International Journal of Polymer and Plastics Technology (IJPLAST)
Volume 02, Issue 01, April 2026, pp. 34-44
DOI:

Utilization of Polypropylene (PP) Waste as a Matrix Material Reinforcement From Empty Palm Oil Fruit Fruit (EFB) Fiber Waste For Composite Board Products

DTM Ahza Yadiy[1*], Syamsul Bahri[1] , Agam Muarif[1,2], Zulnazri[1,2], Rizka Nurlaila[1,2]

[1] Department of Chemical Engineering, Faculty of Engineering, Universitas Malikussaleh, Lhokseumawe, Aceh, Indonesia
[2] Center of Excellence of Technology Natural Polymer and Recycle Plastics Universitas Malikussaleh, Kampus Bukit Indah, Lhokseumawe, Indonesia
[*] E-mail addresses: ahza.190190039@mhs.unimal.ac.id

ARTICLE INFO

Article history:
Received March 02 2026
Revised March 11, 2026
Accepted March 20, 2026
Available online April 30, 2026

Kata Kunci:
Komposit, Resin, serat serabut kelapa, uji tarik, uji impact.

Keywords:
Composite, Resin, coconut fiber, tensile test, impact test.

IJPLAST Journal *is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License*

ABSTRAK

Penelitian ini pemanfaat limbah polypropilene (pp) sebagai matrik berpenguat limbah fiber tandan kosong kelapa sawit (tkks) untuk produk papan komposit. Diharapkan komposit yang diperkuat dengan serat tandan kosong kelapa sawit akan menunjukkan peningkatan sifat mekanik yang baik dan sebagai produk material alternatif. Penelitian ini terdiri dari empat tahap yaitu persiapan limbah PP dan serat tandan kosong kelapa sawit, perendaman menggunakan xylen+BPO (PP) dan NaOH 5% (serat), pembuatan komposit menggunakan mesin hot press, dan pengujian mekanik (tarik, impak, dan daya serap air) pada komposit. Orientasi serat pada penelitian ini adalah acak dengan masing-masing variasi fraksi volume ialah 90:10, 80:20, 70:30, dan 60:40. pengujian yang dilakukan yaitu uji tarik, uji impak, daya serap air dan pengamatan mikroskopik. Uji tarik menggunakan standard ASTM D638 type IV, uji impak menggunakan standard ASTM D256-03. Hasil yang didapat pada penelitian ini ialah nilai kuat tarik tertinggi didapatkan pada perendaman 4 jam dengan variasi komposisi 50:50 dengan nilai kuat tarik 16,889 MPa, dan nilai kuat impak tertinggi didapatkan pada orientasi horizontal variasi 60:40 dengan nilai tenaga impak 32,762 Joule. alkalisasi dan variasi komposisi sangat mempengaruhi nilai kekuatan pada material komposit dikarenakan serat berfungsi menahan beban pada komposit.

ABSTRACT

This study utilizes polypropylene (PP) waste as a reinforced matrix of empty oil palm fruit bunches (EFB) fiber waste for composite board products. It is expected that composites reinforced with empty oil palm fruit bunches fiber will show good mechanical properties and as an alternative material product. This study consists of four stages, namely preparation of PP waste and empty oil palm fruit bunches fiber, soaking using xylene + BPO (PP) and 5% NaOH (fiber), making composites using a hot press machine, and mechanical testing (tensile, impact, and water absorption) on the composite. The fiber orientation in this study is random with each variation of the volume fraction being 90:10, 80:20, 70:30, and 60:40. The tests carried out are tensile tests, impact tests, water absorption and microscopic observations. Tensile tests use ASTM D638 type IV standards, impact tests use ASTM D256-03 standards. The results obtained in this study are the highest tensile strength value obtained at 4 hours of immersion with a composition variation of 50:50 with a tensile strength value of 16.889 MPa, and the highest impact strength value obtained at a horizontal orientation variation of 60:40 with an impact strength value of 32.762 Joules. Alkalization and composition variations greatly affect the strength value of the composite material because the fiber functions to withstand the load on the composite.

1. INTRODUCTION

The processing of empty oil palm fruit bunches (EFB) into useful materials has been widely practiced. Empty oil palm fruit bunches can be used as raw material for organic fertilizer (J. Warsito, 2017). Empty oil palm fruit bunches can also be processed into charcoal briquettes, a substitute for fuel oil and firewood charcoal (Nur Amalia, 2020; Dino Ervianto, 2022). Currently, research related to the utilization of empty oil palm fruit bunches has shifted to the topic of composite materials. Composites are materials consisting of two or more materials, each with distinct properties. (M. Khayati, 2020)

Plastic is widely used in everyday life, resulting in rapid growth in modern plastic use. Plastic offers advantages such as strength, lightness, and stability, but it is very difficult for microorganisms to decompose. Propylene (PP) is the most commonly used plastic. Polypropylene (PP) plastic is a type of plastic that is often used in everyday life because it has good mechanical properties with low mass, heat and moisture resistance and has quite good dimensional stability (Gunawan, 2017).

Today's technology often utilizes environmentally friendly and back-to-nature concepts. Composites are one such environmentally friendly and back-to-nature technology. This is because these composites don't produce waste that can harm the environment, but instead utilize unused oil palm bunches as a raw material. One of the ingredients in these composites is derived from plants or plant fibers as reinforcement, while the matrix is a polymer. The purpose of using composites is to utilize oil palm bunch waste.

Composites

Composite is a new type of engineered material consisting of two or more materials where the properties of each material are different from each other, both chemically and physically, and remain separate in the final result of the material (composite material). Due to the differences in the constituent materials, the composite between materials must be strongly bonded, so it is necessary to add a wetting agent. The purpose of the composite is to improve mechanical properties, simplify difficult designs in manufacturing, flexibility in shape/design that saves costs and makes the material lighter.

