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# Effect of Fiber Length on The Composite Properties of *Salacca zalacca* Pellet Fibers – Epoxy

***Perdinan Sinuhaji* [1*] *and Andreas*[2]**

*[1,2]Department of Physics, Faculty of Mathematics and Natural Science, Universitas Sumatera Utara, Medan 20155, Indonesia*

**Abstract.** Research on the effect of fiber length on the physical and mechanical properties of composite fibers has been conducted, with variations in fiber lengths of 1 cm, 1.2 cm, 1.4 cm, and 1.6 cm, each added Epoxy and Hardener 1: 1 then stirred by the Hand Lay Up method and pressed for 20 minutes at a temperature of 90ºC. The characterization of composite physical properties showed a density value of 1.1325 g/cm$^3$, porosity by 1.53%, and water absorption by 1.33%. The physical properties of composites have met the standard SNI 03-2105-2006 and can be used as a composite replacement material. The characterization of the composite mechanical properties shows a maximum bending strong value of 25.15 kgf – 40.12 kgf, tensile strength of 11.31 MPa – 15.37 MPa, and a strong impact of 50.43 J/mm$^2$-80.93 J/mm$^2$ has met high impact ABS quality standards of 13.48 J/m$^2$. All mechanical properties of the composite meet the JIS A 5905:2003 standard.

**Keyword:** Composites, Epoxy Resins, Mechanical Properties, Physical Properties, *Salacca zalacca* Pellet Fibers.

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## 1 Introduction

Fiber-reinforced composite technology has long been developed by various scientists and scientists who are producing rapid development. One is a natural fiber reinforced composite that has many advantages such as low density, inexpensive and biodegradable materials [1]. This opens up the possibility of competition for natural fiber composites as a replacement for synthetic fiber reinforced composites in industries such as plastics, vehicles and packaging industries to reduce their production costs. One of the potential natural fibers of cellulose is *Salacca zalacca*, a family of *Salacca zalacca*f palm trees (Arecaceae) under the subfamily *Calamoideae* and better known as *Salacca zalacca* trees [2].

To date, only a few research discussed about fiber, a thorough investigation of the characteristics of chemical and physical properties will affect the results of the contact angle and the characterization of the interface, which indicates the interaction between the fiber with other

*Corresponding author at: Jalan Bioteknologi no.1 Medan, 20155, Indonesia

E-mail address: perdinan@usu.ac.id


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materials, in this case, the matrix [3]. There are many approaches to improving the variety of composites that are reinforced by natural fibers, including the chemical treatment of fiber materials [4-6]. The chemical treatment of fiber materials improves the surface of the fiber and increases the bonding strength of the interface which in turn results in better mechanical properties [7-10]. The bond between natural fibers and the polymetric matrix increases after alkaline treatment of the fibers because the bonding impurities, hemiscellulose, pectin and lignin are removed from the surfaces of the fiber walls, which in turn increases the mechanical composite properties of natural fibers [11-12].

Alkaline treatment is done by dyeing natural fibers into an alkaline solution [13], with varying concentrations, time and temperature to get optimal results [14]. Resin is a material that will be strengthened fiber in general. Resins are liquid with low viscosity, which will harden after polymerization [15]. Epoxy resins are one type of polymer derived from the thermoset group [16]. Epoxy resins have isotropic properties and are sensitive to temperature, have properties that cannot melt, cannot be reprocessed, the atoms bind very strongly, cannot undergo chain shifts [17-20]. This research aims to develop composite materials with epoxy-ironed salak pellet fibers, with the length of the fibers used which are 1 cm, 1.2 cm, 1.4 cm, and 1.6 cm. To find out the physical properties: density, porosity and water content, mechanical properties: strong pull, strong bending and strong impact, and microstructure analysis using SEM.

