MALAYSIAN JOURNAL OF APPLIED SCIENCES 2024, VOL 9(2): 137-145
E-ISSN:0127-9246 (ONLINE)
http://dx.doi.org/10.37231/myjas.2024.9.2.412
https://journal.unisza.edu.my/myjas

PENERBIT Universiti Sultan Zainal Abidin

MALAYSIAN JOURNAL OF APPLIED SCIENCES
eISSN:0127-9246

REVIEW ARTICLE

Green Innovation: Kenaf Fiber as a Sustainable Filler in Composites

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Received: 26/08/2024, Accepted: 30/10/2024, Available Online: 31/10/2024

Abstract

Kenaf fiber has recently gained significant attention as a reinforcement in composite materials across various industries due to its excellent mechanical properties, ease of manufacturing, and natural biodegradability. This brief review examines the physical and chemical properties of kenaf. The high cellulose content of kenaf composites enhances their mechanical and thermal properties. Additionally, several previous studies focusing on improving kenaf composites are highlighted. The reinforcement made by using the kenaf fiber shows its potential to replace the glass fiber composite. The review also discusses the applications of kenaf in various industries, as well as the challenges faced by the kenaf industry in Malaysia and globally. Finally, the review addresses the potential and market demand for kenaf fiber and kenaf seed oil.

Keywords: Kenaf; natural rubber; composites; mechanical properties, thermal properties

Introduction

One of the crops that could provide developing nations like Malaysia with a steady stream of income is kenaf, also known as *Hibiscus Cannabinus*. This naturally occurring tropical plant is farmed professionally around the globe. Interestingly, this fiber has exceptional sustainability qualities because it grows quickly—in just 150 days—and is made of renewable resources. The bark (outer fiber) and the kenaf stem's core (internal fiber) are separate fiber types that make up its cylindrical physical form. Various parts of kenaf biofiber are shown in Fig. 1. The fibers present in hardwood are similar to the pith of kenaf. Research has indicated that hemicellulose has a percentage of 15–23% and lignin, 5.9–19%, in kenaf (Díez et al., 2020). A significant amount of cellulose makes up 44–63.5% of the total content. Kenaf has a high cellulose content, which contributes to its mechanical strength and stiffness. Along with other outstanding qualities including high specific strength and modulus, non-abrasiveness, low density, and cost-effectiveness, it also shows good properties under tension stress conditions (Rahman et al., 2024).

kenaf fiber has a high cellulose concentration that makes it capable of offering robust structural support, making it one of the stronger natural fibers (Abdul Khalil et al., 2010). This is the reason why kenaf fiber is being used as a reinforcing agent in the development of composite materials by numerous researchers. Furthermore, it should be mentioned that the chemical composition of kenaf fiber from the bast and core likewise varies.

This member of the *Malvaceae* family is well-known for the superior quality of its fiber, which is extracted straight from the dried stem materials and finds application in a variety of industries, primarily in paper and pulp (Jasmani & Ainun, 2023), bio-composite (Asyraf et al., 2021), textiles (Yosr et al., 2023), and manufacturing (Yusuff et al., 2021). Kenaf fibers are biodegradable, making them an eco-friendly alternative to synthetic fillers. It is lightweight, which can help in producing lighter rubber composites. Kenaf grows quickly, with a harvesting cycle of 4-5 months, making it a sustainable resource. Kenaf grows quickly, with a harvesting cycle of 4-5 months, making it a sustainable resource. Recently, biochar made from kenaf has been developed, along with its composites, for use in a variety of engineering and agricultural applications, such as polymer composites and nanostructure catalysts (Harussani & Sapuan, 2022). The terms "kenaf biochar" and "activated carbon" refer to materials that are primarily employed as soil amendments and adsorbents. Besides, other crops such as Roselle (Liu et al., 2021) and Gelam tree (Hashim et al., 2022, 2025) also have the potential to be used as biochar.

