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Study of the effective fraction of areca nut husk fibre composites based on mechanical properties

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Abstract: Areca nut husk fibers have the potential to be used as reinforcement in polymer composites as a substitute for synthetic fibres. In the manufacture of fibre composites, one of the important factors in determining the strength is the matrix to fibre ratio. This study aims to determine the effective ratio or fraction between areca nut husk fibre and orthophthalic polyester resin. Before using areca nut husk fibre, it was chemically treated so that only cellulose remained in the fibre. The areca nut husk fibre was processed into sheets. The composite was manufactured using the hand lay-up technique. Tensile and flexural tests were carried out to determine the mechanical properties. Based on the results of the tests conducted, there are differences in the mechanical properties of the composites. The tensile test results show that the 40% fibre fraction has the highest tensile strength and modulus values. On the other hand, in the flexure tests, the highest tensile strength and modulus values are found in the 30% fibre fraction.

Keywords: ANHF; Tensile strength; Flexural strength; Natural fibre; Natural composite

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1. Introduction

Natural fibres have started to be widely used by the industry as reinforcements in fibre composites because they are environmentally friendly, biodegradable and non-toxic (Sunny & Rajan, 2022). The use of synthetic fibres is resistant to moisture and has good mechanical strength (Ali et al., 2018).However, it has disadvantages such as it is not made from renewable sources, it is not biodegradable, it becomes hazardous waste when it is no longer used and it causes health problems such as chronic irritation and lung cancer (Bos, 2004; Gapsari et al., 2021; Westman et al., 2010). Therefore, much research has been done to explore fibres from natural sources such as plants, minerals and animals.

One of the plant based fibres that is beginning to be widely used as a reinforcement in composites is Areca Nut Husk Fibre (ANHF). ANHF has the advantages of being low cost, biodegradable and non-toxic. Areca nut husk fibre has a cellulose content of 53.2% (Srinivasan et al., 2023). The potential of areca nut shell fibre is very interesting and needs to be further investigated. For example, the type of matrix suitable for use, the right type of additives to improve quality, and the right fraction of matrix and fibre.

Based on previous published research, it has been shown that the fibre fraction affects the mechanical properties of ANHF composites. In a composite using a polyester resin type matrix and a fibre fraction of 20 wt. % (Haque et al., 2021), while in another study

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using an epoxy type matrix, the highest mechanical properties were obtained with a fibre fraction of 40 wt. % (Alshahrani & Prakash, 2024; Lakshmana & Erko, 2022). Therefore, in ANHF composites with polyester resin matrix, it is necessary to investigate the increase of fibre fraction to improve the mechanical properties of ANHF composites. This study aims to reveal the mechanical properties of composites with orthophthalic polyester resin matrix and ANHF reinforcement. The study was carried out by varying the matrix and fibre fractions.

2. Material and methods

2.1 Preparation of samples

ANHF is chemically treated before being used as a reinforcement. Areca nut shell fibre contains components such as cellulose, hemicellulose, lignin, pectin and waxy substances. In order to use natural fibres as reinforcements in fibre composites, the hemicellulose, lignin, pectin and waxy substances must be removed. This is because these substances absorb moisture from the environment, which can lead to weakening of the fibre bond with the matrix material (Doan et al., 2006). In this study, ANHF were treated by soaking in 6% NaOH solution for 24 hours at room temperature of 26 ± 2°C. This chemical treatment method is more effective, the results of previous studies show that areca nut fibre composites have optimal tensile strength (Jayamani et al., 2014; Srinivasa et al., 2011; Srinivasan et al., 2023; Yousif et al., 2008).

