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Nata De Coco Biocellulose Drying Process for Potential Sound Dampening Applications

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ABSTRACT— Indonesia is the number two coconut producing country in the world with one of its products is nata de coco which is processed from coconut water with a fermentation process. Nata de coco is a source of biocellulose that can be made as raw material for advanced sound dampening material. The purpose of this study was to determine the drying process of biocellulose nata de coco for potential applications of sound dampening and analyzing cellulose fibers formed by testing the moisture content and Scanning Electron Microscope (SEM). In the drying process is carried out at a temperature (95 -100) ^{o}C. During the first 10 minutes of drying, it appears that the forgotten water vapor from nata de coco is very much almost ± (30-40) % of the total water content which is free water content. This is because the free water content contained in the nata de coco sample is still large and easily released while in the final stages of drying the evaporated water content requires a long time because it is bound water. Drying is done until getting a constant mass. In this study the value of the balanced water content (Me) uses the Henderson equation and from the calculation the value is 16.430828706902. In the drying results, it is found that drying which produces biocellulose nata de coco which has a little water content, the potential for fungus growth is getting smaller and from the appearance of morphological biocellulose can be used as a sound dampening material because it has pores and indentations to hold the sound energy that comes so that the potential for dampening applications sound.

KEYWORDS: Nata de coco, Biocellulose, Sound Dampening, Sound Absorption Coefficient.

1. INTRODUCTION

Indonesia is a country with the number two coconut Iproduction in the world with an area of 3.88 million hectares or if it is used as a percentage of 97% (a smallholder estate) which can produce up to 3.2 million tons of coconut. Over 34 years, coconut plantations increased from 1.66 million hectares in 1980 to 3.89 million hectares in 2017 (Ministry of Industry, 2010). Indonesian coconut productivity is still low compared to Sri Lanka and India. Demand for products made from coconuts continues to increase both for export or the domestic market. The coconut derived industry can be developed by diversifying processed products including nata de coco, copra, virgin oil, oleo chemicals and desiccated coconut. Besides being an export material, nata de coco's main product can also have other potentials that can be utilized by diversifying nata de coco derivative products. Utilization of biosellulose contained in nata de coco into bio sheets, bio cellulose masks, bio fiber pulp and bio fiber powder provides opportunities for product diversification and increased exports. At present there have been many requests for exports of bio sheet products, bio cellulose masks, bio fiber pulp and bio fiber powder to developed countries [10]. Biocellulose is a polysaccharide produced from fermented coconut water by microbes. Nata de coco or other materials that use the microbial Acetobacter xylinum which will be able to form nata fiber if inserted into coconut water that has been enriched with nitrogen and carbon in a controlled process. In such conditions, the bacteria will produce enzymes that can arrange sugars into cellulose fiber chains. Of the many microorganisms that grow in coconut water, thousands or millions of sheets of cellulose yarn can be produced that can appear solid white to transparent, which is called nata [8]. This biosellulose from nata can be used as an advanced material.

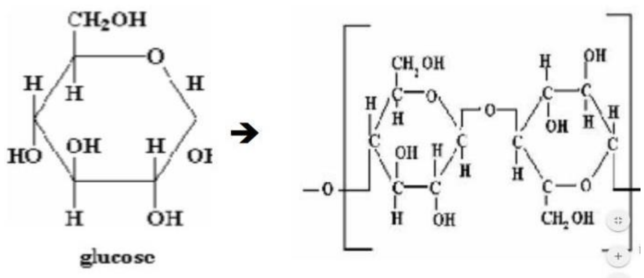

Figure 1. Cellulose structure

According to the advanced material sector report in 2004 advanced material is material and is a modification of existing materials to obtain superior performance in one or more characters. Advanced materials exhibit greater strength, higher strength density ratios, greater hardness and superior thermal, electrical, optical or chemical characteristics when compared to traditional materials. Biocellulose from nata de coco is one of the materials that can potentially be utilized as soundproof advanced material because this biocellulose has cellulose fibers which can be used in making sound dampening material in the face of noise problems. Sound suppression material from biocellulose has a weakness that is easily attacked by fungi and the coefficient of sound absorption is not yet known, so this study is a preliminary study in the manufacture of sound dampers from biocelulose nata de coco. The purpose of this study was to determine the propyl drying of biocellulose nata de coco for potential applications of sound dampening and analyzing cellulose fibers formed by testing the moisture content and SEM.

2 RESEARCH METHOD

2.1 Equipment and Materials

The tools and materials used are nata de coco (sheets), oven vacum, manual press, fabric material, analytical balance with accuracy (0.01 g) and microscopic scanning electron test equipment.

