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Research Article

Analysis of tensile strength of composite fiber reinforced with areca Nut Skin Fiber using BQTN 157 EX Resin

Ferri Safriwardy, Muhammad Nuzan Rizki*, Masrullita, Muhammad Iqbal Simbolon
Universitas Malikussaleh, Aceh, Indonesia, 24352
*Corresponding author: mnuzanrizki@unimal.ac.id | Phone: 082214758964

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ABSTRACT

In the development of materials science, especially polymers, natural fibers such as areca nut shell fiber are increasingly attractive to use. The use of synthetic polymer materials made from fiber can replace conventional materials such as metal, wood and leather. They can replace conventional materials with the advantages of lower price, environmental friendliness, and recyclability. Areca nut shell fiber, as an example of a natural fiber, has great potential in the furniture industry, crafts, and as an ingredient in traditional medicine. This fiber is used as a reinforcing material in composites with an Unsaturated Polyester Yukalac resin matrix. Unsaturated Polyester Yukalac resin, with characteristics such as stiffness, flexibility, water resistance, chemical resistance and weather resistance, is used as a matrix in making composites. The aim of this research is to make a plastic composite prototype reinforced with areca palm fiber, varying the volume fraction of areca nut shell fiber by 30%:50%, 50%:60%, 70%:70%, 90%:80% and for the matrix using polyester resin. BQTN 157 EX. The fiber composition is arranged in a mold in the same direction using the hand lay up method. Composite testing is in the form of a tensile test referring to the ASTM 638-03 standard. The results of the largest tensile testing process were with a volume fraction of 50% with an average value of 7.11 MPa, and for tensile testing the lowest was a volume fraction of 70% with an average value of 6.17 MPa, it can be concluded for reinforced plastic composites Areca nut shell fiber has considerable ability to be applied as a structural material. This is a step towards the development of innovative and environmentally friendly composite materials for various industrial applications.

Keywords: Areca Palm Fiber; Volume Fraction of Fiber; Polyester; Hand Lay Up; Tensile Test

1. INTRODUCTION

The development of materials science, especially in the field of polymers, continues to grow along with human efforts to improve the welfare of life by utilizing materials processing and technology. The synthesis of various types of polymer materials can be used in various aspects of life. The use of natural fibers as a supporting material is increasing from year to year. One aspect that needs to be considered in obtaining new materials is the use of materials derived from plants or organic fibers (Nayan et al., 2023; Putra, Muhammad, et al., 2022). Using synthetic polymers made from fiber can replace metal, wood, leather and other natural materials with various advantages such as: much cheaper prices, environmentally friendly, and some of them are the optimization of waste products that have not been utilized. Various kinds of items needed in everyday life can be made from this synthetic polymer, for example household furniture (from plastic), clothing materials (nylon, polyester), packaging equipment, transportation equipment, and automotive.

Composites are defined as a combination of two or more types of materials with different phases (Schwartz, 1984). The combination of this composite is a combination of matrix/binder material and reinforcement/strengthening material (Putra, Yusuf, et al., 2022). Two or more materials combined in a composite material will produce new properties that are better than those possessed by one of the constituent materials when compared to conventional materials. These properties that can be developed from making composite materials include: strength, fatigue stiffness, wear resistance, corrosion resistance, weight and others (Habibie et al., 2021; Nugraha et al., 2020).

Composites have several types of reinforcing materials. One of them is a fiber-reinforced composite material (Khalid et al., 2022). The fibers used as reinforcing materials in composites are divided into natural fibers and artificial fibers. Natural fibers are fibers that are easy to obtain and cheap compared to artificial (synthetic) fibers.

Areca nut shell fiber is one of the natural fibers used in making scientific composites, areca nut shell fiber is widely used in the furniture and household crafts industries as well as traditional medicinal materials because it is easy to obtain, cheap, can reduce environmental pollution (biodegradability) so that the composite This is able to overcome environmental problems, and does not endanger health. The use of areca nut shell fiber as a composite material is still quite extensive for development, considering that the availability of raw materials is quite abundant (Fitra et al., n.d.; Olanda & Mahyudin, 2013; Paundra et al., 2022).

