Management Systems
in
Production Engineering

2026, Volume 34, Issue 1, pp. 97-102

Date of submission of the article to the Editor: 05/2025
Date of acceptance of the article by the Editor: 01/2026

DOI 10.2478/mspe-2026-0009

EXPLORING GNETUM GNEMON L. FIBERS IN NOKEN BAG: A PATH TO SUSTAINABLE MATERIAL DEVELOPMENT THROUGH MECHANICAL TESTING

Johanis Manuel Ramandey, Wardhana Wahyu Dharsono
Universitas Satya Wiyata Mandala, Nabire

Nugroho Mamayu Hayuning Bawono
Institut Hukum dan Pembangunan Papua

Suryadi
Universitas Satya Wiyata Mandala, Nabire

Paulus Wisnu Anggoro
Universitas Atma Jaya Yogyakarta

Abstract:
This research investigates the mechanical properties of Gnetum gnemon L. fibers, a traditional material used in Papua's UNESCO-recognized Noken bags. The study examined three different weaving patterns (1×1, 2×1, and 2×2) to determine their tensile strength and elongation characteristics. Testing revealed that the 2×2 weave pattern demonstrated the highest tensile strength with a mean breaking force of 678.09 N, while the 1×1 pattern showed the greatest elongation at break at 195.37%. Compared to other natural fibers like pineapple, yucca, coir, cotton, and bamboo, Gnetum gnemon fibers exhibited superior mechanical properties with a tensile strength of 739 N and density of 1.72 g/cm³. These findings suggest significant potential applications in technical textiles, protective clothing, and composite materials. The study highlights the untapped potential of Gnetum gnemon fibers, particularly in Papua where the species is abundant yet underutilized. Further research on durability, environmental resistance, and industrial-scale performance would be valuable for developing practical applications of this promising natural fiber.

Key words: gnetum gnemon fiber, tensile strength, weaving pattern, noken bag, sustainable materials

INTRODUCTION

Natural fibers are gaining importance in materials science as industries seek sustainable alternatives to synthetic materials. Addressing this challenge requires strategic utilization of plant-derived biomass and natural fiber extraction. As seen on previous research that examined other natural fiber such as: Sida Rhombifolia [1], Kenaf Fiber [2], Jute Fiber [3, 4], Oil Palm [5], Bamboo [6], Enset Ventricosum [7], Sisal Fiber [8]. The intrinsic characteristics of natural fibers – including their renewable nature, low environmental impact, and potential for localized production – position them as compelling alternatives to conventional synthetic reinforcement materials [9].

Gnetum gnemon L., a gymnosperm species indigenous to Southeast Asian regions, taxonomically classified within the Gnetaceae family [10], this woody plant is predominantly found in Indonesia, Malaysia, and the Philippines. While previous scientific investigations have predominantly focused on the plant's nutritional and pharmacological properties [11, 12, 13], the mechanical and structural potential of its fibers remains substantially underexplored. The cultural significance of Gnetum gnemon is particularly evident in regions like Papua, where indigenous communities have historically utilized its fibers in traditional crafting, most notably in the production of Noken bags – a cultural artifact recognized by UNESCO as Intangible Cultural Heritage in 2012 [14].

Fig. 1 Noken Bag Made from Gnetum Gnemon Fiber

The material of Noken bags as seen on Fig. 1 incorporates diverse natural fibers, by utilizing planst bark includes the Melinjo tree (Damiyo), Ilam tree bark (Tokeipo), anyamin tree (Kepiyai), tree bark (Woge), Watu tree bark and Epiyo [15]. Among these various natural materials, Gnetum gnemon fibers, derived from the melinjo tree, demonstrate particularly promising characteristics due to their superior tensile strength properties and widespread availability throughout the Indonesian archipelago [12].
Previous research on natural fiber tensile properties vary significantly across plant types. Kenaf fibers show tensile strengths of 200-400 MPa with 1.5-3.5% elongation [16], reaching 692 MPa when combed [17]. Bamboo fibers display more consistent properties with 150-250 MPa tensile strength [18]. These variations, influenced by extraction methods, maturity, environment, and processing, emphasize the importance of studying specific fibers like Gnetum gnemon L. to understand their unique mechanical properties.
This study examines the mechanical properties of the understudied Gnetum gnemon L. fibers, expanding beyond previous research that only focused on its biological and nutritional aspects. Unlike well-researched natural fibers such as hemp, jute, and bamboo, this investigation aims to understand Gnetum gnemon L.'s potential for sustainable materials engineering, textiles, and composites.

