



# Study on the Use of Hybrid Coconut Coir Fiber with Polyester Resin Bqtn 157 as Composite Material Matrix

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## ABSTRACT

The use of natural fibers as reinforcement of composites in recent years has been developing very rapidly. The purpose of this study is to investigate the mechanical properties i.e. tensile strength, impact strength and flexural strength of composites coir fiber. In the future this material can be used for vehicle accessories, ceilings and cabinet and will be able to replace the wood, eternit, bamboo and gipsun which are high price and lower water resistance. The research material made with coconut coir fiber as reinforcement and matrix resin unsaturated polyester resin BQTN 157, with 1% hardener types MEKPO (Methyl Ethyl Ketone Peroxide) and fiber treatment by 5% NaOH. Production methods are press hand lay-up and the variations of fiber volume fraction are 0, 10, 20, and 30% Testing of mechanical properties of the composite tensile strength using standard ASTM E8 M-09.J

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## 1. INTRODUCTION

The use of natural fibers as composite reinforcement in recent years has experienced very rapid development (Sumenda, 2017). One of them is coconut fiber. The huge potential of coconut coir has not been exploited (Maryanti et al., 2019) entirely for production activities that have economic added value (Bantacut, 2013). In the absence of optimal utilization, this coconut fiber will only become waste and cause environmental problems (Astika & Dwijana, 2013). This study aims to study the mechanical properties through mechanical testing (bending) of composites reinforced with coconut fiber (Oroh et al., 2013). As an archipelagic country and the argoclimate conditions that support Indonesia is the main coconut producer in the world (Sarina et al., 2017). Coconut is a plantation crop with the largest area (Chalid, 2011), is wider than rubber and oil palm and ranks first for cultivated crops after rice (Nublina et al., 2016). Coconut occupies an area of 3.70 million ha or 26% of the 14.20 million ha of the total plantation area in Indonesia (Resminiasari et al., 2018). Apart from the flesh, other parts of the coconut also have economic value, such as the shell (Hidayat, 2019), tree trunks and coconut leaves, but coconut fiber (coco fiber) is getting less attention (Hidayat, 2019). According to Budisuari, 2007, coconut coir almost reached 1.7 million tons from the production of coconuts of around 5.6 million tons per year (Putra et al., 2018). The huge potential of coco coir waste has not been fully utilized for production activities that have economic added value (Panggabean et al., 2018). In the absence of optimal utilization (Risa & Uum, 2009), this waste will only cause environmental problems (Hasibuan, 2016). Coconut coir contains fiber which is a natural fiber material (biodegradability) so that its use (Maryanti et al.,

2019)coco coir as a fiber in composites will be able to overcome environmental problems that may arise from the large amount of coconut coir that is not utilized (Dermawan et al., 2022). This composite is environmentally friendly and does not endanger health so that its use continues to be developed in order to produce more composites (Sembada et al., 2018)perfect and more useful. Coconut coir fiber composites can be made in various sizes and thicknesses to suit your needs (Lumintang et al., 2011). The manufacturing process uses simple technology so that the resulting product is cheaper, environmentally friendly and has good mechanical properties so that it can be used as a substitute for other, more expensive materials (Kamsiati et al., 2017).

The objectives of this study were: (1) To determine the mechanical properties of the composite material which was varied with the composition of coco fiber with resin as a matrix. (Nurhidayat, 2021) (2) Determining the best composition variable for composite materials. (Gapsari & Setyarini, 2012)(3) To determine the effect of adding fiber to the coconut fiber composite material (Titani et al., 2018). The benefits obtained from this research are the development of knowledge and insight in the field of polymer composites, especially with the use of coco fiber (Varian Sembada, n.d.). (2) The results of this experiment can be used as a basic or additional reference. So that it can be a new alternative in the manufacture of composite materials that will come in the next research (Rodhi, 2022).

## 2. RESEARCH METHOD

### 2.1 Activity Framework

Research activities begin by studying all the literature related to composites such as about composites, polymers, and the process of making composites (Sari, 2018). Furthermore, research activities are continued with the preparation of ready-to-use coconut fiber (Patandung, 2018). Furthermore, research activities prepare all the tools and materials needed during the research (Eliza et al., 2019). Research activities Research activities begin by studying all literature related to composites, such as about composites, polymers, and the process of making composites. (Nayiroh, 2020)Furthermore, the research activity continued with the preparation of ready-to-use coconut coir fiber. Furthermore, research activities prepare all the tools and materials needed during the research.

