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STUDY OF THE INFLUENCE OF EXTRACT COCOA PODS (Theobroma cacao) AS A PRESERVATIVE INGREDIENT ON MAHONI WOODS (Swietenia mahogany) THROUGH COLD SOAKING ON MECHANICAL PROPERTIES

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ABSTRACT

An attempt has been made to extend the service life of mahogany wood (Swietenia mahogany) by preserving it. The purpose of this study was to determine the mechanical properties of mahogany wood after cold soaking with preservatives of cocoa pods extract (Theobroma cacao). This research uses an experimental method of cold soaking which is carried out in the Material Testing Laboratory of the Mechanical Engineering Department of Padang State Polytechnic. The preservation process used cacao pod extract preservative solution at concentrations of 0%, 3%, 6%, 9%, 12%, and 15%. The observed responses were the preservative retention values and mechanical properties (compressive strength parallel to the fiber direction, flexural strength, and surface hardness) of the wood. The preservation method applied was cold soaking for 120 hours. The increase in retention value was directly proportional to the increased concentration of extract added. The improved properties of wood (compressive strength in the grain direction and flexural strength) also increased with increasing extract concentration. The results obtained showed that the highest value was obtained at a 15% concentration of the added extract with a retention of 7.6078 kg/cm2, a compressive strength parallel to the fiber of 227.92 kg/m2, and a flexural strength of 387.82 kg/m2. This data shows that cocoa pods extract has the potential to be used as an environmentally friendly wood preservative.

1. INTRODUCTION

The need for wood for industrial raw materials is increasing, this means that the supply of raw materials for the timber industry is increasingly difficult if it only relies on wood from natural forests. To make new plantations, it takes a long time to be harvested, so that at this time a lot of wood that is still young has been cut down, to meet these needs [1]. Therefore, it is necessary to look for substitute types of wood that can meet the requirements for various purposes. One of the woods that is very much utilized and used in everyday life is mahogany wood (Swietenia mahagoni) [2].

The mahogany tree is a hardwood species commonly utilized for crafting furniture and intricate carvings. Mahogany trees can grow wild in teak forests or other places close to the coast and are usually planted on the roadside as protective trees [3]. On the other hand, the use of wood as raw material for the wood working and furniture industry has recently increased, but the drawback is that young wood is easily eaten by termites [3,4].

Wood materials for structures with a high level of durability and strength are currently difficult to obtain and prices are getting more expensive, so it is necessary to carry out technology to preserve medium-class wood to meet the

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needs of strong and long-lived structural wood. Wood raw materials can be efficiently exploited through the implementation of preservation technology, drying processes, and residual wood consumption.

One alternative that can be done is to do a wood preservation process that is easy to do through a cold soaking process to extend the life of wood so that it can save the use of wood. In terms of physical and mechanical properties, mahogany wood is classified as strong class II to III wood, while for its durability class mahogany wood is classified as durable class III or equivalent to Ramin wood. However, the level of susceptibility of mahogany wood to insects and blue mold (Blue Stain) is better than Ramin wood [5]. Therefore, to minimize these shortcomings in its utilization, more intensive preservation is needed, especially after cutting or sawing [6].

Termites have caused a lot of damage to buildings in Indonesia, especially from the subterranean termite class, namely Coptotermes curvignathus Holmgren [7]. In terms of the efficiency of forest resource utilization, termite attacks on wood and wood products by these organisms are very detrimental because they can shorten the life of the wood. Therefore, it is necessary to make efforts to extend the service life of wood, for example through chemical preservation. The method of controlling termite attacks on buildings in Indonesia is generally carried out using insecticides, which are insect-killing chemicals that are technically very effective as insect poisoning agents, but sometimes not selective, and not environmentally friendly [8].

Efforts can be made to increase the life of wood through wood preservation. Currently, the preservatives used are generally synthetic chemicals that have the potential to pollute the environment because, in addition to being non-biodegradable, they are also non-renewable resources. In the case of many available biomass waste materials that can be used as preservatives that are environmentally friendly, and non-toxic [9]. To reduce these negative impacts, efforts to utilize natural products or extractive substances contained in wood as natural preservatives are very important [5,9].

