilization is indeed necessary to avoid environmental issues. Given the role of rice as staple food in tropical country especially Malaysia that represent one of the leading countries that cultivates and consumes rice, valorization of rice water for food consumption is considered to be a promising project since it yields more benefits and not widely explored. This review focuses on the valorization of rice water into food products through fermentation process as a method to reintegrate it into the food chain.

Keywords: Fermentation, food, Malaysia, rice water, valorization

INTRODUCTION

Rice (*Oryza sativa* L.) is known as Asian rice and one of the most cultivated and consumed grain throughout the world representing 76% of the calorie intake for South East Asian (Yang et al., 2019). Two major subspecies of *O. sativa, indica* and *japonica* are mainly cultivated in tropical environment at lower altitude and temperate region at higher latitude respectively (Yang et al., 2014). It is closely related to the African rice (*O. glaberrima*) which offers many beneficial traits such as high tolerance to iron toxicity, drought, pest, and diseases. However, the Asian rice shows better grain yield potential and grown worldwide (Linares, 2002; Chen et al., 2016; Sikirou et al., 2018). Generally, various kind of dishes can be made from rice due to its versatility and widespread availability in tropical country like Malaysia, making it suitable to be served as staple food. *Nasi lemak, nasi kerabu, nasi minyak, nasi kunyit, nasi beriani, ketupat, lemang,* and *ketupat nasi* are the main food heritage that can be made from various type of rice (Raji et al., 2017). The rice will be washed with tap water before the cooking process yielding the rice water that will be discarded as a waste product. Recently, it is estimated that about 3 million tonnes of rice are consumed by Malaysians (Bee., 2019), and at least 3 billion litre of rice water is produced yearly (Abba et al., 2021).

The rice will be washed prior to cooking by household to remove the foreign materials namely dirt, dust, remaining hull produced during industrial processing (Champagne et al., 2010). The drawback of this precooking procedure is the drastic nutritional loss such as water-soluble vitamin B, iron and zinc that leach out and subsequently leading to lower nutritional value of the rice (Bouis & Welch, 2010). The rice water will be drained upon the procedure that is often named as *leri* or *tajin* in javanese script. It has been stated that only 10% of the rice water is being reused by the communities for agricultural purposes (Septina, 2019). The remaining portion is most likely disposed as a domestic wastewater. Similarly, the rice will also be subjected to repeated washing in industry to be used as raw materials in food product processing such as rice noodles, healthy snacks, and sweeteners (Jo et al., 2015; Blandino et al., 2021). The polished rice or popularly known as rinse-free rice is made in an effort to eliminate the needs to wash the rice and production of rice wastewater. However, the rice will also be washed prior to the process and rice water is still generated (Ijiri et al., 2013). Consequently, this will generate a large amount of rice washing drainage to be discharged as industrial wastewater.

RICE WATER AND ITS VALUATION

The rice may be washed with water repeatedly depending on the type of the rice. Rice water will be obtained upon the washing procedure as a suspension of dissolved starch that leach out of the rice (Awasthi et al., 2011). As aforementioned in Bouis & Welch (2010), the rice washing procedure can cause nutritional loss to the cooked rice. This includes the removal of free starch adhering to the surface of the rice that is believed to be able to change the stickiness of the cooked rice. Nevertheless, it has been proven that the washing process has no significant impact on the stickiness of the rice since the stickiness of cooked rice is affected by the molecular structure of the leached amylopectin and the leaching behaviour (Li et al., 2017;Li et al., 2019). However, it is recommended for us to wash the rice as the optimized procedure prior to the rice cooking purposely to eliminate the toxin such as inorganic arsenic, chlorine, ochratoxin and aflatoxin contained in the raw rice (Nassehinia et al., 2017;Purwaningsih & Supriyanto, 2017;Mansouri-Nasrabadi et al., 2018;(Roychowdhury et al., 2018). These toxic substances may be introduced to the raw rice during rice cultivation and rice processing. For this reason, the rice washing procedure is deemed to be necessary for safety purposes. In a study, the removal of arsenic during the washing process is analysed and the amount of arsenic that contains in the rice water is below the detection limit and negligible (Halder, 2013). This indicates that rice water is safe for consumption and will not cause health risk to the humans. However, the amount of other toxins that contained in the rice water are unknown.