Empty Oil Palm

Oil palm, as a plant that produces crude palm oil (CPO) and palm kernel, is one of the leading plantation crops and a source of non-oil and gas foreign exchange for Indonesia (Nasrul, 2009). The oil palm (Elaeis guineensis Jack.) is a plantation crop that plays an important role in the food industry. Palm oil production in Indonesia in 2011 increased compared to the previous year, reaching 22,508,011 tons (BPS 2012). Processing oil palm into palm oil produces several types of solid waste, including empty fruit bunches, shells, and mesocarp fiber (Yunindanova et al., 2013).

Empty oil palm bunches (EFBs) can be used as a source of organic fertilizer because they contain essential nutrients for plants. Empty oil palm bunches account for 23% of the total palm oil waste, and utilizing them as an alternative organic fertilizer offers other economic benefits. Oil palm farmers can save up to 50% on synthetic fertilizers compared to organic fertilizers (Fauzi et al., 2002).

Figure 1. Empty oil palm

Polypropylene (PP) Plastic

Polypropylene (PP) is a polymer formed from repeating propene monomers, with the structural formula (CH2=CH-CH3) (Barleany et al. 2011). Polypropylene (PP) consists of C and H elements, therefore it has non-polar properties. Each polypropylene repeat unit has a carbocation on the tertiary carbon which is very stable, so that the H atom bound to the tertiary carbon is reactive and non-polar. PP has a non-polar active group as a reaction center, namely tertiary C (Suharty et al. 2008). The non-polar nature of PP makes it difficult to dissolve in water, but PP can be dissolved in 66% boiling toluene and 100% boiling xylene (Suharty & Al-Malaika, 1995).

Figure 2. Polypropylene Plastic Waste

Tensile Testing

Tensile strength is the maximum tensile force a film can withstand. Tensile strength is the maximum stress achievable on a stress-strain diagram (Ardiansyah, R, 2011). This parameter describes a structure's ability to withstand loads without damage. Damage can occur due to rupture caused by excessive pressure or possibly structural deformation (Anggarini, F, 2013).

Tensile testing is performed to determine the tensile strength of composite materials. Testing is performed using a Universal Testing Machine. Tensile test specimens are formed according to the ASTM D 638 Type 04 standard, as shown in Figure 3 below:

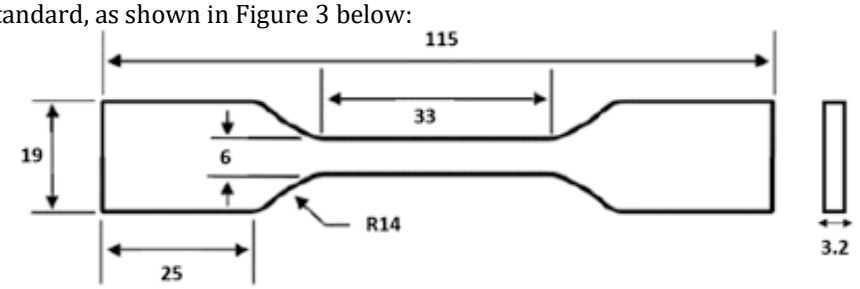

Figure 3. Specimen D 638 Type 04

Tensile testing is used to assess the strength of composite materials by applying a uniaxial force load. The results obtained from tensile testing are crucial for engineering and product design because they provide data on the material's strength. From this tensile testing, we can determine several mechanical properties of the material, which are essential in engineering design. The linear relationship between stress and strain can be seen in the equation below:

Voltage formula:

$$\sigma = F/A \quad (1)$$

Strain formula:

$$\varepsilon = \Delta L/Lo\ x\ 100\% \quad (2)$$

Modulus of elasticity formula:

$$E = \sigma/\varepsilon \quad (3)$$

Impact Test

Impact testing is a test that uses rapid loading and is conducted to determine the strength or measure a material's ability to withstand mechanical or shock loads. Impact strength is a type of mechanical strength. Imron (2010) states that impact testing generally aims to measure the ductility and brittleness of a material under shock loads. The impact test uses the Charpy impact test method. The Charpy impact test principle aims to determine the level of resistance or toughness of a material, and the test is conducted on a machine according to ASTM D 256-03. This can be seen in Figure 4 below.

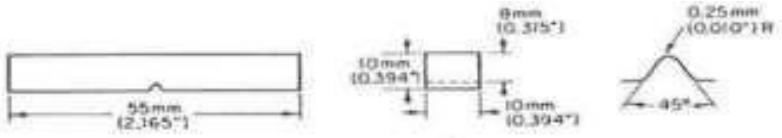

Figure 4. Impact Test Specimen

The breaking force is the pendulum lifted at an angle of less than 150°C, thus generating potential energy. To calculate the energy absorbed by the material, use the following potential energy equation:

Broken power formula:

$$(W) = m.\,r\,(\cos\beta - \cos\alpha) \quad (4)$$

Impact Price:

$$W/A = \quad (5)$$

Water Absorption Test

Water absorption is a critical factor in determining a film's biodegradability when used as packaging. Some films require high solubility, while others require low solubility, depending on the type of product being packaged (Rachmawati, 2009). Measuring water absorption is crucial to achieving the desired bioplastic quality. Mathematically, the percentage of water absorption (water uptake) can be calculated using the following equation:

$$\text{Absorbed water (\%)} = ((w - w0)/w0) \times 100\% \quad (6)$$

w = wet bioplastic weight

$w0$ = dry bioplastic weight

Volume fraction

In the composite manufacturing process, one of the things that must be done before starting the composite manufacturing process is to determine and calculate the composition of the matrix and fiber to

be used. The ratio between the matrix and fiber will determine the mechanical characteristics of the composite (Matasina, ddk 2014). To obtain a high-strength composite, the distribution of the matrix fiber must be even during the mixing process to reduce the formation of voids. To calculate the volume fraction, the parameters that must be known are the specific gravity of the resin, the specific gravity of the fiber, the weight of the composite, and the weight of the fiber. The fiber volume fraction can be calculated using the following equation:

Determining the volume of the composite mold :

$$Vc = (P \; x \; L \; x \; T) \quad (7)$$

Fiberless composite volume :

$$Vm = Vc \; x \; \rho m \quad (8)$$

Composite volume without matrix :

$$Vs = Vc \; x \; \rho s \quad (9)$$

Determine the volume of the composite :

$$Vk = (\%\; serat \; x \; Vs) + (\%\; matrik \; x \; Vm) \quad (10)$$

Microscopic Observation

Microscopy is the process of viewing and analyzing the structure of a material at a microscopic scale using tools such as an optical microscope, digital microscope, or electron microscope. In the context of composite material testing, microscopy aims to understand the internal characteristics of the material that cannot be seen with the naked eye.