MATERIAL AND METHODS

Materials

Gnetum gnemon L. fiber yarn was collected from farmers in Nabire, Central Papua, Indonesia (Fig. 2).

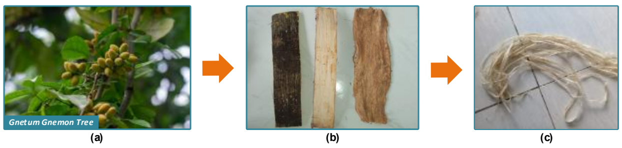

Fig. 2 Gnetum Gnemon L. Fiber Yarn Process: (a) Gnetum gnemon L. tree, (b) bark separation of gnetum gnemon, (c) Yarn made from gnetum gnemon fiber

The fibers are harvested from mature trees (15+ cm diameter) through traditional methods involving bark removal, layer separation, and stone-based softening. After drying to 8-12% moisture content to prevent fungi and maintain quality, the fibers are hand-twisted against the thigh to form yarn, though this traditional Papuan method makes it challenging to maintain uniform fiber diameter.

Fabrication of Gnetum Gnemon Woven

The procedural framework, as illustrated in Fig. 3, demonstrates a systematic progression initiating with the prepared fiber strands, proceeding through a prescribed pattern of interlacement to achieve the desired structural configuration. Using traditional Papuan noken bag weaving techniques, the fibers are woven into a 300 mm x 300 mm textile piece.

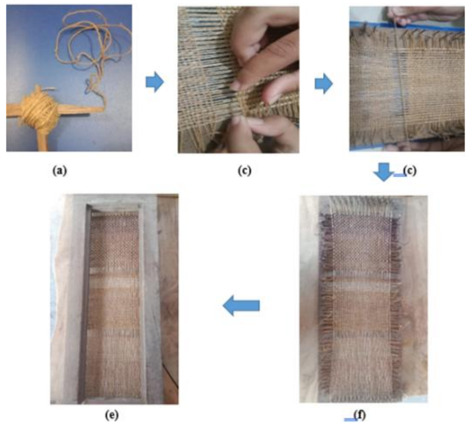

Fig. 3 Woven's Fabrication

Three distinct weave configurations illustrated on Fig. 4 were subjected to testing: plain (1×1), twill (2×1), and basket (2×2), which illustrate conventional fiber interlacement structures.

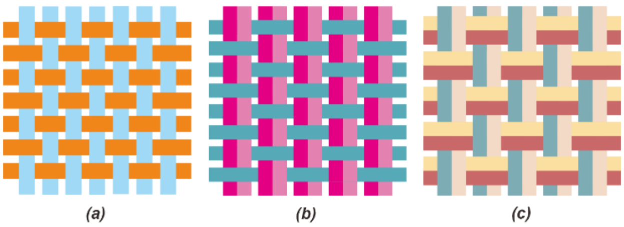

Fig. 4 Weaving Pattern: a) 1×1 Weave, b) 2×1 Weave, c) 2×2 Weave

This process represents a synthesis of traditional craftsmanship and functional design principles, resulting in the characteristic structural integrity commonly used in Papua's noken bag. Weaving patterns constitute a critical determinant in the mechanical properties and durability of natural fiber-based products [19]. The variation in weaving patterns not only influences aesthetic attributes but also demonstrates direct correlation with tensile strength and product longevity [20]. This research attempt to conduct a systematic analysis of Gnetum gnemon fiber tensile strength across different weaving pattern variations.

Tensile Test

Tensile tests followed ISO 13934 and SNI 0276:2009 standards. Nine specimens in total (three from each weaving pattern) were tested, each measuring 150 mm x 25 mm with 2.2 mm thickness as illustrated in Fig. 5, enabling statistical analysis of the fiber's mechanical properties under stress [21, 22].

