Potential of sago products supporting local food security in South Sulawesi

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Abstract. Indonesia still relies on rice as a staple food, while at this time to meet the people's needs for rice, the government still has to import it. Sago is one of the local foods that can meet the needs of the community as a food. This review aims to gather information on the current status of sago production in South Sulawesi, including the advantages and disadvantages of sago as a staple and the type of food technology required to produce the staple food. The advantage of sago compared to other carbohydrate sources is that the sago plant or sago forest is ready to be harvested if desired. Sago can be used for food or non-food purposes. One of the uses of sago for food is sago flour, starch, and various processed food products. Meanwhile, for non-food needs, sago can be used as bioethanol and single-cell protein. Sago has disadvantages as a staple food due to lacking other nutrients such as protein and fat. Thus, in sago processing, the addition of other ingredients must be considered to meet these deficiencies.

Keywords: sago, potential, utilization, food security

1. Introduction
Sago palm is a plant native to Indonesia with a total area of approximately 1.28 million hectares, or 51.3% of the total area of sago in the world [1]. Most of Indonesia’s sago region classified as a sago palm forest and grows naturally without being strongly influenced by the outside world [2]. These areas are located in Sumatra, Kalimantan, Sulawesi, Maluku and Papua. Compared to Papua and Sumatra, Sulawesi does not have sago a large sago area like Papua and no significant sago development like Sumatra [3]. It is distributed in 6 sago producing areas: Luwu Timur Regency, Luwu Utara, Regency, Palopo City, Luwu Regency, Bone Regency, and Selayar Regency. Luwu Utara is the largest producer in South Sulawesi. Most of the villagers still use small-scale techniques for extraction, and traditional (micro-scale) techniques for sago extraction are still exist [4].

Indonesia’s sago palms are vast, but more than 95% of Indonesians consume rice as their staple food. According to the International Rice Research Institute (IRRI), Indonesia consumed a lot rice in 2008, 139 kilograms per person per year. Since World War II, the Indonesian government has prioritized agriculture, especially rice production. Rice self-sufficiency was achieved in 1984, and Indonesia is now the third largest rice producer in the world [5]. A high reliance on a single staple food can mean that the country’s rice production is inadequate to feed Indonesians. According to Indonesian statistics, the average amount of imported rice for five years (2015-2020) is about 917 tons/year, reduces rice dependence and threats to national food security. It is important to diversify the production of staple foods to staple foods other than rice [6]. In the late 1990s, Indonesia’s long-term interest in food security was realized to be achieved by increasing the use of sago sample supplies as an environmentally

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friendly high-carbohydrate food supply. In 2012, the diversification program was launched by the Local Food Diversification Program (MP3L) with a total budget of IDR 18.9 billion. From 2012 to 2014, the total funding for this program was less than 1% of the total state budget of the Department of Food Security, Ministry of Agriculture [7].

As outlined above, locals can buy enough sago as a staple food. In addition, we know that there are many foods, snacks, and drinks that can be made from sago. The emergence of the sago-based food industry can be used as an indicator of sago demand. Twenty-one of the 33 provinces in Indonesia have reached 63 sago-based foods, some of which are produced by the commercial food industry [8].

Sago is one of the natural resources of South Sulawesi. Along with sugarcane, palm oil, nata de coco, and hybrid coconut, it has evolved into an important plantation culture. Sago starch extraction practices in the eastern part of Indonesia, including Sulawesi, still use traditional (micro-scale) and small-scale techniques [6]. These traditional techniques is widely used to make starch for home use. This technology is characterized by its simplicity and the equipment made from locally available materials, making it easy to transport.

In some areas of South Sulawesi, especially in Tana Luwu and eastern Indonesia, sago has high social value, because it is the main food and income source for locals. Paddy fields are the staple food in South Sulawesi and the growing areas have changed little, but local markets and souvenir shops can find innovative new products made from sago. Makassar (the capital city of South Sulawesi) is one example. The purpose of this paper is to collect information on the current state of sago production in South Sulawesi, including the strengths and weaknesses of sago as a staple food and the types of food technology required to produce a staple food.

2. Advantages of sago as a staple food

Sago has the tremendous potential to be used as a substitute for rice. The advantage of sago compared to other carbohydrate sources is that the sago plant or sago forest is ready to be harvested if desired. The sago palm can grow well in marshes and tides, where other carbohydrate-producing crops are difficult to grow. The agronomic requirements are more straightforward than other crops, and harvesting depends on the season [9].

Sago can be used for food or non-food purposes. One of the uses of sago for food is sago flour, starch, and various processed food products. starch or sago flour and processed products can also be grouped as a functional food. In other words, apart from being a potential source of traditional food, sago is also an available food that can be developed in food diversification to support local and national food security. The basis of the consideration is that sago has a nutritional value not inferior to other food sources such as rice, corn, cassava, and potatoes [10]. The nutritional value of sago compared to other food ingredients can be seen in Table 1.