## 2 Materials and Methods

### 2.1 Preparation of *Salacca zalacca* pellet fibers

The old or dark green midrib of *Salacca zalacca* or whose color begins to dark green is separated from the inside and outside. The *Salacca zalacca* smelter fiber contained on the inside, taken by manual means because the fiber is quite strong. Fiber is dried at room temperature to remove moisture content, then soaked using NaOH 5% for 6 hours. Fiber is cleaned with running water, then dried at room temperature. *Salacca zalacca* pellet fiber is ready to be used and tested for its cellulose, lignin and moisture content.

### 2.2 Composite Manufacturing

The smelt fibers are cut to a size of 1 cm, 1.2 cm, 1.4 cm, and 1.6 cm, epoxy resin and hardener are weighed at a ratio of 1 : 1 then mixed using the Hand Lay Up method. Specimen molds are coated in wax so that the sample is not sticky on the mold. Both iron plates are coated in aluminum foil so that the printed sample does not stick to the base iron plate and the lid plate. The *Salacca zalacca* smelt fibers are arranged randomly with a volume fraction of 30% on the mold then poured the epoxy mixture with the hardener into the mold using a spatula. Closed the mold using a cover plate and placed on a hot press. It is then pressed and set to 90°C for 20 minutes. The mold is removed from the pump and left for 10 minutes. The sample is removed from the mold by removing the iron plate from the aluminum foil then the aluminum foil is pulled slowly from the mold, making the sample like the first sample with a long variation of the *Salacca zalacca* smelt fiber. The resulting sample is then tested for mechanical properties, physical properties and SEM.

## 3 Result and Discussion

### 3.1 Chemical Content of *Salacca zalacca* pellet fibers

**Table 1.** Chemical content of *Salacca zalacca*

| Chemical Components | Unit | Test Results | Method |
|---|---|---|---|
| Water Content | % | 09.19 | SNl 08-7070-2005 |
| Lignin | % | 30.19 | SNI 8429:2017 |
| Alpha Cellulose | % | 41.00 | ASTM D 1103-60 |
| Others | % | 19.62 | |

### 3.2 Composite Physical Testing

*A. Density*

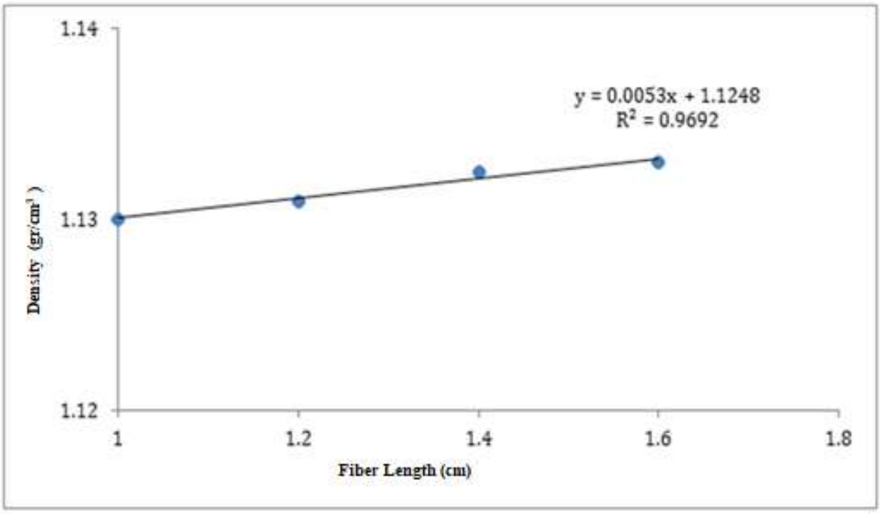



**Figure 1.** Fiber length of the composite of *Salacca zalacca* pellet fibers

Figure 1 shows the fiber length of fibers between the density and the length of the linier-inclined fiber. The average composite density value is 1.13 g/cm$^3$. The difference in fiber length from 1 cm to 1.6 cm does not affect the composite density. *Salacca zalacca* fiber composite can be used as a composite board in accordance with JIS A 5905: 2003 with a fiberboard density value of 0.35 g/cm$^3$ - 1.30 g/cm$^3$. All variations in fiber length from each composite of the resulting *Salacca zalacca* smelt fibers have met JIS A 5905:2003.