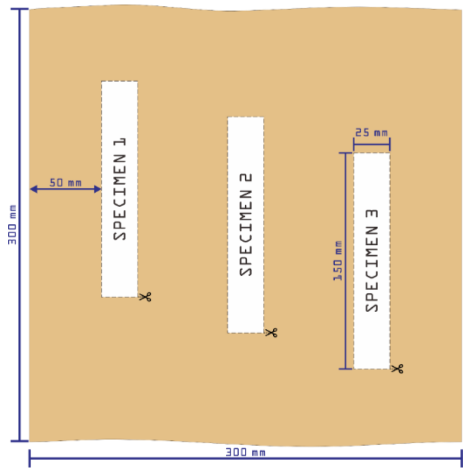

Fig. 5 Illustration of Cutting Specimens

Tensile testing was performed using a HungTa HT2402 Universal Testing Machine under room temperature, with a 30 mm/min crosshead speed and 75 mm initial gauge length (Fig. 6).

Fig. 6 Tensile Testing of Gnetum Gnemon L. Woven

The ultimate tensile strength (σ) was calculated according to paper published by [23].

$$\sigma = \frac{F}{A}, \tag{1}$$

where:
F is maximum failure load (N),
A is initial cross-sectional area (mm²), expressed in N/mm² (MPa).
The extensibility characteristics of the specimens under tensile loading were quantified through percentage elongation at break (ε), according to paper published by [20].

$$\varepsilon = [(Lf - Lo)/Lo] \times 100, \tag{2}$$

where:
Lf is final rupture length,
Lo is original gauge length, indicating the fiber's deformation capacity.

RESULT AND DISCUSSION

Tensile Test Result

The empirical data from Table 1 and Fig. 8 show the 2×2 weave pattern achieved the highest breaking force at 678.09 N, significantly outperforming both 2×1 (562.62 N) and 1×1 (510.79 N) patterns. This superior strength is due to the 2×2 weave's complex structure, which better distributes stress across the fiber matrix.

Table 1
Tensile Tests Result

Woven's Pattern	Tensile Properties	Specimens 1	2	3	Avg
1×1	Max. breaking force (N)	495.99	537.46	498.92	510.79
	Elongation (%) at break	194.50	205.00	186.60	195.37
2×1	Max. breaking force (N)	521.60	554.04	612.22	562.62
	Elongation (%) at break	160.50	117.30	151.30	143.03
2×2	Max. breaking force (N)	662.34	632.46	739.48	678.09
	Elongation (%) at break	196.50	167.00	191.00	184.83

The tensile test results reveal an unexpected pattern: the 1×1 weave showed highest elongation at break (195.37%), followed by 2×2 (184.83%), while 2×1 had the lowest (143.03%). This suggests that the 2×1 weave pattern restricts fiber movement under tension, aligning with research showing weave patterns can limit fiber mobility and affect mechanical performance. [24, 25, 26, 27]. The 2×2 weave's complex architecture allows for a more even distribution of stress across the fiber matrix, reducing the likelihood of localized stress concentrations that can lead to failure [28, 29].

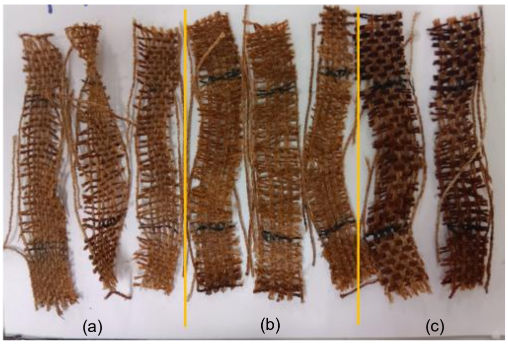

Fig. 7 Post Testing Specimen

Post testing specimen in Fig. 7, reveal that the fibers exhibit minimal length variation, indicating high elasticity. The stress-strain graph in Fig. 8 further illustrates this characteristic, showing the material undergoes both elastic and plastic deformation.

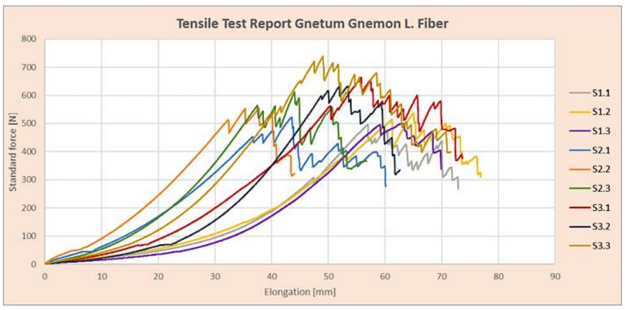

Fig. 8 Comparative Chart of Tensile Properties in Gnetum Gnemon Fiber Weave

The graph initially displays a linear elastic region, followed by a plateau phase, before ultimately experiencing fiber damage and fracture.

