
The Effect of Galangal Fiber Mass Fraction on the Bending Strength of Composites

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Abstract

This study examines the effect of galangal fiber mass fractions on the bending strength of polyester resin composites. The objective is to determine how varying fiber content influences mechanical performance. A quantitative experimental design was employed, with composite specimens fabricated using the hand lay-up method and fiber mass fractions of 6%, 8%, and 10%. Samples were prepared according to ASTM D Type 4 standards, with three replicates per group to ensure reliability. Data were collected using digital scales, grinders, molds, and mechanical testing machines. Statistical analysis involved descriptive statistics and T-tests at a 0.05 significance level, complemented by correlation coefficient evaluation. Results showed that the composite with 10% fiber content achieved the highest average flexural strength of 40.55 MPa, while 8% fraction had the lowest at 31.76 MPa, and 6% fraction yielded 38.38 MPa. However, T-test analysis indicated no statistically significant effect of fiber mass fraction on bending strength ($p = 0.771$). The study concludes that within the tested range, galangal fiber content does not significantly improve the bending performance under current fabrication and testing conditions. Future research should explore wider fiber content ranges and alternative fabrication methods to optimize reinforcement potential.

Keywords: Composite Materials, Environmental Sustainability, Natural Fibers, Polyester Resin, Tensile Strength

INTRODUCTION

Composite materials are engineered materials composed of two or more distinct constituents with differing chemical or physical properties that remain separate and distinct within the finished structure (Tjahjanti, 2018; Nasution & Arifin, 2019). Such composites offer advantages like lightness, stiffness, and durability, drawing significant attention in engineering applications (Rodiawan et al., 2016; Perdana & Yulsardi, 2016). The adoption of natural fibers as reinforcement materials is motivated by environmental concerns, as natural fibers are biodegradable and pose less ecological risk compared to conventional synthetic fibers, which have raised environmental issues due to poor recyclability and pollution (Rodiawan et al., 2016; Perdana & Yulsardi, 2016). Thus, natural fibers serve as sustainable alternatives, promoting the development of eco-friendly composite materials (Kartini et al., 2018; Antonius, 2019).

Composites typically consist of a matrix and reinforcement, where the matrix constitutes the major volume fraction and the reinforcement carries the load (Nayiroh, 2013; Ziansyah et al., 2024). Polymer matrices are broadly divided into thermoplastics and thermosets; polyester resin, a thermoset polymer, is frequently employed due to its strong bonding capabilities, elasticity, cost-effectiveness, and ease of processing compared to epoxy resins (Zhang, 2011; Naelendra et al., 2024). Fabrication was conducted with the hand lay-up method, a simple technique involving manual lamination of fiber fabrics impregnated with resin in open molds, widely used in composite manufacturing (Goodship et al., 2016; Beliu et al., 2016).

Previous studies have explored various natural fibers like ijuk and banana as reinforcement; however, literature focusing on galangal (lengkuas) fiber as a natural

reinforcement remains limited or absent (Kartini et al., 2018; Antonius, 2019). Galangal is a tropical plant that thrives in open sunlight, making it readily accessible for raw material extraction (Samosir, 2018). Its fibers exhibit promising tensile strength, potentially contributing to enhanced bending strength of composite materials (Antonius, 2019). This study investigates the effect of galangal fiber mass fractions on the bending strength of polyester resin composites, aiming to contribute novel insights enriching sustainable composite research and highlight galangal fiber as an environmentally friendly reinforcement alternative.

RESEARCH METHODS

This study employs a quantitative experimental research design aimed at examining the influence of galangal fiber (lengkuas) mass fractions on the bending strength of polyester resin composites. The experimental method is chosen to enable controlled observation and measurement of the mechanical behavior of the composite specimens under specific standardized testing conditions (Sugiyono, 2021; Creswell, 2021). The population consists of composite materials fabricated with varying mass fractions of galangal fiber—specifically 6%, 8%, and 10%—and a polyester resin matrix. Samples were prepared systematically according to ASTM D Type 4 standards for bending tests. The sample size includes three replicates per fiber fraction to ensure data reliability.

Data collection instruments include digital scales for precise mass measurements, grinders for fiber preparation, molds for specimen casting, measuring tools such as rulers and calipers, fabric shears, and specialized machines for tensile and bending testing. The hand lay-up technique is employed to fabricate the composite specimens, where fibers are manually layered and impregnated with polyester resin followed by curing under ambient conditions, reflecting a commonly used manufacturing process in composite production (Goodship et al., 2016; Sugiyono, 2021).

The research procedure consists of several phases: literature review to integrate theoretical support, preparation and processing of galangal fibers including drying and sizing, composite fabrication by hand lay-up, followed by mechanical testing to measure bending strength. Data analyses involve descriptive statistics and inferential statistics using T-tests to examine the significance of the effect of fiber mass fraction on bending strength, with significance levels set at 0.05 (Sudaryono, 2022; Waluyo et al., 2024). Coefficient correlation (R-square) analysis is further conducted to quantify the contribution of the independent variable to the dependent variable. The process ensures statistical rigor and data interpretability.