*B. Porosity*

Figure 2 shows the relation between porosity and the length of the linier-inclined fiber and the land between low data. Therefore the value of composite porosity can be averaged by 1.53% The difference in fiber length from 1 cm to 1.6 cm does not affect the porosity of the composite. Based on the composite porosity value of the variation in the length of the *Salacca zalacca* smelt fiber has met the quality standard of SNI 03-2105-2006 which has a porosity value smaller than 25%.

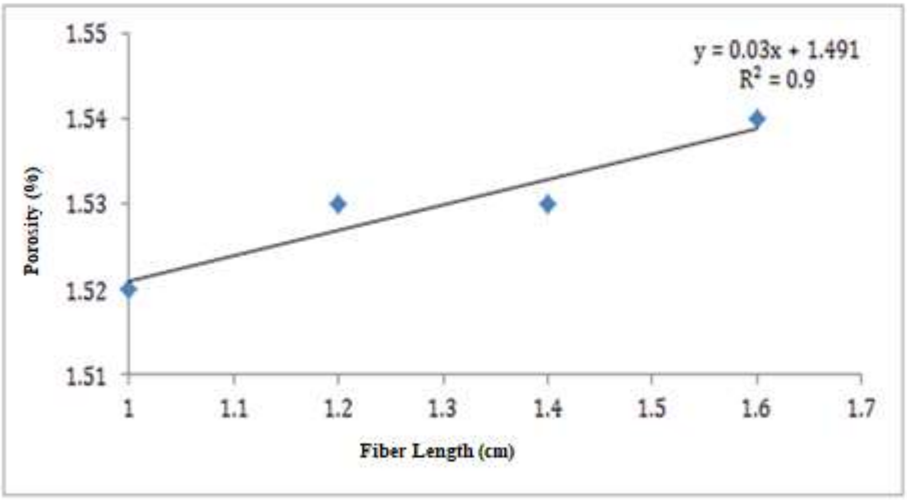



**Figure 2.** Fiber Length with Porosity Composite fiber smelt *Salacca zalacca* Graph

*C. Water Absorption*

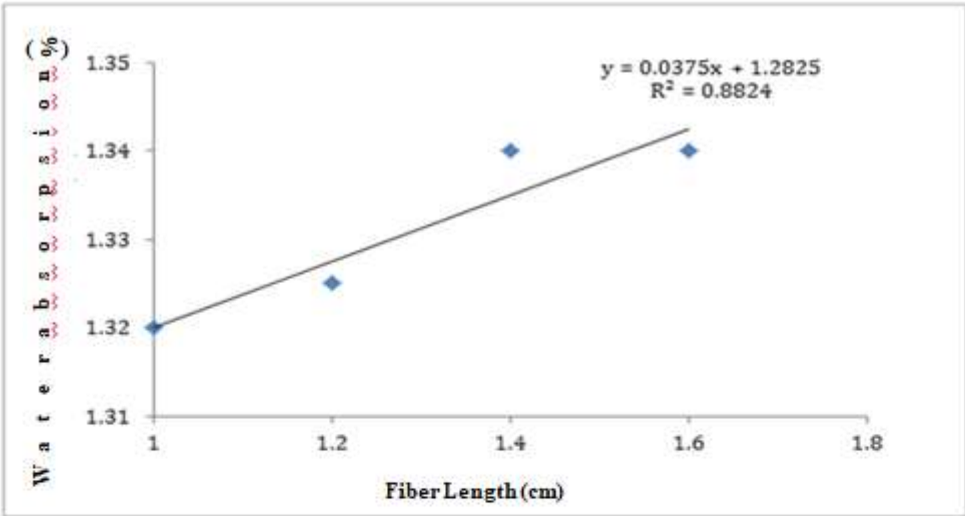



**Figure 3.** Fiber Long with Water Absorption composite *Salacca zalacca* pelepah Graph

Figure 3 shows the relation between water absorption and linier-inclined fiber length. The average water absorption is 1.33%. Based on JIS A 5950:2003 and SNI 03-2105-2006, the maximum fiberboard water absorption value is 25%. The composite water absorption of the *Salacca zalacca* smelter for each variation in fiber length has qualified it to be a fiberboard in accordance with JIS A 5950: 2003 and SNI 03-2105-2006.

## 3.3 Mechanical Testing

*A. Bending Strengh Test*

Sample testing is in accordance with astm D-790 standards. The results of a strong bending composite bending fiber can be seen in Figure 4.

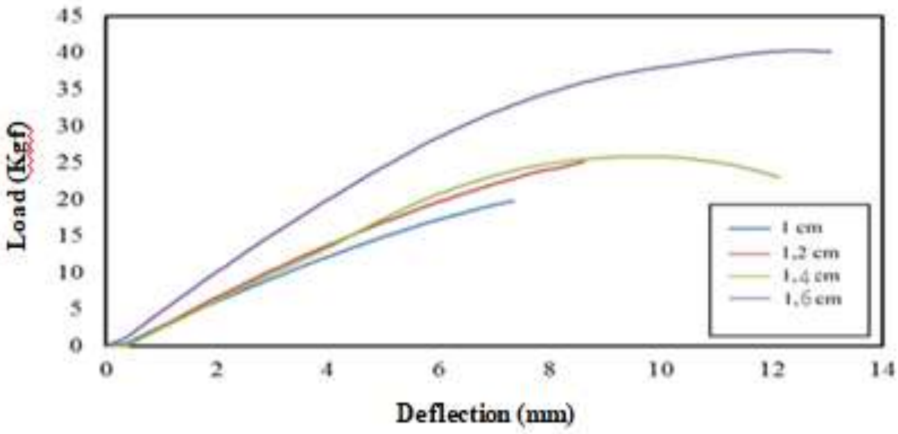



