Conference Paper

Artificial Rice As an Alternative Functional Food to Support Food Diversification Program

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Abstract

Functional food is a food that has a beneficial effect to the body beyond its adequate nutritional effects. It can help improve someone's health and/or decrease the risk of disease. The awareness in the community of the importance of health encourages the development of functional food. One of the functional food that has been developed in Indonesia is the artificial rice. Artificial rice, an alternative paddy rice substitute, has a minimally equal value to paddy rice. Artificial rice is made to reduce people's dependence on paddy rice and to support food diversification program to achieve food security in Indonesia. Artificial rice is made from a non-paddy rice flour with a certain compositions, so that it can be used as a vehichle to make a functional food and can be fortified with ingredients that contain functional active compounds. Indonesian researchers have developed artificial rice products by utilizing local resources, such as corn, sorghum, spices, tubers, and others, to obtain an artificial rice with improved nutritional and functional characters that have some health benefits such as antidiabetic, antioxidant, antihypertensive, and anticancer. Such development has resulted in the observation that artificial rice can be used as a functional food for rice substitute with an equal or better nutritional value than paddy rice. However, further research is still needed to improve the sensory quality of artificial rice so that it can be accepted easily by the community.

Keywords: Artificial rice, food diversification, functional food, rice analogue

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1. Introduction

Food security is a situation where all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life [1]. Indonesian food security has improved over the past two decades and it has the potential to produce enough food to feed its population and achieve food self-sufficiency, but it is hampered by some challenges, such as climate changes, land availability, and increasing number of population[2]. These conditions force Indonesia to rely on foreign markets and import some food supplies to meet the food demand and ensure its food security. For example, to meet the demand

of rice, which is one of the main comodity and agricultural product in Indonesia, the government needs to import rice from other contries, with the amount of imported rice rising from 2013 to 2015, to reach 472.664,7 tons and 861.601 tons respectively [3]. This condition occurs because the production rate of paddy rice in Indonesia is not balanced with the increasing population growth.

To overcome these challenges, the government encourage people to participate in food diversification program that can help Indonesia to achieve food self-sufficiency and food security by making a regulation as outlined in Act no.18/2012 about the importance of food diversification programs to strengthen national food security. Food diversivication program is a program to produce, provide, and consume various alternative food from local resources to achieve a safe, quality, and balanced nutritional dietary habits, and reduce the dependence on rice consumption [4]. Since Indonesia is a country with high biodiversity, the government encourages the use of local resources that are still not fully utilized and have the potential as an alternative rice substitute, such as corn, sago, and tubers, which are also known as carbohydrate sources.

Responding to this situation, various sectors, including researchers, are encouraged to participate and make innovative food products. Being aware of the high dependence of Indonesian people on rice[5], many researchers have made rice substitution products in a form of artificial rice using local resources. This artificial rice can be consumed by anyone in the same way as normal (paddy) rice, making it easily accepted by communities. As the awareness of the importance of health begins to grow[6], the development of functional food intensifies. Researchers usually fortify the artificial rice with functional ingridients, making them to become a functional food that has a health benefits and better nutritional value than paddy rice. This properties become an advantage and strength to compete with (paddy) rice in the market, especially targeting health conscious people and people with special health conditions, such as diabetic patients, who prefer to consume artificial rice rather than paddy rice.

1.1. Artificial Rice: Definition and Making Process

Artificial rice is an alternative paddy rice substitute that has a minimally equal value to paddy rice. Artificial rice is made from a non-paddy rice flour that is molded into a rice grain shape using extrusion technology. Extrusion is a process of flowing food ingredients by force through pressure, a large incision in a high temperature conditions, and passing it through a die to form an extrudate. The extruder consists of a tube containing a screw, either one screw (single screw extruder) or two screws (twin screw

extruder). Single screw extruder is a type that is often used for food production because it is cheaper and easier to operate. In single screw extruder, hot extrusion is more often used to make artificial rice, biscuits, and other products [7].

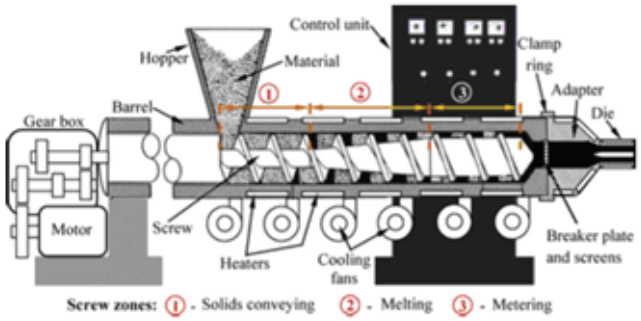

Figure 1: Schematic view of single screw extruder [8].