Thanks to recent discoveries, kenaf can now be considered a multipurpose crop because its uses have expanded beyond its traditional uses in the food (Kujoana et al., 2023), pharmaceutical, and medicinal industries (Norhisham et al., 2023). This is because kenaf extracts have several bioactivities, including antimicrobial, anticancer, antihypertensive, antidiabetic, and antithrombotic properties, among many others. The plant's various plant components, including its leaves, seeds, flowers, and stems, make it useful in many applications. This indicates that kenaf can also be considered a zero-waste crop, which is important for the long-term growth of any therapeutic or medicinal substances derived from kenaf. Kenaf contains phenols, flavonoids, terpene, siloxane, citric acid, tocopherols, and tocotrienol, among other phytochemicals, all of which have been strongly linked to the extracts' demonstrated pharmacological properties. For example, vitamin E, sterol, and polyunsaturated fatty acids are phytochemicals found in kenaf seed oil that can aid in the fight against cancer cells (Abd Ghafar et al., 2013). Type-2 diabetes risk can be reduced with even the most basic oral intake, such as drinking tea prepared from kenaf leaves (Goh et al., 2021).

The current article discussed the properties of kenaf fiber and its potential in several applications. The properties of kenaf composites were also highlighted. Lastly, the challenge and the future demand of the kenaf industry were discussed.

Figure 1. Visual representations of the kenaf plant, kenaf fiber, and ground kenaf

Properties Enhancement and Kenaf Potential as a Filler in Matrix

Composites derived from natural sources are thought to be viable alternatives to or enhancements of their non-biodegradable petrochemical-based equivalents. The most well-known ingredients for creating these eco-friendly materials are cellulose and starch. These two materials are abundant and renewable, coming from many sources. In addition, there is a lot of interest in using these materials in packaging applications because of their lower prices and biodegradability (Diah et al., 2024; Hashim et al., 2023). Despite their excellent strength-to-weight ratio, kenaf composites are not as widely used in automobiles due to their weak fiber-matrix interface bonding. To overcome this, a unique method utilizing graphene nanoplatelets (GNPs), kenaf fibers, and an epoxy matrix was created to create multiphase composites (Malik et al., 2024). These improvements were attributed to the uniform dispersion of GNPs and improved interlocking with the fiber surface. Because of their enormous surface area per unit volume, nanoscale fillers offer the unique benefit of considerable reinforcing at modest loadings in demonstrating dramatic changes in mechanical and electrical properties. When compared to micro or bigger aspect fillers, this processing area produces results that are two or more times greater (Hashim et al., 2020). The developed composite has the potential for interior parts (such as dashboards, interior walls, and luggage compartments) in the automotive vehicle.

In a study, the treated Kenaf fiber was added to polystyrene to improve the fiber-polymer matrix adhesion (Moustafa et al., 2020). The improvement in tensile strength and good correlation in water vapor and oxygen transmission rates supported the possibility of using this material for sustainable automotive components and gas-sensitive packaging applications. Corn starch (CS), sorbitol (a plasticizer), and multi-scale kenaf fiber (a reinforcing filler) were used to create biocomposite films (Hazrol et al., 2022). The fiber's tensile strength, Young's modulus, and elongation at break until (6 wt.%) all rose with the addition of kenaf. The ideal tensile strength, Young's modulus, and elongation at break of the films were achieved with the addition of Kenaf fiber, and they were 17.74 MPa, 1324.74 MPa, and 48.79%, respectively. Overall, the mechanical and physical qualities of CS films were improved by the use of kenaf fiber as a filler.

The blending of kenaf in natural rubber (NR) improved the properties of composites. NR, as a natural renewable resource, has many excellent comprehensive properties, such as outstanding resilience, high strength, and good processability (Norazlina, Firdaus, et al., 2015). The findings of an examination into how kenaf-filled natural rubber (NR) and thermoplastic polyurethane (TPU) composites behave after being treated with alkalinity with sodium hydroxide (NaOH) are presented in a paper (Jamaludin et al., 2024). NR, TPU, and processed kenaf fiber were combined with a single-screw extruder. Sample 1 (TPU:200 g), Sample 2 (TPU:200 g, NR:10 g), and Sample 3 (Kenaf:10 g, TPU:200 g, NR:10 g) were the three sample preparation ratios that were prepared. To find the stress-strain curve for the percentage of elongation and tensile stress values, the generated samples were put through impact and tensile testing. Sample 1 had the greatest Young's modulus, and sample 2 came in second. In conclusion, the characteristics of the kenaf/TPU composites were enhanced by the addition of natural rubber.