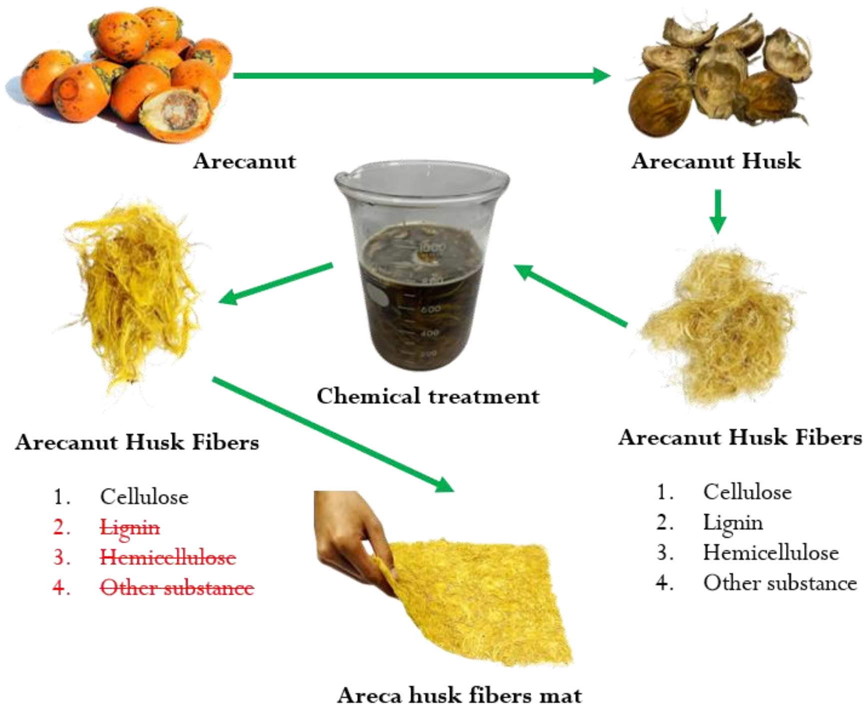


Figure 1. Preparation of ANHF

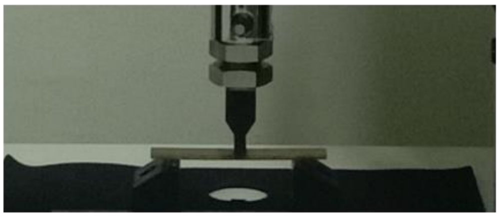
After the ANHF was treated with NaOH, the fibres were washed with water until no NaOH remained and then dried in the sun for two days. The dried ANHF was formed into sheets. Based on the experiment of making composites by the hand lay-up method that was tried. When composite samples were made with ANHF that was not in sheet form, it was very difficult to flatten the fibres on the moulding medium. Based on visual observation, there are parts that do not have fibres. Therefore, in this study, ANHF was first produced in sheet form. In addition, the composite was manufactured using lamination and hand lay-up techniques.

The resin type used was orthophthalic polyester resin. Composite panels were produced with different fibre weight fractions including 20%, 30% and 40%. The tensile test specimens were cast on 300mm x 200mm x 2.5mm moulds, while the flexural test specimens were cast on 100mm x 185mm x 4mm moulds.

2.2 Mechanical testing

Tensile and flexure tests were performed using a universal testing machine. Specimens were tested to ASTM D 3039 for tensile and ASTM D 7264 for flexure. Three samples were tested for each specimen.