2.2 Procedures

The research was carried out in the following stages: purchasing nata de coco for basic materials, determining the water content & the constant rate of drying of nata de coco at the Chemical Engineering Laboratory, Faculty of Engineering, Universitas Muhammadiyah Jakarta. Scanning Electron Microscope testing was carried out by PT. CMM.

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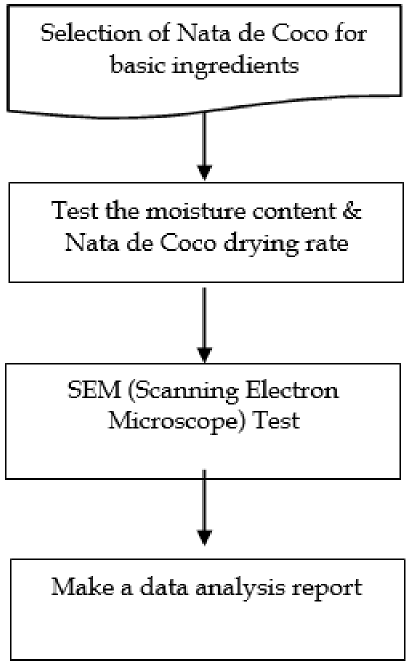

Figure 2. The research chart of propyl drying of nata de coco biocellulose

Detailed research steps in determining the rate of drying of nata de coco are shown in Figure 3.

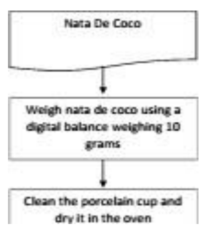

Figure 3. Determination of the constant rate of drying of nata de coco and SEM (Scanning Electron Microscope) Test

2.3 Data Analysis Methods

All tables and figures will be processed as images. You need to embed the images in the paper itself. Please don't send the images as separate files. In this research analysis method there are 2 stages, namely quantitative analysis by calculating the drying rate constant and qualitative analysis by looking at the surface cross section using the SEM (Scanning Electron Microscope) test to see the potential for further research in the use of nata de coco as a silencer. Drying is the evaporation of water from material which is a process of heat transfer and mass transfer that occurs simultaneously, where the hot media is used to evaporate water from the surface of the material to the drying media in the form of air. This drying rate occurs because of the difference in vapor pressure on the surface of the material with the vapor pressure in the drying air [1]. The analysis is done by assuming that the rate of reduction of water content of nata de coco contained in the drying air around it is proportional to the difference between the water content of nata de coco and the equilibrium / stable water content, equations for the calculation of constant values using the empirical equations of Newton and Lewis [7]. The whole equation model can be used to determine the constant value of the nata de coco drying rate. The general equation for determining the value of a constant can be stated in Equation (1):

$$\frac{dM}{dt} = -k(M - Me) \ldots\ldots\ldots\ldots\ldots(1)$$

From equation (1), we obtain the water evaporation equation shown in the equation below (Uwem Ekwere Inyang, 2018):

$$\frac{(M - Me)}{(Mo - Me)} = e^{-kt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

If it is changed in the form of another equation to get the value (k) the constant rate of drying rate of nata de coco is as follows:

$$\ln\left[\frac{M - Me}{Mo - Me}\right] = -kt \ldots\ldots\ldots\ldots\ldots(3)$$

Information:

$$Value \left[\frac{M - M_e}{M_O - M_e}\right]: \text{ moisture ratio (MR)}$$

M: moisture content of the material at a time of drying t minutes
M_e: is the water content equal to nata de coco during the drying process
M_o: is the initial water content of nata de coco

To find the value (Me) use:
Henderson's equation

$$Me = \left[-2779{,}32 \frac{\ln(1 - RH}{T}\right]^{1{,}447}$$

The next analysis is to test the basic surface of the biocellulose nata de coco with SEM test. Testing with SEM is one of the methods of qualitative analysis to determine the morphology or surface topology of the specimens with the help of certain detectors. Usually the detectors used are the Electron Secondary Electron (SE) Image and Backscattered Electron (BSE) Image. [11].

3 RESULTS AND DISCUSSION

3.1 Analysis of changes in water content during drying

At this stage the nata de coco that we use is the finished nata de coco taken from the nata de coco farmers in Cianjur, this nata de coco is used in sheet form, then weighed with a mass of 10 grams and put into the oven for 60 minutes at a controlled temperature range (95-100) °C, and every 10 minutes the mass is measured with a digital scale and the results are recorded. During the drying process, mass and heat transfer occur together. Water mass transfer of material occurs due to the incoming heat and the difference in water vapor pressure. The heat entering the nata de coco material will evaporate the water content in the nata de coco slowly into the drying chamber because the drying chamber water vapor pressure is lower than the water vapor pressure in the material. Following are the results of the nata de coco drying constant test process.

