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Fabrication of Anti-Termite Particle Boards Made from Bintaro (*Cerbera manghas*): Analysis of Physical and Mechanical Properties

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Kata kunci:

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ABSTRAK

Rayap dipandang sebagai pengganggu, karena kemampuannya merusak barang-barang kayu. Insiden serangan rayap pada furniture sehingga mengakibatkan peningkatan kerugian finansial akibat serangan rayap tersebut. Oleh karena itu, sangat penting untuk mencari bahan baku alternatif yang memiliki ketahanan terhadap kerusakan rayap, sehingga memenuhi kebutuhan akan penggantian papan partikel. Penelitian ini telah mencapai produksi papan partikel menggunakan bahan pengisi biji buah bintaro dan matriks urea formaldehida, dengan tujuan untuk mengembangkan alternatif papan partikel konvensional yang memiliki sifat anti-rayap. Perbandingan fraksi pengisi terhadap fraksi matriks menunjukkan variasi 50:50, 60:40, 70:30, dan 80:20. Proses produksi partikel papan yang digunakan pada penelitian ini menggunakan teknik cold press dengan memberikan tekanan sebesar 15 MPa dengan durasi 120 menit. Partikel papan yang diperoleh menjalani pengujian untuk mengetahui parameter fisiknya, termasuk massa jenis dan kadar air. Pengujian ini dilakukan sesuai dengan Standar SNI 03-2105-2006. Pengujian kuat lentur papan partikel diiuji mengacu SNI 03-2105-2006. Evaluasi ketahanan papan partikel terhadap serangan rayap dilakukan sesuai standar SNI 01-7207-2006. Hasil pengujian massa jenis dan kadar air yang dilakukan pada papan partikel sesuai dengan standar yang ditetapkan dalam SNI 03-2105-2006. Hasil percobaan penilaian kerentanan partikel papan terhadap serangan rayap telah berhasil memenuhi kriteria yang ditetapkan dalam pedoman SNI 01-7207-2006.

Keyword:

Bintaro Seeds, Particle Board, Biocomposite, Termite Resistant

ABSTRACT

Termites are commonly seen as a nuisance due to their capacity to cause harm to wooden objects. The occurrence of termite infestations on furniture has led to a rise in financial damages attributed to such attacks. Hence, it is of utmost need to seek alternative raw materials that exhibit resistance to termite-induced deterioration, thereby fulfilling the requirement for substituting particle board. The present study has successfully demonstrated the fabrication of particle boards by including bintaro fruit seed filler and urea formaldehyde matrix. The primary objective of this research endeavour was to explore an alternate approach to standard particle board production, specifically focusing on the development of anti-termite qualities. The filler fraction-to-matrix fraction comparison exhibits variations of 50:50, 60:40, 70:30, and 80:20. The particle board production process employed in this study utilizes a cold pressing method, wherein a pressure of 15 MPa is applied for a duration of 120 minutes. The board particles that have been acquired are subjected to testing to ascertain their physical characteristics, such as density and water content. The experiment was conducted in compliance with SNI Standard 03-2105-2006. The flexural strength of particle board was evaluated in accordance with the standard SNI 03-2105-2006. An assessment was conducted to evaluate the susceptibility of particle board to termite infestation in accordance with the guidelines outlined in the SNI 01-7207-2006 standards. The density and moisture content testing findings conducted on particle board match the specifications outlined in the SNI 03-2105-2006 standard. The Experimental outcomes evaluating the susceptibility of board particles to termite infestations have effectively fulfilled the requirements outlined in the SNI 01-7207-2006 standards.

1. INTRODUCTION

Particle boards are a type of composite material that consists of wood particles, including sawdust, wood chips, and wood shavings. These particles are combined with a resin binder and subjected to high pressure and temperature to produce a solid and inflexible board [1]. These boards are frequently utilized within the construction sector for a multitude of purposes, including but not limited to flooring, wall panels, and furniture [2]. Nevertheless, particle boards are prone to infestation by termites, leading to substantial structural harm and a decrease in their overall durability. To address this issue, researchers have undertaken inquiries into the manufacturing of particle boards possessing qualities that deter termites [3], [4].