Comparison with other Natural Fiber

The Gnetum gnemon fibers exhibit higher mechanical properties compared to other natural fibers as seen on Table 2.

Table 2
Comparison With Other Natural Fiber Yarn

Fiber Material	Source	Density (g/cm^3)	Tensile Strength (N/mm^2)	Elongation (%)
Gnetum Gnemon	Present Study	1.72	739	191
Pineapple	[30]	1.41	242	48
Yucca	[31]	1.33	444	4.30
Coir	[32]	1.15-1.46	95-230	15.00-51.50
Cotton	[33]	1.14	494	22.95
Bamboo	[34]	1.10	630	23.80

This research demonstrates that the Gnetum gnemon fibers have a tensile strength of 739 N/mm^2, which is significantly higher than the tensile strengths of other natural fiber. Additionally, the Gnetum gnemon fibers exhibit an exceptional elongation at break of 191%, greatly exceeding the elongation values of other natural fiber. Only bamboo approaches the exceptional mechanical performance of the Gnetum gnemon fibers.

The density of the Gnetum gnemon fibers, measured at 1.72 g/cm^3, is also relatively high compared to other natural fibers such as pineapple (1.41 g/cm^3), yucca (1.33 g/cm^3), coir (1.15-1.46 g/cm^3), cotton (1.14 g/cm^3), and bamboo (1.1 g/cm^3). This combination of high strength, significant elongation, and increased density suggests that the Gnetum gnemon fibers possess unique structural and compositional characteristics that contribute to their superior mechanical properties.

The mechanical performance of Gnetum gnemon fibers stems from their unique fiber structure, chemical makeup, and constituent interactions. Their controlled deformation pattern, different from other natural fibers' brittle failure, indicates special cell wall structure and fiber bonding. The behavior also relates to cellulose crystal structure, whose compression and alignment under stress affects the fiber's deformation capacity [35, 36]. These microstructural features likely play a pivotal role in the fibers' ability to withstand high tensile loads while maintaining structural integrity and ductility [37, 38].

Gnetum Gnemon Fiber Potential Application

Gnetum gnemon fibers show potential for technical textiles, protective clothing, and performance wear. With a tensile strength of 739 N/mm^2 and 191% elongation, the fiber offers robust performance and flexibility. Its low density of 1.72 g/cm^3 creates lightweight materials that reduce wearer fatigue and enhance comfort in demanding applications like athletic and protective equipment.

The 2×2 weaving configuration enables precise fabric engineering, allowing targeted design for specialized uses. The fiber's structural integrity and adaptability make it suitable for industrial workwear, and protective gear that requires both strength and flexibility.

In composite material development, Gnetum gnemon fibers present compelling advantages. Their high tensile strength, low density (1.72 g/cm^3), and superior strength-to-weight ratio make them particularly attractive for automotive, aerospace, and construction industries. Compared to established natural fibers like bamboo, these fibers demonstrate competitive and often superior mechanical characteristics, particularly in terms of elongation and tensile performance.

The fibers offer significant sustainable development opportunities, especially in Papua where they are abundant but underutilized. While currently limited to traditional products like Noken bags, their potential extends far beyond current uses. This creates an opportunity for economic growth through sustainable material production, benefiting local communities while providing an environmentally friendly alternative to synthetic materials.

CONCLUSION

The mechanical properties of the Gnetum gnemon fibers are strongly influenced by the weaving pattern. This demonstrates that the structural architecture of the woven fabric plays a critical role in determining the fiber's overall mechanical behavior. These findings have important implications for the potential application of Gnetum gnemon fibers in textile industries, make it a promising candidate for use in high-performance textile applications, such as composite materials, where controlled failure progression is desirable.

Future investigations should focus on optimization weaving pattern studies, environmental resistance testing, extraction technique optimization, and exploration of hybrid textile formulations.