The primary function of microscopy in testing is to evaluate the quality and structural integrity of the material. For example, in the composite manufacturing process, microscopy can be used to ensure that fibers are evenly distributed and that there are no agglomerations or voids that could reduce the material's strength. Furthermore, microscopy also plays a crucial role in failure analysis, namely identifying the type and cause of damage in composites, such as cracks due to mechanical loading or thermal degradation.

2. METHOD

This research will be conducted at the Materials Engineering Laboratory, Chemical Engineering, Malikussaleh University from August to September 2025.

Tools in Research

The equipment used in preparing the samples in this study included several main tools, namely a digital scale that functions to measure the mass of materials with high accuracy, as well as a measuring cup used to measure the volume of additional materials if needed. A hot plate was used to assist the heating process of the materials so that they are easily processed and mixed well. Scissors function to cut fibers or materials to the desired size. Two types of iron molds were used in this study, each measuring 15 x 17 x 0.3 cm and 3.5 x 6 x 1 cm, respectively, as containers for forming composite samples. The mixing and forming process of the material was carried out using an extruder to ensure material homogeneity. After that, the resulting samples were tested using a tensile testing machine to determine the mechanical strength of the material that had been made.

Material in Research

The materials used in this study consist of several main components, namely empty oil palm fruit bunches (EFB) fiber which functions as a composite reinforcing material, and polypropylene (PP) waste which is used as a matrix or base material. To increase the adhesive power between the fiber and the matrix, a 5% NaOH solution is used as a pretreatment (alkalization) for the EFB fiber. In addition, the chemical BPO (Benzoyl Peroxide) is used as an initiator in the mixing process or chemical reaction that occurs during the manufacture of the composite. Xylene acts as a solvent that helps soften the polypropylene so that it is easily mixed with the fiber, while the lubricant is used to facilitate the molding process and prevent the material from sticking to the mold during the composite sample manufacturing process.

Composite Manufacturing

The initial processing of empty oil palm fruit bunches (EFB) involves collecting the EFB from plantations and cleaning them of dirt and dust. The EFB is soaked in a 5% NaOH solution to reduce lignin, washed with hot water, dried for 24 hours, and cut into approximately 3 cm pieces.

The composite pellet production process begins with sorting plastic waste containing polypropylene (PP), washing, drying, and cutting it into 1 cm pieces. Next, a solution of 0.1 gram of BPO is prepared in 100 ml of xylene heated to 100°C. Then, 20 ml of the solution is mixed with the PP. The EFB and PP mixture is then processed using an extruder until homogeneous, producing composite pellets.

The composite production process involves placing the pellet and EFB mixture into an ASTM-compliant mold and pressing it at 160°C for 10 minutes without pressure, followed by a press of 10 kg/m^2. The process is repeated for each composition variation, and the resulting samples are cut to ASTM standards for testing purposes.

Table 1. Research design

Volume Fraction (%) PP : Fiber	Immersion in NaoH (5%)
100 : 0	
70 : 30	2 Hours
60 : 40	
50 : 50	
40 : 60	
30: 70	
70 : 30	4 Hours
60 : 40	
50 : 50	
40 : 60	
30: 70	

3. RESULT AND DISCUSSION

Result

Mechanical properties are properties that indicate the ability to withstand loads, forces, or energy. The mechanical properties of a material reflect the relationship between the load and energy received by a material and the resulting reaction or deformation. Mechanical properties are divided into several properties, including strength, stiffness, elasticity, hardness, fatigue, toughness, plasticity, and creep-crack.

This study conducted several tests, including impact and tensile strength tests. The composites used were made from polypropylene (PP) waste and coconut fibers. The NaOH soaking ratios were 2 and 4 hours, with PP:fiber ratios of 70:30, 60:40, 50:50, 40:60, and 30:70, respectively.

Tensile Test

Tensile testing was conducted on variations of immersion of composites from a mixture of TKKS fiber and PP plastic waste. This test was conducted to determine the effect of tensile strength of the two types of immersion with a predetermined volume fraction. The test was conducted on Wednesday, October 6, 2025, in the mechanical engineering laboratory of Malikussaleh University. The number of specimens tested was 11 specimens, where each variation had 2 specimens to be tested. The shape of the specimens that had been tested can be seen in Table 2.

Table 2. Tensile Test Results on Composites

Volume Fraction (%) PP : Fiber	Immersion in NaoH (5%)	Tensile Stress (MPa)	Strain (%)	Modulus of Elasticity (MPa)
100 : 0		8,717	4,73	1,842
70 : 30	2 Hours	5,992	5,43	1,103
60 : 40		9,806	6,34	1,546
50 : 50		14,165	7,85	1,804
40 : 60		11,441	6,61	1,730
30: 70		7,082	5,76	1,229
70 : 30	4 Hours	9,261	6,91	1,340
60 : 40		14,709	13,31	1,105
50 : 50		16,889	7,44	2,270
40 : 60		14,709	11,99	1,226
30: 70		10,896	9,07	1,201

Table 3. Impact Test Results on Composites

Volume Fraction (%) Resin : Fiber	Immersion in NaoH (5%)	Degree		Broken Power (joule)	Impact Price (joule/mm2)
		α	ß		
100 : 0		160	150	6,858	0,0857
70 : 30	2 Hours	160	134	22,812	0,2851
60 : 40		160	132	25,189	0,3148
50 : 50		160	138	18,298	0,2287
40 : 60		160	141	15,133	0,1891
30: 70		160	144	12,165	0,152

70 : 30		160	129	28,895	0,3611
60 : 40		160	126	32,762	0,4095
50 : 50	4 Hours	160	131	26,406	0,33
40 : 60		160	134	22,812	0,2851
30: 70		160	139	17,221	0,2152