Yukalac Unsaturated Polyester Resin is a liquid resin with low viscosity and will harden at room temperature using a catalyst. The resin that will be used is a resin with production serial number 157 BQTN-EX. Apart from being cheap, this resin has unique characteristics, namely that it can be made rigid and flexible, transparent, water resistant, chemical resistant and weather resistant, and can be colored. Polyester can be used at working temperatures reaching 79^{O}C or higher depending on the resin particles and requirements, with a specific gravity of 1.3 – 1.4 g/cm^3 and a tensile strength of 55 – 60 N/mm^2.

Areca nut is a type of plant that is quite often found in Indonesia. Areca nuts are also rich in fiber. Some of the wider community still pay little attention to and utilize areca nut as a source of renewable energy technology. With the abundance of areca nut and the lack of knowledge about the benefits of areca nuts for technology, this research aims to examine the properties of composites with reinforcing materials from areca nut skin fiber. With the aim of this research, we can determine the optimal tensile resistance value of the areca palm fiber composite material and BTQN 157 EX resin based on composite variations.

2. RESEARCH METHOD

The place of this research was carried out in the Mechanical Engineering laboratory at Malikussaleh University. The collection of areca fiber is obtained from people who have areca nut plantations in the Lhokseumawe area. The process of making composite materials and tensile testing is also carried out in the Mechanical Engineering laboratory at Malikussaleh University. The materials and equipment used in conducting research can be seen in Table 1.

Table 1. Materials and equipment used in making tensile test specimens

No	Material	Quantity
1	Resin BQTN Type 157	2 liter
2	Areca palm fiber	1 Kg
3	NaOH	1 Unit
4	Grinder	1 Unit
5	ASTM D-638 standard tensile test equipment	1 Unit
6	Measuring degree	3 Unit
7	Mold	1 Unit

Fiber Collection Procedure

This research is experimental with variables divided into:

1. Independent variables are variables that are not dependent or influenced by other variables.
2. Fixed variables are variables that are deliberately kept constant. The goal is to ensure that changes in experimental results are not due to these variables.
3. This research is a test method and specimen composition, the type of test method used is the tensile test. There are four types of composition variations used, namely:
   a. Specimen 1, 30%: 50 with fiber length 165 mm.
   b. Specimen 2, 50%: 60 with fiber length 165 mm.
   c. Specimen 3, 70%: 70 with fiber length 165 mm.
   d. Specimen 4, 90%: 80 with fiber length 165 mm.

Composite Manufacturing

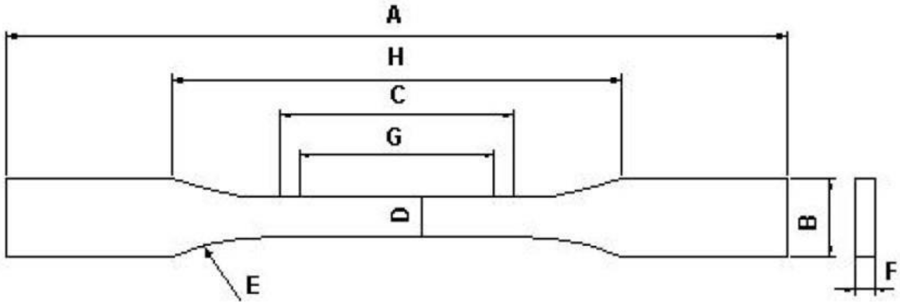
The composites made have sizes adjusted to ASTM D-638 standards with variations in fiber weight and predetermined fiber length. The steps taken in this test are as follows:

1. Weigh the weight of areca nut shell fiber and BTQN 157 EX Polyester resin in a ratio of 30%:50%, 50%:60%, 70%:70%, 90%:80%, with the fibers in the same direction.
2. Mix areca palm fiber with BTQN 157 EX Polyester resin by adding a little catalyst to speed up drying, stir gently for about 1 minute until the fiber and resin are evenly mixed.