ACKNOWLEDGEMENT

This research has been financially supported by Beginner Lecturer Research Grant from the Directorate of Research and Community Service, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia under Primary Contract Number: 483/LL14/PG.02.00.PL/2024, Derivative Contract Number: 483/LL14/PG.02.00.PL/2024, 001/LPPM-USWIM/PN/VI/2024.

REFERENCE

[1] Ngoup, T. et al. (2024) ‘Physical, Chemical and Mechanical Characterization of Sida Rhombifolia Fibers from the Center Region of Cameroon for their potential use in textiles and composites’, *Journal of Natural Fibers*, 21(1). Available at: https://doi.org/10.1080/15440478.2023.2294478.

[2] Abdulkareem, M. et al. (2024) ‘Compressive and Flexural Strengths of Bio-Recycled Concrete Incorporated with Kenaf Fibre’, *Journal of Natural Fibers*, 21(1). Available at: https://doi.org/10.1080/15440478.2023.2296913.

[3] Alimuzzaman, S. et al. (2024) ‘A Novel Approach of Manufacturing Sustainable Seamless Jute Bags and Evaluation of Its Properties: A Comparative Study with Commercial Bags’, *Journal of Natural Fibers*, 21(1). Available at: https://doi.org/10.1080/15440478.2023.2299548.

[4] Haniel, Bawono, B. and Anggoro, P.W. (2023) 'Optimization of Characteristics Polymer Composite Reinforced Kenaf and Jute Fiber Using Taguchi-Response Surface Methodology Approach', *Journal of Natural Fibers*, 20(2). Available at: https://doi.org/10.1080/15440478.2023.2204453.

[5] Mahardika, M. et al. (2024) 'Recent Developments in Oil Palm Empty Fruit Bunch (OPEFB) Fiber Composite', *Journal of Natural Fibers*, 21(1). Available at: https://doi.org/10.1080/15440478.2024.2309915.

[6] Shahapurkar, K. et al. (2024) 'Impact and Compression Behavior of Habesha Moringa/Bamboo Fiber Reinforced Epoxy Composites', *Journal of Natural Fibers,* 21(1). Available at: https://doi.org/10.1080/15440478.2024.2311301.

[7] Dejene, B.K. (2024) 'False Banana (Enset Ventricosum) Fibers: An Emerging Natural Fiber with Distinct Properties, Promising Potentials, Challenges and Future Prospects – A Critical Review', *Journal of Natural Fibers*, 21(1). Available at: https://doi.org/10.1080/15440478.2024.2311303.

[8] Gudayu, A.D. et al. (2022) 'Effect of surface treatment on moisture absorption, thermal, and mechanical properties of sisal fiber', *Journal of Industrial Textiles*, 51(2), pp. 2853S-2873S. Available at: https://doi.org/10.1177/1528083720924774.

[9] Jagadeesh, P. et al. (2022) 'Recent developments and challenges in natural fiber composites: A review', *Polymer Composites*, 43(5), pp. 2545-2561. Available at: https://doi.org/https://doi.org/10.1002/pc.26619.

[10] [10] Carlquist, S. (1996) 'Wood and bark anatomy of lianoid Indomalesian and Asiatic species of Gnetum', *Botanical Journal of the Linnean Society*, 121(1), pp. 1-24. Available at: https://doi.org/10.1006/bojl.1996.0021.

[11] Barua, C.C., Haloi, P. and Barua, I.C. (2015) 'Gnetum gnemon linn: A comprehensive review on its biological, pharmacological and pharmacognostical potentials', *International Journal of Pharmacognosy and Phytochemical Research*, 7(3), pp. 531-539.

[12] Aiso-Sanada, H. et al. (2018) 'Reaction wood anatomy and lignin distribution in Gnetum gnemon branches', *Journal of Wood Science*, 64(6), pp. 872-879. Available at: https://doi.org/10.1007/s10086-018-1772-2.

[13] Anisong, N. et al. (2022) 'A comprehensive review on nutritional contents and functional properties of Gnetum gnemon Linn.', *Food Science and Technology* (Brazil), 42. Available at: https://doi.org/10.1590/fst.100121.