Table 1. Data Drying Nata De Coco

Time (minutes)	The Third Research					Average
	1 (gram)	2 (gram)	3 (gram)	4 (gram)	5 (gram)	
0	10	10	10	10	10	10
10	6,35	5,46	6,63	6,23	5,89	6,112
20	4,23	4,65	5,05	5,22	4,84	4,798
30	2,71	2,66	2,96	3,45	3,13	2,982
40	1,33	1,28	0,92	1,44	1,62	1,318
50	0,51	0,48	0,92	0,7	0,72	0,666
60	0,51	0,48	0,92	0,63	0,72	0,652

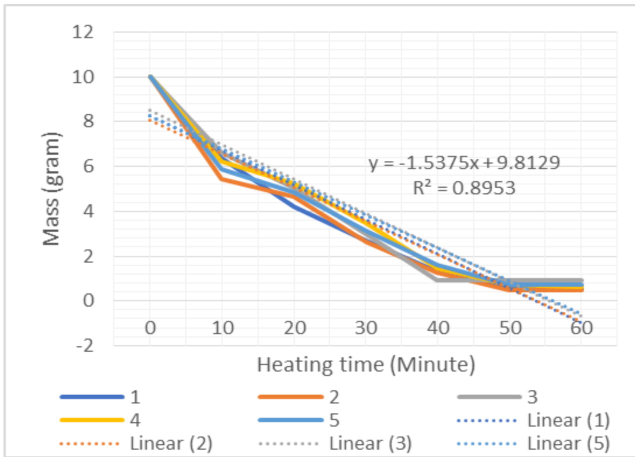

Figure 4. Graph of drying of nata de coco from 5 experiments

In the drying process is carried out at a temperature (95-100) ^oC. In the first 10 minutes of drying in 5 experiments it was seen that the water vapor excited/escaped from the nata de coco material was very much almost ± (30-40) % of the total water content. This is because the free water content contained in the nata de coco sample is still large and easily released while in the final stages of drying the water content has begun to be difficult to release because the water content is still bound or confined in the nata de coco biocelulose. So the ratio of water vapor pressure from bound water vapor pressure will be lower than the pressure of free water vapor at the same temperature. In this study temperature variations were not carried out but we can analyze from previous studies about temperature variations according to [4] states that the higher the drying temperature, the faster the drying rate will be. This can occur because the heat entering the sample will evaporate the water content of the material gradually out, starting from the free water content on the surface and then the bound water content in the biocelulose nata de coco fiber. The high air temperature around the material will cause the thrust between the surfaces of the material with the drying chamber air to increase. The same thing was explained by Rachmawan (2001). He mentioned that the higher the temperature of the drying air, the more heat energy carried by the air, so that the amount of mass of water that is evaporated greater. So it can be concluded that the length of drying time and temperature increase are directly proportional to the drying rate of water content.

3.1 Determination of Equilibrium Water Content (Me)

Before we look for determination of water content, we look for a balanced water content (Me) value. Balanced water content is the water content of a product when the water in the product is in balance with water in the air. According to [3]. Equilibrium water content is the water content when the vapor pressure of the material is balanced with the environment. Material is in a state of balance with its environment when the rate of water lost from the material to the environment is the same as the rate of water that increases into the material from the environment [2]. In determining the equilibrium water content, I did not find a fixed value of the nata de coco equilibrium water content or in previous studies, so I searched for the value (Me) using the Henderson equation and got the value of 16.430828706902 ≈ 16.43.

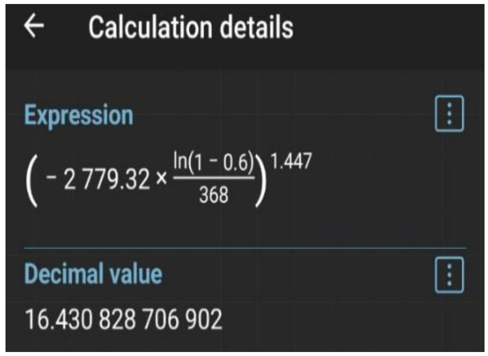

Figure 5. Calculation of determining the value of Equilibrium Moisture (M_e)

3.3 Determination of the drying rate constant

The price of the drying rate constant depends very much on the value of the diffusion coefficient of the dried material, both of which are directly proportional [9]. So that the drying constant value is different for each thin layer drying model. The drying constant value (k) is obtained together with the calculation of the value of the equilibrium water content using (equation 3). The drying rate constant (k) is a quantity that can be used as an indicator of how fast the drying process can take place on a material.