Rice water is considered as a sewage and commonly disposed by household. The microorganisms tend to multiply owning to the nutrients in rice water causing pollution to the environment (Y. Chen et al., 2021). Hence, the rice water is used in some industries and utilize it in many products formulation. It is widely being used in agriculture and cosmetic industry. As it is biocompatible with organic agriculture concept and human skin, the rice water is widely being used in biofertilizer and skincare product formulation respectively. The functional properties of rice water can be further enhanced through the fermentation process and can be incorporated into various cosmetic products such as skin toner, face cleanser and hair conditioner (Bajpai, 2018). On the other hand, fermentation of rice water can increase the plant growth due to its nutrients and beneficial microbiome species (Nabayi et al., 2021a,2021b).

The rice water is not widely being used in food and beverage industry. This is because of the public preference to avoid reusing the wastewaters for other purposes that involves less human contact and not willing to consume it without endorsement by the expert (Akpan et al., 2020). However, the rice water still can be consumed for health benefits (Marto et al., 2018) but the inability of rice water to maintain its slurry texture that will further render its barrier towards its utilization in beverage product. Similarly, the rice milk that was produced from milled rice lacks the physical attribute to stabilize the slurry texture for period of time allowing it to settle at the bottom of the product making rice slurry is difficult to be used as a food ingredient especially in beverage product (Koyama & Kitamura, 2014). Nevertheless, some studies revealed that more researches have been done to reutilize the rice water to produce different kind of food products that are prominently beneficial to food industry implying the rice water is suitable to be used as a substrate to produce various foods. This indicates that there is a growing concern and interest in valorizing the rice water into food products despite its challenges.

NUTRITIONAL AND FUNCTIONAL PROPERTIES OF RICE WATER

Rice consists of the outer layer that includes seedcoat, pericarp, bran, germ, and endosperm. The rice undergoes dehulling process to remove the rice husk from the grain to obtain whole brown rice. Next, the rice may be subjected to milling process to remove the outer bran layer leaving only the grain to produce polished rice or commonly known as white rice (Wang et al., 2019). Generally, the brown rice is more nutritious than white rice as the bran layer remains intact thus preserving large amount of nutrients. More bioactive compound were found in the brown rice such as phenolic compound, aminobutyric acid (GABA), flavonoids, tocotrienol and tocopherol that are highly concentrated in the outer bran layer of rice grains (Seo et al., 2013; Sharif et al., 2014; Sheng et al., 2017; Pang et al., 2018). It has higher nutrient retention than white rice due to the significant amount of insoluble phenolic compound that can reduce the amount of rice component leached into the water during the washing procedure (Ian et al., 2004). In contrast, more nutrients can leach out from the white rice grains making the white rice water more nutritious with 5 to 208% higher nutrients than brown rice water (Nabayi et al., 2023). However, the process can remove a significant amount of water-soluble nutrients from the rice grains up to 7% protein, 30% crude fiber, 59% thiamine, 26% riboflavin, 60% niacin, 26% Ca, 47% P, 47% Fe, 11% Zn, 70% Mg, and 41% K into the water as reported by Juliano (1994). Even though these nutritional losses mean fewer nutrients availability in the rice, they also mean the rice water yielded is now enriched by these leached nutrients and highly recommended for human consumption (Abba et al., 2021).

The nutrients of rice water from white rice and brown rice are summarized in Table 1. The rice water produced in household is enriched by the leached nutrients including carbohydrates in the form of starch by 89-90%, cellulose, hemicellulose, protein, sugar, and B vitamins which are abundantly found in pericarps and aleurone that eroded during the washing procedure (Anisa et al., 2018; Alfianti et al., 2021). It has anti-aging properties by reducing the production of reactive oxygen species approximately at 80% in human body (Marto et al., 2018). This might be attributed to the antioxidant activity by leached phenolic compounds such as γ-oryzanol, tocopherol and tocotrienol that were identified in rice (Walter & Marchesan, 2011). This antioxidant-promoting properties also can be used to reduce the enzymatic browning reaction in fruits and vegetables (Tasnim et al., 2020). Other bioactive compounds that may leach into the rice water include the arabinoxylans and β-d-glucans that are considered as major component of soluble dietary fiber present in rice grain (Fernando, 2013). Rice water is suitable to be used in food product in conjunction with the growing concern over recent decades about the large amount of industrial byproduct that contain more nutrients and bioactive compound (Jaime & Santoyo, 2021).