3. Insert the mixture of areca fiber and BQTN 157 EX Polyester Resin into a mold that has been made according to applicable standards, smooth the surface of the mold.
4. Drying process for approximately 24 hours at room temperature, the dried specimen is removed from the mold and then smoothed on the surface with a file and sandpaper.
5. The specimen is then cut to standard size ASTM D-638 (ASTM, n.d.) using a hand grinder.
6. The composite specimen has been ground and the specimen is ready to be tested.

Dimensions of Tensile Test Specimen

The processed particle board is cut according to the pattern referring to the JIS 5908: 2003 standard as shown in **Figure 1**.



A. LO (Length Overral) = 165 mm
B. WO (Width Overral) = 19 mm
C. L (Length of narrow section) = 57 mm
D. WC (Width of narrow section) = 13 mm
E. R (Radius of fillet) = 76 mm
F. T (Thickness) = 5 mm
G. G (Gage length) = 50 mm
H. D (Distance between grips) = 115 mm

Figure 1. Test Specimen Size Based on JIS 5908.

The research was carried out by preparing areca nut shell fiber and BTQN resin. Then proceed to the process of making fibers and making composites as explained above. Then proceed to the stage of making specimens with volume variations as previously determined. Then the specimens were tested using tensile test equipment by applying the ASTM D 638-03 test standard. After the test data is obtained, data processing is carried out so that later a research conclusion can be drawn. The research stages are generally described using a flow diagram as can be seen in **Figure 2**.

3. RESULTS AND DISCUSSION

Tensile Test Results Data

Tensile testing was carried out after the process of making the areca nut skin fiber composite with polyester resin (BQTN 157 EX), in order to determine the strength of the composite with different volume fractions in the areca nut skin fiber reinforced composite. Tensile testing was carried out using a universal testing machine in the Mechanical Engineering laboratory at Malikussaleh University.

Tensile testing was carried out using standards (ASTM D638-03) on composites reinforced with areca nut shell fiber. Before the specimen is tensile tested, the specimen goes through an alkaline treatment process of (5% NaOH). Then optimization of the fiber volume fraction of 30%, 50%, 70%, and 90% was carried out with maximum tensile strength. From the results of tensile tests that have been carried out on three test specimens with a composite volume fraction of 30%. The lowest maximum load was found in test specimen number 1 with a value of 6.81 MPa, and a tensile strength value of 0.70 MPa. The highest maximum load was found in test specimen number 2 with a value of 7.36 MPa, and a tensile strength value of 0.75 MPa (**Table 2**).