Artificial products from hot extrusion process usually have a texture that is more similar to the original due to the better degree of starch gelatinization. Starch gelatinization is the main process in the formation of artificial rice. Starch gelatinization happens because of the destruction of the molecular arrangement between starches from the double helix and crystals form that become hydrated by water. Gelatinization occurs in two stages, the destruction of hydrogen bonds in the amorph region, and then hydration by water. These stages causes the release of amylose, rupture granules, and forming a colloidal gel structure [9]. Amylose:amylopectin ratio affects the gelatinization process. The ideal ratio of amylose:amylopectin to reach a good gelatinization process is 1: 3 to 1: 5. If the amount of amylose is too high, the development power will decrease, but if the ratio of amylopectin is too high, the rice will become more resilient[10]. Higher temperature, retention time, and screw rotation speed increase the viscoelasticity of the gelatinization results, but reduce the essence value of the product's color[11,12].

In the process of making an artificial rice, there are some other components that can affect the texture of the rice, such as water content, starch level, hydrocolloid agent, fiber content, and additives. Water content above 50% w/w can make a sticky texture, while water content below 25% can make a rigid texture. Starch level that is good for gelatinization is in the range of 40-70% w/w. The hydrocolloid agent (0,5-5% w/w) is needed to increase the ability to retain water to produce an artificial rice with a soft texture. High level of fiber can make a crisp texture on the rice produced [13]. While additives such as minerals, vitamins, and phytochemicals that are added in the mixture, as much as possible, do not affect the texture of the artificial rice [14].

1.2. Artificial Rice: Health Benefits

Artificial rice is made with a certain composition to produce expected results. Artificial rice usually designed to has a low Glycemic Index (GI) and good nutritional values, minimally equal to paddy rice. Artificial rice that is made from local resources usually has a high dietary fiber, with some having bioactivity functions. It can be easily fortified with naturally functional ingredients, such as, vegetables, fruits, or other fortificant, such as vitamins, folate, iodine, that bring health benefits like antidiabetic, antioxidant, antihypertensive, and anticancer. Artificial rice can also be fortified using waste, such as eggshell and fish bones to produce a high calcium artificial rice. The followings are some example of artificial rice that have been made and is claimed to have health benefits.

1.3. Artificial rice with hypoglycemic effect

This artificial rice is made from 60% arrowroot flour and 40% rice flour with the addition of 2% Na-alginate. The Meal Tolerance Test (MTT) result shows that rats, fed with arrowroot rice, had the lowest increase in blood glucose level (24,7 mg/dl) compared to rats fed with paddy rice (46,61 mg/dl). The higher the increase in blood glucose after meals shows the higher the glycemic index. This result shows that the artificial rice has a low glycemic index and can be a potential medical food for diabetic patients. Arrowroot and alginate contain water soluble fiber that help to reduce postpandrial glucose levels and insulin by making gastric emptying slower and reduce carbohydrate absorption. The presence of water soluble fiber from arrowroot flour and alginate as food fiber also help the absorption of starch so that it can keep of from being hydrolized by the α-amylase enzyme. The hypoglycemic effect assay shows that this artificial rice has a hypoglycemic effect if it is consumed regularly within a certain period of time and can decrease the blood glucose level by 89,9 mg/dl blood (Figure 2) [15]. Other types of artificial rice that have a hypoglycemic effect are artificial rices from corn, sorghum, and arenga starch. Such artificial rice has a low glycemic index that is 47,09 and contain some phenolic compounds and dietary fiber. The fiber content (water soluble fiber) result in the rice to have a hypoglycemic activity [16].

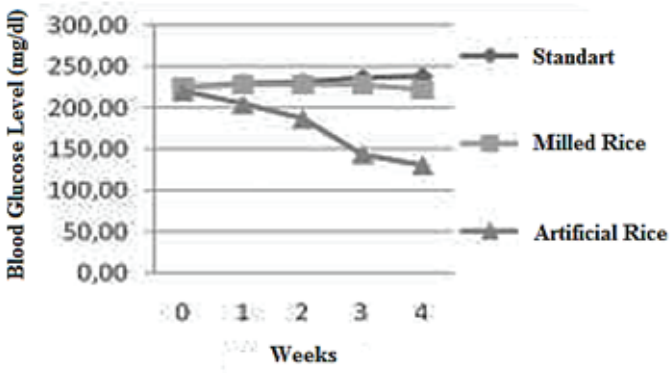

Figure 2: Artificial rice from arrowroot and alginat with hypoglycemic effect [15].