Table 1. The nutritional value of rice water from different studies

Type of rice water	Nutrient content (mg L^{-1})									
	Vit. B1	N	P	K	Ca	Mg	S	Fe	B	References
Brown Rice Water	431-560	47-140	62-14452	78-200	12-3574	66-1328	50-114	257-698		(Juliano, 1994 ; Wulandari G.M, Sri Muhartini, 2013)
White Rice Water	5000	440	300		2000			600		(Malakar & Banerjee, 1959)
	32-430	40-150	43-16306	51-200	8-2944	36-1425	27-212	49-427		(Nurhasanah, 2011); Wulandari

										G.M, Sri Muhartini, 2013)
		400	280	1000						(Hapsoh et al., 2019)
		80.50	64.64	130.66	23.97	25.23	452			(Nabayi et al., 2021)
			90.94	118.16	18.17	27.91			0.12	(Abba et al., 2021)
	18.21*									(Yazid et al., 2018)
	28.25**									
	32.58***									
Fermented Rice Water				2910		2710		180		(Kumaran et al., 2021)

Note: *, 1st rice washing water; **, 2nd rice washing water; ***, 3rd rice washing water

There is a significant loss of water-soluble vitamin B1(thiamine) due to the washing process (Fattal-Valevski, 2011). Washing the rice with chlorinated water will further remove thiamine content due to its chlorine sensitive characteristic thus discarding the rice water leads to significant thiamine loss from diet (World Health Organization, 1999). The reliance of society on staple rice that has been milled and washed may put them at risk of thiamine deficiencies. Thiamine content analyzed by Yazid et al. (2018) showed the concentration of thiamine loss leached to the water increases with repeated washing. This indicates that the level of thiamine that dissolves in rice water increases with number of washings. Thiamine is important to regulate the energy metabolism and perform immune functions (Edwards et al., 2017). It also plays a key role in eliminating the SARS-CoV-2 virus by stimulating the cell-mediated and humoral immunity (Shakoor et al., 2021). Hence, the rice water may supply a sufficient level of thiamine owing to the increasing level of this vitamin in subsequent rice washing waters to develop the immunity against the virus in covid patients. However, the level of other nutrients in different number of rice washings remain unknown and unexplored.

There are lack of studies analyzing the amount of true protein that leached into the rice water. However, it is estimated to be present at significant level (0.374 mg/g) which is second to total carbohydrate (0.461 mg/g) (Kumaran et al., 2021). The protein can be used to lower the amount of formalin content in food products that is illegally added as food preservative by forming the methylene bridge between the formalin and proteins (Thavarajah et al., 2012). The food products can be immersed in the rice water to draw out the formalin residue. The formalin content in noodles and tofu can be decreased by 91.8% and 67.2% respectively (Anjelina, 2016; Ramdan, 2018). From a nutritional and functional point of view, the rice water can be used in food preparation, food development, and for human consumption.

FERMENTATION OF RICE WATER

As previously mentioned, the rice water can be derived from the household and food industry as a domestic and industrial waste product respectively. In a recent study, it had been stated that the wastewater from food industry is considered as valuable resource for novel products and not regarded as waste or which is in our case, the rice water (Costa et al., 2021). These rice water can serve as bio-economical source of carbon and nitrogen for fermentation processes to produce value added product and thus reducing the production cost. It has a relatively high amount of carbon and starch that can be used by various microorganisms for fermentation as shown in Figure 1. Considering the high nutritional profile of rice water stated above, the valorization of rice water into food and beverage product through fermentation process could be a platform to enhance the nutritional recovery especially for Malaysian.

