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Effect of Foam Mat Drying on Antioxidants in Secang Wood Extract (Caesalpinia Sappan L)

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Abstract:- There is a notable increase in interest in utilizing herbal plants, with some herbal products being particularly rich in bioactive compounds, including antioxidants. Antioxidants play a pivotal role in the protection of the body against oxidative stress, through the neutralization of harmful free radicals. One plant extract that exhibits notable antioxidant activity is sappan wood extract (Caesalpinia sappan L). The objective of this study is to assess the impact of foam formulation and temperature on the drying process and antioxidant activity of sappan wood extract, which has been dried by the foam-mat drying method. The research was conducted in three stages, namely extraction, drying and analysis of results. Drying of sappan wood extract was carried out at 40, 60 and 80°C, with different compositions of foaming agent. The results demonstrated that antioxidant activity exhibited a tendency towards stability at a drying temperature of 40°C. However, the highest reduction in water content was observed with drying at 80°C. The most effective foam composition was identified as foam composition 2, 0% CMC + 20% egg white (albumin) + 10%. Conversely, the foam composition with the highest antioxidant activity was identified as foam composition 5, 0.5% CMC + 30% gum Arabic. The most appropriate antioxidant degradation equation for this study was the first-order equation. The most accurate drying rate model for this study was the Lewis drying rate model.

Keywords:- *Caesalpinia Sappan L., Extract, Antioxidant, Foaming Agent, Drying.*

I. INTRODUCTION

Natural goods with possible health advantages have seen a noticeable surge in popularity in recent years. Because certain herbal products are rich in bioactive chemicals, such as antioxidants, there is an increasing interest in using herbal plants (Marliani et al., 2020). Antioxidants play a pivotal role in the body's defense against oxidative stress by neutralizing the detrimental effects of free radicals. In the context of everyday life, the impact of free radical compounds is pervasive, encompassing a range of sources, including air pollution caused by cigarette smoke, motor vehicle emissions, excessive sunlight, synthetic drugs, and the consumption of baked or fried foods (Maharani et al., 2021).

One plant extract that exhibits notable antioxidant activity is secang wood extract (Caesalpinia sappan L). The wood of the Caesalpinia sappan L tropical tree species, which is indigenous to Southeast Asia, is the source of secang wood, also referred to as Brazilwood or Sappanwood. Because of its medicinal qualities, secang wood has long been used in traditional medicine. These qualities are ascribed to the presence of several phytochemical substances, such as flavonoids and phenolic compounds, which have potent antioxidant effects (Parwata, 2016). Currently, the utilization of secang wood extract is in liquid form. In a study conducted by Nirmal et al. (2015), the maceration method was employed to extract secang wood using a solvent of 35% ethanol, resulting in an IC50 value of 5.6 ppm. In 2018, Febriyenti et al. also studied the extraction of secang wood using a solvent of 70% ethanol, with an IC50 value of 13.99 ppm.

However, storage in liquid form presents certain disadvantages. Firstly, the shelf life is limited due to the high-water content. Secondly, the use of ethanol as a solvent in the extraction process for food additives is still open to question. As a solution, secang wood is extracted using another solvent, namely distilled water, and then stored in powder form through a drying process. In their 2017 study, Utari et al. examined the extraction process of secang wood with distilled water and determined an IC50 value of 15.69 ppm. The resulting secang wood extract, obtained at a neutral pH, exhibited a red coloration, indicating that the water solvent did not alter the nature of the brazilein compound in secang wood. Subsequently, in 2023, Utari et al. conducted a re-examination of the sappan wood extraction process with distilled water. They identified optimal conditions for digest extraction, namely 70°C for 2 hours, with a ratio of ingredients to distilled water as a solvent of 1:1.