To develop kenaf-reinforced PLA-based composites, a study used poly(lactic acid) (PLA) as the matrix and untreated and surface-treated kenaf fibers as reinforcement (Singh et al., 2024). The produced treated kenaf/PLA composites exhibit enhanced tensile and flexural performances as a result of surface changes. The ideal tensile and flexural strengths of alkali-treated woven kenaf fiber composites with increased matrix adhesion are 72.81 MPa and 94.45 MPa, respectively. According to the current investigation, composites with a fiber volume fraction of 35% exhibit the highest tensile and flexural strength when manufactured at a molding temperature of 170 °C. The results of various surface treatments on the tensile strength are shown in Fig. 3. After all, kenaf fiber-reinforced PLA composites had a higher tensile strength thanks to three different surface treatments. Rheological properties are dependent on temperature, molecular weight, and shear rate (Norazlina, Retenam, et al., 2015). Under the same processing conditions, semicrystalline PLA typically has a higher shear viscosity than its amorphous counterpart. As the shear rate increases, the viscosities of the melt decrease significantly.

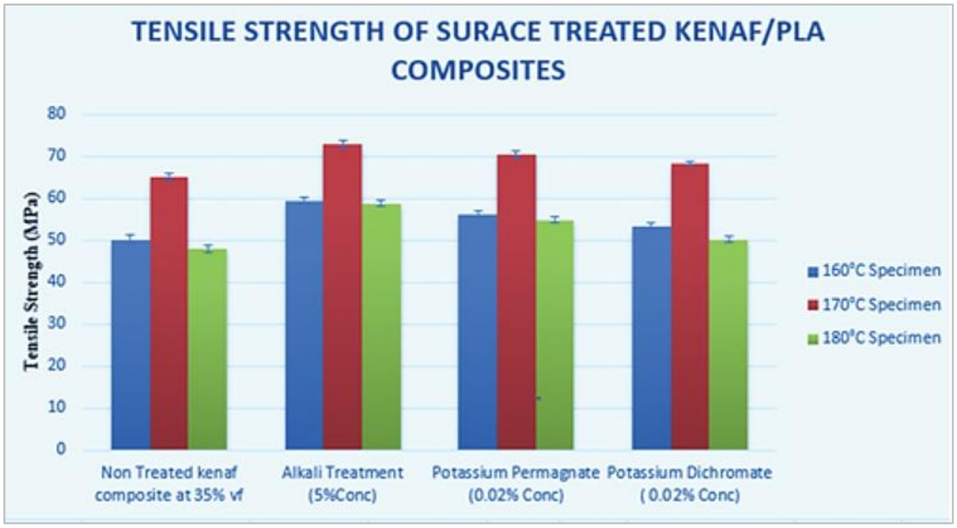

Figure 2. Surface treatment's impact on a surface's tensile strength PLA/Kenaf composites (Singh et al., 2024)

Hybrid composites are engineering material that consists two or more types of reinforcing fibers or fillers, show casting unique features with combination of properties of each individual fiber/filler. Maslinda et al. (Maslinda et al., 2017) reported on the reduction of moisture absorption in kenaf fibers epoxy composites by hybridizing with high lignin content fibers such as jute and hemp. An investigation of the mechanical, morphological, and physical characteristics of various hybrid CR/kenaf fiber reinforced with 0.5 wt.% MWCNT–phenolic composites were the main goal of the study (Loganathan et al., 2021). Plant *Cyrtostachys renda* (CR) is added to agro-waste materials to enhance polymer composites. CR fiber composites demonstrated a higher quantity of void content and lower thickness swelling compared to pure kenaf fiber composites. The addition of kenaf fiber in CR composites has increased the tensile stress, tensile strain, flexural stress, flexural strain, and impact strength in all cases.