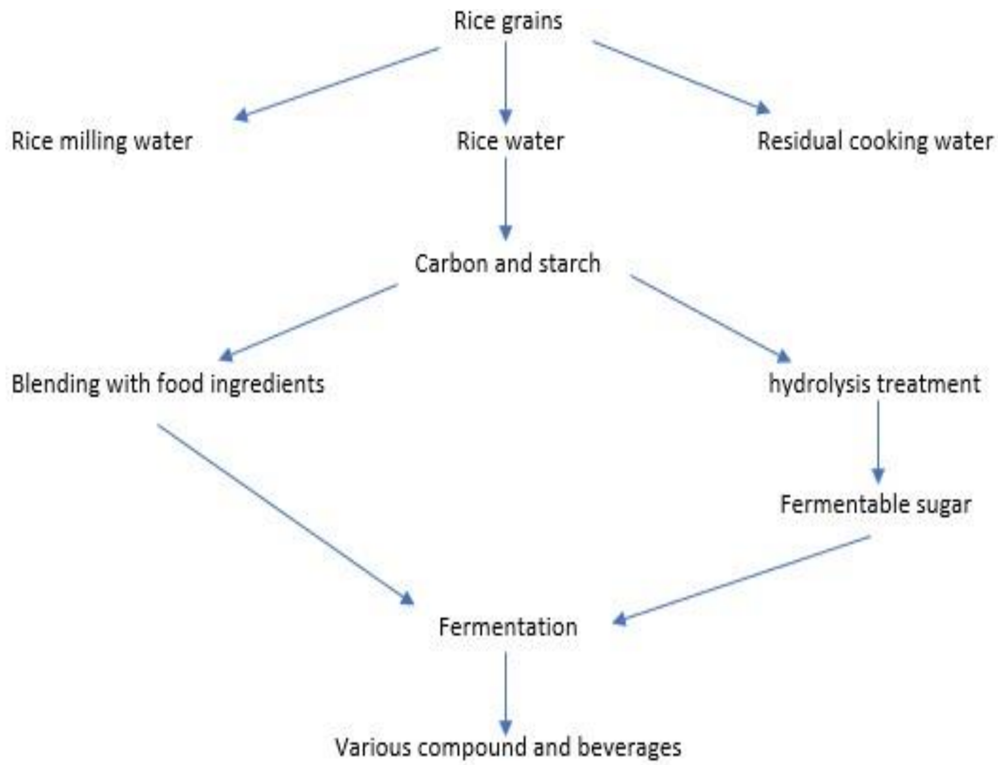

Figure 1. Valorization schemes of rice water

Fermentation process by lactic acid bacteria

Lactic acid bacteria (LAB) are microorganism group that poses a great industrial interest, that involve in many fermented food formulations from raw materials of cereal and grains origin within East-Asian countries (Rhee et al., 2011). LAB is specialized in biotransformation of carbohydrate into various organic acids prolonging the shelf-life of the fermented foods (Alvarez-Sieiro et al., 2016;Yalcin & Çapar, 2017). It is associated with health-promoting properties due to the presence of probiotic effects that can maintain the composition of gut microflora and induce beneficial biological functions in host (Hemarajata & Versalovic, 2013;Quinto et al., 2014; Ayivi et al., 2020). The fermented rice water can harbour many LAB from different genera namely *Lactobacillus sp,* and *Streptococcus sp* that are accompanied with antifungal and antibacterial properties (Susilawati, 2016). Both LAB are widely being used as a starter culture in formulation of many fermented beverages. The growth of LAB can be further enhanced by using 1:3 rice-water ratio from first washing or 1:1 rice-water ratio from second washing that serve as compatible media for early proliferation and highest amount of viable LAB (Gil et al., 2015).

In the previous work done by Zona et al. (2019), the rice water was added with curcuma extract and used as a substrate to produce probiotic drink with high antioxidant level. Only the filtrate of rice water from the second and third washing is used in the study as shown in Table 2 to avoid sedimentation to occur in the product. The total viable *Lactobacillus casei* count yielded after 24 hours of incubation at 30°C are 2.4×10^8 CFU/mL and this value satisfies the Malaysia's regulation enacted by Food Safety & Quality Division of the Ministry of Health (MOH) exceeding the minimum value (not less than 1.0×10^6 CFU/mL) of viable culture in the products to be labelled as probiotics (Food (Amendment) (No. 2) & Regulations 2017). Same approach can be used to produce different kind of drinks with different LAB strain to provide wider range of probiotic characteristics such as *L. acidophilus, L. plantarum L. bulgaricus L. fermentum* and *L. kefiranofaciens* that are widely incorporated in fruit juice, grain-based yogurt and fermented dairy products.

