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# Characterization of Chemical-Physical Properties on a Dried Waste of Sago Pith

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ABSTRACT

*Sago palm is the oldest tropical plant that has been explored to get starch. However, untreated sago waste is often disposed to the nearest river, and it will contribute to the environmental problem. Since it still has a high content of starch, namely amylose and amylopectin, it has the potential to be turned into other high value-added products such as poultry feed, bioassay, and substrate in laccase production. However, before it can be converted, it must be dried to the desired moisture level. Its chemical-physical properties must be evaluated before it can be applied to ensure its composition fulfils the substrate specification for other usages. After it has undergone the drying process via the fluidized bed dryer, the analysis of its chemical-physical properties, determination of its moisture content, fat content and solubility in a distilled water must be performed. The results showed the final moisture content of samples were $MC_f$=9.2-10.9 w/w% that fulfil the minimum specification; $MC_f \leq 12$ w/w%. In addition, the fat content of samples was <1%, and the water solubility increased at a higher temperature. This occurred due to the gelatinization process when the water bath temperature exceeded 60°C. Besides, it was determined that the optimum drying temperature was achieved at T=106.6°C with the optimum drying time was t=56 minutes, and the optimal temperature of the water bath was at T=60°C. These optimal conditions are very crucial and should be considered as the sago pith tends to be retrograded.*

*Keywords: Sago; Moisture content; Fat; Water solubility; Poultry feed*

## INTRODUCTION

Generally, starch is one of the compositions in the plants and sources in a human diet. Globally, the starch production is about 27.5 million MT, while the starch consumption is about 200 000 to 0.3 MT per year, and it has contributed to 3% of the total market value of corn, potatoes, and sweet potato flour (Bujang K. 1996). The sago starch is extracted from sago palm, which is a tropical plant that can grow in a wet soil condition (Karim et al. 2008), and it can also grow in high humidity environments such as Indonesia, Vietnam, Thailand, Philippines, and Papua New Guinea (Singhal et al. 2008). It is one of the oldest tropical plants that has been explored for its starch which is also known as sago (Karim et al. 2008). Apart from that, it has the ability to stay immune to floods, fires, strong winds and drought (Awg-Adeni et al. 2010). Malaysia, Papua New Guinea, and Indonesia are the primary producers of sago worldwide, where sago is one of the sources of economy for their countries (Singhal et al. 2008). It is processed not only as a staple food for the locals but also for the biotechnology industry to be used in the production of bioethanol.

There are also various uses of each part of the sago palm, including the sago bark and pith. The sago bark can be used as a pad for home walkways to cover water pores around the sago extraction plant and the exterior; it can also be turned into fuel, walls, ceilings, and fences (Awg-Adeni et al. 2010). In comparison, the sago pith has a potential application in laccase enzymes production since it is cheaper and has a high starch content (Kumaran et al. 1997). Table 1 shows the percentage composition of ash, protein, fiber, starch and lipid in sago starch and pith. It shows the waste of sago pith that still has a high content of starch and other compositions.

TABLE 1. The composition of sago starch and sago pith

| Composition (%) | Sago starch | Sago pith |
|---|---|---|
| Ash | 0.12 | 7.59 |
| Protein | 0.19 | 0.86 |
| Fiber | 0.19 | 15.34 |
| Starch | 97.83 | 55.33 |
| Lipid | 1.84 | 2.04 |

*Source* : *Sunarti et al. 2018*

Yet, incontrollable, and ineffective disposal of sago waste becomes a serious issue as the producer usually throw out the waste into rivers which will cause water pollution and odors. It also violates the laws of the environment and river pollution. As it still has high fiber, cellulose, lignin, and starch content, it can be converted to other value-added products where it should be treated first before it can be converted to others such as a bioassay and poultry feed substrate. Thus, the objectives of this study are to determine the chemical-physical properties of the sago residues by analyzing the final moisture content of the sago pith, fat content and water solubility level.

## METHODOLOGY

In this study, the materials used were sago pith, distilled water, and hexane solution. There were two kinds of sago piths used in this study, classified as Sample A and Sample B, where both samples undergo a similar drying process via fluidized bed dryer. The sources of the samples were from various sago processing sites in Mukah, Sarawak. Each analysis was repeated in triplicate to reduce errors. The left side in a Figure 1 shows Sample A and the right side is a Sample B of the dried waste of sago pith. These samples were analyzed using a drying oven (ECOCELL Laboratory Drying Oven), desiccator, moisture analyzer (Sartorius MA37-1 Moisture Analyzer), weighing balance, Soxhlet extraction (FOSS/1043 Soxhlet Extraction), hotplate and centrifuge (Sigma 2-16p Microcentrifuge). Then, the samples were analyzed to determine their chemical-physical properties, such as the fat content and solubility level in the sago pith.