The previous work's goal was to assess the hybrid nanocomposites made of nano clay and epoxy, non-woven bamboo mat (B), woven kenaf mat (K), and water absorption, thickness swelling, and thermal expansion (Chee et al., 2020). Through the manual lay-up process, montmorillonite (MMT), halloysite nanotube (HNT), and organically modified montmorillonite (OMMT) were incorporated at a weight percentage loading to create the hybrid nanocomposites based on natural fibers as shown in Fig. 3. The density and void content of the B/K/Epoxy hybrid composite was enhanced by hybridizing non-woven bamboo mats with woven kenaf mats. This is due to the non-woven bamboo mat having a more compact structure than the woven kenaf mat, which is porous. The density and void content of the hybrid nanocomposites are enhanced by the inclusion of nanoclay, as the nanofiller closes the open pores within the hybrid composites. The developed nanocomposites in this work have the potential to be applied in construction and automobile manufacturing that call for excellent dimensional stability.

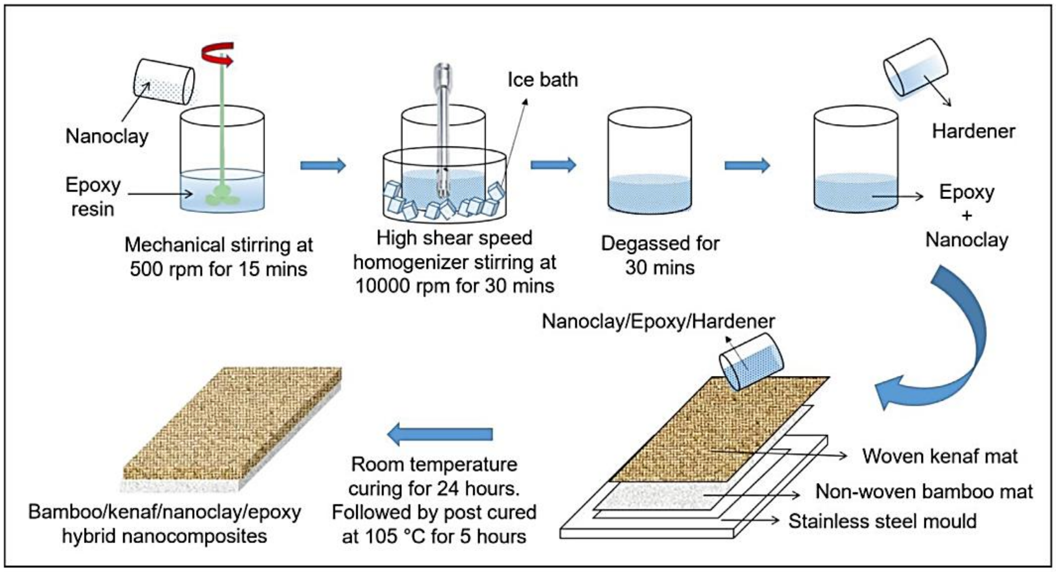

Figure 3. Preparation of bamboo/kenaf/nanoclay/epoxy hybrid nanocomposites (Chee et al., 2020)

Challenges and Future Directions of Kenaf Crop

A tropical climate presents a great opportunity for the production of kenaf. It provides raw materials for the manufacture of paper and other fiber-based industries. The sustainability of raw kenaf resources is a significant concern for Malaysia's kenaf sector, as a result of a decrease in both supply and demand. Fig. 4 shows the factors that cause the restriction in the development of the kenaf industry. In the kenaf sector, another difficulty is the lack of consumer awareness regarding the advantages of products based on kenaf (Vayabari et al., 2023). Consequently, there is less demand, which impedes the expansion of the sector. An additional difficulty facing the local kenaf business is a lack of skilled workers. For the production, processing, and cultivation of kenaf-based products, the industry is experiencing a labor shortage among competent workers. An important barrier to the industry's expansion is the scarcity of skilled workers. Kenaf's low yield is another problem facing the industry. Numerous things, including illnesses, pest infestations, and inadequate soil fertility, are to blame for this. These elements affect the quantity and quality of kenaf produced, which in turn affects the expansion of the sector. Further investigation and advancement are necessary to maximize the potential of kenaf as a raw material. Lack of sufficient research and development hinders the industry's ability to enhance and create new products, which is a major problem.