Tensile Testing



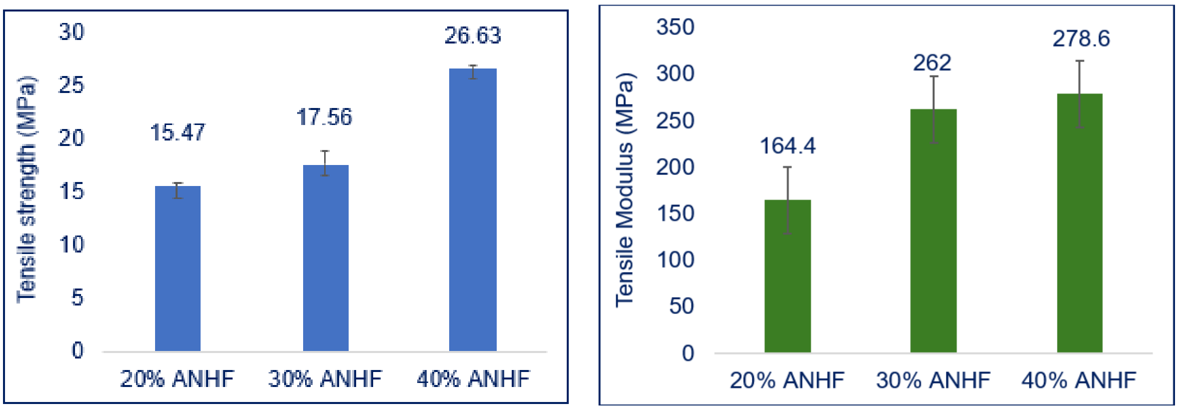
Flexural Testing

Figure 2. Tensile and flexural testing

3. Results and discussion

3.1 Tensile testing

The tensile test results for each specimen with different fibre fractions are shown in Figure 3.a. The tensile test results show that there are differences in the tensile strength of ANHF composites based on different fibre fractions. As the fibre fraction increases, so does the tensile strength. The tensile test results show that 40% ANHF fraction has the highest tensile strength of 26.63 MPa and. The lowest tensile strength is at 20% fibre fraction with a tensile strength value of 15.47 MPa and at 30% fibre fraction the tensile strength is 17.56 MPa. Previous research using polyester resin and a fibre fraction of 20 wt. % showed that the tensile strength of the ANHF composite was 22.06 MPa. However, in this study 20% pumpkin sponge was added (Haque et al., 2021). Based on this, the addition of 20% gourd sponge was able to increase the tensile strength of ANHF composites by 42%, while increasing the fibre fraction from 20 wt. % to 40 wt. % in ANHF composites can increase the tensile strength by 72%.

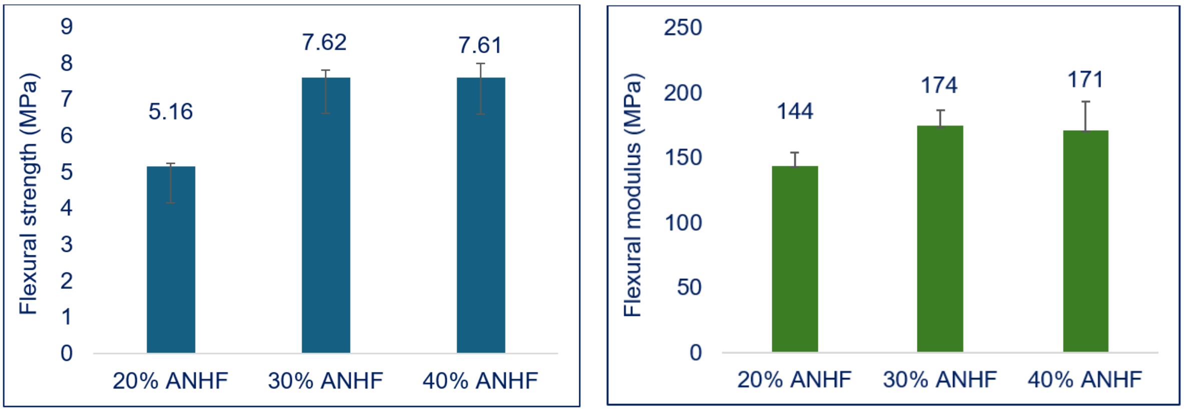


(a) (b)

Figure 3. Tensile properties of composites. (a) Tensile strength and (b) Tensile modulus

3.2 Flexural testing

The flexural test results are shown in Figure 4.a. The test results show that the specimen with 30% fibre fraction has the highest flexural strength which is 7.62 MPa. The 40% fibre specimen has a flexural strength of 7.61 MPa and the lowest is the 20% fibre specimen with a flexural strength of 5.16 MPa. In a study with the addition of 20% sponge gourd and a fibre fraction of 20 wt% (Haque et al., 2021), had higher flexural strength and modulus values than research from all fibre fractions used. This shows that there is an effect of adding 20% sponge gourd to ANHF composites. Increasing the fibre content only increased the tensile strength but not the elasticity of the material.



(a) (b)

Figure 4. Flexural properties of composites. (a) Flexural strength and (b) Flexural modulus

4. Conclusion

ANHF can be used as a reinforcement and orthophthalic polyester resin as a matrix for the manufacture of composites. To improve fibre bonding to the matrix, ANHF is treated with NaOH to remove hemicellulose, lignin, pectin and waxy substances, leaving only cellulose. Based on the experience of sample preparation, the hand lay-up process is very straightforward when ANHF is produced in sheet form. From the results of the tensile and flexural tests carried out, the fraction with the highest value in terms of tensile strength and modulus is the 40% ANHF fraction, while the highest flexural strength and modulus is the 30% ANHF fraction. Further research is needed with the addition of appropriate additives to improve the mechanical properties of ANHF composites.

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Declarations

Author contribution

Irfan Muhammad Akbar: Experiment, Anylisys VosViewer, dept-review and write original articles. Anna Niska Fauza: Data Curation, Writing - Review & Editing, and Supervision. Zainal Abadi: Writing - Review & Editing, and Supervision. Dieter Rahmadiawan: Writing - Review & Editing, and Supervision

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Competing interest

There is no conflict of interest in this study.