FIGURE 1. Samples of sago pith: Sample A (left) and Sample B (right)

### ANALYSIS ON MOISTURE CONTENT

The moisture content analysis was performed using two different methods; method (i) using a moisture analysis system (Sartorius MA37-1 Moisture Analyzer) and method (ii) calculated using a mathematical formula. Firstly, the petri dish was dried in the oven at 105°C for 2 hours, and then it was cooled at room temperature. Once the sample was dried, it was weighted using the moisture analyzer. The percentage of moisture content was calculated using Equation 1, where $w_1$ is the weight of the sample before drying, $w_2$ is the weight of sample after drying, and $w_0$ is the weight of the petri dish. The process was repeated in triplicate to validate the data.

$$\text{Moisture Content, } MC_f\ (\%) = \frac{W_1 - W_2}{W_1 - W_0} \times 100 \qquad (1)$$

### ANALYSIS ON A FAT CONTENT

Then, the analysis on the fat content was conducted by following the standard of the AOAC 2000 Procedure (U. Uthumporn et al. 2014). Firstly, two extraction beakers were dried in the oven at 105°C for an hour. Then, the samples were placed on filter paper in a thimble. Hexane was added to the beaker, which was placed on a Soxhlet Extraction. After the extraction process, the beakers were placed in the oven for an hour, and then the fat was weighted. The percentages of the fat content were calculated by using Equation 2, where $w_b$ and $w_a$ were the weight of the beaker before and after the fat extraction, respectively.

$$\text{Fat content } (\%) = \frac{W_b - W_a}{W} \times 100 \qquad (2)$$

### ANALYSIS ON SOLUBILITY

The ability of sago's solubility was determined using the Kainuma Method (Kusumayanti et al. 2015). The sample was placed in the distilled water and then was heated in the water bath without stirring it. Afterward, the sample was placed in the microcentrifuge (Sigma 2-16p). The analysis of the sample was repeated using 10 mL of a distilled water and the sample was placed in a water bath at a wide range of temperatures: T=40, 50, 70 and 80°C. The percentage of the water solubility was calculated using Equation 3, where $w_{ss}$ was the weight of soluble starch, and $w_s$ was the weight of the sample.

$$\text{Solubility, } Z\ (\%) = \frac{w_{ss}}{w_s} \times 100 \qquad (3)$$

## RESULTS AND DISCUSSION

Three analyses were carried out to determine the chemical-physical properties of sago pith: moisture content, fat content and water solubility. Then, the optimization condition for drying sago pith was studied to determine the optimum parameter for poultry feed production.

### DETERMINATION OF MOISTURE CONTENT OF SAGO PITH

The moisture content of the sago samples was performed within 2 hours until the moisture content was reduced to around 9-15%. These ranges of the final moisture content are significant conditions for determining the sample's quality as it affects the production of a poultry feed. Besides, it is to prevent any bacteria growth and to ensure safety. Figure 2 shows a time-dependent final moisture content for both dried samples by using method (i) moisture analysis machine and (ii) calculated using Equation (1). It showed both methods resulted in a similar pattern where the percentage of moisture content decreased over the drying time. As the drying time took longer, the level of moisture content in the samples was reduced. As the drying temperature was above 105°C, the droplet of the water molecules reached the boiling point and evaporated, reducing the water level inside the sago pith.

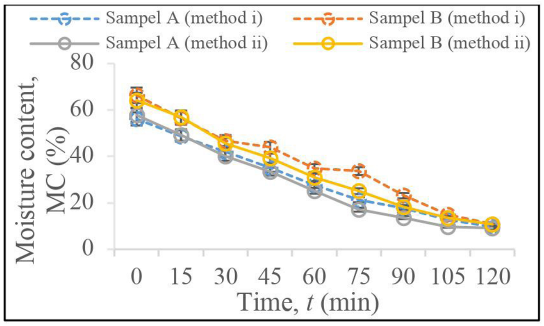


FIGURE 2. The time-dependent of a final moisture content for both dried samples using (i) moisture analysis machine and (ii) calculated using an Equation (1)

Quantitatively, initially, the moisture content of the samples using the first method was 56.13 and 66.31%, respectively, while by using the calculated formula, the moisture content is 57.78 and 64.18%, respectively. Both samples have a different final moisture content as the drying process was carried out at different sago processing sites. At $t$=120 minutes, the moisture content of both samples that used moisture analysis machine is 9.68 and 10.85%, respectively, while the moisture content of both samples using the formula is 9.19 and 10.76%, respectively. Based on the previous study by Ahmad et al. (1999), they also obtain the moisture content of sago starch in a range of 10.6-20.0%. Meanwhile, the moisture content of the unmodified sago starch is 12% which is below ambient temperature, and the humidity is high.