Table 4. Water Absorption Test Results

Volume Fraction (%) Resin : Fiber	Immersion in NaoH (5%)	Specimen Weight (Gram)		Water Absorption Capacity (%)
		Initial weight	Final Weight	
100 : 0		1,017	1,02	0,294
70 : 30		0,929	0,950	2,260
60 : 40		1,033	1,091	5,614
50 : 50	2 Hours	1,02	1,080	5,882
40 : 60		0,969	1,030	6,295
30: 70		1,193	1,275	6,873
70 : 30		1,333	1,34	0,525
60 : 40		1,068	1,105	3,464
50 : 50	4 Hours	1,027	1,083	5,452
40 : 60		1,077	1,141	5,942
30: 70		1,36	1,448	6,470

Discussion

Table 2 shows that the tensile strength values obtained ranged from 5.992 MPa to 16.889 MPa. A bar chart for the comparison of tensile strengths can be seen in Figure 5.

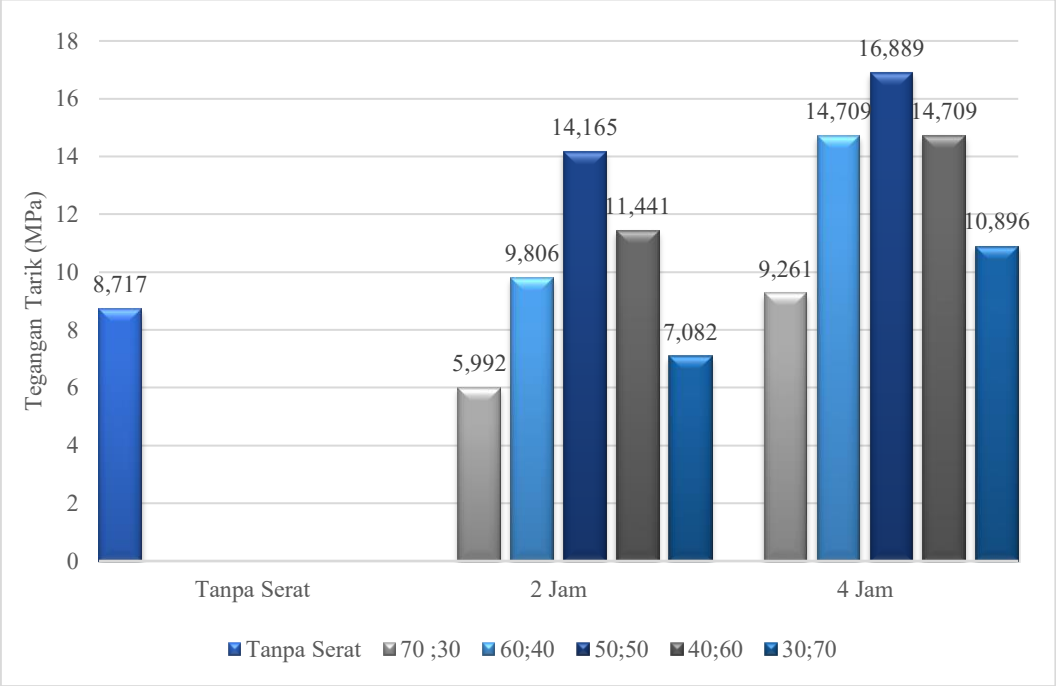

Figure 5. Comparison Line Diagram of Tensile Strength from Tensile Test Results

Based on the tensile strength test results, the addition of empty oil palm fruit bunches (OPEFB) fiber with random orientation to the polypropylene (PP) matrix significantly affects the mechanical properties of the composite. The tensile strength value of pure PP is only 8.717 MPa, but increases to 9.261 MPa in the composition of 70% PP: 30% fiber with 4 hours of alkali immersion. The highest increase occurs in the composition of 50% PP: 50% fiber, which reaches 16.889 MPa, indicating optimal stress distribution and interfacial bonding between the matrix and fiber. Conversely, in the composition with excess fiber (30% PP: 70% fiber), the tensile strength decreases due to fiber agglomeration and a decrease in the matrix's ability to coat the fiber evenly, thus inhibiting stress transfer efficiency.

Table 2 shows that the strain/elongation values obtained ranged from 4.73% to 13.31%. The bar chart for the strain/elongation comparison can be seen in Figure 6.

.