Valorization of rice water using LAB includes the organic acids that could be reintegrated in the food chain as well as producing food ingredients to be incorporated in food products as shown in Table 3. In the previous study, the rice water was tested for its capability as a substrate to produce hyaluronic acid (Tu & Trang, 2013). The rice water was autoclaved and only the supernatant was used. It had been found that the production of hyaluronic acid by using rice water inoculated with *Streptococcus thermophilus* was higher than MRS broth by twice. According to Lee et al. (2023), the organic acids produced by LAB with rice water can act as a food additive to be added into food product to prolong the shelf-life.

Table 2. Valorization of rice water into beverage product from different studies

Food product	Raw materials	starter culture	Reintegration	References
Yogurt drink	Rice water, sugar, skim milk powder	Yogurt stater	No, only rice slurry is used	(Leko et al., 2018)
Probiotic drink	Rice water, curcuma extract	*Lactobacillus casei*	No, only filtrate is used	(Zona et al., 2019)
	Rice water, skim milk, honey,	Kefir stater	Yes	(Fazriyanti, 2015)
Rice cake	Rice water, rice flour	*L. reuteri*	No, only the rice slurry is used	(Lee et al., 2023)
Nata de *leri*	Rice water, acetic acid, ammonium sulfate, phenol crystal, glucose, cane sugar	*Acetobacter xylinum*	Yes	(M. Faiz Al Laily, 2019; Suratmiyati et al., 2016)
	Rice water, *tempe* waste, sugar		Yes	(Wahab et al., 2016)
	Rice water, red dragon fruit extract		Yes	(Septina, 2019)
	Rice water	*Acetobacter xylinium, Aspergillus oryzae*	Yes	(Bayuana, 2015)

Fermentation by other bacteria

Apart from LAB-mediated fermentations, other fermentative bacteria can be employed to valorize the rice water namely *Acetobacter xylinium*. The species belong to the acetic acid bacteria (AAB) that is capable to oxidize the alcohols, sugars, sugar alcohol and aldehydes to carboxylic acids (Gomes et al., 2018). This bacteria is mainly found on cereals, herbs, and fruits and considered to be potent microorganism in production of fermented beverages such as kefir, kombucha, and beer (Sengun & Karabiyikli, 2011; Lynch et al., 2019). The bacteria also specialize in production of bacterial cellulose as shown in Table 3 that is reported to be non-toxic, biodegradable, and biocompatible with the food industry to produce low calorie food ingredients, low cholesterol food and food packaging materials (Shi et al., 2014).

Bacterial cellulose that has been commercialized in a gel form, popularly known as nata that originated from Philippines, is a traditional dessert in Southeast Asia. The widespread production of nata in food industry is attributed to its high hydrophilicity to hold water over 100 times its weight forming a jelly like food (Gayathry, 2015). Nata de Coco dominates currently the production of nata product as it is the major substrate to produce it (Photphisutthiphong & Vatanyoopaisarn, 2020). However, in event of coconut water shortage, rice water can be used as a cheap source to ferment bacterial cellulose due to its high concentration of carbohydrate (Karina dusthuri, 2016). The rice water generated during the production of rinse-free rice also rich in amino acids, vitamins, saccharides and other nutrients could be used to produce bacterial cellulose at a larger scale (Sudying et al., 2019). Its structure is examined to be more condensed and similar to the standard cellulose (Apriyana et al., 2020). Nata that is made from rice water is famously known as *nata de leri* in Indonesia and often added with sugar and fruit extract to enhance the flavour as shown in Table 3. The red rice water is reported to be the best substrate to produce *nata de leri* with the highest mass (Suratmiyati et al., 2016).