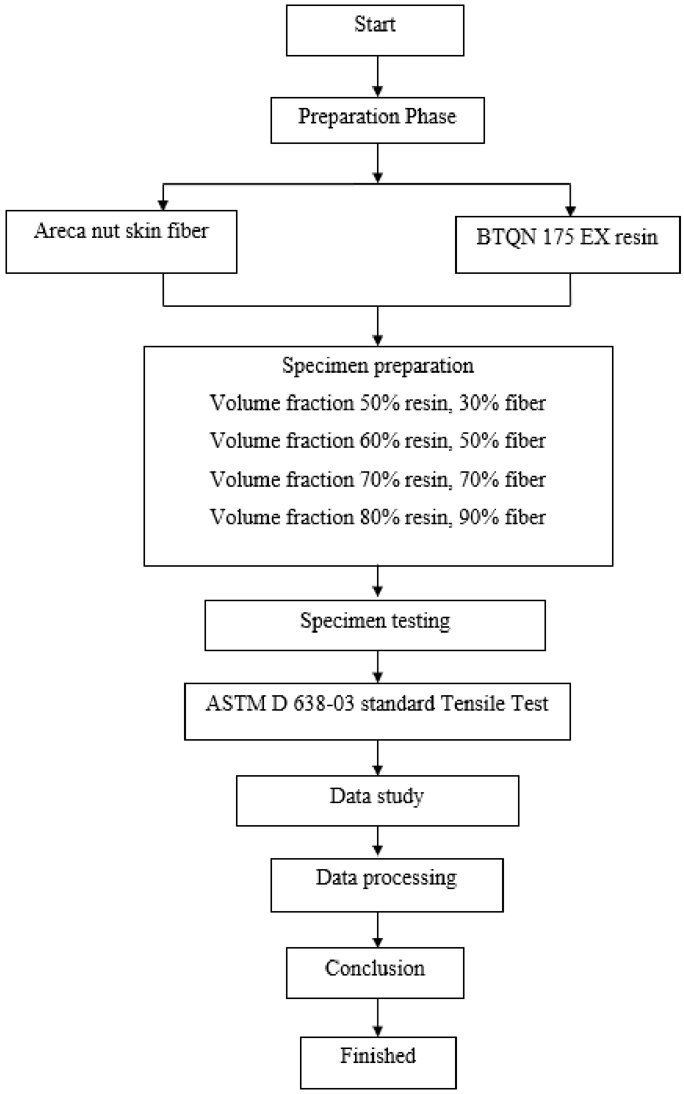


Figure 2. Flow diagram of the research

Based on the results of tensile tests that have been carried out on three test specimens with a composite volume fraction of 50%. The lowest maximum load was found in test specimen number 1 with a value of 6.89 MPa, and a tensile strength value of 0.71 MPa. The highest maximum load was found in test specimen number 3 with a value of 7.49 MPa, and a tensile strength value of 0.77 MPa **(Table 3**). From the results of tensile tests that have been carried out on three test specimens with a composite volume fraction of 70%. The lowest maximum load was found in test specimen number 3 with a value of 6.00 MPa, and a tensile strength value of 0.61 MPa. The highest maximum load was found in test specimen number 1 with a value of 6.49 MPa, and a tensile strength value of 0.66 MPa (**Table 4**). From the results of tensile tests that have been carried out on three test specimens with a composite volume fraction of 90%. The lowest maximum load was found in test specimen number 3 with a value of 6.69 MPa, and a tensile strength value of 0.69 MPa. The highest maximum load was found in test specimen number 2 with a value of 7.45 Newtons, and a tensile strength value of 0.76 MPa (**Table 5**).

Comparison of Specimen Strength According to Volume Fraction Values

The influence of differences in strain and tensile strength can be caused by the sum of the volume fractions and the adhesive ability of the matrix. In Figures 3 and 5 you can see a graph of the relationship between strain and average tensile strength that occurs at fiber volume fractions of 30%, 50%, 70%, and 90%.

Table 2. 30% Fiber Tensile Testing Results

No	Thick (mm)	Wide (mm)	Broad(mm)	Load (kg)	Tensile strength (MPa)	L°(mm)	ΔL (mm)	E (%)
1				6,81	0,70	165	1,3	0,78
2	5	19	95	7,36	0,75	165	1,1	0,66
3				7,13	0,73	165	1,1	0,66
		Average		7,1	0,72		1,16	0,7

Table 3. 50% Fiber Tensile Testing Results

No	Thick (mm)	Wide (mm)	Broad(mm)	Load (kg)	Tensile strength (MPa)	L°(mm)	ΔL (mm)	E (%)
1				6,89	0,71	165	1,4	0,84
2	5	19	95	6,96	0,71	165	1,2	0,72
3				7,49	0,77	165	1,1	0,66
		Average		7,11	0,73		1,23	0,74

Table 4. 70% Fiber Tensile Testing Results

No	Thick (mm)	Wide (mm)	Broad(mm)	Load (kg)	Tensile strength (MPa)	L° (mm)	ΔL (mm)	E (%)
1				6,49	0,66	165	1,6	0,96
2	5	19	95	6,02	0,62	165	1,3	0,78
3				6,00	0,61	165	1,6	0,96
		Rata-Rata		6,17	0,63		1,5	0,9