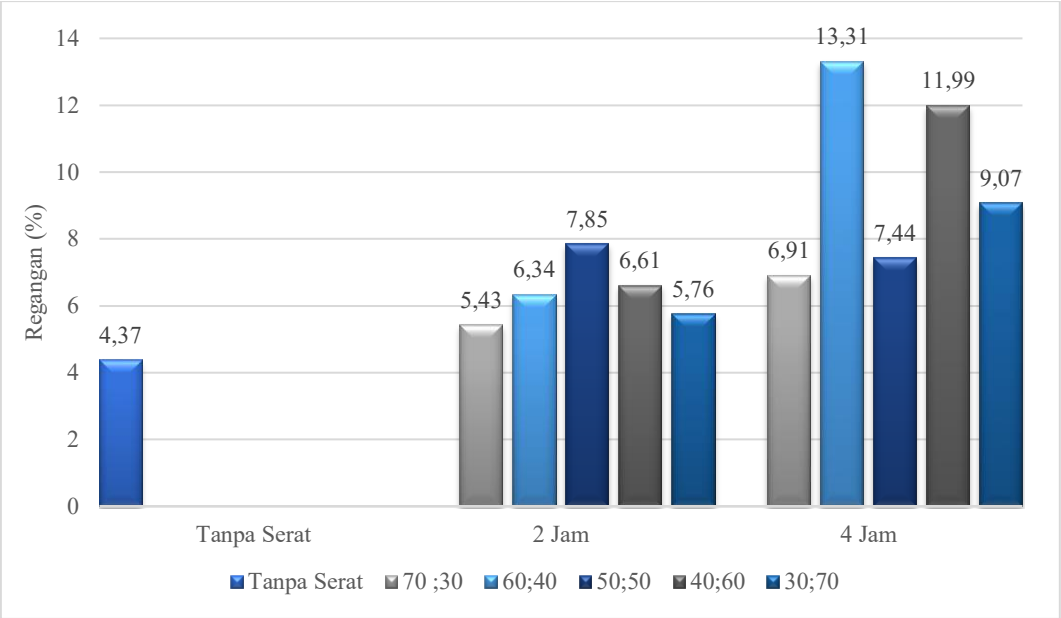

Figure 6. Strain Comparison Line Diagram from Tensile Test Results

Based on the results of the strain test, the addition of empty oil palm fruit bunches (OPEFB) fiber and alkali treatment significantly affected the elasticity of polypropylene (PP) composites. The strain value of pure PP was 4.37%, increasing to 6.91% at a composition of 70% PP: 30% fiber with a 4-hour soaking time. The highest strain was achieved at a composition of 60% PP: 40% fiber, which was 13.31% after a 4-hour soaking time, indicating even fiber distribution and good interfacial bonding. Alkali treatment (NaOH) increased the roughness of the fiber surface and strengthened the adhesion between the fiber and the matrix, so that the stress was more evenly distributed and the material was able to withstand longer. However, at a high fiber composition (30% PP: 70% fiber), the strain decreased due to increased stiffness and the possibility of cracks between the fibers. Overall, a fiber ratio of 60% PP: 40% fiber and a 4-hour soaking time provided the best elastic properties in the composite.

Table 2. shows that the elastic modulus values obtained ranged from 1.103 MPa to 2.270 MPa. A bar chart for the comparison of elastic modulus can be seen in Figure 7.

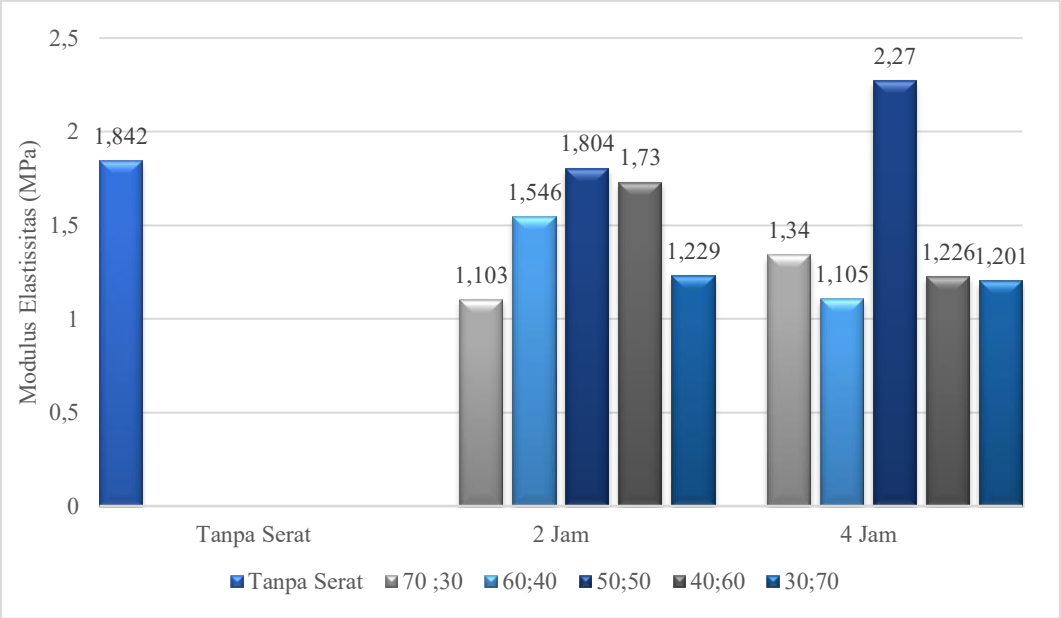

Figure 7. Line Diagram of Comparison of Elastic Modulus of Tensile Test Results

Based on test results, the addition of empty oil palm fruit bunches (OPEFB) fiber and alkali treatment significantly affected the elastic modulus of polypropylene (PP) composites. For the pure PP sample, the modulus value was 1.842 MPa, indicating the material's baseline stiffness. After the addition of OPEFB fiber and two hours of alkali treatment, stiffness increased, with the highest value being 1.804 MPa for the 50% PP:50% fiber composition, indicating good mechanical interaction between the fiber and matrix. However, excessive increases in fiber fraction resulted in a decrease in the modulus due to uneven

fiber distribution and the formation of voids, which reduced the composite's ability to withstand elastic deformation.

A longer alkali treatment, lasting four hours, significantly increased stiffness, particularly for the 70% PP:30% fiber composition, which achieved the highest modulus value of 2.27 MPa. This was due to the removal of lignin and hemicellulose from the fiber surface, which increased roughness and strengthened the interfacial bond between the fiber and matrix. Although random fiber orientation makes the stiffness increase not as optimal as unidirectional orientation, the test results still show that chemical treatment and the right fiber ratio can increase the material's ability to withstand elastic strain.

The toughness of a composite can be determined using an impact test, which measures the toughness or ability of a composite material to absorb energy before breaking (toughness). A comparison of the fracture strength values from the impact test results on 11 samples is presented in Figure 10, while the ductility values from the impact test results are presented in Figure 9.