In order to find natural insecticides, it is necessary to conduct research using materials that are more environmentally friendly. One of the biological resources that can be utilized as a natural preservative is cocoa pod peel extract (Theobroma cacao). Natural extracts containing phenolic compounds are thought to have effective insecticidal activity and can be adsorbed on the surface of the wood to form a thin layer on the wood surface [10].

This underlies the need to research the preservation of mahogany wood with cocoa fruit peel extract with variations in the concentration of the extract. Starting from the background of the problem which is abundant in availability, the main problem arises, namely how much is the increase in compressive strength parallel to the fiber and flexural strength by using this natural preservative by cold soaking with variations in the concentration of cocoa pod extract used 0%, 3%, 6%, 9%, 12%, and 15% with a soaking time of 120 hours and its effect on mechanical properties.

2. METHODS

The research was conducted at the Material Testing Laboratory of Padang State Polytechnic, Payakumbuh Agricultural Polytechnic and Wood Workshop of the Faculty of Forestry, Muhammadiyah University of West Sumatra for ± 3 (three) months. The tools used were a Moisture meter, Mesh screen, Thermo-Hygrometer, grinding machine, Electric oven, Rotary evaporator, Measuring flask, and Analytical scales. Ketam, Saw, Sandpaper, Scales, Hallway, Oven, Universal Testing Machine (UTM).

The materials used in the study were mahogany wood that had been made according to the test sample with a size of 5 cm x 5 cm x 1 cm and cocoa pods (Theobroma cacao). Cocoa pods were pre-prepared by slicing and drying in the sun until dry. The dried skin was mashed and sieved into powder. Then the powder was macerated with an alcohol solvent. The maceration results were then evaporated using a rotary evaporator to separate the alcohol from the extract. The extract obtained is then stored in a bottle to be used as a wood preservative.

3. RESULT AND DISCUSSION

Sample preparation begins with the collection of fresh cocoa pods, then the sample is cleaned and followed by slicing or thinly chopping with a chopping machine. The results of the slices are dried in the sun by air drying in the room until the water content is reduced to about 85% (± 9-14 days). The dried skin is then mashed until it becomes powder [11].

The powder was then macerated with an ethanol solvent to extract the extract from the cocoa fruit skin. The maceration process is done repeatedly until enough extract is obtained. The extract that is still mixed with alcohol is then evaporated with a rotary evaporator to separate the extract from the alcohol. The pure extract of cocoa fruit peel resulting from the separation will be used as an ingredient for wood preservatives.

The next stage of mahogany wood that has been prepared is to sand the surface until it is smooth with sandpaper according to the desired smoothness size, then dried with the help of sunlight. After it is dry enough, the wood is cut into 5 cm x 5 cm x 1 cm sizes. Wood samples that are ready for preparation are stored in an open box so that the dryness is maintained. The dried mahogany wood was subjected to proximate testing, the results of which can be seen in Table 1.

Table 1. Proximate Analysis

Analysis / Sample Code	Cellulose (%)	Hemicellulose(%)	Lignin (%)
Wood 1	62.07	7.21	32.44
Wood 2	62.52	6.91	32.05

Analysis from Table 1 shows that mahogany wood contains cellulose, hemicellulose, and lignin compounds, where the average content of cellulose: is 62.30 ± 0.32, the average hemicellulose: is 7.06 ± 0.22, and average lignin: 32.24 ± 0.27. The high cellulose content causes this wood to be easily attacked by pests. When viewed from an economic perspective, mahogany wood has a fairly high economic value. The quality of the wood is hard and is very well used for furniture, furnishings, and home accessories. The quality of mahogany wood is almost the same as teak, but mahogany wood has good durability and strength, besides that, it also has a long service life.

