Sago Rice as an Environmentally Sustainable Food

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Abstract. Sago rice is artificial rice made from sago starch and others flour by extrusion process. This study aims to recommend the sustainability of sago rice as a staple food to deal with climate change by utilizing technology to explore and innovate the sago palm. Sago rice has the potential for economic, social, and environmental sustainability. Regarding social sustainability, sago rice can be processed from a mixture of sago starch and several other local flours, including brown rice flour, corn flour, red bean flour, and black rice flour, producing healthy food that tastes similar to rice and is acceptable to consumers. The four formulations of sago rice have gelatinization properties and textures that are similar to rice and are acceptable to consumers. The starch gelatinization properties were, namely, peak viscosity, breakdown viscosity, setback, and final viscosity, 1384–3234 cP, 684–1380 cP, 1071–2704 cP, and 371–850 cP, respectively. The texture of sago rice with hardness ranged from 3759.665–5003.699 g/f, and the stickiness ranged from 773.527–1038.35 g/f. Based on the social aspect, sago rice can be used for staple food reserves other than rice, healthy food, and supporting sustainable development. Keywords**:** Sago rice, development of sustainable food.
Keywords: Sago Rice, Climate Change, Sustainability, Food Innovation, Sustainable Development.

1 Introduction

In the quest for sustainable and eco-friendly resources, innovative solutions are emerging across various industries. One such notable development is the utilization of analog rice made from sago as a sustainable alternative to conventional rice. Analog rice refers to rice-like grains that are derived from alternative sources and offer comparable taste, texture, and nutritional value. Sago rice is a versatile agricultural product with great potential to support the Sustainable Development Goals (SDGs) program in agriculture.

The SDGs, adopted by the United Nations in 2015, provide a comprehensive framework to address pressing global challenges, including poverty, hunger, climate change, and environmental degradation. Sustainable agriculture, as one of the critical components of the

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SDGs, aims to ensure food security, promote sustainable land use, and enhance rural development. In this context, the use of sago rice is acceptable to consumers and aligned with the goals of the SDGs [1].

First and foremost, sago rice offers a sustainable alternative to conventional crops in agricultural production. It requires fewer resources, such as water, fertilizers, and pesticides, than traditional staple crops like rice, wheat, or corn. Sago palms are highly resilient and thrive in diverse ecological conditions, including areas unsuitable for other crops. By promoting the cultivation and consumption of sago rice, we can reduce the strain on natural resources and minimize the environmental impact associated with conventional farming practices.

Furthermore, sago rice possesses inherent nutritional benefits that contribute to food security and improved health outcomes. It is gluten-free, cholesterol-free, and low in fat, making it a healthy option for individuals with dietary restrictions or health concerns. Sago rice is also rich in carbohydrates, providing a good energy source. Integrating sago rice into local diets can diversify food choices, reduce dependence on imported staple crops, and enhance overall nutrition for communities.

Additionally, cultivating sago palms and processing sago rice can stimulate rural development and create sustainable livelihood opportunities. Sago palm plantations require skilled labor for planting, maintenance, and harvesting, thus generating employment opportunities for local communities. Sago processing into various forms, such as noodles, macaroni, and snacks, can foster entrepreneurship and value addition within rural economies. We can empower farmers and rural communities by supporting the sago industry, thereby contributing to poverty alleviation and economic growth. Research on sago rice has been extensively researched as a diversification of local and healthy food. Sago rice can be formulated with several other local flours and fortified with vegetable and animal protein sources [2-5].

Moreover, sago rice can contribute to climate change mitigation and adaptation efforts. Sago palm trees have a high carbon sequestration capacity, which absorbs and stores significant amounts of carbon dioxide from the atmosphere. Expanding sago palm plantations can contribute to reducing greenhouse gas emissions, enhancing carbon sinks, and mitigating the impacts of climate change. Additionally, sago palms are known to be drought-tolerant and resilient to extreme weather conditions, making them suitable for cultivation in regions prone to climate-related challenges.

The objective of the research was to show that sago rice made from sago starch and other local flour mixtures has similar characteristics to paddy rice. Assessed the textural characteristics and viscosity profiles of substituting various local flours into formulations of sago rice. The potential of sago rice as a sustainable food resource from social, economic, and ecological sustainability.

2 Methodology

Present the potential of sago rice as a sustainable food source from the aspect of social, economic, and ecological sustainability. Economic and ecological sustainability aspects were obtained from secondary data from several references to related journals and conferences. In terms of social sustainability, by examining the physical characteristics of the texture and viscosity profile of the sago rice formulation compared to paddy rice. The raw materials used in this study were sago starch from Riau, Indonesia. Corn flour, red bean flour, red rice flour, and black rice flour were purchased from the local market (South of Tangerang, Indonesia). Instruments used are a single screw extruder (Barata, Indonesia), a silver shaker (RX 863, W.S Tyler, USA), a cabinet dryer (BRIN, Indonesia), a steamer (Akebonno MSP 10107, China), a texture analyzer (Perten 4500, USA), and Rapid Visco Analyzer (RVA 4500 Perkin Elmer).