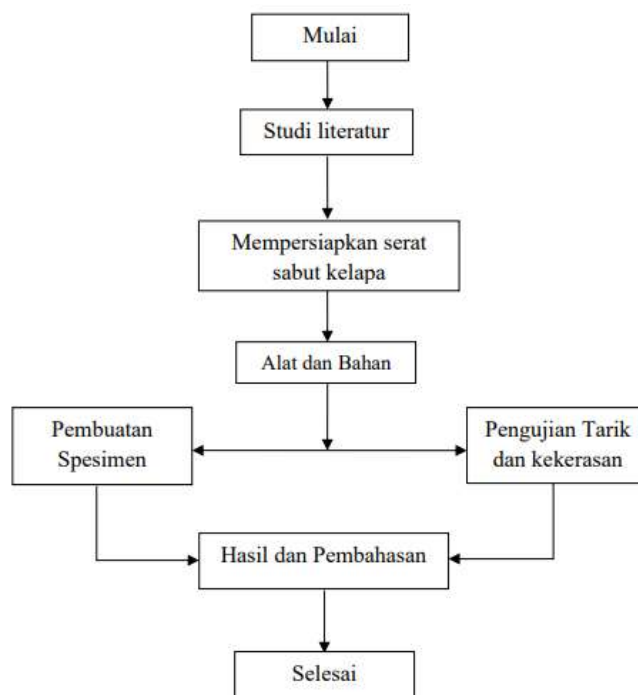


Figure 1. Research Flowchart

### 3. RESULTS AND DISCUSSIONS

#### 3.1. Test result

The test results in this study include the test results of its mechanical properties such as tensile testing, and hardness testing

##### 3.1.1. Tensile Test Results

The following are the test results and a table of test results for stress, strain and modulus of elasticity from the results of the tensile strength test: (1) Stress ( $\sigma$ ), the stress in the tensile test is the weight of the load (P) divided by the cross-sectional area (A) of the specimen. Then the results of the stress calculation for each specimen are the same. It can be calculated by the following equation:

$$\sigma = \frac{P}{A} \quad (1)$$

Where : = Voltage (N/mm<sup>2</sup>)

A = Cross-sectional area (mm<sup>2</sup>)

P = Load at Maximum (N)

(2) Strain ( $\epsilon$ ), The strain in the tensile test is the elongation ( $\Delta L$ ) divided by the initial length (L<sub>0</sub>) in the specimen multiplied by 100%. So the results of the stress calculation for each specimen are the same. It can be calculated by the following equation:

$$\epsilon = \frac{\Delta L}{L_0} \times 100\%$$

Where: = Strain (%)

L = Elongation (mm)

L<sub>f</sub> = Final Length (mm)

L<sub>0</sub> = Initial Length (mm)

(3) Elastic modulus (E), The elastic modulus in the tensile test is the stress ( $\sigma$ ) divided by the strain ( $\epsilon$ ) in the specimen. Then the results of the stress calculation for each specimen are the same. It can be calculated by the following equation:

$$E = \frac{\sigma}{\epsilon} \quad (2)$$

Where: E = Modulus of Elasticity (N/mm<sup>2</sup>), = Stress (N/mm<sup>2</sup>), = Strain (%).

From the test results in table 4.1, the maximum tensile load on a mixture of 0% fiber with 100% resin is 161,586 kgf, while the minimum tensile load on a mixture of 30% fiber and 70% resin is 9.24 kgf. Calculation. Based on the table above, the tensile strength, elongation and elastic modulus of the specimen can be found based on the following calculations: 1kgf=9,807N. Initial cross-sectional area (A<sub>0</sub>) 0% fiber: 100% Resin (Sample A1) is: A<sub>0</sub> = 7mm x 12mm = 84mm<sup>2</sup>. Then the max tensile strength (stress) of the specimen is:

$$\sigma_{maks} = \frac{F_{maks}}{A_0} = \frac{1441,119036}{84} = 17,156179\text{Mpa} \quad (3)$$

The strain is the ratio between the increase in length and the initial length L<sub>0</sub> where the initial length of the specimen is 83mm and the increase in length of the specimen is 3.33562mm, then we get:

$$\epsilon = \frac{\Delta L}{L_0} \times 100\% = \frac{3,33562}{83} \times 100\% = 4,0188\%$$

The elastic modulus (E) is a constant of the straight ratio between stress and strain. The magnitude of this modulus is equal to the slope number of the stress-strain curve which is a straight line in the part close to point 0.