The carbohydrate content of sago is higher than that of rice and some other carbohydrate sources (Table 1). The calorie content of sago is not much different from rice and corn, even more so than potatoes, breadfruit, cassava, sweet potatoes, and yams (gembili and yam/yam). It shows that sago can replace rice which has always been the primary source of carbohydrates in Indonesia. In addition, other mineral sources such as the value of calcium and iron content are higher than rice. Apart from the carbohydrate value that is close to the carbohydrate value of rice, sago is also superior in terms of fiber content, glycemic index value. Sago starch contains: 3.69-5.96 percent of dietary fiber [12], and the Glycemic Index (GI) value of 28 is included in the low category because it is less than 55 [13], so that sago can be grouped as a functional food. According to POM RI (2005) in [14], functional food is processed food containing one or more components functional, which based on the study has certain physiological functions, proved not harmful and beneficial to health. Based on studies has certain physiological functions and is proven to be harmless and beneficial to health. The glycemic index or GI is the glycemic response when eating many carbohydrates in food and thus is an indirect indicator of the body’s insulin response [15]. Based on the use of glucose as a comparison (GI = 100), foods are categorized into three groups, namely low GI foods with a GI value range of <55, medium GI foods with a GI value range of 55-69, and high GI foods with a GI value range > 70 [16]. The low glycemic
index of sago indicates the potential for sago to be consumed by people with diabetes. [17] recommends increasing the intake of low-GI foods, especially for diabetics and people who are intolerant of glucose. Based on the WHO report [18], the relationship of low GI diets in preventing obesity and diabetes is possible. It shows that sago is one of the low-GI foods recommended for people with special needs such as diabetics. Dietary fiber in sago starch can provide beneficial physiological effects, such as laxatives, lowering blood cholesterol, and lowering blood glucose. The American Association of Cereal Chemists (2001) in [19] defines the dietary fiber as the edible part of plants or carbohydrates that are resistant to digestion and absorption by the walls of the small intestine, which are then fermented in the large intestine. According to [20], dietary fiber is carbohydrates (polysaccharides) and lignin which human digestive enzymes cannot digest. Most dietary fiber will be a substrate material for fermentation for bacteria that live in the large intestine.

| Table 1. Nutritional value of sago and some foodstuffs per 100 grams. |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Commodity         | Sago             | Milled Rice       | Potato            | Corn Flour        | Cassava           | Breadfruit        | Gembili           | Uwi               | Sweet Potato      |
| Water content (%)| Calories (Cal)   | Protein (g)       | Carbohydrates (g)| Minerals (g)      | Calcium (mg)      | Phosphorus (mg)  | Thiamine (mg)    | Calcium (mg)      | Water content (Cal) |
| 14.00             | 343.00           | 0.70              | 84.70             | 0.40              | 11.00             | 13.00             | 0.01              | 11.00             | 13.00             |
| 13.00             | 349.00           | 0.70              | 78.90             | 0.60              | 10.00             | 14.00             | 0.12              | 14.00             | 13.00             |
| 77.80             | 85.00            | 2.00              | 19.10             | 1.00              | 11.00             | 56.00             | 1.50              | 12.00             | 19.10             |
| 12.00             | 367.00           | 9.00              | 73.70             | 1.20              | 10.00             | 256.00            | 0.80              | 10.00             | 73.70             |
| 62.50             | 146.00           | 1.20              | 34.70             | 0.30              | 7.00              | 40.00             | 2.40              | 4.00              | 34.70             |
| 55.50             | 96.00            | 1.00              | 22.60             | 0.20              | 0.70              | 47.00             | 0.70              | 0.70              | 22.60             |
| 75.00             | 97.00            | 1.50              | 22.40             | 0.10              | 1.00              | 49.00             | 0.10              | 1.80              | 22.40             |
| 75.00             | 89.00            | 2.00              | 19.80             | 0.20              | 3.00              | 280.00            | 0.30              | 1.80              | 19.80             |
| 68.50             | 125.00           | 1.80              | 0.70              | 27.90             | 1.00              | 49.00             | 0.09              | 49.00             | 0.70              |

Source: [11]

One of the food fiber groups, namely resistant starch, produces hydrogen, methane, carbon dioxide, short-chain fatty acids, and a certain amount of energy (0.3 cal/g). Short-chain fatty acids resulting from microbial fermentation are quickly absorbed into the liver, and it is suspected that propionic acid is fermented inhibits cholesterol synthesis in the liver. Sago also contains butyrate, which helps maintain the intestinal flora, improve immunity, reduce the risk of lung cancer and obesity, and promote excretion [14]. In addition to fiber and GI, sago also contains resistant starch, non-starch polysaccharides, and short-chain carbohydrates, beneficial for health. Resistant starch has functionalities for the health of the body. Resistant starch of sago has physiological effects beneficial to health, such as preventing colon cancer, hypoglycemic impact (lowers blood sugar levels after eating), probiotics, reduce the risk of gallstone formation, and inhibits fat [21].