It is suggested that low-temperature drying technique be used to preserve the product's antioxidant content. Low temperature drying is one such technique that has the ability to manufacture food with great energy efficiency while maintaining nutritional quality. According to Utami et al.'s research, there is a positive link between maltodextrin concentration and antioxidant activity in instant beverages produced with brown rice extract and dried using the Foam-Mat technique. This was discovered by antioxidant content testing. The Foam-Mat drying method was conducted at a temperature range of 50-60°C. The application of this drying process has the potential to raise several problems that must

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be addressed through this research. In detail, these problems include the effect of foam formulation and temperature on the drying process and antioxidant activity of sappan wood extract dried by the Foam-Mat drying method.

II. MATERIALS AND RESEARCH METHOD

➢ *Research Materials and Equipment*

The materials used in this study were sappan wood obtained from the traditional market of Karawang Regency, distilled water, egg white (albumin), food grade Gum Arabic Powder KB-120 (from Acacia Senegal, purity 99.5%), food grade CMC (purity 99.5%), and DPPH. While the equipment used in this study were blender, 500 ml beaker glass, Whatman filter paper, vacuum pump, hand mixer, aluminum cup, oven, UV-Vis spectrophotometer and analytical balance.

➢ *Research Method*

One hundred grams of sappan wood was cleaned and then chopped using a blender. The extraction process was then carried out at 70°C for two hours using aquadest solvent in a 500 ml beaker glass. The ratio of material and solvent was 1:1 (100 grams of secang wood in 100 ml solvent). During the extraction process, stirring was carried out at a speed of 150 rpm in order to increase solubility. Once the extraction was complete, the extract was filtered using Whatman filter paper and a vacuum pump (Utari et al., 2023). Following the extraction of the sappan wood extract, water content analysis and antioxidant analysis were conducted. The extract was then dried using the foam mat drying method. The extract was combined with a foaming agent using a hand mixer for 15 minutes to create a foam (Utari et al., 2023). The foam was then placed in an aluminum cup with a diameter of 9.5 cm and a thickness of 0.5 cm. The foaming agent formulations used were: The following foaming agent formulations were tested: 0% CMC + 20% egg white (albumin) + 10% gum Arabic; 0% CMC + 30% gum Arabic; 0.5% CMC + 20% egg white (albumin) + 10% gum Arabic; and 0.5% CMC + 30% gum Arabic. In addition, drying of the extracts without foaming agent was also carried out for comparison. The drying process was conducted at temperatures of 40°C, 60°C and 80°C with a drying air rate of 5 m/s (Utari et al., 2023). The drying time was 50 minutes, with weighing conducted every 10 minutes.

➢ *Antioxidant Analysis*

A solution containing 10 mg of the compound was prepared in 100 ml of methanol, designated as the "sample mother solution." This solution was then diluted to create a series of samples with varying concentrations, including 20 ppm, 40 ppm, 60 ppm, 80 ppm, and 100 ppm. Additionally, a control solution was prepared, containing 2 ml of methanol and 1 ml of a 50 ppm DPPH solution. Additionally, a sample solution comprising 2 ml of the sample and 2 ml of the 50 ppm DPPH solution was prepared. The control solution and sample solution were then incubated for 30 minutes, until a color change indicative of DPPH activity was observed. The incubated control solution and sample solution were then measured for absorbance using a UV-Vis spectrophotometer at a wavelength of 515 nm.

- *The Antioxidant Activity was Quantified by:*

$$\%\text{antioxidant} = \frac{A_c - A}{A_c} \times 100\% \quad (1)$$

Where A_c is the absorbance value of the control solution; and A is the absorbance value of the sample solution. The IC50 value is obtained from the % antioxidant activity and then regressed with concentration as x value and % antioxidant as y value. The plot results obtained a line equation with the value of 50 substituted for the value of y then will get x as the IC50 value.

➢ *Degradation of Antioxidant*

The degradation of antioxidant activity in secang wood extract can be approximated by a zero-order (equation 2) or first-order (equation 3) equation.

$$C - C_0 = -kt \quad (2)$$

$$\frac{C}{C_0} = \exp(-kt) \quad (3)$$

Where C is the concentration at a given time t; and k is the reaction rate constant (1-n concentration units/time) (1/minute). By evaluating the coefficient of determination (R2) and root-mean-square error (RMSE) values of the two equations, the best antioxidant degradation equation model can be determined. The reaction rate constant (k) can be known from the slope of the equation of that order (Herdiana et al., 2014).