The plant known as Bintaro, scientifically classified as Cerbera odollam and Cerbera manghas, has been the subject of much research pertaining to its environmentally sustainable use, pharmacological properties, and toxicological characteristics. Scientists have seen that oleic acid from Bintaro seeds can kill two types of termites: Coptotermmes gestroi, which lives underground, and Cryptotermes cynocephalus, which lives in dry wood [5, 6]. The repellent efficacy of Bintaro leaf extract against Spodoptera litura has also been investigated. Bintaro seeds possess saponins, polyphenols, flavonoids, tannins, steroids, and alkaloids, which are considered toxic substances [7]. Consequently, these seeds have promising potential as a viable alternative material to produce anti-termite particle boards. Bintaro seeds exhibit significant efficacy in termite control due to their high concentration of anti-termite properties [8] [9].

Extensive research has been conducted on the utilization of Bintaro seeds in the production of anti-termite particle boards. An analysis has been conducted on the physical and mechanical properties of these boards. The research conducted revealed that Bintaro seed particle boards have favorable mechanical characteristics, hence presenting a viable substitute for traditional particle boards. Additional research has also indicated that bintaro wood possesses the potential to serve as a viable material to produce particle board, gypsum particle board, and medium density fiber (MDF) board [5].

The data indicate that Bintaro exhibits promise as a viable and environmentally conscious material for the manufacturing of diverse board products. It has been observed that bintaro seeds possess insecticidal and repellent characteristics, while bintaro wood exhibits promising potential as a viable material for the fabrication of several board types. A comprehensive investigation has been conducted on the production of particle boards with anti-termite capabilities utilizing Bintaro fruit seeds. Subsequently, an in-depth analysis has been performed to evaluate the physical and mechanical characteristics of these specified boards.

2. MATERIALS AND METHODS

2.1 Materials

The ingredients utilized in this study consisted of bintaro fruit seeds sourced from the Riau province of Indonesia, as well as water and urea formaldehyde resin. The research employed many tools, including a cutter, caliper, file, digital balance, material container, 50 mesh sieve, beaker, oven, grinding machine, mixer, aluminum foil, and an iron mold measuring 21 x 21 x 2 cm^3.

2.2 Process of Bintaro Seed Preparation

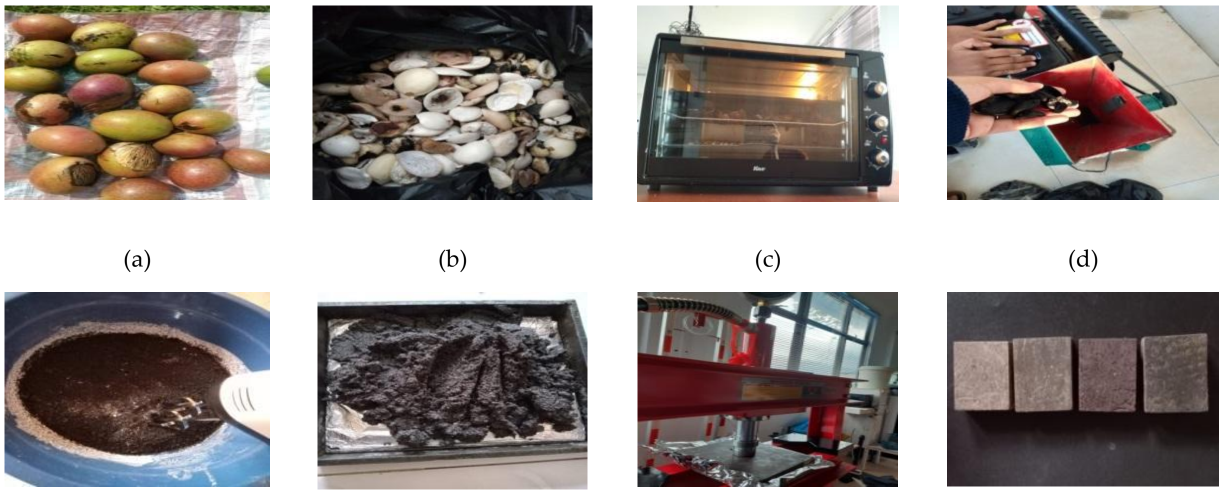
The bintaro fruit should be washed using clean water and subsequently dried using a clean cloth. The bintaro fruit should be sliced into small segments, and the seeds should be extracted. To desiccate the sliced bintaro fruit, it is recommended to subject it to direct sunlight until it reaches a state of complete dryness. After the bintaro fruit has undergone thorough drying, it should be subjected to grinding using suitable grinding equipment until it achieves a particle size that allows it to pass through a 50-mesh filter [9]. The procedure is visually depicted in Figure 1(a–d).