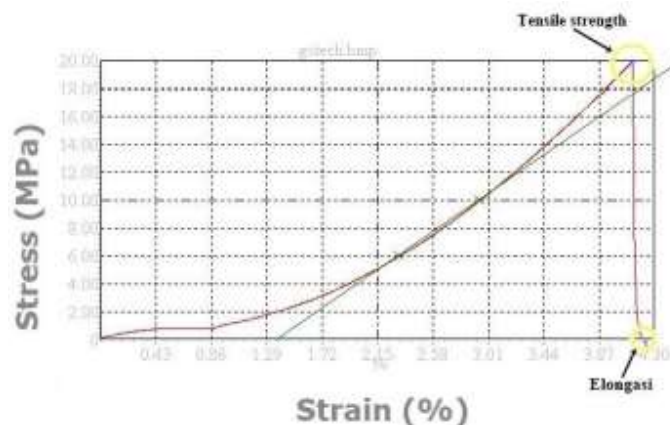
$$E = \frac{\sigma_{maks}}{\epsilon} = \frac{17,156179}{0,04188} = 426,89805$$

For further specimens can be obtained using the same formula as above, and the results are in the following table:

**Table 2.** Calculation Results/Data Processing

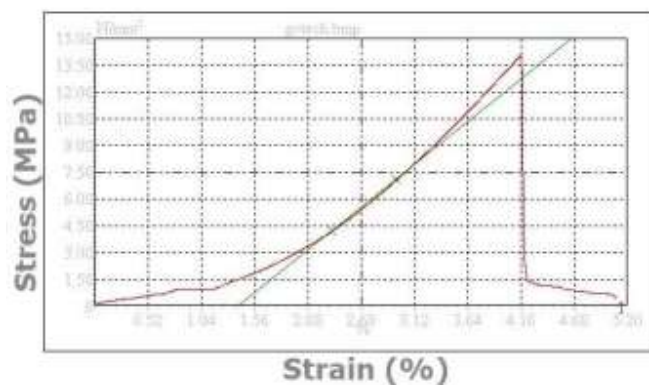
% W Serat	Sampel	Kekuatan Tarik (Mpa)	Elongasi (%)	Modulus Elastisitas (Mpa)
0%	A1	17,15617	4,1088	426,89805
	A2	18,02065	4,1825	430,9085
	A3	19,97823	4,2015	475,49687
10%	B1	14,13091	5,1025	276,94091
	B2	11,69174	4,2817	273,06303
	B3	11,06299	4,374	252,92615
20%	C1	5,20454	5,61	100,8631
	C2	10,14368	4,772	210,7414
	C3	9,99122	4,843	206,3022
30%	D1	1,30316	4,537	28,72294
	D2	1,45284	5,363	27,09006
	D3	1,11706	8,086	12,9229

From the results of the tensile test calculations that have been carried out, it is obtained 4 samples that have optimum conditions, namely: (1) Sample A3 with a composition of 0% fiber: 100% Resin. (2) Sample B1 with 10% fiber composition: 90% Resin (3) Sample C2 with 20% fiber composition: 80% Resin (4) Sample D2 with a composition of 30% fiber: 70% resin. The following is the stress vs strain curve of the specimen under optimum conditions: Sample A3 with 0% fiber composition: 100% Resin.



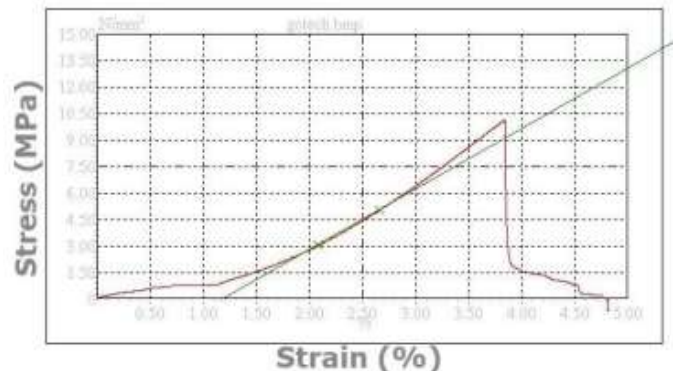
**Figure 2.** Stress Curve Vs A3 Sample Strain With 0% Fiber Composition: 100% Resin