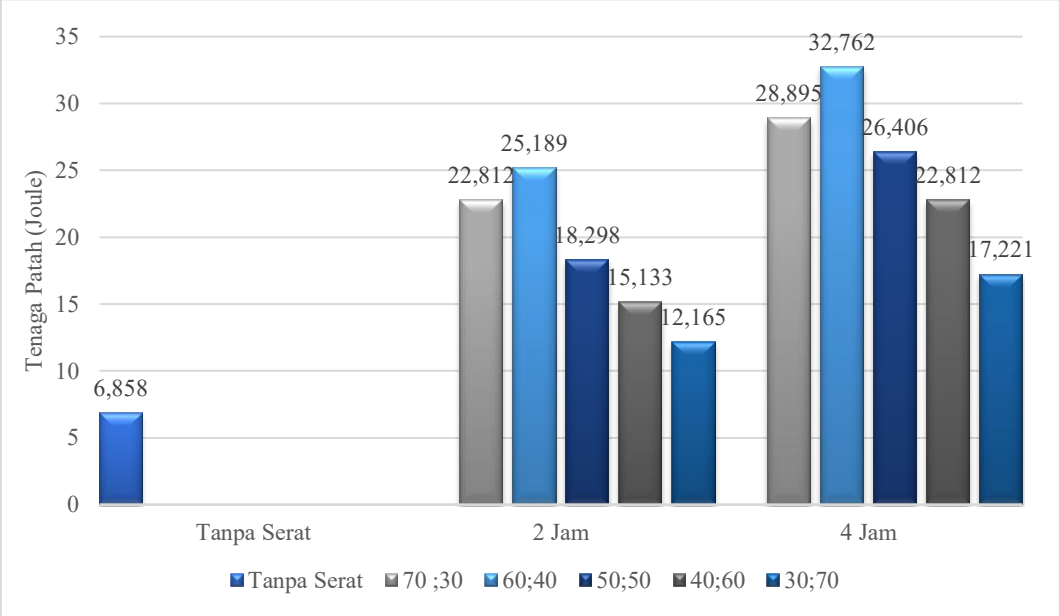

Figure 8. Comparison Line Diagram of Impact Energy from Impact Test Results

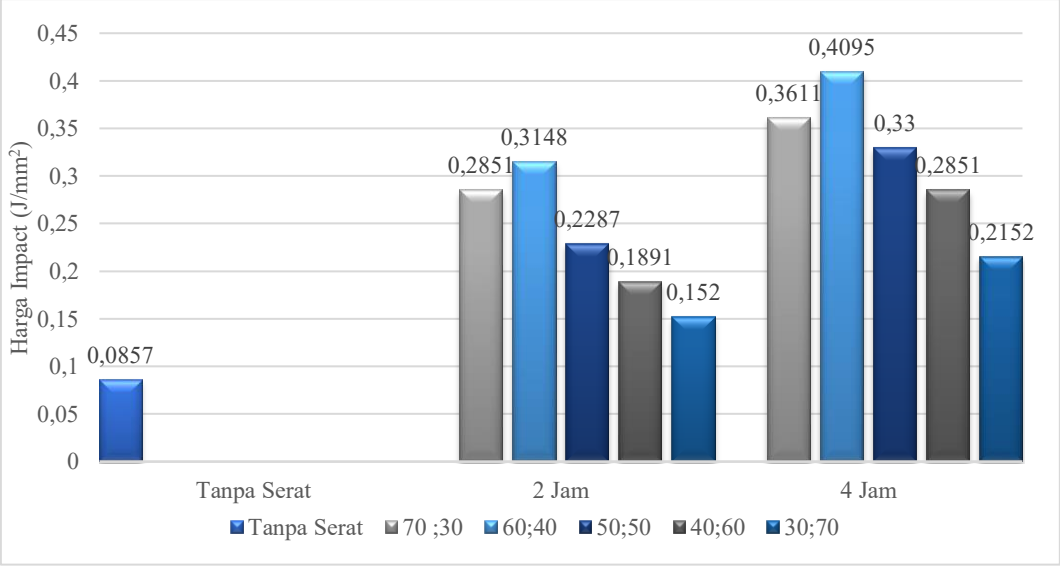

Figure 9. Comparison Line Diagram of Impact Price from Impact Test Results

Based on impact test results of polypropylene (PP) composites reinforced with empty oil palm fruit bunches (OPEFB) fibers with random orientation, the addition of fibers significantly increased the material's toughness. Pure PP only had a fracture strength of 6.858 Joules (0.0857 Joules/mm^2), indicating brittleness and low energy absorption capacity. After fiber addition, particularly in a 60% PP:40% fiber composition, the fracture strength increased sharply to 25.189 Joules (0.3148 Joules/mm^2) after a 2-hour alkali immersion and reached 32.762 Joules (0.4095 Joules/mm^2) after a 4-hour immersion. This increase

is due to the alkali treatment, which removes lignin and hemicellulose, thereby improving interfacial bonding and increasing the efficiency of impact energy transfer.

However, in compositions with too high fiber content (>50%), the breaking strength value decreases due to fiber agglomeration, air cavity formation, and uneven force distribution. Random fiber orientation also limits the fiber's contribution to resisting impact energy. Overall, the composition of 60% PP: 40% OPEFB fiber with alkali treatment for 4 hours produces the best impact performance due to the balance between adhesion strength, flexibility, and optimal fiber distribution in the composite matrix.

In this study, microscopic observations were conducted using a digital microscope with a 30- In this study, microscopic observations were conducted using a digital microscope with 30 SPF. The best composite specimens of PP waste and empty oil palm fruit bunch fiber were selected, which had undergone tensile and impact tests. The following are images of the microscopic observations of tensile and impact test specimens with the highest and lowest values.

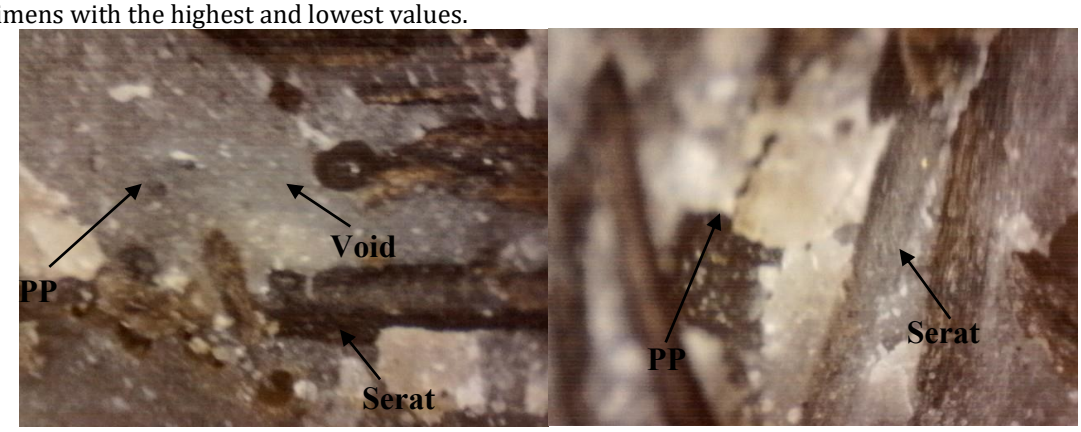

Figure 10. Micro Observation of Tensile Test Specimens with the Highest Stress Value at a 4-hour immersion variation (50:50).