2.3 Process of Pressing Particle Board

Bintaro seeds that pass a 50-mesh sieve and a mixture of urea formaldehyde resin are placed in a 21 cm x 21 cm x 2 cm iron mold lined with aluminum foil and leveled with a spatula. The material in the mold is pressed for two hours at a pressure of 15 MPa using a cold press. The resulting mold is left in the mold for two hours before it is taken out. The particleboard kept at ambient temperature for one week [1] The procedure is depicted in Figure 1(e–h). Table 1 displays the composition of the raw materials utilized in the production of particle board.

Table 1: Composition of Particle Board Materials

Code Sample	Bintaro Fruit Seeds: UF Resin (%)	Mass of Bintaro Seeds (Grams)	UF Resin Mass (Grams)
1	80 : 20	705,6	176,4
2	70 : 30	617,4	264,6
3	60 : 40	529,2	352,8
4	50 : 50	441,0	441,0



(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 1. Illustrates the various steps involved in the processing of bintaro fruit. These steps include collecting and drying the fruit (a), removing the seeds from the fruit (b), roasting the seeds (c), milling the seeds (d), mixing the raw materials (e), placing the material into iron molds (f), producing the particle board (g), and finally, obtaining the particle board as the product (h)

2.4 Process for Preparing for a Particle Board Test

The particle board underwent cutting using a grinding machine in accordance with the prescribed standard samples for conducting tests on physical and mechanical qualities, as outlined in SNI 03-2105-2006. Table 2 displays the results of particle board cutting based on laboratory test samples for each respective type of test [10].

Table 2. Dimensions of particle board laboratory tests

No.	Particle Board Test	Sample size (cm)
1.	Density Test	10 × 10
2.	Moisture Content Test	5 × 5
3.	Termite Resistance Test	5 x 5
4.	Flexural Strength Test	20 × 2

2.4 Physical and Mechanical Properties Test

The physical and mechanical properties of a material are essential factors to consider in various scientific and engineering applications. These properties provide valuable insights into the behavior and performance of materials under different conditions. By studying the physical and mechanical The examination procedure is [11], [12], [13].

2.4.1 Particle Board Density Testing

The purpose of this experiment is to evaluate the correlation between the mass and volume of particle board. The dimensions of the density test object fabricated are 10 cm by 10 cm. The examination employs the standards outlined in SNI 03-2015-2006. Equation 1 allows for the determination of density.

$$\rho = \frac{m}{V} \tag{1}$$

The given information pertains to the density (ϱ) of particle board, which is measured in grams per cubic centimeter (g/cm³). Let m represent the mass of the particle board in grams, and v represent the volume of the particle board in cubic centimeters, which is calculated as the product of the average length ($\bar{l}$), average width ($\bar{w}$), and average thickness ($\bar{t}$) of the particle board.

2.4.2 Particle Board Moisture Content Testing

The moisture content test entails determining the quantity of water that can be extracted from the particle board with the application of heat in an oven. The test is conducted in accordance with the SNI 03-2105-2006 standard. Equation 2 can be utilized to determine the moisture content of particle board.

$$M = \frac{B_a - B_k}{B_k} \tag{2}$$

The variable M represents the moisture content expressed as a percentage, while B_a the initial weight is measured in grams. B_k refers to the dry weight of a substance after it has been subjected to an oven drying process, measured in grams.