### DETERMINATION OF FAT CONTENT OF SAGO PITH

To produce poultry, adding an extra nutrient depends on the fat content's analysis. Table 2 shows the average fat content for both samples using a fat analysis machine (FOSS/2043 Soxhlet Extraction). It shows the fat content of Sample A is 0.09%, while the fat content of Sample B is 0.10%. Based on the previous study by Duque et al. (2018), they found the level of the fat content in the sago was less than 1.0%, and it was also agreed by Ahmad et al. (1999), Uthumporn U. et al. (2014) and Sari (2018) where the fat content of sago pith was in between 0.10-0.13% and 0.17-0.24%, respectively.

TABLE 2. Result of the fat content in a sago pith

| | Sample A | Sample B |
|---|---|---|
| Fat content (%) | 0.09 ± 0.08 | 0.10 ± 0.05 |

### DETERMINATION OF SOLUBILITY OF SAGO PITH

Figure 3 shows the percentage of water solubility for both samples at various volumes of distilled water. It shows that the percentage of water solubility of Sample B is slightly higher compared to Sample A. Besides, when a higher volume of a distilled water is added, the water solubility in the sago pith will decrease due to the swelling factor (Kumoro et al., 2012).

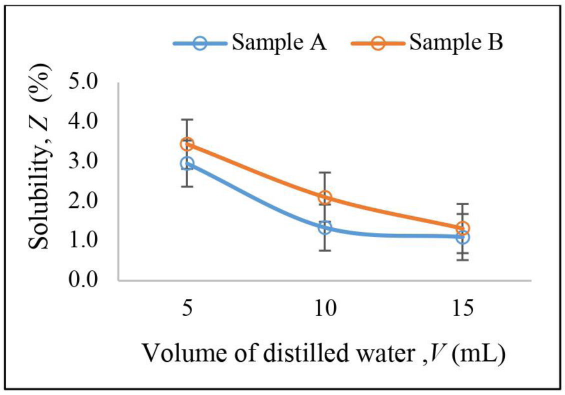


FIGURE 3. The percentage of water solubility at various volume of a distilled water

Figure 4 shows analysis result on percentage of water solubility for both samples at various range of water bath temperatures. It shows that the percentage of water solubility of Sample B is slightly higher compared to Sample A. It is because the percentage of water solubility will depend on the ratio of amylose-amylopectin, the length of the starch chain and the molecular weight distribution of starch. Therefore, the water bath temperature plays a vital role in determining the percentage of water solubility in the sago pith.

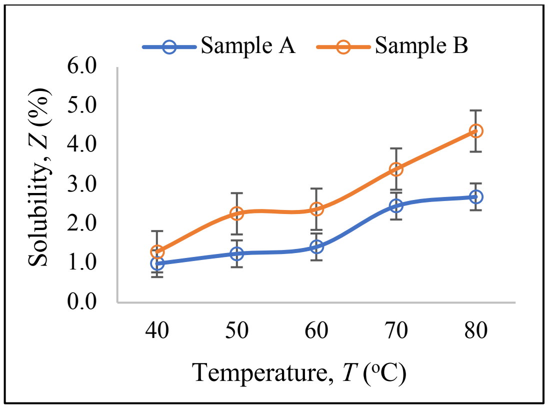


FIGURE 4. The percentage of water solubility at various temperature of water bath

Besides, the analysis shows that with the higher water bath temperature, the water solubility is also increased. This result is also supported by Abdel-Rahman et al. (2008) where they found the percentage of water solubility in a sago pith was increased as the higher starch was heated. This is due to breaking the hydrogen bonds between the starch molecules and replacing them with hydrogen bonds between the starch and water molecules.

### OPTIMIZATION PROCESS

The Design Expert software was used to determine the optimum parameters of the sago pith before being used as substrates to convert other high value-added products.