Preference or taste is a concept used in the social sciences in a particular economy. This preference assumes a real or imaginary choice between alternatives and the possibility of ranking those alternatives based on existing pleasure, satisfaction, gratification, fulfillment, usefulness. Based on research conducted by Hayati et al [22], 20.83% of respondents consume sago only because of chronic factors. It is often found in the North Luwu area, where almost every day people consume sago. The habit of eating sago has existed since their ancestors. If they don't eat sago for one day, they feel "thirst." The demand for sago will increase when the month of Ramadan approaches because they make lime as fast food. Every time there is a party or traditional ceremony, there is always a food menu made from sago.
The other results show that in North Luwu Regency, 85.26% people consume sago as staple food. Still, there is a tendency for this figure to decrease if the government does not promote food diversification programs. It is also due to the narrowing of the sago palm area. Many sago lands have been converted into plantations, roads, housing, and offices [22]. If allowed to continue without rehabilitation and intensive cultivation of sago, sago trees will be increasingly difficult to find, so that sago will become a source of expensive and rare carbohydrates in the market. It will undoubtedly increase the community’s dependence on rice so that food security is threatened. Therefore, the North Luwu Regency Government has initiated the planting of a million sago trees. It is intended to cultivate sago trees that are starting to decrease. The North Luwu district government brought in experts from the Bogor Agricultural University (IPB) in sago tree cultivation and sago processing technology [23].

Not only are sago palms produced from wild or semi-wild plants and only produced as a staple food for the locals, but sago palms have become a commercial crop and an important source of starch for industry [24]. Sago, as a local food, has a great potential for development due to its high concentration of carbohydrates [25]. Its carbohydrate content is up to 85 g per 100 g, which is higher than only 80 g per 100 g in rice [26]. Sago palm can produce up to 25 tonnes of starch per hectare per year. This is higher than rice (6 tonnes), corn (5.5 tonnes), wheat (5 tonnes), and tapioca (1.5 tonnes) [27]. In addition to being highly productive, sago palms are not suitable for agricultural production and can grow in drought and flood resistant wetlands and swamps [28]. The number of restaurants has also increased by one since 1999 to in 2011, all of which are located in Makassar. These observations can be used as a parameters of sago palm demand, and demand is projected to increase in the future. As a new source for the food industry, the sustainability of sago supply as a raw material will be a future challenge [4].

3. Disadvantages of sago as a staple food
Sago starch is poor in other nutritional elements such as protein and fat. Thus, the menu that must be developed is different from other staple foods such as rice and flour. In simple terms, it can be said that the fulfillment of nutritional elements with the staple food of sago requires more protein sources. For this reason, it is necessary to develop food formulas and menu construction so that they meet the requirements for calorie and nutritional adequacy [29].

There are several difficulties in increasing the consumption of sago. In society, sago foods is considered inappropriate because it is difficult to prepare and not always available. Traditionally, sago starch is consumed by mixing hot water and stirring it in a batter. The dough is then eaten with side dishes or processed first. That view can be changed by developing more attractive and more easily available sago-based staples. Proper counseling is expected to change the way we think and perceive all ingredients. From the above, we can conclude that the main factors that play an important role are sociological, psychological, and physiological problems [29].

In line with sociological problems, it is psychologically challenging to accept low-class food as the main menu. It is also influenced by the global perspective where sago consumption is limited. Efforts to expand consumption and increase the "degree" of sago through intensive and adequate promotion followed by the development of proper processing and presentation technology will change this view. It is also intended to facilitate preparation and presentation with a menu composition formed from the harmony of taste, aroma, texture, and people’s habits. Physiologically the body’s acceptance of new food intake needs adequate adjustment and introduction. Consumption of the same number of calories can lead to different satiety effects. But the fact that many people can survive and thrive by eating sago so this problem is just a habit that takes time Introduction. The previous causes the great potential and high productivity not to be utilized optimally. Other factors that influence it include: (i) cultivation has not developed well, so most of it is still obtained from wild sago, (ii) primary processing (extraction) of sago is still mostly done traditionally using straightforward equipment so that efficiency very low, (iii) the use of food as food and industry is not yet developed so that it requires a well-planned introduction and socialization process, and (iv) the enormous market potential has not been utilized [29].
4. Kind of technology needed to produce that kind of staple food

4.1. Starch extraction

Sago starch extraction has been changed from the traditional manual process as its original location (New Guinea Island) to an effective mechanical process (western Malay Archipelago) in response to changes in usage from staple food to industrial products [30]. The transportation costs of sago stalks from the logger to the sago noodle business could be minimized. The comfort of neighbors can be guaranteed if sago bark waste causes no odor. Because the process of grating sago stalks is no longer carried out at the Sago Noodle business and from the results of testing the sago stick grater, the average time for one portion of sago stick is 4.14 minutes. While the capacity of grating for 1 (one) hour, the resulting weight of grind is 600 kg. The results of a portable sago stick grater [31].