Table 5. 90% Fiber Tensile Testing Results

No	Thick (mm)	Wide (mm)	Broad(mm)	Load (kg)	Tensile strength (MPa)	L° (mm)	ΔL (mm)	E (%)
1				7,05	0,72	165	1,7	1,03
2	5	19	95	7,45	0,76	165	1,3	0,78
3				6,69	0,69	165	1,7	1,03
		Average		7,06	0,72		1,56	0,94

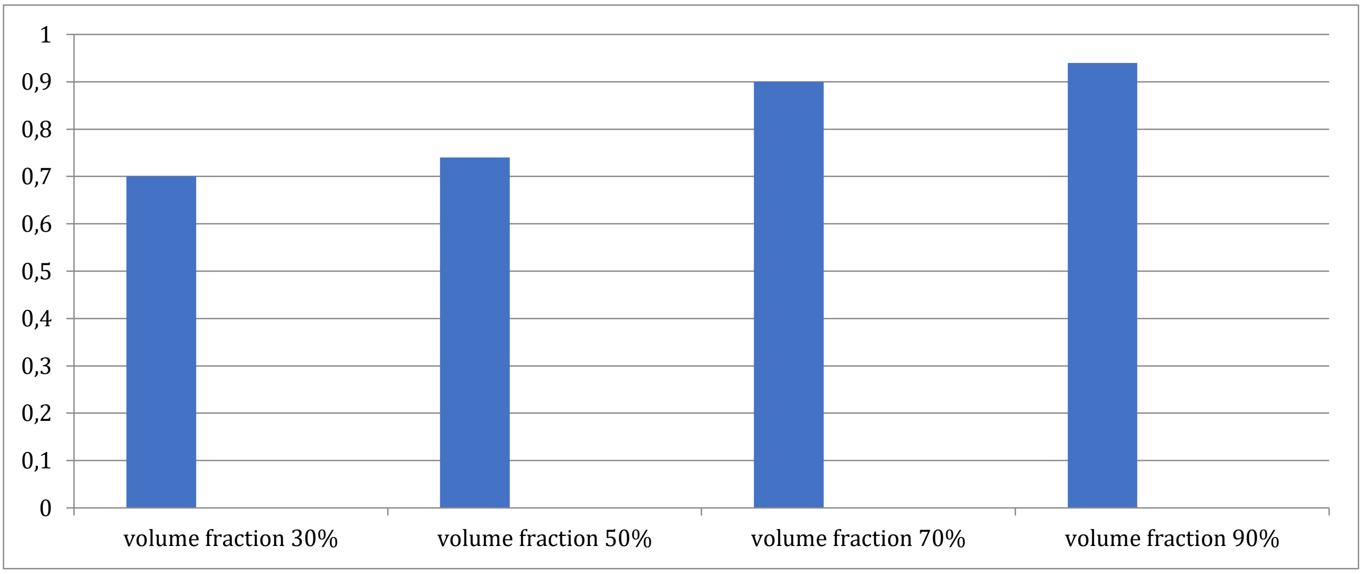


Figure 3. Average Strain Graph

Based on the results of tests carried out on areca nut shell fiber specimens with volume fraction values of 30%, 50%, 70% and 90%, it shows an increase based on the value of the volume fraction. This can be shown from the average value at a volume fraction of 30% with a strain of 0.7 MPa which is smaller than a volume fraction of 50%, which is 0.74 MPa. And the value of the average volume fraction of 70% is 0.9 MPa. Meanwhile, for the value of the average volume fraction of 90%, the stress value is 0.94 MPa, which is higher than the volume fraction of 30%, 50%, and 70%. From the above results it can be concluded that the more the number of fibers, the higher the tensile strain. (**Figure 3**).