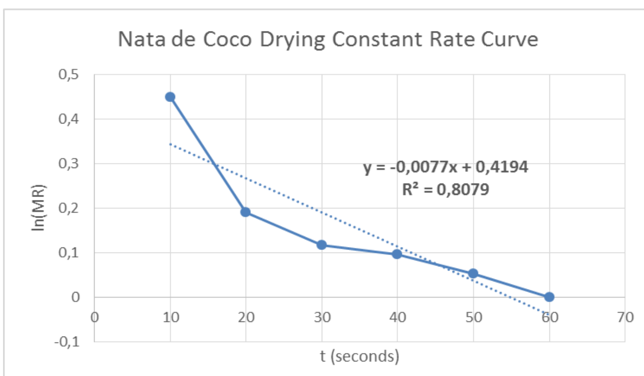

Figure 6. Graph of Constant Nata de Coco Drying Rate Curve 1st experiment

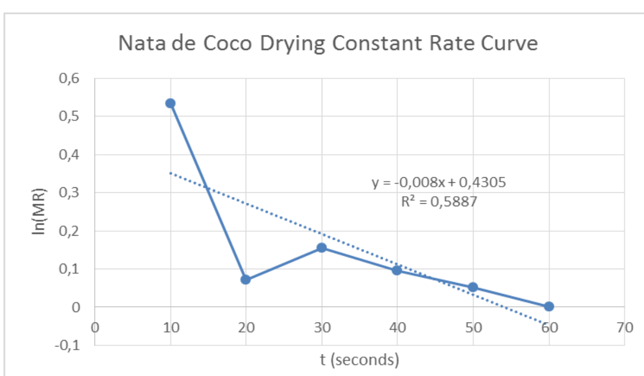

Figure 7. Graph of Nata de Coco Drying Constant Rate 2nd experiment

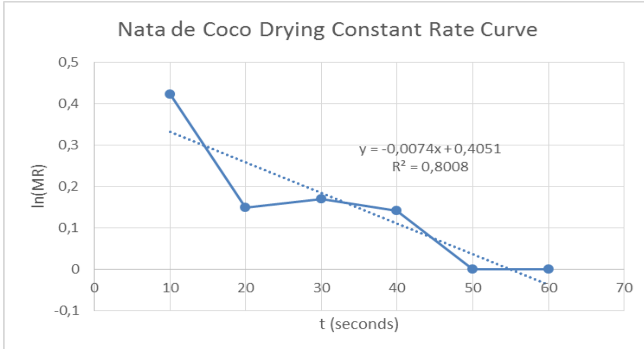

Figure 8. Graph of the Nata de Coco Drying Constant Rate of the 3rd experiment

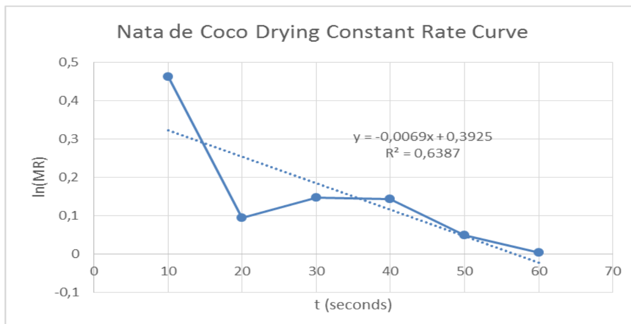

Figure 9. Nata de Coco Drying Constant Rate Curve graph 4th experiment

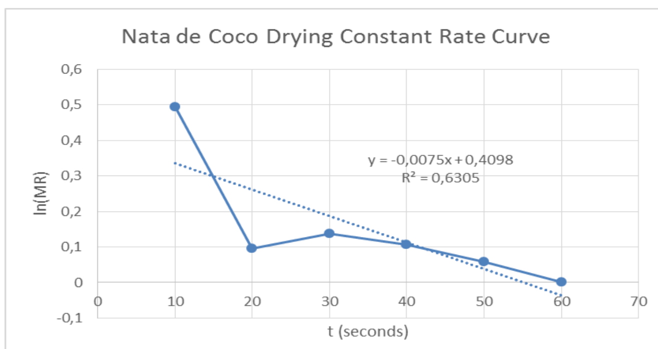

Figure 10. Graph of Nata de Coco Drying Constant Rate 5th experiment

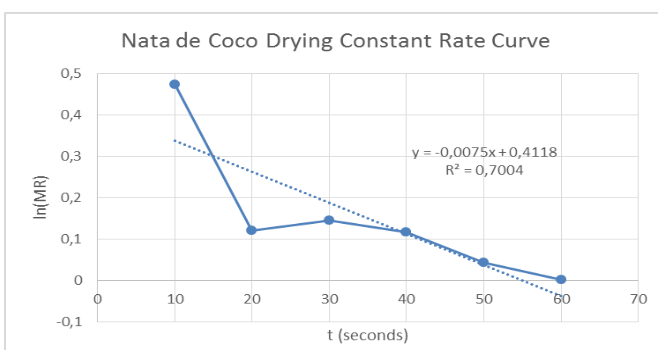

Figure 11. Graph of Nata de Coco Average Drying Rate Constant Curve

Figure 11 above we get the k value (-0.0075x + 0.4118), the k value can be used to estimate the time needed to reach a certain water content. From Figure 11 it can be seen that the value of k is negative resulting from the slope on the negative graph. The longer the drying time, the smaller the moisture content produced. (Kalse,

2012) states that the MR value is directly proportional to the drying time. Slope will be greater if the heat is higher.

3.4 Analysis of Drying Results

In the results of drying it was found that drying which produces biocellulose nata de coco which has a little water content, the potential for the growth of fungi is smaller and the biocellulose fibers that are still have enough water content, the greater the potential for fungal growth.

Figure 12. Biocellulose which is dried with large water content with released water content (80.82%)

Figure 13. Biocellulose which is dried with large water content with released water content (91.32%)

3.5 Analysis of Biocellulose Potential of Nata De Coco for Potential Sound Dampening Applications

Based on the results of surface morphological analysis of nata de coco cellulose from SEM test, it can be seen that the surface of nata de coco has a good damping system.