**Figure 4.** Load - composite deflection of *Salacca zalacca* pellet fibers

Figure 4 shows a variation in fiber length of 1 cm has a load of 19.19 kgf, experiencing a linear increase in the length variation of 1.2 cm fiber of 25.81 kgf. Up to a variation in fiber length of 1.6 cm by 40.12 kgf. Figure 4 also shows deflection at a volume fraction of 2% which is 7.816 mm experiencing an increase in liner on variations in fiber lengths of 1.2 cm, 1.4 cm, and 1.6 cm, namely 8.9 mm, 12.43 mm and 13.178 mm. This condition causes deflection directly proportional to the load. Based on JIS A 5905: 2003, the composite of the fiber with each fiber length has qualified the Fiber Board with a firmly bending greater than 35 MPa.

*B. Tensile Strengh Test*

Specimen testing using the ASTM 638 D standard. The results of the strong tensile tensile test of *Salacca zalacca* smelt fibers can be seen in Figure 5. Figure 5 shows the relation of variations in the length of the fiber and stress that increases, where the longer the fiber given, the greater the stress produced. This suggests that the matrix still works well receiving the load and being passed on to the fiber. Figure 5 also shows a strain at a fiber length of 1 cm which is 0.05% experiencing an increase in liner at the length of fiber 1.2 cm which is 0.06% but experiencing a decrease in strain at the length of fiber 1.4 cm which is 0.055% and increases back at the length of fiber 1.6 cm which is 0.08%. This condition causes the strain not directly proportional to the stress, based on Japanese Industrial Standard A 5905:2003. Fiberboard requires a pull strength greater than 0.4 MPa, the composite of the *Salacca zalacca* smelt fiber for each volume fraction has met the specified requirements.