In terms of quality, mahogany wood has the advantage of being durable and not easily deformed. So, it is suitable for use as a house-building material, but it is quite prone to pests [10, 12].

Prepared mahogany wood samples were then immersed into the cocoa pod peel extract solution with concentration variations of 0, 3%, 6%, 9%, 12%, and 15%. The soaking process was carried out for 120 hours, where every day the wood samples were reversed in position so that the cocoa fruit peel extract was evenly adsorbed on the surface of the wood. After the targeted time was reached, the wood samples were removed from the container and then hung to dry. After it was dry and not sticky when held, the moisture content was tested, as presented in Table 2.

Table 2. Moisture Content Test

No.	Extract concentrati oncocoa pods (%)	Average Moisture Content (%)
1	0	14.12
2	3	16.25
3	6	17.81
4	9	15.42
5	12	16.97
6	15	17.02

Based on the results of the mass gain of mahogany wood during 120 hours of immersion in cocoa pod peel extract, the average value of retention of cocoa pod peel extract on mahogany wood (Swietenia mahagoni) at each extract concentration can be seen in Table 3. From the table, it can be seen that the increase in retention is directly proportional to the increase in cocoa pods extract concentration. This condition shows that mahogany wood has better retention than other woods [13].

Table 3. Retention of Cocoa Pods Extract Against Mahogany Wood

No.	Extract Concentration (%)	Retention (Kg/cm^2)
1	0	0.0000
2	3	1.1565
3	6	2.6521
4	9	3.0198
5	12	5.4431
6	15	7.6078

Table 3 shows the results of the calculation of wood retention at various concentrations of cocoa pods extract. It can be seen that the greater the concentration of cocoa pod extract, the greater the average retention. This is supported by the results of research by Malau (1995) which explains that the retention of merbau wood extract on rubber wood test samples has the lowest value of 0.0000 Kg/m3 at 0% concentration and the highest value is 3.0661

Kg/m3 at 10% concentration. The range of average retention values of Gerunggang bark extract (C. arborescens) was 0.0000 kg/m3 to 2.2480 kg/m3. The lowest mean retention value of 0.0000 kg/m3 was at 0% extract concentration and the highest mean retention value of 2.2480 kg/m3 was at 5% extract concentration. The highest average retention value of 2.2480 Kg/m3 includes a low retention value because it does not comply with the SNI 03-5010-1999 standard which requires the minimum use of wood under the roof and outside the roof, the retention is 8.2 Kg/m3 and 11.3 Kg/m3 respectively [14]. This is supported by the results of Daviyana's research, (2011) which states that the retention in the soaking process in 5% CB Wolmanite solution on rubber wood (H. Brasiliensis) test samples only has a value of 3.6 Kg/m3.

The results of the analysis in Table 3 show that the concentration, preservation method, and their interaction have a significant effect on the retention value of wood preservation. In this case, the increase in concentration increases the retention value of wood. Priadi, T. (2014). Stated that variations in wood volume affect the retention value. Wood density also affects the spread of preservatives, this density depends on the moisture content and constituent materials in the cell wall, wood with low density usually has large open vessels with a larger proportion and a more uniform distribution than wood with high density and therefore can receive better infiltration of preservatives.

Similarly, the anatomical properties of mahogany wood include a smooth, soft, and malleable texture. The grain is straight and even, and relatively free of voids and pockets. Mahogany wood has a reddish-brown color that will darken over time. Quality mahogany wood will have a dark color indicating that the wood is old. Mahogany wood has a high economic value. The quality of the wood is hard and very well used for furniture, furniture, and complementary home accessories. the quality of mahogany wood is almost the same as teak, mahogany has good durability and strength, and besides that, it also has a long service life. In terms of quality, mahogany wood has the advantage of being durable and not easily deformed. So it is suitable for use as a house building material. mahogany wood is quite prone to pests [14]. Mahogany wood has the advantage of tending to be durable and not easily deformed, making it suitable for home building materials. then from cell to cell, the flow is only possible through the cell wall in the north pair [4, 15].