Table 3. Valorization of rice water into various products from different studies

Products	Raw materials	Microorganisms	Compound yield	Reference
Organic acids	Rice water	*Streptococcus thermophilus*	Hyaluronic acid	(Tu & Trang, 2013)
	Rice water containing rice bran	*Lactobacillus rhamnosus*	Lactic acid	(Watanabe et al., 2013)
Syrup	Rice water, rosella flower extract	*Rhizopus oryzae*	Reducing sugar	(Asngad et al., 2013)
Single cell protein	Rice water, pineapple peel,	*Saccharomyces cerevisiae*	Microbial protein	(Mujdalipah & Putri, 2020)
Alcohol	Rice water, sulfuric acid	*Saccharomyces cerevisiae* (immobilized)	Bioethanol	(de Oliveira et al., 2012)
Cellulose	Rice water	*Acetobacter xylinium*	Bacterial cellulose	(Pongjinapeth et al., 2020)
Enzyme	Rice water	*Aspergillus sp.*	α -amylase	(Pimpa, 2004)

Fermentation by fungi and yeast

Fungi represent some of the first microorganisms that have been employed in fermentation process purposely to yield compound of interest for industrial applications. Fungi produce diverse array of microbial enzymes, pigments, and metabolites. Hence, culturing them on rice water has long been used for their production. Some examples include reducing sugar, alcohol, protein, and enzymes to be reintegrated in the food chain as shown in Table 3. Some of the fungi can be used to impart anti-odor properties to the fermented water (Elfarisna et al., 2014). This is important to improve the organoleptic and sensory properties of rice water. However, the fungal strain is not specified. Some of the yeast was reported to be naturally grown in the fermented rice water that consists of nine yeast strain from seven genera which are *Candida intermedia, C. parapsilosis, C. metapsilosis, Trichosporon asahii, Papiliotrema aspenensis, Meyerozyma caribbica, Hyphopichia burtonii, Cystobasidium calyptogenae* and *Rhodotorula toruloides* (Wongwigkarn et al., 2020). This discovery can widen the scope of fungal fermentation in rice water.

Yeast has crucial role in the production of ethanol in alcoholic beverages. The yeast species that is prominently used in the production of alcoholic beverages is *Saccharomyces cerevisiae* which could elevate the aroma and flavour characteristics in different products (Walker & Stewart, 2016). The higher amount of starch in the rice water could serve as a valuable substrate for alcoholic fermentation by *S. cerevisiae* provided that the rice water is subjected to hydrolysis treatment to produce fermentable sugar (Watanabe et al., 2009). There are substantial research studies has been published on the production of alcohol from waste product aiming to produce high amount of ethanol. However, the rice water that could produce up to 3.4 g/L/h of ethanol by subjecting it to acid hydrolysis prior to fermentation with immobilized *S. cerevisiae* (de Oliveira et al., 2012). In another study, the ethanol productivity was up to 0.529 g/L/h with minimum inhibitory compound formed during the pre-treatment of rice water (Hatami-manesh et al., 2020). The alcohol productivity shown by both studies comply with the ethanol standard amount that is allowed in beverages (below 1.0% of ethanol) and to be used as food additive (below 0.5% of ethanol) in halal product by Department of Islamic Development Malaysia (JAKIM) (Pauzi et al., 2019). This shows that rice water can act as a suitable source for production of alcohol to be used in halal products. Therefore, these fermentative alcohol production from rice water could be further optimized and implemented to be used in many beverages without deteriorating its halal status.

DEVELOPMENT OF RICE WATER VALORIZATION

As previously mentioned, the valorization of rice water was done in several researches. Various innovations were invented to produce food products that can be commercialized for human consumption. The valorization method can be done either by direct addition of rice water in food formulation as depicted by (Elaveniya & Jayamuthunagai, 2014; Ramdan, 2018; Tasnim et al., 2020) or by utilizing the rice water into a food product through fermentation with different microorganisms. This is most likely because of the compatibility of rice water to be used as food additive and main substrate for its functional properties to prolong the shelf-life of product due to the high antioxidant value or to improve the characteristics of food product respectively. However, one might discard the rice slurry from the rice water suspension that formed as mentioned in Koyama & Kitamura, (2014) and use only the filtrate or vice versa as shown by Leko et al. (2018) to be used in food production. Therefore, waste product is still generated, and the full valorization of rice water could not be materialized.