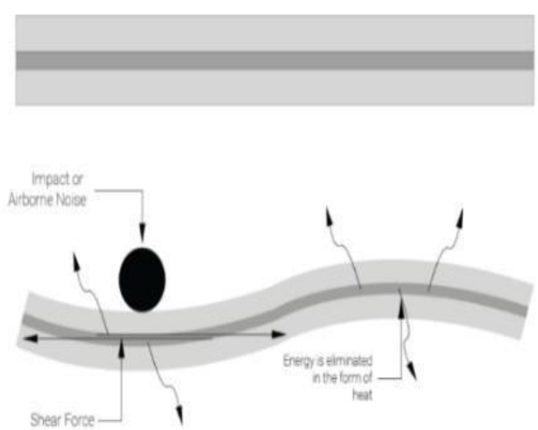

Figure 14. Damping system effect

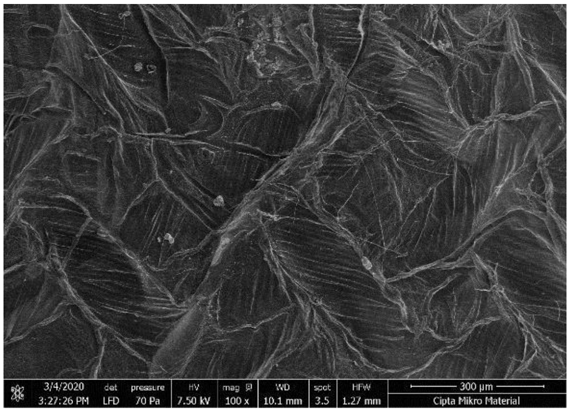

Figure 15. SEM test results at 100x magnification, surface morphology of biocellulose

In Figure 14 it can be seen that the appearance of biocellulose morphology can be used as a sound dampening material because it has pores and grooves to hold the incoming sound energy. Damping the system is a material effect that has the property to be softened (inert = the material properties that oppose or inhibit changes in momentum or the state of motion of objects related to inertia). Sound energy will decrease when the damping material is moving. Vibration energy is not isolated but converted to heat energy in small amounts, the efficiency value depends on the damping material contained in the system.

4 CONCLUSION

In the drying process is carried out at a temperature (95-100) ^{o}C. In the first 10 minutes of drying it was seen that the water vapor excited / escaped from the nata de coco material was very much almost ± (30- 40) % of the total water content. This is because the free water content contained in the nata de coco sample is still large and easily released while in the final stages of drying the water content has begun to be difficult to release. Value (Me) uses the Henderson equation and the value is 16.430828706902 ≈ 16.43. The drying rate constant value (k) is (-0.0075x + 0.4118). In the results of drying it was found that drying which produces biocellulose nata de coco which has a small water content and from the appearance of the morphology of biocelulose can be used as a sound dampening material because it has pores and indentations to hold the sound energy that comes.

5. ACKNOWLEDGMENT

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