In addition, the mortality may be caused by the extractive substances contained in the cocoa pods extract causing the protozoa in the stomach of termites to die or damaging the nervous system in termites. This research is collaboborated by Sari and Hadikusumo (2004), which asserts that termite mortality may result from two factors: firstly, the bark extract induces the death of protozoa in the termite's stomach, and/or secondly, the bark extract inflicts damage to the termite's nervous system. The protozoa in the termite stomach destroy cellulose that cannot be destroyed by termites or enzymes contained in the termite stomach itself. So with the death of the protozoa in the termite's stomach, the termite also dies because the bait eaten by termites, which mainly consists of cellulose, cannot be absorbed by the termite's body. As a result of its resistance to termite attack, the service life of wood becomes longer [4,8,16].

Mass Gain of Test Sample

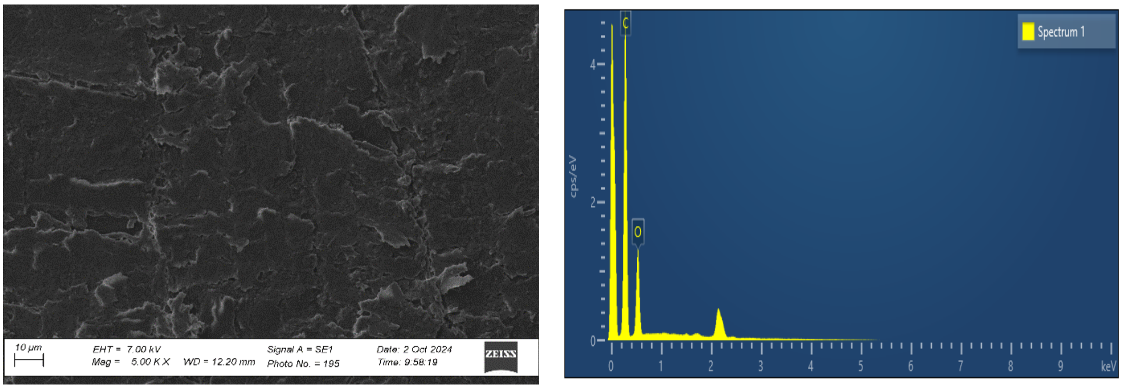
The observation of the increase in the mass of the test sample shows that the soaking treatment has caused adsorption on the surface of the wood. Table 4 shows that the average value of the increase in mass is directly proportional to the increase in soaking time, at a constant extract concentration of 9%. Table 4 shows that the highest average value level is produced with a 144-hour soaking time of 2.6797 grams and the lowest at 24 hours of 0.0047 grams. The results of the study of the addition of the test sample period have a relationship that is directly proportional to the time variation. The longer soaked the more extracts are adsorbed on the surface of the wood. The extract contained in the mahogany wood test sample causes the wood to be resistant to termite attack because basically, the extract contains poison for termites so that termites will die after eating it [5,12].

Table 4. Mass gain of mahogany wood after soaking

No.	Soaking Time (hours)	Initial Mass (grams)	Final Mass (grams)	Δ Mass (grams)	Δ Average mass (grams)
1	24	14.7566	14.7656	0.0090	0.0047

2		14.6770	14.6773	0.0003	
3	48	14.9394	14.9525	0.0131	0.0176
4		13.8072	13.8292	0.0220	
5	72	13.7657	13.7894	0.0237	0.0269
6		13.6999	13.7299	0.0300	
7	96	14.3924	14.4330	0.0406	0.0550
8		14.4379	14.5072	0.0693	
9	120	14.9282	15.0318	0.1036	0.9231
10		14.3118	16.0543	1.7425	
11	144	14.3693	16.9233	2.5540	2.6797
12		14.1555	16.9608	2.8053	

The results of surface morphology analysis using Scanning Electron Microscopy (SEM) as shown in Figure 1 show that there are very different surfaces between those immersed in the extract solution and those without the addition of extracts in the solution.