Future trend in rice water valorization

Both the rice slurry and filtrate are able to be served as a potential substrate in the production of food. Therefore, we suggest that they can be used separately to produce different kind of beverages based on their characteristics. It can be seen that rice slurry can be used to produce semi-solid beverages products like yogurt as presented by Leko et al. (2018) without causing sedimentation to occur in the products while the rice water filtrate can be used to produce liquid-phase drink as presented by Zona et al. (2019). However, the whole rice water can be used for beverage production with the addition of hydrocolloids to improve the stability of the rice water suspension. Stabilizers that widely used in beverages include gum, carrageenan, pectin, alginates and cellulose derivatives (Krempel et al., 2019). Xanthan gum is reported to be able to provide good product stability at 0.3 % concentration while guar gum can improve the physiochemical properties at concentration range from 0.05 to 0.5% applied in rice milk (Issara & Rawdkuen, 2017). Same approach could be used in the production of beverages made from rice water and the amount of gum applied is expectedly to be lesser than 0.3% due to small portion of rice slurry in rice water. Therefore, valorization of rice water can be achieved without producing waste. The development of rice water filtration system by using filtration with muslin cloth to eliminate the large impurities followed by 0.20 µm syringe filter can further enhance the result yielding filtrate with abundance of amino acids after fermentation and free of pathogens Ibrahim & Tan Kofli (2019). Toxicity test is needed to ensure the safety of the filtrate.

Worldwide Valorization of Rice Water

Worldwide, the rice water is mainly used for agriculture followed by cosmetic industry. However, our findings reveal that rice water was utilized in many researches particularly in Indonesia to produce different kind of food ingredients, condiments, and beverages. Other study in India revealed that rice water could be incorporated in drinks for health benefits (Kumaran et al., 2021). Recent study includes the utillization of fermented rice water in traditional Korean rice cake which is *Garaetteok* (Lee et al., 2023). This phenomenon shows that other countries also begin to show interest in valorization of fermented rice water into food products.

There is no record of valorization in food and beverage industry found in Malaysia as there are no studies available in any database that complement to the topic. This shows that valorization of rice water is not yet explored in Malaysia. However, Malaysia had developed the rice water filtration system as previously mentioned by Ibrahim & Tan Kofli (2019) and a similar research valorisewas done that used pigmented rice cooking water to produce high antioxidant drink (Handayani et al., 2014). Both of these researches show that Malaysia do have the opportunity to widen the exploration of valorization of fermented rice water in food industry. Kedah could serve as a suitable pioneer to valorise the rice water into food products as it is a major rice producer in Malaysia. About 85.5% of the paddy production is cultivated in Peninsular Malaysia that has been reserved for research and development purposes (Firdaus, 2013). This would create opportunities for more rice-based products innovation including rice water. Since that the product innovation is considered to be crucial in order to survive in business world (Nasir & Ahmad, 2015), business entities, small medium enterprise (SME) and other manufacturing industries also can participate to promote and commercialize novel products. The industries that pose such opportunities include the parboiling industry, rice noodles manufacturing, and rinse-free rice industry as they would produce more rice water as a byproduct during the industrial production. The rice water yielded can be used in production of different kind of food products.

CONCLUSION

Although the rice water can serve as a potential substrate for microbial fermentation and bring more benefits to food industry, these have not yet been widely explored. The fermentation of rice water can be carried out by various microorganisms to improve the functional and nutritional properties of the beverage product. Other ingredients may be added as a co-substrate to compensate the poor attributes of the rice water enhancing the value of the products. Malaysian are encouraged to execute this novel project since Malaysia poses opportunity owing to the widespread production of rice water throughout the country. Many challenges need to be overcome: 1) the lack of awareness about rice water and its potential within the society. 2) Assessing the perception and willingness of public to consume foods made from rice water. 3) Lack of research focusing on valorization of rice water into food products. 4) Exploring new methods and technologies to maintain the rice component in beverage products to promote full utilization of rice water in food products thus broadening its application in food industry. Hence, Malaysians are encouraged to execute more researches related to utilization of rice water in food products as being one leading country that produce and consume rice.

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