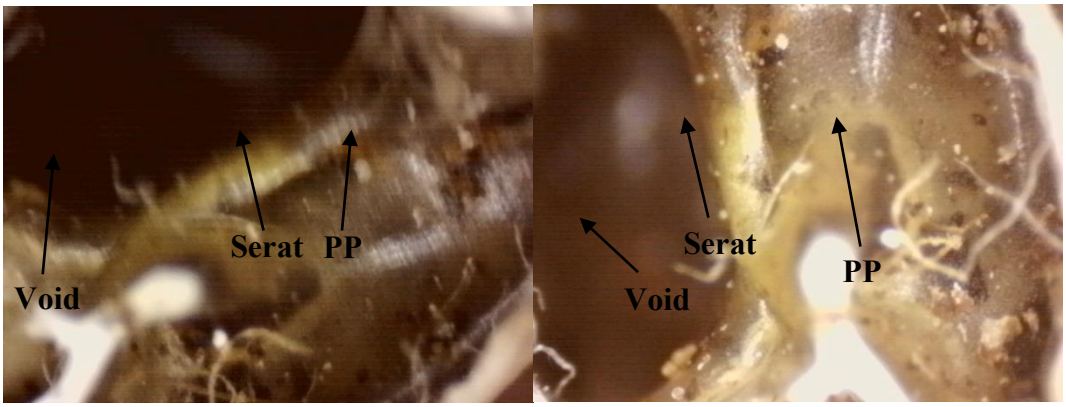

Figure 11. Micro Observation of Tensile Test Specimens with the Lowest Stress Value at 2-hour immersion variation (70:30).

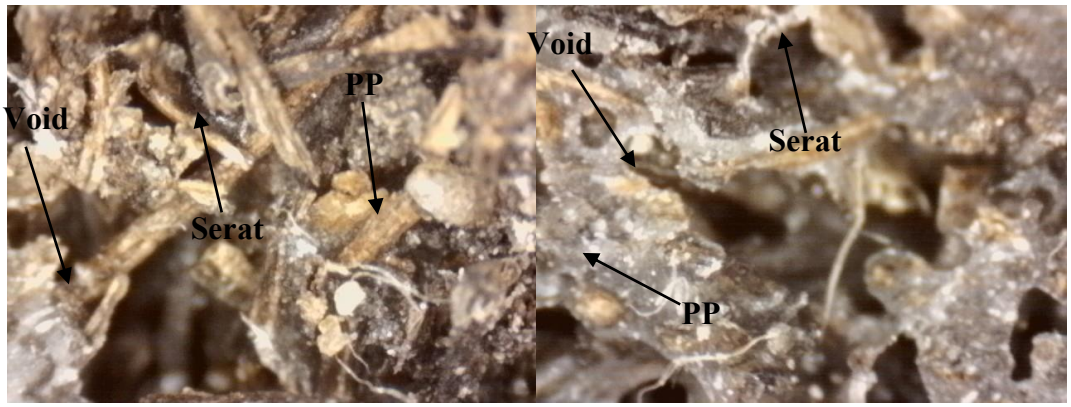

Figure 12. Micro Observation of Impact Test Specimens with the Highest Fracture Strength Values at 4-hour immersion variation (60:40).

Figure 13. Micro Observation of Impact Test Specimens with the Lowest Fracture Strength Values at 2-hour immersion variations (30:70).

Microscopic observations serve to evaluate the quality and internal structure of the composite, including fiber distribution, the presence of voids, and the bond strength between the matrix and the fibers. Based on microscopic observations of the PP–OPEFB composite, the 70:30 specimen exhibited poor interfacial bonding and voids due to uneven mixing, resulting in reduced tensile strength. Conversely, the 60:40 composition, with a 4-hour alkali immersion, exhibited homogeneous fiber distribution, strong fiber-matrix bonds, and a minimal number of voids. This resulted in a dense composite structure capable of absorbing impact energy well, resulting in the highest fracture strength.

Meanwhile, the 30:70 composition, with a 2-hour immersion, exhibited numerous air voids and weak adhesion between the fibers and the matrix. The fibers were not fully embedded, resulting in uneven impact force distribution and ineffective energy absorption. Excessive fiber dominance and short immersion times impaired the composite's homogeneity and strength. Overall, micro observations prove that the ratio of 60% PP : 40% fiber with 4 hours of immersion produces the best structure with strong interfacial bonding, few voids, and high toughness.

The data listed in Table 4.6 can be visualized in the form of a bar chart. This is done to compare the differences in water absorption parameters from the results of the water absorption test of 11 research samples tested by immersion in water for 24 hours, which can be observed in Figure 4.10.