Explanation of the image: The image is an image of the tensile test results curve for optimum conditions at the composition of 0% fiber: 100% resin sample A3 which has been tested. Starting from the zero point which is the beginning of the withdrawal of the specimen, the movement of the line upward indicates the increase in the tensile applied to the specimen until it breaks, while the movement of the line to the right indicates an increase in the value of the strain. The line moves slowly from the zero point to the point of maximum tensile strength. Until the maximum point which is the peak point and is known to be 19.97823 MPa, then the line on the curve descends vertically downwards, which means that the tested specimen breaks with a strain of 4.2015%. (2) Sample B1 with 10% fiber composition: 90% Resin



**Figure 3.** Stress Curve vs. Strain Sample B1 With Composition 10% Fiber : 90% Resin

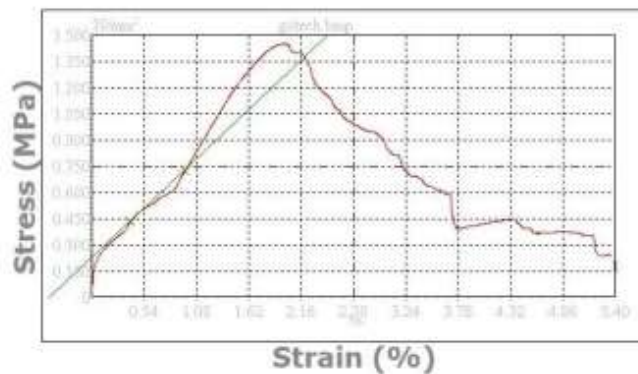
Image Explanation: The image is an image of the tensile test results curve for optimum conditions at the composition of 10% fiber: 90% resin sample B1 which has been tested. Starting from the zero point which is the beginning of the withdrawal of the specimen, the movement of the line upward indicates the increase in the tensile applied to the specimen until it breaks, while the movement of the line to the right indicates an increase in the value of the strain. The line moves slowly from the zero point to the point of maximum tensile strength. Up to the maximum point which is the peak point and is known to be 14,13091 MPa, then the line on the curve descends vertically downwards, which means that the tested specimen breaks with a strain of 5.1025%. (3) Sample C2 with a composition of 20% fiber: 80% Resin.



**Figure 4.** Stress Curve vs Strain Sample C2 With Composition of 20% Fiber : 80% Resin

Image Explanation: The image is an image of the tensile test results curve for optimum conditions at the composition of 20% fiber: 80% resin sample C2 which has been tested. Starting from the zero point which is the beginning of the withdrawal of the specimen, the movement of the line upward indicates the increase in the tensile applied to the specimen until it breaks, while the movement of the line to the right indicates an increase in the value of the strain. The line moves

slowly from the zero point to the point of maximum tensile strength. Up to the maximum point which is the peak point and is known to be 10,14368 MPa, then the line on the curve descends vertically downwards, which means that the tested specimen breaks with a strain of 4.772%. (4) Sample D2 with a composition of 30% fiber: 70% resin.



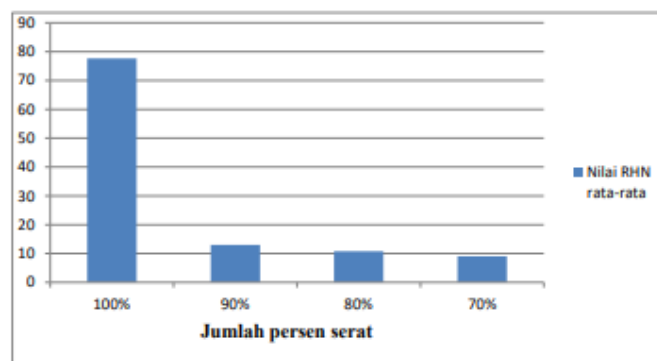
**Figure 5.** Stress Curve vs. Strain Sample D2 With Composition of 30% Fiber : 70% Resin