2.4.3 Particle Board Flexural Strength Testing

The flexural strength of a material is a fundamental attribute that quantifies its ability to withstand the application of bending forces in a direction perpendicular to the cross-sectional area of the specimen. The flexural strength test is employed to quantify the extent of elasticity demonstrated by the composite material. The experiment involves the application of a load or force to a lengthy rectangular specimen of the material, which is positioned with support at its extremities. Consequently, there is an absence of support in the central region, while the ends exhibit robustness. There exist two distinct methodologies for evaluating flexural strength, namely the three-point and four-point testing techniques, which exhibit notable similarities. The flexural strength (denoted by the symbol σ) for a three-point test can be determined by the utilization of a specific equation. Equation 3 can be utilized to compute the flexural strength test.

$$\sigma b = \frac{3PL}{2bd^2} \tag{3}$$

Flexural strength represents the highest stress experienced within the material at its moment of yield and is measured in terms of stress. The variable σb represents the flexural strength, measured in kilograms per square centimeter (Kgf/cm²). The variable "p" represents the applied load, measured in kilograms-force (Kgf). The variable "L" represents the measurement of support distance in centimeters. The variable "b" represents the thickness of the sample (cm). The variable "d" represents the sample width, measured in centimeters.

2.4.4 Testing the Resistance of Particle Board to Termite Attacks

The goal of this study is to find out how easy it is for termites to get into particle board using the JIS K 1571 method in line with the SNI 01-2707-2006 standard and equation 4 for analysis. Mass loss assessment is a technique utilized to evaluate the susceptibility of particle boards to termite infestation by quantifying the reduction in mass of the boards. The experimental procedure entails the measurement of the initial weight of the particle board, followed by its exposure to termites. Subsequently, the final weight of the particle board is determined, allowing for the computation of the percentage of weight loss. A positive correlation exists between increased mass loss and heightened susceptibility to termite infestation. Based on the degree of weight reduction, Table 3 categorizes the susceptibility of wood to dry wood termites.

$$W(\%) = \frac{(w1 - w2)}{w1} x\ 100 \tag{4}$$

The variable W represents the percentage loss of sample weight, $w1$ = Sample weight before testing (grams) and $w2$ = Sample weight after testing (grams).

3. RESULTS AND DISCUSSION

3.1 Particle Board Density Test Results

The objective of density testing is to determine the density of a particle within specific volumes. Calculating the aggregate mass by the mean volume results in the density of a material. A urea formaldehyde matrix was used to do a density analysis on particle board made from bintaro seeds. The results are shown in Figure 2. The density range of the resultant particle board is 1.299-1.491 g/cm³. Sample 4 exhibits the lowest density of particle board, characterized by a composition ratio of 80%:20% and a density of 1.299 g/cm³. Conversely, sample 1 demonstrates the greatest density value among the particle board samples, including a composition ratio of 50%:50% and a density of 1.491 g/cm³.

Figure 2 illustrates a positive correlation between the density value and the quantity of matrix while displaying an inverse relationship with the quantity of filler. The increase in the density of particle board is observed when there is a higher proportion of matrix material and a lower amount of filler material. These phenomena can be attributed to the subsequent variables [14] and [15]. The matrix demonstrates a greater density in comparison to the filler material. The matrix of a composite material is typically composed of materials with higher hardness, such as resins or adhesives, whereas the filler component often consists of elements with lower density. As a result, increasing the amount of matrix material while decreasing the amount of filler material will result in an increase in the overall density of the particle board. Increasing the volume of the matrix requires a proportional increase in the amount of adhesive or glue used during the manufacturing process. The density of particle board is subject to the influence of glue content, with an observed correlation between higher levels of glue content and increased density in the boards [16] and [17].