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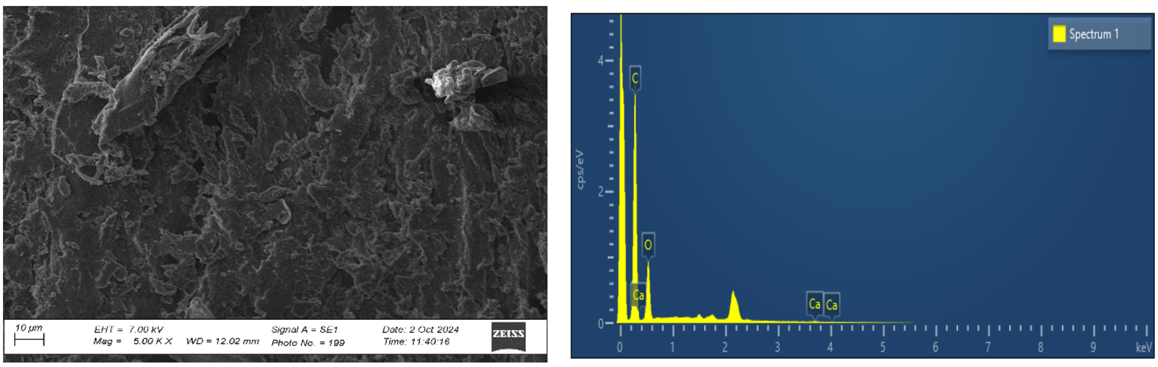

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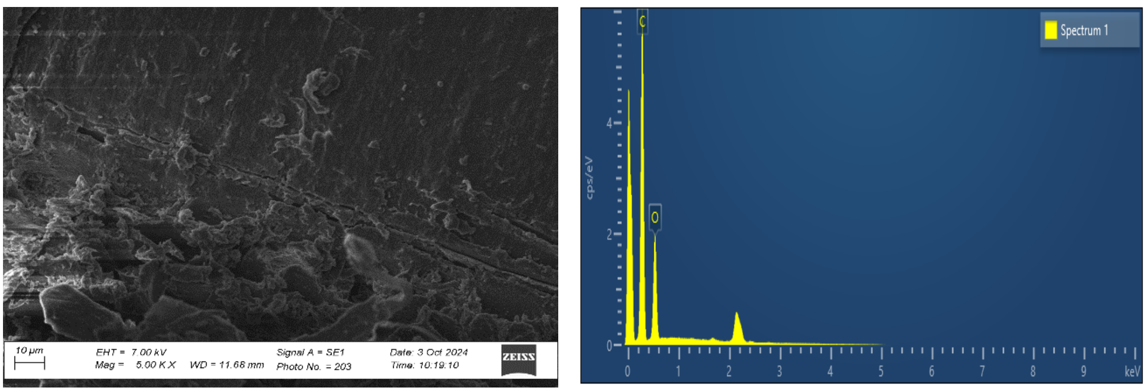