Image Explanation: The image is an image of the tensile test results curve for optimum conditions at the composition of 30% fiber: 70% resin sample D2 which has been tested. Starting from the zero point which is the beginning of the withdrawal of the specimen, the movement of the line upward indicates the increase in the tensile applied to the specimen until it breaks, while the movement of the line to the right indicates an increase in the value of the strain. The line moves slowly from the zero point to the point of maximum tensile strength. Until the maximum point which is the peak point and is known to be 1.45284 MPa, then the line on the curve descends vertically downwards, which means that the tested specimen breaks with a strain of 5.363%. Hardness is a measure of load resistance to compressive deformation. A hard indenter is pressed against the surface of the specimen being tested. The deformation that occurs is a combination of elastic and plastic behavior, but hardness is generally only related to plastic properties and only a small part depends on elastic properties. Hardness testing in this study was carried out in order to know the effect of mixing coconut coir fibers on Polyester Resin BQTN 157. The calculation of the hardness value of the test object carried out in this study was using the Rockwell scale with the RHN (Rockwell Hardness Number) value adjusted to the hardness table. The table of RHN values for composite materials can be seen in the following table: Hardness testing in this study was carried out in order to know the effect of mixing coconut coir fibers on Polyester Resin BQTN 157. The calculation of the hardness value of the test object carried out in this study was using the Rockwell scale with the RHN (Rockwell Hardness Number) value adjusted to the hardness table. The table of RHN values for composite materials can be seen in the following table: Hardness testing in this study was carried out in order to know the effect of mixing coconut coir fibers on Polyester Resin BQTN 157. The calculation of the hardness value of the test object carried out in this study was using the Rockwell scale with the RHN (Rockwell Hardness Number) value adjusted to the hardness table. The table of RHN values for composite materials can be seen in the following table:

**Table 3.** RHN Value Table

Spesimen	Sampel	Rockwell Hardness Number (RHN)	Nilai Rata-rata
Spesimen A (100% resin)	A1	78,77	77,63
	A2	77,51	
	A3	76,61	
Spesimen B (90% resin)	B1	13,65	13,01
	B2	11,94	
	B3	13,44	
Spesimen C (80% resin)	C1	10,97	10,81
	C2	10,53	
	C3	10,93	
Spesimen D (70% resin)	D1	9,03	9,053
	D2	8,36	
	D3	9,77	

In table 4.3, the maximum hardness test results on specimen A (100% resin) have an RHN value of 78.77 while the minimum tensile test results in specimen D (70% resin) have an RHN value of 8.36. The graph of the average RHN value of the composite material with the percent fiber forming the composite material can be seen in the following figure:

**Figure 5.** RHN Value Chart

### 3.2. Discussion of Research Results

From the research results obtained 2 different types of materials, namely pure resin material and coconut fiber composite material. (1) Pure Resin Material Specimen. The pure resin material referred to in this study is specimen A, where the constituent material is only a mixture of polyester resin and catalyst. Physically this pure resin is hard and plastic transparent.



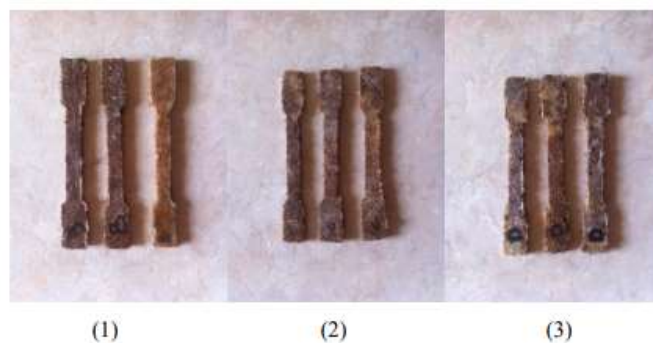
**Figure 6.** Pure Resin Specimen Before Testing



**Figure 7.** Pure Resin Specimen After Testing

In the tensile test and get the maximum force on this pure resin specimen. And in the hardness test, pure resin specimens have a very far hardness number compared to specimens mixed with coconut fiber.

Coir Fiber Composite Material Specimens. The coconut fiber composite materials referred to in this study are specimens B, C and D where the constituent materials of this material consist of a mixture of polyester resin mixed with a catalyst with coconut fiber. Coir fiber composite specimens are not as transparent as pure resin specimens.



**Figure 8.** (1) Specimen B making up 10% fiber: 90% resin, (2) Specimen C making up 20% fiber: 80% resin, (3) Specimen D making up 30% fiber: 70% resin

In specimens of coco fiber mixture obtained different properties with pure resin specimens. The specimens with the best strength and strain properties can be seen in Table 4.2. Results of Calculation/Data Processing where the best tensile strength value is found in specimen B at 14,13091 Mpa and the best strain in specimen C at 8,086%.