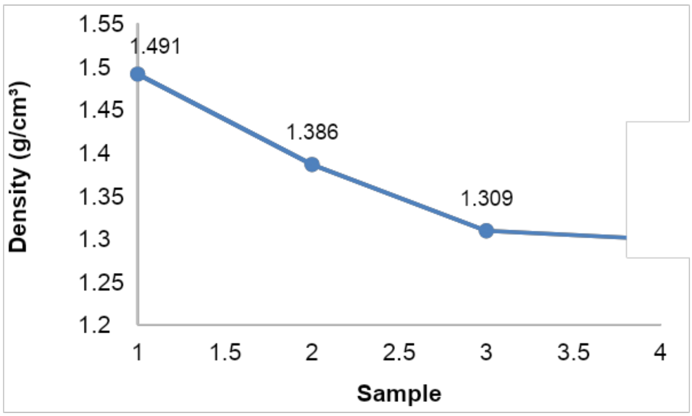


Figure 2. Graph of Particle Board Density Test Results

3.2 Particle Board Moisture Content Test Results

The moisture content test is a technique employed to ascertain the quantity of water contained within a given sample of particle board. The experimental procedure involves subjecting the sample to thermal treatment within an enclosed chamber, facilitating the elimination of any moisture present. Subsequently, the sample is weighed both prior to and after the thermal treatment, enabling the determination of the proportion of moisture content as a percentage. The moisture content of particle board can be defined as the quantity of water that can be extracted from the board through the application of heat in an oven [18].

The findings from the conducted tests indicate that the moisture content of particle board varies between 0.94% and 1.16%. According to the findings depicted in Figure 3, it can be observed that the moisture content of all particle board samples examined in this investigation was found to be below the threshold of 14%. In brief, the presence of a moisture content below 14% in a particle board signifies that it has undergone a drying procedure aimed at diminishing its water content. This leads to a reduced moisture level, which is advantageous for its physical and mechanical characteristics. The decrease in moisture content can additionally enhance the density of the particle board, thereby enhancing its structural integrity and longevity.

The moisture content of particle board is a significant variable that impacts both the production procedure and the characteristics of the board. The optimal moisture content is contingent upon various parameters, including the shape and density of the wood. The optimal strength of the board is achieved when the moisture content falls within the range of 8 to 12 percent at the interface of the particles. Surface roughness, wettability, and formaldehyde emission are just a few examples of how a particle board's moisture content can affect its physical and mechanical characteristics. Excessive or inadequate levels of moisture in the supply might lead to problematic functioning and the production of substandard boards [19].

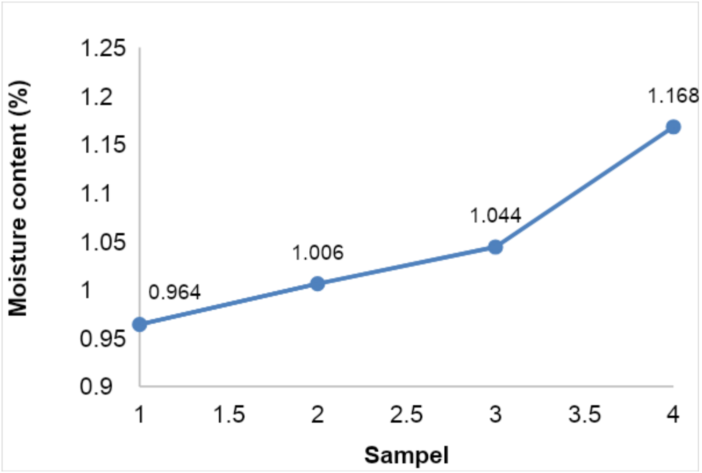


Figure 3. Graph of Particle Board Moisture Content Test Results

3.3 Particle Board Flexural Strength Test Results

The flexural strength test graph depicted in Figure 4 illustrates that sample 1 had the highest flexural strength value among the tested samples. This sample had a composition consisting of 80% matrix and 20% filler fractions, resulting in a flexural strength value of 29.469 Kgf/cm^2. The sample with a matrix and filler fraction of 50%:50%, namely sample 4, had the lowest flexural strength value of 4.377 Kgf/cm^2. In general, the flexural strength values obtained from the research test findings fail to comply with the standard specified in SNI 03-2105-2006.