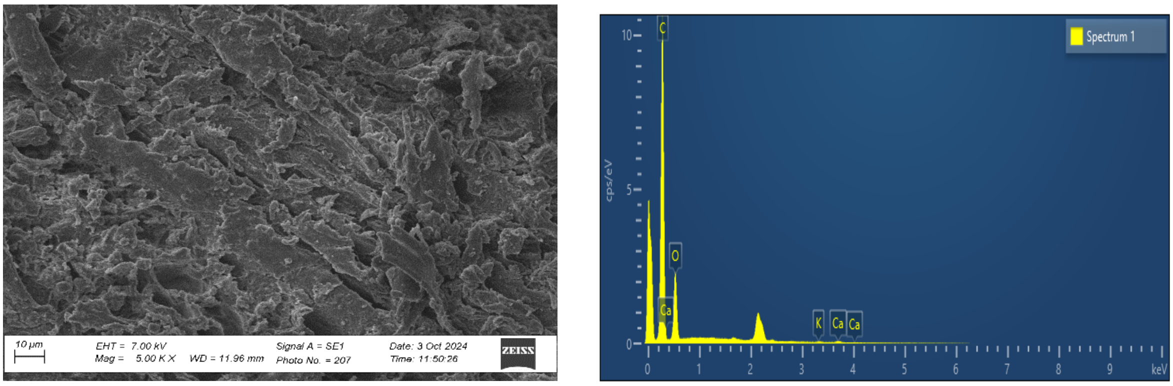

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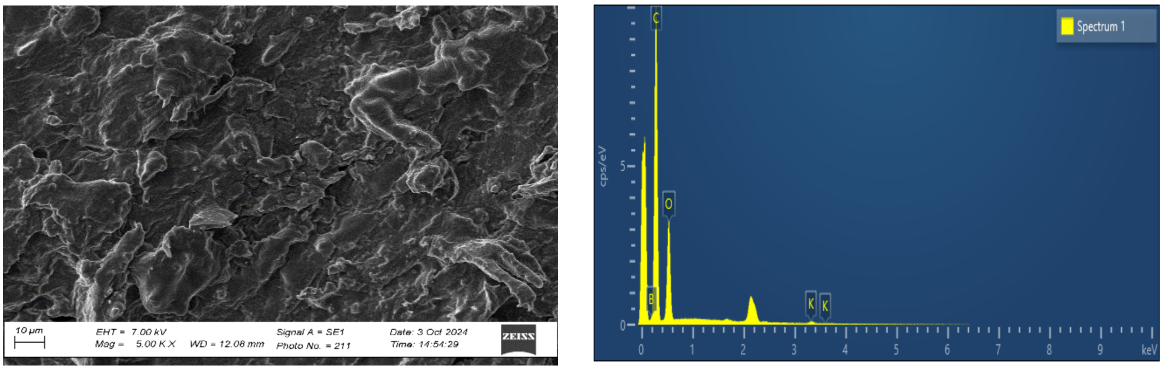

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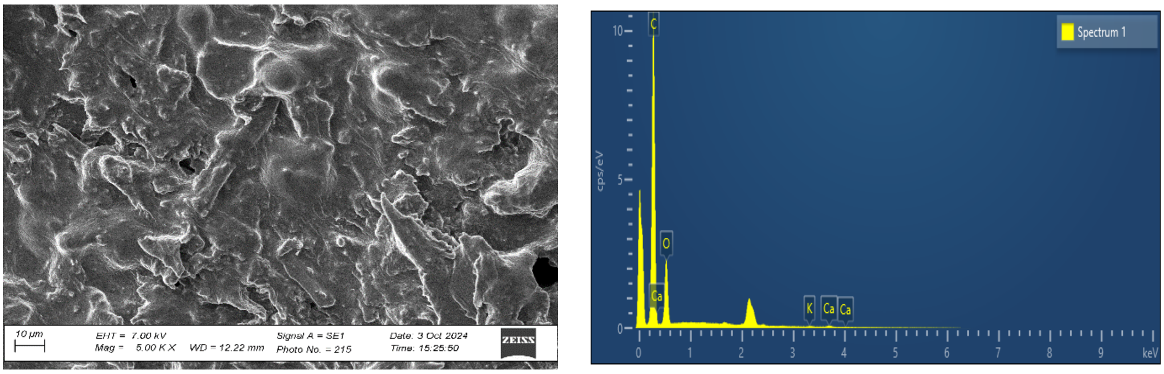

f

Figure 1. Surface morphology of wood soaked in different variations of cocoa pod shell extract at 15,000x magnification. a. 0%, b. 3%, c. 6, d. 9%, e, 12%, and f. 15%.