#### 4. CONCLUSION

After conducting research, testing and analysis of the specimens of the Coconut Coir Fiber mixture, it can be concluded: (1) A new specimen was produced between a mixture of Polyester Resin and coconut fiber. (2) The addition of coco fiber (weight fraction) decreased the tensile strength and hardness of the coconut fiber composite. (3) From the calculation results of the tensile test of mixing polyester resin and coconut coir fiber obtained 4 samples that have optimal conditions, namely sample A3, sample B1, sample C2 and sample D2 (4) From the results of tensile strength obtained the best composition variable in specimen B1 (10 % fiber) which is 14,13091 Mpa. The best strain on specimen D3 (30% fiber) was 8,086%. (5) From the results of the calculation of the hardness test of the mixture of polyester resin and coconut fiber resin, obtained 4 sample average values: sample A 77.63 sample B 13,

Suggestions in this study are: (1) When printing composite specimens, voids often occur, this results in a decrease in the strength of the composite. Thus, efforts are made to avoid voids as much as possible. (2) To increase the interaction between polyester resin and coco fiber, it is necessary to add binder compounds so that the characteristics of the resulting mixture can be further improved. (3) There is a need for new variations to answer future challenges to utilize industrial waste, thereby reducing environmental pollution and increasing the selling price of coco fiber waste.

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#### REFERENCES

- Astika, I. M., & Dwijana, I. G. K. (2013). Karakteristik sifat tarik dan mode patahan komposit polimer dengan penguat serat sabut kelapa. *Dinamika Teknik Mesin*, 4(2), 2088.
- Bantacut, T. (2013). Pembangunan ketahanan ekonomi dan pangan perdesaan mandiri berbasis nilai tambah (Rural Economic and Food Security Development Based on Added Value Formation). *Jurnal Pangan*, 22(2), 181–196.
- Chalid, N. (2011). Perkembangan Perkebunan Kelapa Sawit Di Provinsi Riau. *Jurnal Ekonomi*, 19(03).
- Dermawan, W. R., Pambudi, R. F., Hifani, R., Sembada, I. V., & Musaffa, Q. S. (2022). PENGARUH VARIASI FRAKSI VOLUME SERAT SABUT KELAPA KOMPOSIT UNSATURATED POLYESTER TERHADAP KEKUATAN BENDING. *STATOR: Jurnal Ilmiah Mahasiswa Teknik Mesin*, 2(1), 31–32.
- Eliza, F., Suriyadi, S., & Yanto, D. T. P. (2019). Peningkatan Kompetensi Psikomotor Siswa Melalui Model Pembelajaran Project Based Learning (PjBL) di SMKN 5 Padang. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, 19(2), 57–66.
- Gapsari, F., & Setyarini, P. H. (2012). Pengaruh Fraksi Volume Terhadap Kekuatan Tarik Dan Lentur Komposit Resin Berpenguat Serbuk Kayu. *Jurnal Rekayasa Mesin*, 1(2), 59–64.
- Hasibuan, R. (2016). Analisis dampak limbah/sampah rumah tangga terhadap pencemaran lingkungan hidup. *Jurnal Ilmiah Advokasi*, 4(1), 42–52.
- Hidayat, S. (2019). Analisis kekuatan laminat komposit dengan sabut kelapa sebagai serat penguat.
- Kamsiati, E., Herawati, H., & Purwani, E. Y. (2017). Potensi pengembangan plastik biodegradable berbasis pati sagu dan ubikayu di Indonesia. *Jurnal Litbang Pertanian*, 36(2), 67–76.
- Lumintang, R. C. A., Soenoko, R., & Wahyudi, S. (2011). Komposit hibrid polyester berpenguat serbuk batang dan serat sabut kelapa. *Jurnal Rekayasa Mesin*, 2(2), 145–153.
- Maryanti, B., Arifin, K., & Saputro, A. N. P. (2019). Karakteristik Kekuatan Impak Komposit Serabut Kelapa Dengan Variasi Panjang Serat. *Prosiding SENIATI*, 339–343.
- Nayiroh, N. (2020). Studi pengaruh variasi fraksi volume filler partikel cangkang kerang hijau terhadap sifat fisis dan mekanik komposit polimer poliester.
- Nublina, D., Sofyan, S., & Rahmaddiansyah, R. (2016). Analisis Nilai Tambah Buah Kelapa Dan Kelayakan Usaha Minyak Goreng Kelapa Kecamatan Juli Kabupaten Bireuen. *Jurnal Ilmiah Mahasiswa Pertanian*,