1.4. High calcium artificial rice

This artificial rice is made due to the fact that the calcium intake of Indonesian people is still very low - about 270-300 mg per day for adults, compared to the recommended intake, which is 1000-1200 mg per day for adults. This condition results in high prevalence of osteoporosis in Indonesia (prevalence of osteopenia is 41,7% and prevalence of osteoporosis is 10,3%). This artificial rice is made of mocaf flour, corn flour, soybean flour, and seaweed flour, and then fortified with eggshell flour to made a high calcium artificial rice. The addition of 2% eggshell flour results in a high calcium artificial rice with calcium content of 141,267 mg/100 g, which is higher than the calcium content in cow's milk (125 mg/100 g). Moreover, the sensory factor of this artificial rice has been tested and can be accepted by the panelists. This artificial rice can be used as a vehichle to fulfill calcium needs per day and prevent various diseases that can be caused by calcium deficiency, such as osteoporosis [17].

1.5. Artificial rice with antioxidant activity

This artificial rice is made from baruk sago (*Arenga microcarpha*) and purple sweet potato (*Ipomea batatas* L. *Poiret*). The antioxidant content obtained from the purple sweet potato that contain anthocyanin. The total antioxidant content of this artificial rice is 62,01 mg/ml which considered as having a high antioxidant activity [18]. Another artificial rice that has an antioxidant activity is artificial rice from sorghum and red bean flour. Red bean flour contain some antioxidant compounds, such as flavonoid which is the most dominant antioxidant compounds. This artificial rice has an antioxidant activity of 113,93 mg vit C/100 g and glycemic index 54 (low glycemic index)[19].

There are many more artificial rice that have been developed and tested to have health benefits. Most of the artificial rice that has been developed is made from a carbohidrate source and fortifying agent, which tends to have an antioxidant content and/or high fiber - mostly water soluble fiber. The fiber content helps to develope an artificial rice that has a low glycemic index and hypoglycemic effect that are good for diabetic diets. Some examples of other artificial rice that have been developed can be seen in Figure 3.

Figure 3: Some Examples of Artificial Rice That Have Been Made. A) Artificial rice from *Dioscoreahispidadennst* flour for diabetics diet [20]; B) Artificial rice from purple sweet potato flour and starch with zinc fortification [21]; C) Artificial rice from corn flour with antioxidant properties and low GI [22]; D) Artificial rice from sorghum fluor and sago with spices fortification for diabetics diet [23].

Artificial rice from *Dioscoreahispidadennst* flour has 24,66 % amilose, 5,85% total dietary fiber, and 62,54% starch digestibility. It's GI avarage score is 51,96, which is considered as a low GI food good for diabetics diet [20]. Artificial rice from purple sweet potato flour and starch with zinc fortification is made to help overcome the zinc deficiency problem. Zinc deficiency occurs in quite a number of people in developing countries and can cause indigestion, respiratory disorder, and immune system disorder. The artificial rice with zinc fortification, in a form of zinc acetate (50 ppm), produce artificial rice with zinc concentration 89 ppm/100 g ingredients. This artificial ricce can fulfill the zinc adequacy rate recommended by WHO, which is 55-100 ppm/100 g ingredients [21]. Artificial rice from corn flour, sago, soy flour, and rice bran is made as a functional food that has antioxidant properties and low GI [22]. It contains high fiber content (13,3%), bioactive compound such as α-tocopherol 1,00% and γ-oryzanol 48,70%, amilose content 28,02%, and low GI score, which is 54±18, that made this artificial rice is a good choise for diabetics diet [22]. Artificial rice from sorghum fluor and sago with 1% spices (onion, garlic, bay leaves, ginger, and lemongrass) fortification is made as a functional food that has a high fiber content. Besides its utilisation as a fiber source, the spices are used as a fortificant to raise the sensory acceptability and enhance the physico-chemical characteristics of the rice. This artificial rice contains 9,56% moisture, 0,72% ash, 0,53% fat, 6,22% protein, 92,53% carbohydrate, 26,48% amylose, and 6,67% dietary fiber [23].

1.6. Artificial Rice Position in Current Market

There are several artificial rice products that have been sold on the market, mostly in the form of artificial rice made from corn. These artificial rice emphasizes its superiority in terms of high levels of dietary fiber, antioxidant content, and low GI (good for diabetic diets) compared to ordinary rice (paddy rice) (Table 1). An artificial rice product that is well known in Indonesia is the corn artificial rice from PT FITS Mandiri (Figure 4). PT FITS Mandiri has been increasing their promotional activity through online media, to let people know more about their products, expand distribution area, and boost their sales [24].