Ethical clerance

There are no human subjects in this manuscript and informed consent is not applicable.

References

Ali, A., Shaker, K., Nawab, Y., Jabbar, M., Hussain, T., Militky, J., & Baheti, V. (2018). Hydrophobic treatment of natural fibers and their composites—A review. *Journal of Industrial Textiles*, *47*(8), 2153–2183. https://doi.org/10.1177/1528083716654468

Alshahrani, H., & Prakash, V. R. A. (2024). Effect of silane-grafted orange peel biochar and areca fibre on mechanical, thermal conductivity and dielectric properties of epoxy resin composites. *Biomass Conversion and Biorefinery*, *14*(6), 8081–8089. https://doi.org/10.1007/s13399-022-02801-w

Bos, H. L. (2004). *The potential of flax fibres as reinforcement for composite materials*. https://api.semanticscholar.org/CorpusID:221260580

Doan, T.-T.-L., Gao, S.-L., & Mäder, E. (2006). Jute/polypropylene composites I. Effect of matrix modification. *Composites Science and Technology*, *66*(7–8), 952–963. https://doi.org/10.1016/j.compscitech.2005.08.009

Gapsari, F., Purnowidodo, A., Hidayatullah, S., & Suteja, S. (2021). Characterization of Timoho Fiber as a reinforcement in green composite. *Journal of Materials Research and Technology*, *13*, 1305–1315. https://doi.org/10.1016/j.jmrt.2021.05.049

Haque, M. M., Rejaul Haque, M., Munshi, Md. R., Alam, S. S., Hasan, M., Gafur, M. A., Rahman, F., Firdaus, M., & Ahmod, S. (2021). Physico-mechanical properties investigation of sponge-gourd and betel nut reinforced hybrid polyester composites. *Advances in Materials and Processing Technologies*, *7*(2), 304–316. https://doi.org/10.1080/2374068X.2020.1766298

Jayamani, E., Hamdan, S., Rahman, M. R., & Bakri, M. K. Bin. (2014). Investigation of Fiber Surface Treatment on Mechanical, Acoustical and Thermal Properties of Betelnut Fiber Polyester Composites. *Procedia Engineering*, *97*, 545–554. https://doi.org/10.1016/j.proeng.2014.12.282

Lakshmana, K. T., & Erko, K. G. (2022). Mechanical Properties of Epoxy Composite Using Papaya Slice Biochar and Areca Nut Chopped Fibre. *Advances in Polymer Technology*, *2022*, 1–8. https://doi.org/10.1155/2022/4733375

Srinivasa, C. V., Arifulla, A., Goutham, N., Santhosh, T., Jaeethendra, H. J., Ravikumar, R. B., Anil, S. G., Santhosh Kumar, D. G., & Ashish, J. (2011). Static bending and impact behaviour of areca fibers composites. *Materials & Design*, *32*(4), 2469–2475. https://doi.org/10.1016/j.matdes.2010.11.020

Srinivasan, H., Arumugam, H., A, A. D., Krishnasamy, B., M.I, A. A., Murugesan, A., & Muthukaruppan, A. (2023). Desert cotton and areca nut husk fibre reinforced hybridized bio-benzoxazine/epoxy bio-composites: Thermal, electrical and acoustic insulation applications. *Construction and Building Materials*, *363*, 129870. https://doi.org/10.1016/j.conbuildmat.2022.129870

Sunny, G., & Rajan, T. P. (2022). Review on Areca Nut Fiber and its Implementation in Sustainable Products Development. *Journal of Natural Fibers*, *19*(12), 4747–4760. https://doi.org/10.1080/15440478.2020.1870623

Westman, M. P., Fifield, L. S., Simmons, K. L., Laddha, S., & Kafentzis, T. A. (2010). *Natural Fiber Composites: A Review*. https://api.semanticscholar.org/CorpusID:135781056

Yousif, B. F., Gill, N. S., Lau, S. T. W., & Devadas, A. (2008). The Potential of Using Betelnut Fibres for Tribo-Polyester Composites Considering Three Different Orientations. *Volume 4: Design and Manufacturing*, 79–84. https://doi.org/10.1115/IMECE2008-68648