Based on Figure 1, it can be analyzed that for 1a, the surface is flat and there is no absorption because the wood sample has not been immersed in cocoa pods extract. However, from Figure 1b to 1f, it can be seen that the surface of the wood is getting rougher and there is a lot of build-up. The build up is thought to be cocoa pod extract adsorbed and attached to the surface of the wood, and it can be seen that the greater the concentration of the extract, the more sediment, and build up on the surface of the wood. The amount of adsorption that occurs on the surface of the wood is proven by SEM-EDX analysis to see the composition of the elements on the surface of the wood. The results of the analysis of the composition of the elemental content on the surface of the wood after soaking can be seen in Table 6. From the table, it can be seen that the higher the concentration of cocoa pods extract added, the higher the carbon content on the surface of the wood. This indicates that adsorption has occurred on the surface of the wood in the form of a thin layer, which can inhibit the attack of pests and termites so that the wood can be more durable [6, 18, 19].

Table 6. Chemical Composition of Wood Surface of Concentration Variation

Elements	Concentrations (%)											
	0		3		6		9		12		15	
	%Mass	%Atom	%Mass	%Atom	%Mass	%Atom	%Mass	%Atom	%Mass	%Atom	%Mass	%Atom
C	86.75	90.62	87.05	91.02	87.87	91.49	91.33	94.05	92,01	94,32	92.82	95,25
O	10.72	8.73	10.12	7.95	9.65	7.54	6.75	5.22	6.31	5,02	6.15	4,09
Mg	0.93	0.39	0.75	0.39	0.94	0.48	0.68	0.35	0,50	0,49	0,40	0,50
Ca	2.07	0,58	2.07	0,65	1.55	0.48	1.23	0.38	1.13	0,30	1.04	0, 21

Adsorption formed on the surface can improve the mechanical properties of wood [20, 21]. The results of the analysis of mechanical properties, namely compressive strength and flexural strength, show that the compressive strength parallel to the fiber and flexural strength increases with increasing concentration of extract added, as can be seen in Table 7 and Table 8.

Tabel 7. Mahogany wood fiber parallel compressive strength test

No	Extract concentration (%)	Compressive Strength in Fiber Direction (Kg/cm^2)
1	0	141.31
2	3	165.25
3	6	171.18
4	9	189.92
5	12	196.57
6	15	227.92

Tabel 8. Mahogany Wood Flexural Strength Test

No	Extract concentration (%)	Flexural Strength (Kg/cm^2)
1	0	173.12
2	3	231.35

3	6	279.37
4	9	319.29
5	12	356.75
6	15	387.82

Based on Tables 7 and 8, it is known that the cold soaking method has increased the value of flexural strength (MOR), and compressive strength parallel to fiber (TSS) from the control that did not undergo wood preservation. The highest increase occurred at a 15% concentration of cocoa husk extract added, namely 387.82 Kg/m2 for MOR and 227.92 Kg/m2. The study showed a decrease in the strength of A. mangium wood up to 25% with the vacuum press method at preservative concentrations of 0.57%; and 5.58% except for the MOR value which decreased by 14.05% followed by the TSS value by 6.88% and Vus by 4.31% from the control. The study results in Tables 7 and 8 indicate that the cold soaking wood preservation method significantly influences the flexural strength (MOR) and wood fiber parallel compression (TSS) values.

4. CONCLUSION

Preservation of mahogany wood with variations in the concentration of 0%, 3%, 6%, 9%, 12%, and 15% with a cold soaking process for 120 hours has been carried out following established standards to determine the mechanical properties of the material. The results showed that the value of moisture content, retention, and mechanical properties of mahogany wood were influenced by the preservation treatment, and the concentration of extract used. In general, the value of moisture content, mass, and mechanical properties (compressive strength parallel to the fiber direction and flexural strength) of mahogany wood increased, with increasing extract levels in soaking. The highest increase was obtained with the addition of 15% extract, where the retention, MOR, and TSS values were 7.6078 Kg/m2, 387.82 Kg/m2, and 227.92 Kg/m2, respectively. The cold soaking method was found to be influenced by two key factors: the length of soaking and the concentration of cocoa pods extract used. The interaction between the type of cocoa pods extract and the soaking period yielded a highly significant effect on the adsorption of the extract onto the wood surface.

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