Despite its superiority, artificial rice is still not well known and in demand by the public because of the lack of introduction of and education for these products. This is exacerbated by its sensory factors, especially its color, which is less attractive than the paddy rice. These conditions cause fluctuative sales rate and difficulty to increase sales volume [24]. The product's price is also higher compared to paddy rice (PT FITS Mandiri corn artificial rice price is IDR 30.000/800 g, while paddy rice price is in the range of IDR 10.000-15.000/kg), due to its high the production cost. This may become a limiting factor, with only limited number of customers that can buy and consume this artificial rice in daily basis.

Figure 4: Corn artificial rice from PT FITS Mandiri.

To increase the sales and consumption of artificial rice in the community, there have been several studies conducted to develop an artificial rice marketing strategy. These studies revealed that the most appropriate marketing strategy is to focus on maintaining the product's quality and functionality that offers health benefits and high nutritional value, increasing the promotional activity, expanding the distribution area, and last but not least, focusing the market segments into adult (30-40 years old) that has an income level of IDR 4.000.000-6.000.000 [24,25].

TABLE 1: Nutritional value comparison between corn artificial rice from PT FITS Mandiri and white (paddy) rice.

Parameter (per 100g)	Corn Artificial rice (FITS)	White (Paddy) Rice
Energy (Kcal)	370,78	400,66
Dietary Fiber (%)	10,34	6,82
Total Carbohydrate (%)	77,42	88,01
Total Sugar (%)	Not Detected	0,12
Protein (%)	5,78	10,85
Total Fat (%)	4,22	0,58
GI	52	70

2. Conclusion

From most artificial rices that have been developed so far, it can be observed that artificial rice can be used as functional food for rice substitutes with equal or better nutritional values than paddy rice. Artificial rice usually has a low glycemic index, high dietary fiber, with some of them having bioactive ingredients that provide good biological functions (bioactivity), such as hypoglycemic, antihypertensive, and antioxidants. However, further research is still needed to improve the sensory quality of artificial rice so that it can be accepted easily by the community. Aside from the product quality aspect, appropriate marketing strategies are also needed to promote this innovative and functional product so that artificial rice can be more well-known in the community and can be a daily-consumed substitute to paddy rice.

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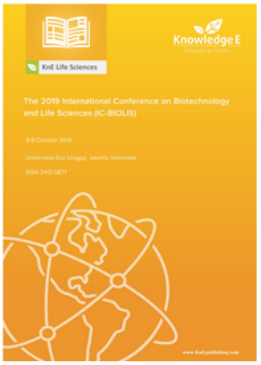

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The fourth industrial revolution era – which is denoted by automation in all fields including industry, financial, medical and education – is predicted to bring opportunities as well as disruption of relationships between human (society) and technology. This 4.0 Industrial Revolution will create new realms that humankind has never experience before. The readiness of human resources, technology and infrastructures are required to face the impacts of this revolution, as it will fundamentally change the way human lives, works and socializes. As such, it is important to ensure that the revolutionized technology will bring positive impacts to the society. This should be brought about by creating an integrated and comprehensive approach that involves stakeholders from all sections of society, including practitioners from public and private sectors, academia and researchers. Indonesia is a developing country which undergoes progressive changes towards a rapidly industrializing society. The country is characterized by its abundant natural resources and a demography dominated by parts of society at a productive age. It is a country on the verge of becoming a developed one. As with other developing countries, the shift towards the 4.0 industrial revolution demands a careful and measured management of existing opportunities and challenges. This requires human resources that are empowered with pertinent skills. Biotechnology, which moves around the interface between technology and biological sphere, holds a key role in assisting the country in navigating its course through the new industrial revolution. It utilizes biological resources for the welfare of human society and assists the progression of a nation towards prosperity. The advancement of biotechnology, supported by skilled human resources in the sector, is essential to ensure that Indonesia is well prepared in facing both the challenges and opportunities brought about by the 4.0 industrial revolution. By adopting a theme on "The Role of Biotechnology in the Era of 4.0 Industrial Revolution", The 2019 International Conference on Biotechnology and Life Sciences (IC-BIOLIS) aims to create a platform for relevant experts and stakeholders in the field of biology and biotechnology to discuss and share experience relating to the management and appropriate utilization of biological resources, as well as the recent advancement of biotechnology.

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