➢ *Moisture Content and Moisture Ratio*

The gravimetric method (AOAC, 2005) can be employed to determine the initial moisture content of the extract. After being heated to 105°C for thirty minutes in an oven, the empty cup was cooled in a desiccator and its mass (W0) was calculated. Then, 2 grams of extract were added to the cup and weighed (W1). The extract-filled cup was then allowed to cool in a desiccator for an hour, after which it was dried in an oven at 105°C and weighed in mass (W2). The moisture content can be calculated by:

$$X_0\ (\%) = \frac{W_1 - W_2}{W_1 - W_0} \times 100\% \quad (4)$$

- *While the Moisture Ratio can be Calculated by:*

$$MR = \frac{X_t - X_e}{X_0 - X_e} \quad (5)$$

Where X_t is the moisture content at a certain time, X_0 is the initial moisture content, and Xe is the equilibrium moisture content (Utari et al., 2023).

➢ *Drying Rate Model*

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Sample moisture content and equilibrium moisture content data were used to create a drying rate model equation. The drying rate equation was created following the following drying model.

Lewis Model $MR = \exp(-k.t)$ (6)

Page Model $MR = \exp(-k.t^n)$ (7)

Henderson & Pabis Model $MR = a.\exp(-k.t)$ (8)

By evaluating the coefficient of determination (R2) and root-mean-square error (RMSE) values of the three models, the best drying rate model can be determined (Mutuli and Mbuge, 2015).

III. RESULT AND DISCUSSION

➢ *Antioxidant Activity*

Table 1 indicates that the secang wood treatment exhibited antioxidant activity. The degree of antioxidant activity differed among the treatments. The lowest antioxidant activity was observed in the foam 1 treatment at all temperatures, while the antioxidant activity increased in the foam 2 to 5 treatments.

Table 1 Antioxidant Activity

Number	**Temperature**	**Foam Treatment**				
		1	**2**	**3**	**4**	**5**
1	40	40.84 ± 14.51 d	69.06 ± 30.61 cd	270 ± 149.9 ab	276 ± 151.70 ab	317.08 ± 176.53 ab
2	60	22.85 ± 15.53 d	61.13 ± 29.22 cd	285 ± 187.40 ab	244.84 ± 135.47 abc	260.86 ± 144.38 ab
3	80	39.26 ± 7.95 d	57.04 ± 16.50 cd	370.89 ± 209.66 a	194.82 ± 106.00 abcd	169.28 ± 83.54 bcd

The reduction in antioxidant activity can be attributed to factors such as light, heat, metal peroxides, and direct contact with oxygen. Antioxidants possess unstable properties, particularly in the presence of heat. The higher the temperature employed, the greater the reduction in antioxidant activity. The decline in antioxidant activity of an ingredient due to temperature and storage time affects the capacity of a compound to donate hydrogen atoms to inhibit free radicals (Sarinah et al., 2022).

Table 1 also indicates that the most effective foam composition in this study is foam composition 2, namely 0% CMC + 20% egg white (albumin) + 10% gum Arabic. This composition provides stable results against temperature addition. This can occur because with a high concentration of egg white, there is more foam that causes the solution to dry easily, but does not damage the important compounds of the dried material. However, the foam composition with the highest antioxidant activity is foam composition 5, which is 0.5% CMC + 30% gum Arabic. According to Haryanto (2016), the high composition of foaming agent and foam stabilizer resulted in a higher free radical capture activity in the sample.

The observation of antioxidant degradation was conducted at temperatures of 40, 60, and 80 °C over a period of 0 to 2 hours. The coefficient of determination (R^2) and root-mean-square error (RMSE) values of the two equations were evaluated to determine the best antioxidant degradation equation model. The reaction rate constant (k) can be determined from the slope of the equation of that order (Herdiana et al., 2014). As illustrated in Table 2, the antioxidant degradation results obtained from the entire study exhibit considerable fluctuations. The overall equation results in an R square value approaching 1.