Formulations of sago rice consist of 80% sago starch and 20% other flours, such as red rice, red bean, black rice, and corn [6]. The flour mixture was mixed and added 25% of water. The dough was steamed for 30 minutes and put into an extruder. Sago rice is dried in a cabinet drier at 55 ^{0}C for 6 hours. Then was packed into vacuum plastics for further analysis. Sago rice was analysed for the viscosity profiles and texture properties (hardness and stickiness).

3 Results and discussion

The theme for World Food Day is "Our actions are our future-Better production, better nutrition, a better environment, and a better life," according to FAO. The food we pick and consume has an impact on both our health and the environment. This will influence the food farming system. At the Food System Summit event in September, the UN Secretary-General underlined the importance of altering how we produce and consume food to accomplish the Sustainable Development Goals (SDGs) agenda [7]. The population continues to grow, increasing demand for food and shelter.

Food insecurity results from widespread rice consumption and human dependence on it. The availability and sustainability of food with sufficient nutritional value for people is a crucial topic, and it can have a negative impact on health. Based on the Food and Agriculture Organization (FAO), a sustainable food system delivers food security and nutrition for economic, social, and environmental [8]. It must have three points, namely, economic, social, and ecological sustainability.

In terms of the economy, a food system must be profitable for all stakeholders, namely, workers, governments, and businesses. Sago has a great deal of potential for growth as a food source. It is important to note that the sago forest in Indonesia covers around 1.25 million hectares, 1.2 million of which are in Papua. Only 14,000 hectares of land in Papua have been semi-cultivated, compared to 120 thousand hectares outside the country in Sumatra, Sulawesi, Maluku, and Kalimantan. Sago land in Papua covers 1.2 million hectares and has a production capacity of 10–20 tons of sago per hectare per year. About 12 to 24 million tons of reserves of carbohydrates are anticipated to be readily available each year [9]. Sago consumption can be considered a potential application of economic sustainability and was used in food and non-food products. The food industry and diversification have developed, attracting consumer interest in taste, form, and quality. Artificial rice is described as non-paddy rice that resembles rice and is made from locally available carbohydrates such as sago, cassava, corn, and grains. Sago was chosen due to its high level of carbohydrates and affordable price. Sago rice is one of the sago diversification products already known and accepted by society. It has a long shelf life and is easy to produce. Sago rice can be used as a substitute for staple food besides rice, and consumption can be started from the producing area. Sago provides food diversification and non-food industries and promotes the local bioeconomy, thus encouraging sustainable production. The Sago plant's ability to compete with other commodities in terms of usage, which will also impact the land-use change, depends on ensuring its sustainability. Therefore, innovation in producing value-added sago-based products is crucial to assuring the sustainable supply of sago and the bioeconomy.

Social sustainability must contribute to nutrition, health, traditions, labor conditions, and animal welfare. Sago is a potential agricultural commodity as a carbohydrate source, almost equal to rice flour, cassava, and potatoes. The high percentage of people consuming sago is due to sago for most of the surrounding community is the second staple food after rice, and it tastes good and has been a habit for generations. Older generations primarily consume traditional sago food, and the youthful generation is beginning to leave it. The younger generations prefer rice to sago, so it needs diversification into sago rice, similar to paddy rice.

This study used sago and local flours to produce sago rice for some good reasons. Making sago rice can be formulated and enriched with various other flour such as corn flour, red bean flour, brown rice flour, black rice flour, and others. Utilization of different local flours in Indonesia can be utilized to enrich local food products. Incorporating local flours enhances sago rice's nutritional value, providing a more balanced and diversified diet for consumers. Moreover, the positive sensory attributes indicate that alternative flour-enriched sago rice can be readily accepted by individuals accustomed to traditional sago.

The high content of sago amylopectin (73%) makes it high in elasticity, so it needs to be substituted with other flours to produce sago rice with a texture similar to paddy rice. The characteristics of sago rice are similar to paddy rice, although it has a distinctive color, aroma, and taste but is acceptable to consumers. The color of sago rice depends on the type and origin of sago and its mixture. Based on previous study, sago analog rice from Baruk sagu has a lighter color with more Baruk sago [10]. The characteristics of sago rice being compared are its viscosity and texture. Rapid visco analyser (RVA) can predict the texture of cooked rice [11]. The viscosity characteristics of sago rice paste were measured to determine the properties of the paste during heating and compared to paddy rice (Table 1). Characteristic of five formulations of sago rice has a peak viscosity with ranged from 1384 to 3234 cP; breakdown viscosity ranging from 684 to 1380 cP, final viscosity ranging from 1071 to 2704 cP, setback viscosity ranging from 371 to 850 cP, the pasting temperature ranged from 79.05 to 80.80 ^{0}C. Meanwhile, the viscosity profiles of rice (IR 64) had a peak viscosity of 2197 cP, breakdown viscosity of 991 cP, final viscosity of 2653 cP, setback viscosity of 456 cP, a peak time of 6.33 minutes, and past temperature of 84.50 ^{0}C. Sago-red bean composition has closer peak viscosity to paddy rice. Meanwhile, sago-red rice has high peak viscosity. Viscosity properties depend on amylose content and the type of starch.