There exists a positive link between the rise in flexural strength and the augmentation of the mass percentage of the particle board matrix. The relationship between the variables can be elucidated based on the search results provided. The relative proportion of matrix material to fiber reinforcement is a critical factor in influencing the mechanical characteristics of composite materials.

The flexural strength of fiber-reinforced composites, such as particle boards, can be improved by increasing the mass percentage of the matrix [20]. This phenomenon occurs due to the matrix's ability to distribute a portion of the given stress to the particles, resulting in the particles sharing the load.

Empirical investigations have demonstrated that there exists a positive correlation between the mass percentage of the matrix and the flexural strength and flexural modulus of composites. In a particular investigation, it was shown that the composite exhibiting the greatest flexural strength and flexural modulus possessed a matrix composition of 64.9% [21].

Getting the best results when making particle boards depends on using certain matrix-to-fill ratios in the best conditions. For the fruit bunch, it was determined that the ideal conditions corresponded to a matrix-to-filler ratio of 50:50 [22]. This implies that maintaining an appropriate proportion between the matrix and filler materials can potentially enhance the flexural strength [23].

In summary, augmenting the mass percentage of the particle board matrix typically results in a corresponding augmentation in flexural strength. The matrix assumes a crucial function in the transmission of stress to the particles, and determining the ideal ratio between the matrix and filler is of utmost significance in attaining desirable qualities. However, it is important to note that the relationship between mass fraction and flexural strength can change depending on the ingredients and manufacturing process of the particle board.

The mechanical strength inadequacies of particle board can be attributed to the presence of excessively fine filler particles for the following reasons:. The bonding strength is reduced when dealing with small particles due to their increased surface area, necessitating a greater amount of adhesive for effective adhesion. Nevertheless, the surplus adhesive has the potential to induce brittleness and weakness in the board, resulting in a reduction in bonding strength. The introduction of fine particles into the board can result in a reduction in its overall density as these particles are able to occupy the empty spaces between larger particles. This phenomenon may result in diminished mechanical strength, including reduced resistance to screw removal and decreased internal bond strength [24]. Reduced load-bearing capacity: Research has indicated that coarse particles exhibit superior characteristics compared to fine particles, particularly in relation to load-bearing capabilities. This phenomenon can be attributed to the fact that coarse particles possess a greater aspect ratio, resulting in an increased surface area available for adhesive interaction [25]. In summary, the inclusion of overly small filler particles in particle board might result in mechanical strength deficits because of diminished bonding strength, decreased density, and reduced load-bearing capacity. The consideration of particle size and composition plays a crucial role in the manufacturing process of particle board, as it directly impacts the quality of particle bonding and the resulting mechanical qualities.