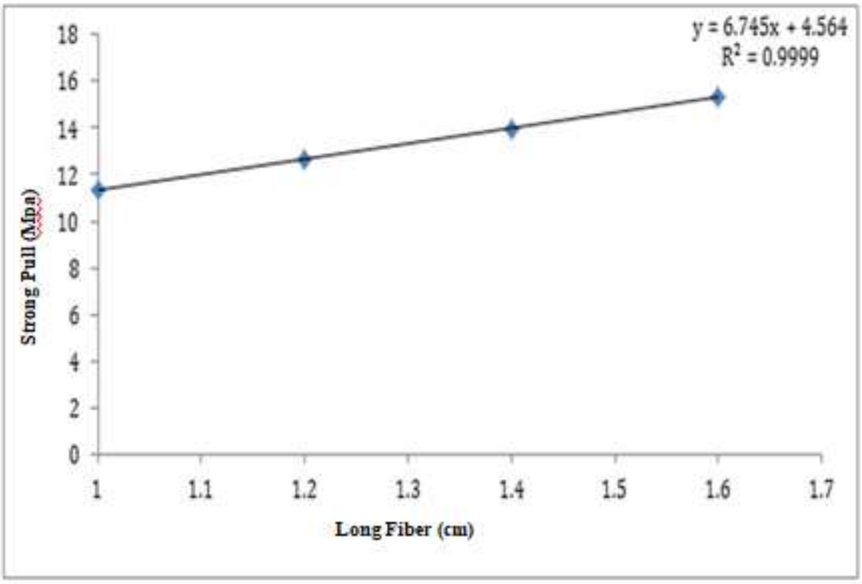



**Figure 5.** Long Fiber vs Strong Pull Composite Fiber shedding of *Salacca zalacca*

*C. Impact Strength Test*

Sample testing in accordance with ASTM 256 D. The results of strong test impact composite fiber *Salacca zalacca* can be seen in Figure 6.

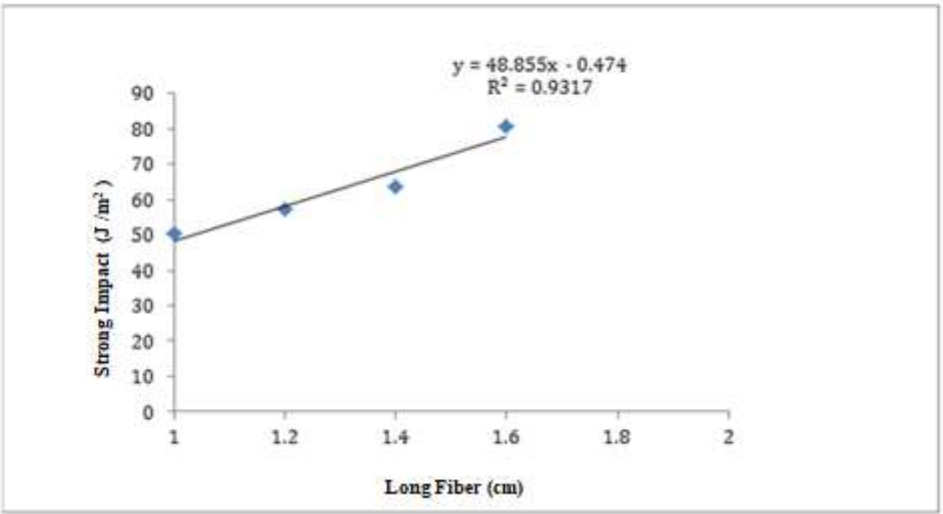
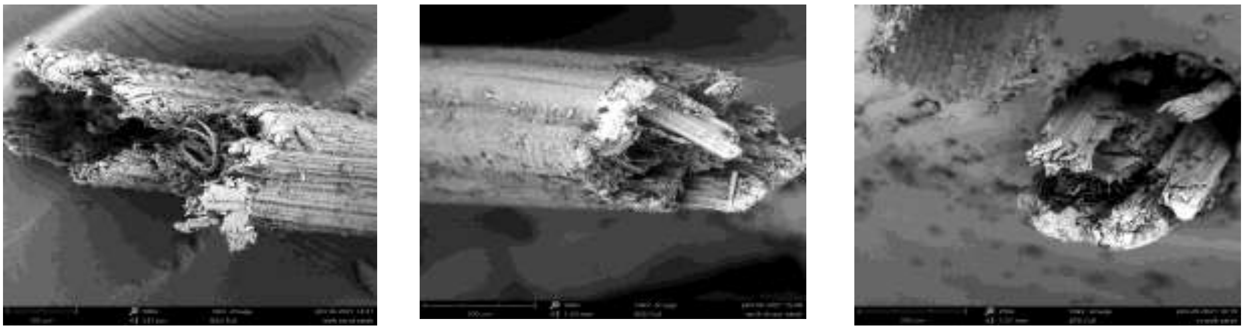