Figure 5 shows the optimization model on a temperature and moisture content parameter using a response surface methodology (RSM) approach. It shows the moisture content of the sago pith based on RSM is 35.21%, and the percentage of a standard time error is 1.86%. The results indicate that the optimum parameter condition for drying of sago pith is at T=106.6$^{o}$C with $t$=56 minutes of drying time. Therefore, this optimum condition can be applied in the drying process before it is used as a substrate to produce other products.

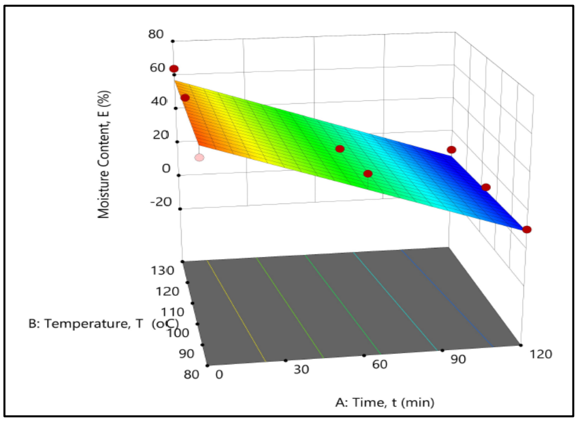


FIGURE 5. The optimization model of temperature and moisture content using RSM

Figure 6 shows the optimization model of a volume of distilled water and water bath temperature using RSM approach. The water solubility for sago pith is achieved at 1.84%, while the water solubility obtained from the previous test is 1.67%. The percentage of standard water solubility error was considerably low, which is 0.18%. This indicates that the optimized volume of distilled water is 10 mL of distilled water, and the water bath temperature for sago pith is T=60$^{o}$C. It also shows that the percentage of the water solubility has increased dramatically at T>60°C. Thus, this parameter is very important as once the sago pith is heated at T> 60°C, it will lead to the occurrence of the gelatinization process. This condition should be avoided to achieve the desired dried sago pith.

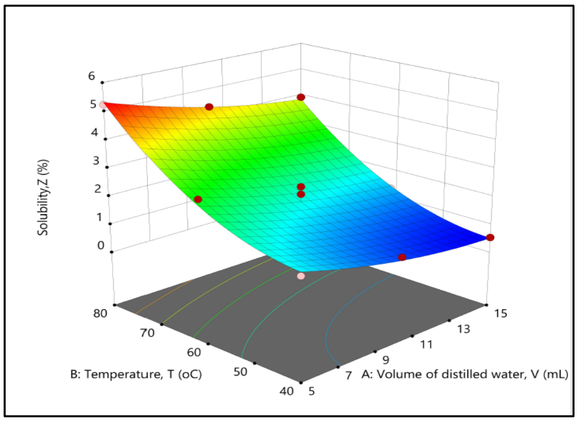


FIGURE 6. The optimization model of a volume of distilled water and water bath temperature using RSM

## CONCLUSION

The analysis of the chemical-physical properties of the sago pith was successfully performed. It can be concluded that the drying time required to reach 9-15% of the final moisture contents of Sample A is between 84-120 minutes, while 100-120 minutes for Sample B. The final moisture content of both samples using a moisture analyzer is 9.68% and 10.85%, respectively, while the final moisture content of both samples, calculated using the formula, is 9.19% and 10.76%, respectively. Also, the fat content in Sample A is 0.09%, while in Sample B is 0.10%. The percentage of water solubility decreases as the volume of distilled water increases due to the swelling factor. In addition, the solubility of water increases as the temperature of the water bath used is high. It is due to the hydrogen bonding of starch, which is the bond that binds the long chain of amylose-amylopectin that is broken and replaced by hydrogen bonds of distilled water molecules. Based on the optimization study, the optimal temperature of the sago drying is at T=106.6$^{o}$C, while the optimum drying time is $t$=56 minutes. Also, to determine the water solubility of sago pith, the ideal volume of distilled water is $V$=10 mL, while the optimum water bath temperature is T=60$^{o}$C. Lastly, both samples have the potential to be used as the substrates to produce some other value-added products, such as bioassay or poultry feed production. This is primarily because the composition and content of the sago pith in both samples were high in starch and fiber content but lower in fat content. Thus, nutrient supplementation is necessary for the further production of poultry to enhance the nutritional value of the animal feed.


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## DECLARATION OF COMPETING INTEREST

None

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