Darma [32] reported that the traditional method of sago starch extraction is a time-consuming and labor-intensive process. The most difficult step is to breakdown the pith using a hammer-like tool called a tamper, followed by washing and sieving the starch. However, using mechanical processing equipment can save time and energy. As a result, sago starch production has increased both quantitatively and qualitatively. For automatic processing, it is necessary to provide easy-to-use machinery and equipment suitable for general farmers. It consists of two separate operating units; Sago Rasp Machine with Cylinder and Sago Starch Extractor with Impeller. The performance of the improved Sago Rasp Machine is characterized by (a) rasp capacity 730–1009 kg/h, (b) the percentage of starch is 47.2%, and (c) the loss of starch in sagomark waste is only 4%. On the other hand, the performance of the improved sago extractor is (a) the ability to extract 1007 kg of grated pulp per hour, (b) the percentage of starch was 24%, and (c) starch loss of starch in waste is 2.1%. Thiese machines are designed for small-scale (household) processing of sago and are suitable for use in most sago-producing areas, including Papua and Papua New Guinea.

5. Sago starch as an ingredient in cooking

5.1. Noodles

The result of physical characteristics for sago noodles shows that sago noodles affect the fortification of fish meals. Sago noodles with the fortification of 8% fish meal (A8) provided the best quality with degrees white sago noodles 46.70, cooking time 8.0, cooking loses 23.8, and elasticity 16.20 [33]. Starch is used as a partial replacement for wheat flour in the production of Chinese noodles, and the effectiveness of this replacement has been studied. The Chinese noodles became harder and more elastic when the amount of starch was increased. Comparing Chinese noodles made from sago starch and potato starch, the former was harder and swelled more strongly. It was found that making Chinese noodles using sago starch significantly reduces the amount of solids lost in water during cooking. Sensory evaluation showed that replacing wheat flour with 10% or 20% sago yielded more transparent, less sticky, and tasty Chinese noodles compare to reference sample (0% starch) [35].

5.2. Bread and muffins

Bread and muffins were produced to investigate the potential use of sago starch in puff foods. Muffins made with sago starch were found to swell better and have a more uniform texture and elasticity than muffins made with corn starch or potato starch. It was found that when sago starch was replaced by 30% of bread flour and vital gluten (10% of the bread flour and sago starch) was added, the bread grew from 1.3 to 1.5. In the sensory evaluation, sago bread was more elastic and uniform than other starch-based breads [34]. Based on the above evidence, it can be concluded that sago starch is fully usable ingredient in puff foods.

5.3. Biscuits

Biscuits are a baked product with flour, butter, sugar, and milk used as main ingredients. Some biscuits are made with starch performing as a partial substitute for flour. When 50% of the flour turn into changed
with sago starch, the biscuits exhibited better swelling ability, softness, and tractability than a potato or corn starch biscuits. These traits intensified because the ratio of sago starch increased, with 50% displaying the maximum terrific improvement. The sensory assessment observed that biscuits with partial sago starch substitution have been grater crumbly than wheat-only biscuits and have been given considerably better choice in form, taste, hardness, fracturability, feeling at the tongue, and overall rating. The 50% substitution turned into mainly preferred. Furthermore, even when if a low level of butter turned into used, as the level of substituted sago starch turned into increased, the biscuit has become much less crumbly. This circumstance turned into maintained till the level of butter used turned into decreased through as lots as half. The use of egg in sago cookies rather than baking powder and milk have been observed to have the equal hardness degree however have been three to four times more crumbly [35].

5.4. Sago sugar
Sago sugar can also be utilized by enzymatic hydrolysis of physically treated sago residues, producing significant amounts of sugar (70% w / w). Current research also shows the potential to produce cellobiose (about 12% w / w) from fresh sago leaves, a type of drug that is more expensive than glucose. Sago palm is very likely to be used as a new sugar source to replace sugar cane sugar [36].

6. Conclusion
Sago can be used as a staple food with several advantages, including ease of processing, and its derivatives can be used for various processed products. The disadvantage of using sago as a staple food is related to the distribution process because sago plants can only be found in certain areas in Indonesia. Several sago-derived products can be used as staple food ingredients, such as processing various cakes and bread. In addition, sago starch can also be processed into sago sugar and used for multiple purposes. Apart from being a food ingredient, sago can also be used for industrial purposes.

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