When referring to the potential products made from the kenaf crop, achieving uniform dispersion of kenaf fibers in the rubber matrix is critical for consistent performance. Kenaf fibers can improve the tensile strength, tear resistance, and durability of natural rubber films. Incorporation of kenaf fibers can enhance the thermal stability of natural rubber composites. Research should be further proceeded to improve the interfacial bonding between kenaf fibers and the rubber matrix can further enhance the mechanical properties. The government should develop standardized processing techniques and formulations that will help in the commercial adoption of kenaf-filled natural rubber films. In another way, utilizing agricultural waste reduces landfill usage and decreases environmental pollution. Kenaf waste has a big potential in development of composites due to the cheaper cost than synthetic fillers, thus reducing production costs.

Using Kenaf waste as a filler in natural rubber films offers a promising route toward sustainable material development. Integrating kenaf fibers can significantly improve natural rubber's mechanical and thermal properties, providing an eco-friendly and cost-effective alternative to traditional synthetic fillers. With ongoing research and development, kenaf-filled natural rubber composites are poised to become an integral part of various industries, contributing to a more sustainable future.

The Kenaf seed oil market outlook is shown in Fig. 5. Global Kenaf seed oil consumption is projected to rise at a compound annual growth rate (CAGR) of 6.1% between 2023 and 2033, provided that a market valuation of US$228 million is taken into account in 2033. Accordingly, it is projected that by the end of 2033, the global kenaf seed oil market will generate sales revenue of US$412.5 million. The widespread usage of kenaf seeds in the production of biofuels is a significant factor that is anticipated to drive market expansion in the future. Because of the rise in chronic illnesses in recent years, there has been a noticeable global emphasis on fitness and health, which has led to a growth in the market for functional foods.

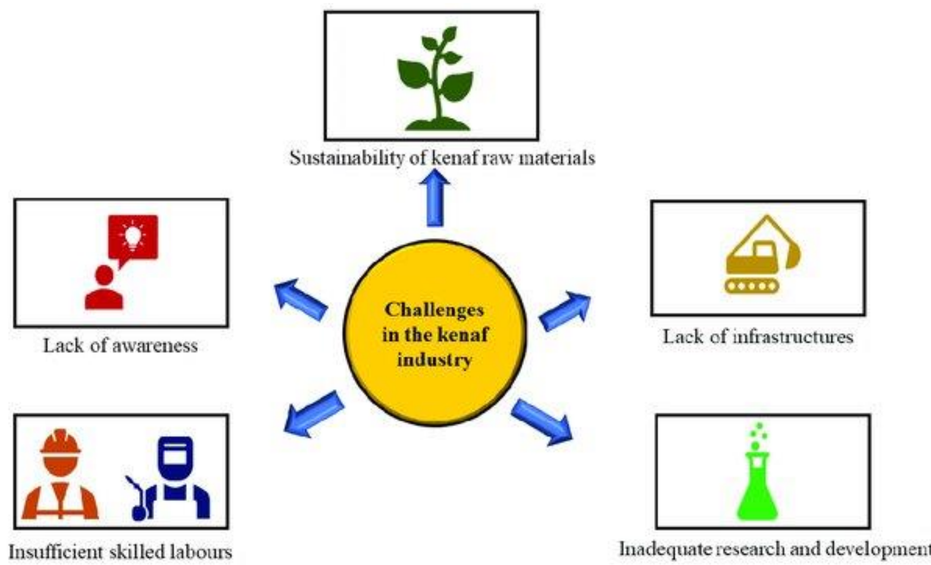

Figure 4. Challenges in the kenaf industry (Vayabari et al., 2023)

Figure 5. Kenaf seed oil market for year 2023–2033 (Kenaf Seed Oil Market, 2022)

Throughout the projected period, prices for kenaf seeds are expected to be a significant limitation on market evolution. A few companies that specialize in processing kenaf seed oil, low production, and a scarcity of commercialized raw materials are some other obstacles that may hinder the growth potential of several kenaf seed oil manufacturers in the years to come.