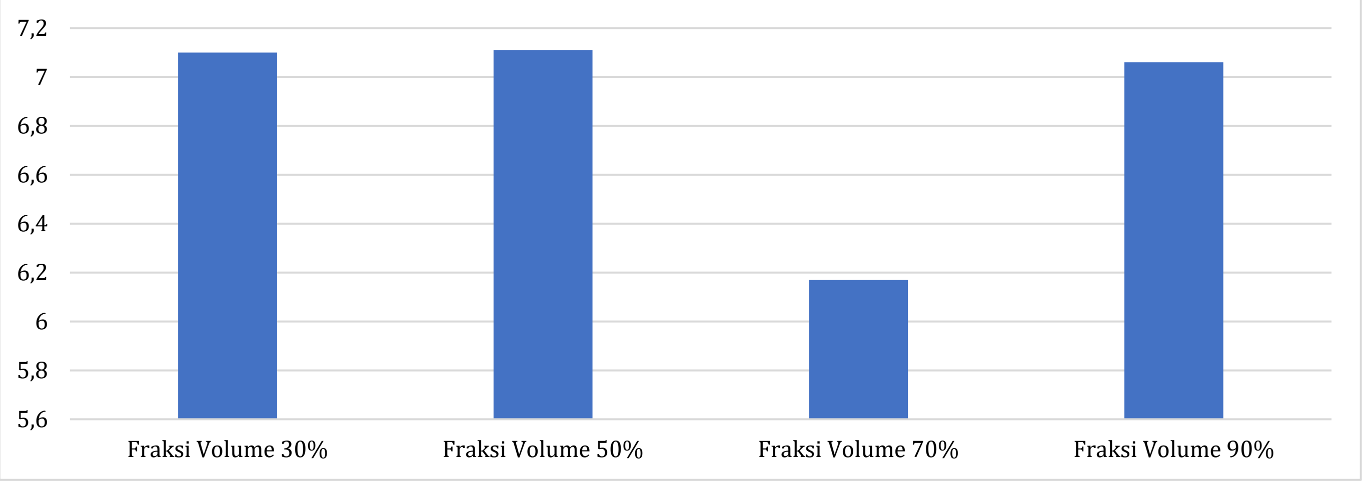


Figure 4. Average Tensile Strength Graph

The results obtained at the average maximum load values for volume fractions of 30%, 50%, 70%, and 90% can be seen in **Figure 4**. The average maximum load of a 30% volume fraction is 7.1 MPa, for the average maximum load of a 50% volume fraction is 7.11 MPa, and the average maximum load of a 70% volume fraction is 6.17 MPa, while the average maximum load from a volume fraction of 90% is 7.06 MPa. So, it can be concluded that the highest maximum load was obtained at a volume fraction of 50% with a value of 7.11 MPa (**Figure 4**).

Analysis of Tensile Test Results

Based on tests on three specimens each for volume fractions of 30%, 50%, 70%, and 90%, it was concluded that the load and tensile strength varied according to the volume fraction of the composite. The load and tensile strength are greatly influenced by the volume fraction of the fiber so that by increasing the volume fraction the load and strength of the composite will also increase. The highest value of areca nut skin fiber composite research data results was obtained at a volume fraction of 50% with an average value of 7.11 MPa.

4. CONCLUSION

After carrying out analysis and calculations from the data and test results regarding the results of this research it can be concluded as follows: 1). The results and tensile tests on composites reinforced with areca nut shell fibers have the lowest value for composites with a volume fraction of 70% with an average value of 6.17 MPa, due to the emergence of air voids in the mold results or imperfect bonding between the fibers and the matrix. Thus, causing the fibers to separate from the matrix, and meanwhile the highest tensile strength was obtained at a fiber volume fraction of 50% with an average value of 7.11 MPa, due to the balanced bonding of the fibers with the resin, making the composite have high strength. 2). The strain results in composites reinforced with areca nut shell fiber have the lowest value in composites with a volume fraction of 30% with an average value of 0.7 MPa, and meanwhile the highest strain is obtained at a fiber volume fraction of 90% with an average value of 0.94 MPa.

AUTHOR'S CONTRIBUTION

All authors discussed the result and contributed from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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