This methodical approach aims to produce valid and generalizable findings regarding the performance of galangal fiber as a natural reinforcement in polyester composites under bending load, filling a research gap in natural fiber composite materials literature (Antonius, 2019; Kartini et al., 2018; Creswell, 2021).

RESULTS AND DISCUSSION

Results of the Bending Test

The bending test was conducted using the ASTM D 790 standard with a total of 9 samples, and the following data were obtained:

Table 1. Bending Test Result Data

No.	Mass Fraction Specimen	Flextural Strength (MPa)	Average (MPa)
1	Galangal Fiber 6%	36,62	38,38
2		43,36	
3		35,16	
1	Galangal Fiber 8%	42,48	31,76
2		22,45	
3		30,37	
1	Galangal Fiber 10%	37,34	40,55
2		45,10	
3		39,23	

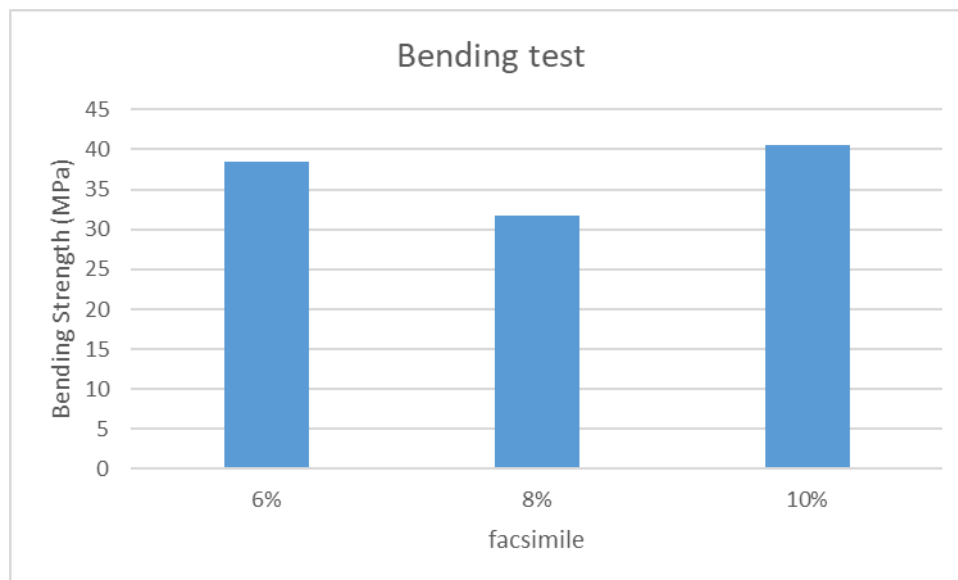


Figure 4. Average Results of Bending Test Graph

Based on the graph above, it can be seen that the flexural test results of the specimen with a 10% mass fraction of galangal have the highest average flexural value of 40.55 MPa, and the specimen with an 8% mass fraction of galangal has the lowest average value of 31.76 MPa. The composite with a 6% mass fraction produces an average bending strength value of 38.38 MPa.

Analysis of Bending Test Data

After obtaining the flexibility test data, the next step is to analyze the data and determine the factors affecting the response values of the test specimens. The data analysis of the test results was carried out using a T-test with the SPSS program. The following are the results of that data analysis.

Table 2. Results of T-Test Analysis for Flexibility (Bending) Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	34.947	6.595		5.299	.001

FRAKSI	-922	3.053	-.113	-.302	.771
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a. *Dependent Variable: FLEXTURAL*

Based on the coefficient table above, it is known that the significance value (sig.) for the effect of the independent variable on the dependent variable is 0.771. It can be seen that the independent variable (mass fraction) does not affect the dependent variable (flexural), as the significance value of 0.771 is greater than 0.05. This is because the results of the t-test show that the independent variable (mass fraction) does not influence the dependent variable (flexural).

CONCLUSION

This study investigated the effect of galangal fiber mass fractions on the bending strength of polyester resin composites. The experimental results showed that composites with 10% galangal fiber content exhibited the highest average flexural strength of 40.55 MPa, while the 8% fraction had the lowest average at 31.76 MPa. However, statistical analysis using the T-test revealed that variations in mass fraction did not significantly influence the flexural strength, as the significance value was 0.771, exceeding the 0.05 threshold. These findings indicate that within the tested range, the galangal fiber mass fraction has limited impact on improving bending performance under the given fabrication and testing conditions.

Limitations of this research include the relatively narrow range of fiber mass fractions tested and the exclusive use of the hand lay-up fabrication method, which may affect fiber distribution and resin impregnation homogeneity. Future studies should explore a wider range of fiber contents, alternative manufacturing techniques, and additional mechanical properties to fully understand the reinforcing potential of galangal fibers. Practical implications suggest that while galangal fiber composites offer an eco-friendly alternative, optimizing processing methods and fiber treatment is essential to enhance structural performance in engineering applications. This research contributes to sustainable composite development by highlighting both the promise and current constraints of galangal fiber reinforcement.

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