Leading providers of kenaf seed oil are concentrating on broadening their business reach globally by implementing innovative approaches and pursuing prospective markets. In January 2022, Kenaf Venture Global (KVG), a prominent Malaysian kenaf planter and producer, inked a Memorandum of Understanding (MoU) with the Aceh government to encourage the growth of the kenaf seeds industry in Aceh, Indonesia (Bernama, 2022). The signed agreement is expected to have a favorable effect on the environment, the economy, and society.

Conclusion

In conclusion, kenaf fiber presents a highly promising alternative to synthetic fibers and fillers, driven by its sustainability, biodegradability, and robust mechanical properties. Its high cellulose content enables it to enhance the mechanical and thermal characteristics of composites, making it valuable across diverse industries, from automotive and construction to agriculture and health. Despite challenges in scaling its production, optimizing processing techniques, and increasing consumer awareness, the kenaf industry shows potential for growth, particularly with the integration of kenaf in natural rubber films and the expanding global market for kenaf seed oil. Continued research and development, along with supportive government policies, could help overcome these obstacles, positioning kenaf as a key player in the global move toward eco-friendly materials and sustainable development.

Acknowledgments

The authors would like to thank University College TATI for its financial support under Short Term Grant (STG) 1/2023 No. 9001-2302.

References

Abd Ghafar, S. A., Ismail, M., Saiful Yazan, L., Fakurazi, S., Ismail, N., Chan, K. W., & Md Tahir, P. (2013). Cytotoxic activity of kenaf seed oils from supercritical carbon dioxide fluid extraction towards Human colorectal cancer (HT29) cell lines. *Evidence-Based Complementary and Alternative Medicine*, *2013*(1), 549705.

Abdul Khalil, H.P.S., Yusra, A.F.I., Bhat, A.H. & Jawaid, M. (2010). Cell wall ultrastructure, anatomy, lignin distribution, and chemical composition of Malaysian cultivated kenaf fiber. Industrial Crops and Products, 31(1), 113–121

Asyraf, M. R. M., Rafidah, M., Azrina, A., & Razman, M. R. (2021). Dynamic mechanical behaviour of kenaf cellulosic fibre biocomposites: a comprehensive review on chemical treatments. *Cellulose*, *28*(5), 2675–2695.

Bernama. (2022). *KVG inks MoU to expedite expansion in Indonesia's kenaf market*. NST Online. https://www.nst.com.my/business/2022/08/822981/kvg-inks-mou-expedite-expansion-indonesias-kenaf-market

Chee, S. S., Jawaid, M., Sultan, M. T. H., Alothman, O., & Luqman Chuah, A. (2020). Effects of nanoclay on physical and dimensional stability of Bamboo/Kenaf/nanoclay reinforced epoxy hybrid nanocomposites. *Journal of Materials Research and Technology*, *9*.

https://doi.org/10.1016/j.jmrt.2020.03.114

Diah, S.B.M., Abdullah, S.H.Y.S., Seok, Y.B., Fatah, I.Y.A., Rahman, Nor Iza A., Hafizulhaq, F., Alias, N.N. (2024). Towards Sustainable Food Packaging: A Review of Thermoplastic Starch (TPS) as a Promising Bioplastic Material, its Limitations, and Improvement Strategies with Bio-fillers and Essential Oils. Journal of Advanced Research in Fluid Mechanics and Thermal Sciences, 119(1), 80–104

Díez, D., Urueña, A., Piñero Hernanz, R., Barrio, A., & Tamminen, T. (2020). Determination of Hemicellulose, Cellulose, and Lignin Content in Different Types of Biomasses by Thermogravimetric Analysis and Pseudocomponent Kinetic Model (TGA-PKM Method). *Processes*, *8*, 1048. https://doi.org/10.3390/pr8091048

Goh, K. M., Ng, S. Y., & Nyam, K. L. (2021). The infusion of goji berries and red dates ameliorates the overall qualities of kenaf leaves tea. *International Food Research Journal*, *28*(6), 1216–1222.