**Figure 6.** Relationship of Long fiber vs Strong Impact Composite *Salacca zalacca* pellet fibers

Figure 6 shows the highest impact strength is at a fiber length of 1.6 cm of 80.93 J/m$^2$ and the lowest impact strong is found at a fiber length of 1 cm of 50.43 J/m$^2$. The relationship of the variation in the length of the *Salacca zalacca* fiber with a strong impact is directly proportional, where the longer the fiber given, the greater the impact produced. The impact power of the car dashboard that has a type of HIGH IMPACT ABS material of 13.48 J/m$^2$ so that the results of research from the composite of the accompany fiber *Salacca zalacca*-epoxy with variations in the impact test volume fraction meet the standards of the car dashboard.

### 3.4 Composite microstructure

Composite fault microstructure of *Salacca zalacca*-smelting fiber-epoxy is analyzed with SEM. Composite samples are taken from the best tests on Strong Tens, Strong Bending, and Strong Impact, where for testing the best is at a fiber length of 1.6 cm. The composite microstructure is strong pull at a fiber length of 1.6 cm, strong bending at a fiber length of 1.6 cm and strong impact on the length of the fiber 1.6 cm in a row given in Figure 7.



(a) (b) (c)

**Figure 7.** (a) Strong microstructure tensile, (b) Strong microstructure bending, (c) Strong microstructure impact on a fiber length of 1.6 cm

Figure 7 (a-c) shows a composite of *Salacca zalacca* pellet fibers with epoxy resin binders that the matrix and fiber are well-tinged. Composite surface damage after tensile tests, bending tests and impact tests saw more uprooted fibers and pore-raised.

## 4 Conclusion

Variations in fiber length in composites *Salacca zalacca* pellet fibers affect the mechanical properties of composites so that they can be used as natural fiber composite amplifiers. The longer the fiber in the composite, the mechanical properties will increase linearly. The physical properties of composites are also improved but not very significant. The same volume fraction for each variation in fiber length results in less significant physical properties. The results of the Composite Physical Properties test showed a density value of 1.1325 g/cm$^3$. Porosity value of 1.53% and water absorption value of 1.33%. Mechanical Property Testing results showed a strong bending value of 25.15 kgf – 40.12 kgf has met the quality standards of JIS A5905:2003 which is strong bending > 32 MPa or 3.26 kgf. The tensile strength value worth 11.31 MPa – 15.37 MPa, has met the quality standards of JIS A5905:2003. Fiberboard requires a tensile strength greater than 0.4 MPa and a strong impact of 50.43 J/mm$^2$ - 80.93 J/mm$^2$ has met the high impact ABS quality standard of 13.48 J/m$^2$. Composite application with variations in the length of the 1 cm, 1.2 cm, 1.4 cm, and 1.6 cm with epoxy matrix, can be used as a car bumper material with a flexibility requirement greater than 32 MPa while at strong use the bending fraction of 2% volume has met the specified requirements.

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