Table 2 Degradation of Antioxidant Analysis

Treatment	**R^2**		**RMSE**	
	Order 0	**Order 1**	**Order 0**	**Order 1**
401	0.9819	0.9971	0.007458	0.003905
402	0.9879	1		
403	0.9989	0.993		
404	0.9994	0.9899		
405	0.9933	0.9936		
601	0.7949	0.9718	0.085062	0.011311
602	0.9972	0.9969		
603	0.959	0.9969		
604	0.9917	0.9963		
605	0.9812	0.9981		
801	0.7949	0.993	0.081649	0.002929
802	0.9972	0.9899		
803	0.9812	0.9936		

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804	0.9581	0.9981		
Average	0.958343	0.993443	0.058056	0.006048

The results indicated that the first-order results exhibited good antioxidant degradation, with an average RMSE value close to 0 and an R square value close to 1. These findings align with several studies (Turturica et al., 2016) that have demonstrated the efficacy of the selected reaction order. The reaction order is the order of reaction with an equation that has an average R2 close to 1. Furthermore, research by Ursu et al. (2020) indicates that the presence of thermal or temperature factors affects the kinetic process of antioxidant degradation, resulting in the results in each equation at order 1 being close to 1.

- *Drying Process*

The effect of the specified temperature is to reduce the water content of the sample. Based on Table 3, it can be seen that the water content value of the results of each foam and temperature treatment has different results.

Table 3 Moisture Content

Number	Temperature	Foam Treatment				
		1	2	3	4	5
1	40	0.77 ± 0.17 ab	0.76 ± 0.17 ab	0.89 ± 0.07 a	0.88 ± 0.08 a	0.37 ± 0.18 bc
2	60	0.19 ± 32 c	0.20 ± 0.33 c	0.36 ± 0.36 bc	0.33 ± 0.36 bc	0.19 ± 0.11 c
3	80	0.14 ± 0.30 c	0.17 ± 0.31 c	0.27 ± 0.33 c	0.16 ± 0.33 c	0.27 ± 0.04 c

The results for each sample size from 1 to 4 showed an increase and for each temperature from 40, 60 and 80 showed a decrease in each result. The lowest water content value was obtained in treatment 1 at 80°C. These results are in agreement with the research of Purbasari (2019), where different drying temperatures have a significant effect on the water content of the resulting powder products. Higher drying temperatures produce products with lower water content. In addition, this study is consistent with the research findings of Pratiwi and Suharto (2015) where drying temperature affects the moisture content because the longer the water evaporates. Based on the results, it shows that the best temperature treatment is 80°C.

Table 4 shows the drying rate model appropriate for this study. The best drying rate model is determined by calculating the R-squared value of each equation.

Table 4 Drying Rate Model

Drying Rate Model	Temperature	R Square	RSME
Lewis Model	40	0.998	0.716359
	60	0.884	0.335258
	80	0.9470	0.2964
Page Model	40	0.9890	0.7297
	60	0.5170	0.1481
	80	0.6720	0.3180
Henderson & Pabis Model	40	0.998	0.7297
	60	0.9140	0.3553
	80	0.7128	0.2049

Using the Lewis model, the R-squared value obtained at each temperature is close to 1. Therefore, the best drying rate model for this study is the Lewis drying rate model.

IV. CONCLUSION

The antioxidant activity tended to be stable at a drying temperature of 40°C. The most effective foam composition was foam composition 2, 0% CMC + 20% protein (albumin) + 10%, but the foam composition with the highest antioxidant activity was foam composition 5, 0.5% CMC + 30% gum arabic. The best antioxidant degradation equation for this study is the 1st order equation. The lowest moisture content value was obtained at 80°C. The best drying rate model for this study is the Lewis drying rate model. Further studies need to be conducted on the drying process of sappan wood extract using other drying methods, the composition of other chemical compounds in sappan wood that are degraded during the drying process, and the good storage temperature of sappan wood extract.

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