Hardness and stickiness are the most important physical qualities of rice, and they have a substantial influence on enhancing consumer acceptability. Amylose content significantly impacts the hardness and stickiness (adhesiveness) of rice products. Table 2 shows that the textural properties of sago rice are close to rice properties, hardness, and stickiness, respectively. Sago rice with substituted red rice has the smallest stickiness. Meanwhile, sago-black rice was the highest. The composition of comparison amylose and amylopectin affected stickiness. Based on previous studies, the cooked artificial rice similar to native rice which had a soft texture, was not too sticky, and was swell after cooling [12]. The texture of sago rice from sago starch mixed with arrowroot flour has a harder texture with more sago starch [13].

Based on the preference test, sago rice from sago and red rice is preferred by consumers. The nutrition described in table 3, has a high carbohydrate content (87,06%), fiber (6,86%), and calories (380 kcal), and a low glycemic index (GI) (35). Previous study measured the GI value of commercial sago rice, papeda and roast sago which was higher, 50,9;59;6 and 64,2, respectively, than this result (sago-red rice) [12]. Artificial rice from *Dioscoreahispidadennst* flour has 24,66% amilose, 5,85% total dietary fiber, 62,54% starch digestibility, and GI value is 51,96 [14]. Meanwhile, the nutrition of paddy rice was calorie

(400,66 kcal), carbohydrate (88%), fiber (6,82), and GI (70). The low glycemic index of sago rice maintains blood sugar levels and is suitable for diets.

Table 1. Viscosity profiles of sago rice

Viscosity (cP)	Sago-red rice	Sago-corn	Sago-black rice	Sago-red bean
peak	3234	1384	2002	2195
breakdown	1380	684	839	1234
final	2704	1071	1832	1613
setback	850	371	669	652
peak time (min)	4,87	4,27	5,07	4,00
pasting temperature (^{0}C)	80,60	79,90	80,80	79,05

Table 2. Textural properties of sago rice

Formula	Hardness (g/f)	Stickiness (g/f)
Sago-red rice	3759,665	-773,527
Sago-corn	3836,717	-832,965
Sago-black rice	5439,498	-1038,35
Sago-red bean	5003,699	-945,13
Rice	4912,907	-919,296

Table 3. Nutrition of sago rice

Nutrient content (%)	Sago-red rice
Protein	3,16
Fiber	6,86
Carbohydrate	87,06
Fat	2,14
Energy (kcal)	380,14
Glycemic index	35
Ca (mg)	15,36
Na (mg)	34,86
Fe (ppm)	14,26
P (ppm)	781,96

Using sago rice as a diversified product of sago food that can be consumed, such as rice, can support sago as a naturally sustainable resource that is climate change resistant and food security. Sago rice is more resistant to fleas than rice during storage, so the shelf life is longer. The high content of resistant starch and low glycaemic index in sago makes you full longer and control sugar levels.

In environmental sustainability, the effects of food system operations on the surrounding natural environment are neutral or positive [7]. Sago palm can assist the Indonesian government in reaching its objectives for public health, food security, and carbon emissions. The potential of sago as a sustainable food resource has been discussed recently. When evaluated considering the social, economic, and environmental facets of sustainability, sago palm grown in peatlands is categorized as "sustainable" [9]. Sago reserves with large amounts of potential are a valuable source of. Sago palms and also other minor palms, which easily survive in various environmental conditions, need to be assessed for their possible contribution to food security under the predicted global climate change. Konuma stated that the sago palm played an important role as a symbol for the protection of traditional landscapes and ecosystems, biodiversity, and sociocultural heritage in the southern part of Thailand [9]. Sago development efforts are still insufficient because sago agriculture is still exploitative and not done by the community. Sago agribusiness expansion must be followed by ongoing rejuvenation to prevent its extinction.

Based on the benefits of the sago palm, Sago rice has various advantages in terms of productivity, nutrition, and the environment. Besides nutrition (low index glycaemic, resistant starch, free gluten, and organic food) and acceptance by the consumer, it is environmentally sustainable, grows in mineral and marginal lands, is free of fertilizers, doesn’t need a lot of water, and has climate change. Government support is required to produce and distribute sago rice so that the whole community can enjoy it. Then it is necessary to test the shelf life of sago rice and analyze the economic feasibility of sago rice manufacturing.

4 Conclusion

The utilization of sago rice presents numerous benefits that align with the SDGs program in agriculture. Its sustainable cultivation practices, it is profitable for workers, government and business, and potential for rural development (economy sustainability), and it survive in various environmental conditions which adaptation to climate change (ecological sustainability), low GI, organic, nutritional value and acceptable to consumers (social sustainability), make it an attractive option for promoting sustainable agricultural systems. Sago rice is acceptable to consumers in terms of its texture, similar to paddy rice. Sago rice can be enriched with other local flour such as corn, red bean, and rice flour to increase consumer acceptance and nutrition of sago rice. By recognizing and harnessing the potential of sago rice, we can contribute to achieving the SDGs, ensuring food security, and advancing sustainable development in agriculture.

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