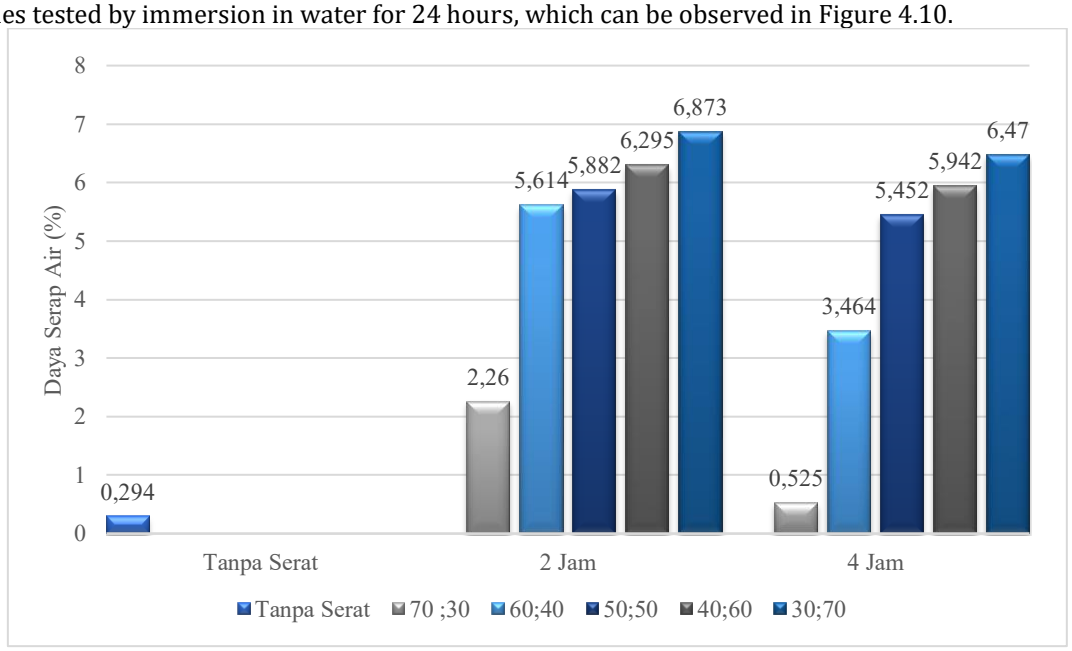

Figure 4.10 Comparison Line Diagram of Water Absorption Capacity from Water Absorption Test Results for (24 Hours)

Based on the results of water absorption tests on polypropylene (PP) and oil palm empty fruit bunch (OPEFB) fiber composites, the addition of fiber has been shown to increase the material's water absorption capacity. The pure PP sample only absorbed 0.294% of its water content due to its hydrophobic nature, while after the addition of OPEFB fiber, the absorption value increased with increasing fiber fraction. After a 2-hour soaking period, the lowest value was found in the 70:30 composition at 2.26%, and the

highest was found in the 30:70 composition at 6.873%. This increase is due to the hydrophilic nature of OPEFB fiber, which contains cellulose, hemicellulose, and lignin, which readily bind water.

After the soaking time was extended to 4 hours, water absorption increased in all variations, with the 30:70 composition remaining the highest (6.47%). This indicates that the longer soaking time and higher fiber content increase water absorption due to greater porosity. Overall, the higher the OPEFB fiber content, the higher the water absorption capacity of the composite, while a higher PP content reduces absorption due to its hydrophobic nature. Therefore, the 70% PP: 30% OPEFB composition has the best water resistance compared to other variations.

4. CONCLUSION

After conducting a series of tests on the composite of empty oil palm fruit bunches (OPEFB) and polypropylene (PP) with random fiber direction, the results showed that in the tensile test, NaOH immersion for 4 hours provided better quality than 2 hours of immersion. The highest value was found in the composition ratio of 50:50 with a maximum tensile stress of 16.889 MPa, a strain of 7.44%, and an elastic modulus of 2.27 MPa. This indicates that a balanced ratio between the matrix and fiber is able to produce good stress distribution and strengthen the interfacial bonding. In the impact test, the results showed that NaOH immersion for 4 hours also provided better quality than 2 hours, with the highest value in the 60:40 ratio, namely a fracture strength of 32.762 Joules and an impact value of 0.4095 J/mm^2. These findings indicate that the addition of OPEFB fibers increases the material's ability to absorb energy before breaking. Meanwhile, in the water absorption test, soaking in NaOH for 2 hours produced better quality than soaking in NaOH for 4 hours, with the highest value at a 30:70 ratio, with a water absorption of 6.873%. This indicates that the higher the OPEFB fiber content in the composite, the greater its water absorption.

5. REFERENCES

Al-Malaika, S., & Suharty, N. S. (1995). *Reactive processing of polyolefins using antioxidant systems*. Aston University.

Anggarini, F. (2013). *Aplikasi Plasticizer Gliserol pada Pembuatan Plastik Biodegradable dari Biji Nangka* (Skripsi). Universitas Negeri Semarang.

Badan Pusat Statistik. (2012). *Statistik Indonesia 2012 / Statistical Yearbook of Indonesia 2012*. Jakarta: BPS.

Barleany, D. R., Hartono, R., & Santoso, S. (2011). *Pengaruh komposisi montmorillonite pada pembuatan polipropilen-nanokomposit terhadap kekuatan tarik dan kekerasannya.* (daftar/workshop/abstrak yang terindeks).

Gunawan, G. (2017). *Pengembangan perangkat pembelajaran matematika SMP berbasis konstruktivisme.* PYTHAGORAS : Jurnal Matematika dan Pendidikan Matematika, 12(1), 47-56.

Imron, Ali. (2010). *Penerapan Model Pembelajaran Berbasis Masalah Dilengkapi Teknik Penilaian Learning Journal Untuk Meningkatkan Hasil Belajar Peserta Didik Kelas VII SMPN 3 Karanglewas Tahun Pelajaran 2009/2010 Materi Pokok Segiempat.* Skripsi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Semarang.

Matasina, M., Boimau, K., & Jasron, J. U. (2014). Pengaruh Perendaman Terhadap Sifat Mekanik Komposit Polyester Berpenguat Serat Buah Lontar. Teknik Mesin Undana.

Suharty, N. S. (1993). *Reactive processing of polyolefins using antioxidant systems*. PhD Thesis, Aston University.

Suharty, N. S., Wirjosentono, B., Firdaus, M., Handayani, D. S., Sholikhah, J., & Maharani, Y. A. (2008). *Synthesis of degradable bio-composites based on recycled polypropylene filled with bamboo powder using a reactive process*. J. Phys. Sci., 19, 105–115.

Yunindanova, M. B., Darsana, L., & Pradana Putra, A. (2013). *Pengaruh tingkat kematangan kompos tandan kosong sawit dan mulsa*. Sains Tanah – Jurnal Ilmu Tanah dan Agroklimatologi, 10(2), 98-103.