Harussani, M. M., & Sapuan, S. M. (2022). Development of kenaf biochar in engineering and agricultural applications. *Chemistry Africa*, *5*(1), 1–17.

Hashim, N., Amin, N. R. B., Abdullah, S., Abdullah, A. H., Abdullah, N., Mohamed, R. M., Yahya, N. A. M., & Yusoh, K. (2020). The Effect of Blending Methods on the Properties of PLA/Gr Nanocomposites. *Journal of Physics: Conference Series*, *1532*(012012), 1–7.

Hashim, N., Ghani, M. A., Emran, M. F., & Badrulhaswan, M. (2025). Optimizing application of Melaleuca Cajuputi biochar on removing H2S odour from poultry manure. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *47*(1), 199–205.

Hashim, N., Mohd BadrulHaswan Besar, Muhammad Fauzan Emran, & Marsita Abd Ghani. (2022). Synthesizing the biochar from Gelam tree leaves by pyrolysis method. *International Journal of Synergy in Engineering and Technology*, *3*(2), 143–149.

Hashim, S.A., Seok, Y.B., Fatah, I.Y.A., Hoon, W.F., Abdullah, N.A. (2023). Leaf anatomical characteristics of the Pandanus immersus Ridley virgin fibres using Field Emission Scanning Electron Microscope (FESEM). Malayan Nature Journal, 75(2), 267–278.

Hazrol, M. D., Sapuan, S. M., Zainudin, E. S., Wahab, N. I. A., & Ilyas, R. A. (2022). Effect of Kenaf Fibre as Reinforcing Fillers in Corn Starch-Based Biocomposite Film. In *Polymers* (Vol. 14, Issue 8). https://doi.org/10.3390/polym14081590

Jamaludin, N., Salim, N., Abu Bakar, N. H., & Roslan, R. (2024). *Properties of Kenaf Fibre Filled with Natural Rubber/Thermoplastic Polyurethane Composites* (pp. 521–532). https://doi.org/10.1007/978-981-99-9848-7_47

Jasmani, L., & Ainun, Z. M. A. (2023). *Chapter 8 - Pulping and papermaking of kenaf* (Z. M. A. Ainun, S. M. Sapuan, & R. A. B. T.-P. and P. of N. P. F. Ilyas (Eds.); pp. 143–155). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-323-91625-7.00010-2

Kenaf Seed Oil Market. (2022). In *Fact.MR*. https://www.factmr.com/report/1087/kenaf-seed-oil-market

Kujoana, T. C., Weeks, W. J., Van der Westhuizen, M. M., Mabelebele, M., & Sebola, N. A. (2023). Potential significance of kenaf (Hibiscus cannabinus L.) to global food and feed industries. *Cogent Food & Agriculture*, *9*(1), 2184014.

Liu, D., Zheli, D., Ali, F., Kheir, A., Eissa, M., & Ibrahim, O. (2021). Biochar and compost enhance soil quality and growth of roselle (Hibiscus sabdariffa L.) under saline conditions. *Scientific Reports*, *11*, 1–12. https://doi.org/10.1038/s41598-021-88293-6

Loganathan, T. M., Hameed Sultan, M. T., Jawaid, M., Ahsan, Q., Naveen, J., Shah, A. U., Abu Talib, A. R., & Basri, A. A. (2021). Physical, Mechanical, and Morphological Properties of Hybrid Cyrtostachys renda/Kenaf Fiber Reinforced with Multi-Walled Carbon Nanotubes (MWCNT)-Phenolic Composites. In *Polymers* (Vol. 13, Issue 19). https://doi.org/10.3390/polym13193448

Malik, K., Ahmad, F., Dawood, M. S. I. S., Islam, M. S., Ali, S., Raza, A., & Shahed, C. A. (2024). Mechanical property enhancement of graphene-kenaf-epoxy multiphase composites for automotive applications. *Composites Part A: Applied Science and Manufacturing*, *177*, 107916.