- 1(1), 596–606.
- Nurhidayat, A. (2021). ANALISIS VARIASI KETEBALAN CORE KOMPOSIT SANDWICH SERBUK TEMPURUNG KELAPA LIMBAH TERHADAP SIFAT MEKANIK: Komposit Serbuk Tempurung Kelapa Limbah. *Teknika*, 7(1), 21–27.
- Oroh, J., Sappu, F. P., & Lumintang, R. C. (2013). Analisis sifat mekanik material komposit dari serat sabut kelapa. *Jurnal Poros Teknik Mesin Unsrat*, 1(1).
- Panggabean, F. Y., Dalimunthe, M. B., & Suharianto, J. (2018). Peningkatan pendapatan masyarakat Desa Sei Kepayang Tengah melalui pemanfaatan limbah tempurung kelapa. *Widya Laksana*, 7(1), 18–25.
- Patandung, P. (2018). Pengembangan Pembuatan Plafon Dari Abu Sekam Padi Dengan Menggunakan Serat Sabut Kelapa. *Jurnal Penelitian Teknologi Industri*, 8(1), 39–50.
- PUTRA, R., Tunggal, T., & Hersyamsi, H. (2018). KINERJA MESIN PENCACAH TIPE CIRCULAR SAW PADA BERBAGAI KECEPATAN PUTARAN PISAU PENGHANCUR LIMBAH PADAT KELAPA SAWIT (*Elaeis guineensis jacq.*) DAN SABUT KELAPA (*Coco Fiber*). Sriwijaya University.
- Resminiasari, N., Rahmat, S., & Imbarwati, S. (2018). *Budidaya tanaman kelapa (cocos nucifera) ditinjau dari segi ekonomi*.
- Risa, A., & Uum, U. (2009). *Pemanfaatan tanaman ubi kayu dan limbahnya secara optimal sebagai pakan ternak ruminansia*.
- Rodhi, N. N. (2022). *Metodologi Penelitian*. Media Sains Indonesia.
- SARI, N. I. (2018). *Fabrikasi dan Karakterisasi Bahan Komposit Ramah Lingkungan Berpenguat Serbuk Limbah Kayu Sengon dan Matriks Asam Poli Laktat (PLA)*.
- Sarina, N., Suprayitno, G., Damayanti, L. F., Islamsyah, H., & Mahardika, R. (2017). PEMANFAATAN SERABUT KELAPA SEBAGAI BAHAN DASAR PEMBUATAN SOFA DENGAN METODE ADHESIVE GUNA MENINGKATKAN PEREKONOMIAN MASYARAKAT SERTA PEMANFAATAN MEDIA ONLINE SEBAGAI STRATEGI PEMASARAN PRODUK. *Prosiding SNasPPM*, 2(1), 317–320.
- Sembada, I. V., Dermawan, W. R., Pambudi, R. F., Aulia, R. H., & Musaffa, Q. S. (2018). PENGARUH SIKLUS THERMAL TERHADAP KEKUATAN TARIK KOMPOSIT UNSATURATED POLYESTER-SERAT KELAPA. *STATOR: Jurnal Ilmiah Mahasiswa Teknik Mesin*, 1(1), 121–123.
- SUMENDA, A. (2017). *PENGARUH FRAKSI VOLUME DAN PANJANG SERAT TERHADAP KEKUATAN PUNTIR KOMPOSIT SERAT SABUT KELAPA RESIN POLYESTER*. Politeknik Negeri Manado.
- Titani, F. R., Imalia, C. L., & Haryanto, H. (2018). Pemanfaatan Serat Sabut Kelapa sebagai Material Penguat Pengganti Fiberglass pada Komposit Resin Polyester untuk Aplikasi Bahan Konstruksi Pesawat Terbang. *Techno (Jurnal Fakultas Teknik, Universitas Muhammadiyah Purwokerto)*, 19(1), 23–28.
- Varian Sembada, I. (n.d.). *Pengaruh Variasi Suhu Siklus Termal Terhadap Kekuatan Mekanis Komposit Polyester Sabut Kelapa Dengan Aditif Montmorillonite*.