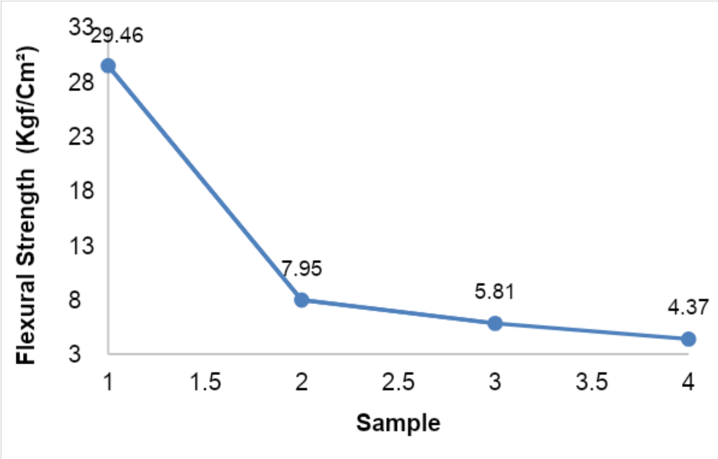


Figure 4. Graph of Particle Board Flexural Strength Test Results

3.4 Particle Board Resistance to Termite Attacks Results

The susceptibility of particle board to termite infestation significantly impacts the structural integrity of the material. The experiment involved assessing the durability of particle board against termite infestation over a period of three weeks. However, it was seen that the termites had perished by the twelfth day of the experiment. According to the data presented in Figure 5, the resistance of particle board against termite attacks was assessed over a period of 12 days, resulting in a range of 2.62% to 6.62%. The particle board weight loss is highest when 50% bintaro seeds and 50% urea formaldehyde resin are used together, resulting in a 6.62% weight loss on average. The variation consisting of 80% bintaro seeds and 20% urea formaldehyde resin exhibits the lowest average particle board weight loss, with a recorded value of 2.62%. This can be attributed to the higher proportion of bintaro seeds present in this variation, accounting for 80% of the composition.

According to the findings of the inquiry, it has been observed that bintaro seeds contain certain compounds such as oleic acid, flavonoids, and the glycoside cerberin, which exhibit insecticidal properties against termites[5]. Termites are eusocial insects that reside in a communal setting and possess the capability to inflict substantial harm onto wooden edifices and furnishings. There exist several potential factors that may contribute to the aversion of termites towards the constituents present in bintaro seeds[26]. The potential lethality of these chemicals can result in mortality or act as a deterrent for termites in their consumption of the wood substrate. It is possible that these compounds possess properties that deter termites, thereby reducing the likelihood of infestation in wooden constructions.

Oleic acid from bintaro seeds has been shown to kill termites, specifically Coptotermes gestroi, which are subterranean termites. The toxicity of oleic acid is said to have the potential to induce mortality or act as a deterrent for termites in their consumption of wood. Bintaro seeds are known to possess toxic and fatal chemicals, specifically the glycoside cerberin, which has the potential to cause injury to termites. The potential lethality of these chemicals can result in mortality or act as a deterrent for termites in their consumption of wood. Flavonoids, including as quercetin, are abundantly present in bintaro and possess potential as an agent for termite control[27].

The composition of filler materials in particle boards in this study can influence their properties. The utilization of bintaro fruit seeds as a filler material for particle boards has been proven to enhance their termite-resistant properties. The presence of cerberin glycosides and flavonoids such as quercetin in bintaro seeds exhibits insecticidal activity against termites [28].

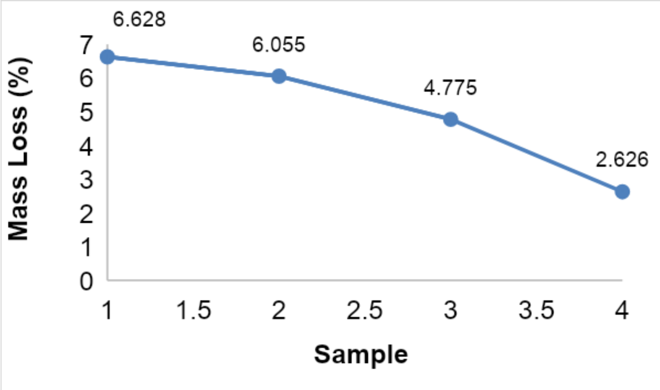


Figure 5. Graph of Mass Loss Test Results on Particle Board Resistance to Termite Attack

Table 3. Results of Calculation of Resistance to Termites

Sample	Mass Loss (%)	Level resistant	Kelas
1	6,628	Moderate	III
2	6,055	Moderate	III
3	4,775	Moderate	III
4	2,626	High	II

4. CONCLUSION

The incorporation of bintaro fruit seeds as a filler material in particle board has the potential to enhance its resistance against termite infestation. Based on the study, a matrix filler ratio of 50:50 was found to be the best way to get particle boards made from bintaro fruit seeds with good properties. The physical features of anti-termite particle board derived from bintaro fruit seeds were evaluated, specifically in terms of density and water content. The results of the testing indicate that the particle board meets the criteria outlined in the SNI 03-2105-2006 standard. The minimum acceptable density range according to the standard is 0.40–0.90 gr/cm3, which is satisfied by the particle board. Additionally, the moisture content of the particle board does not exceed the permissible limit of 14%.

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