Maslinda, A. B., Abdul Majid, M. S., Ridzuan, M. J. M., Afendi, M., & Gibson, A. G. (2017). Effect of water absorption on the mechanical properties of hybrid interwoven cellulosic-cellulosic fibre reinforced epoxy composites. *Composite Structures*, *167*, 227–237. https://doi.org/https://doi.org/10.1016/j.compstruct.2017.02.023

Moustafa, H., El-Wakil, A. E. A. A., Nour, M. T., & Youssef, A. M. (2020). Kenaf fibre treatment and its impact on the static, dynamic, hydrophobicity and barrier properties of sustainable polystyrene biocomposites. *RSC Advances*, *10*(49), 29296–29305.

Norazlina, H., Firdaus, R. M., & Hafizuddin, W. M. . (2015). Enhanced Properties From Mixing Natural Rubber With Recycled Polyvinyl Chloride By Melt Blending. *Journal of Mechanical Engineering and Sciences*, *8*(June), 1440–1447. https://doi.org/10.15282/jmes.8.2015.18.0140

Norazlina, H., Retenam, K., Somderam, S., & Yusoh, K. (2015). Effect of processing method on thermal behavior in PLA/PEG melt blending. *Advanced Materials Research*, *1134*, 185–190.

Norhisham, D. ‘Aizat, Saad, N. M., Ahmad Usuldin, S. R., Vayabari, D. A. G., Ilham, Z., Ibrahim, M. F., & Wan-Mohtar, W. A. A. Q. I. (2023). Bioactivities of kenaf biomass extracts: A review. *Processes*, *11*(4), 1–24. https://doi.org/10.3390/pr11041178

Rahman, M., Islam, M. N., Ara, M. A., Habib, M. A., & Parvez, M. M. H. (2024). Mechanical properties of Kenaf and Palmyra Palm leaf stalk fiber reinforced composite. *Results in Surfaces and Interfaces*, *15*, 100229.

Singh, J. I. P., Sharma, V., Singh, S., Dhawan, V., Belaadi, A., Kumar, R., Sharma, S., Kumar, A., Awwad, F. A., Khan, M. I., & Ismail, E. A. A. (2024). Impact of Molding Temperature, Fiber Loading and Chemical Modifications on the Physicomechanical, and Microstructural Morphology Properties of Woven Kenaf Fiber/PLA Composites for Non-Structural Applications. *Journal of Natural Fibers*, *21*(1), 2326586. https://doi.org/10.1080/15440478.2024.2326586

Vayabari, D. A. G., Ilham, Z., Md Saad, N., Usuldin, S. R. A., Norhisham, D. A., Abd Rahim, M. H., & Wan-Mohtar, W. A. A. Q. I. (2023). Cultivation Strategies of Kenaf (Hibiscus cannabinus L.) as a Future Approach in Malaysian Agriculture Industry. *Horticulturae*, *9*(8), 1–24.

Yosr, B. M., Mounir, J., & Slah, M. (2023). Study of the kenaf fibres spinnability: Influence of the percentage of kenaf cotton mixture on the yarn properties. *Journal of Natural Fibers*, *20*(1), 2166187.

Yusuff, I., Sarifuddin, N., & Ali, A. M. (2021). A review on kenaf fiber hybrid composites: Mechanical properties, potentials, and challenges in engineering applications. *Progress in Rubber, Plastics and Recycling Technology*, *37*(1), 66–83.

How to cite this paper:
Hashim, N., Mohamed, R.M., Sidik, M., Ireana Yusra, A.F. (2024). Green Innovation: Kenaf Fiber as a Sustainable Filler in Composites. *Malaysian Journal of Applied Sciences,* 9*(*2), 137-145.