[14] Salhuteru, A. and Hutubessy, F.K. (2020) 'The Transformation of Noken Papua: Understanding the Dynamics of Noken's Commodification as the Impact of UNESCO's Heritage Recognition', JSW (*Jurnal Sosiologi Walisongo*), 4(2), pp. 151-164. Available at: https://doi.org/10.21580/jsw.2020.4.2.5569.

[15] Irnawati, I. et al. (2023) 'Social Culture and Localism of Mee Tribe In Knowing Noken At Beko Village Obano District Regency Paniai, Province of Papua', *KnE Social Sciences*, 2023, pp. 45-53. Available at: https://doi.org/10.18502/kss.v8i4.12881.

[16] da Silva, T.T. et al. (2022) 'Dynamic Mechanical Analysis and Ballistic Performance of Kenaf Fiber-Reinforced Epoxy Composites', *Polymers*, 14(17), pp. 1-14. Available at: https://doi.org/10.3390/polym14173629.

[17] Mohd Radzuan, N.A. et al. (2020) 'New processing technique for biodegradable kenaf composites: A simple alternative to commercial automotive parts', Composites Part B: Engineering, 184, p. 107644. Available at: https://doi.org/https://doi.org/10.1016/j.compositesb.2019.107644.

[18] Palanisamy, S. et al. (2024) 'The prospects of natural fiber composites: A brief review', *International Journal of Lightweight Materials and Manufacture*, 7(4), pp. 496-506. Available at: https://doi.org/10.1016/j.ijlmm.2024.01.003.

[19] Ermeydan, M.A. (2024) 'New Methodologies to Improve the Interfacial Interaction in Natural Fibre Polymer Composites BT – Interfacial Bonding Characteristics in Natural Fiber Reinforced Polymer Composites: Fiber-matrix Interface In Biocomposites', in S. Krishnasamy et al. (eds). Singapore: Springer Nature Singapore, pp. 23-45. Available at: https://doi.org/10.1007/978-981-99-8327-8_2.

[20] Patti, A. and Acierno, D. (2023) 'Materials, Weaving Parameters, and Tensile Responses of Woven Textiles', Macromol, 3(3), pp. 665-680. Available at: https://doi.org/10.3390/macromol3030037.

[21] Shiyong, J. et al. (2013) 'Simple device applicable to fiber reinforcement tensile strength test'.

[22] Arifin, Y.F. et al. (2023) 'Equipment for Testing the Tensile Strength of Natural Fibers: Design and Implementation', *IOP Conference Series: Earth and Environmental Science*, 1184(1), pp. 0-6. Available at: https://doi.org/10.1088/1755-1315/1184/1/012002.

[23] Sitotaw, D.B. and Adamu, B.F. (2017) 'Tensile Properties of Single Jersey and 1×1 Rib Knitted Fabrics Made from 100% Cotton and Cotton/Lycra Yarns', *Journal of Engineering* (United Kingdom), 2017. Available at: https://doi.org/10.1155/2017/4310782.

[24] Abot, J.L., Gabbai, R.D. and Harsley, K. (2011) 'Effect of woven fabric architecture on interlaminar mechanical response of composite materials: An experimental study', *Journal of Reinforced Plastics and Composites*, 30(24), pp. 2003-2014. Available at: https://doi.org/10.1177/0731684411431118.

[25] Jeyaguru, S. et al. (2024) 'Effect of various weaving architectures on mechanical, vibration and acoustic behavior of Kevlar-Hemp intra-ply hybrid composites', Composites Part A: *Applied Science and Manufacturing*, 176, p. 107845. Available at: https://doi.org/https://doi.org/10.1016/j.compositesa.2023.107845.

[26] Ma, Zhenyu et al. (2023) 'Effect of fabric structural stability on the tensile property of bidirectional angle-interlock woven composites', *International Journal of Damage Mechanics,* 32(8), pp. 989-1007. Available at: https://doi.org/10.1177/10567895231181608.

[27] Schwaiger, M. et al. (2024) 'Effect of different weft-knitted structures on the mechanical performance of bio-based flexible composites', Composites Part C: Open Access, 13 (January), p. 100436. Available at: https://doi.org/10.1016/j.jcomc.2024.100436.

[28] Aruchamy, K. et al. (2023) 'Influence of weave arrangements on mechanical characteristics of cotton and bamboo woven fabric reinforced composite laminates', *Journal of Reinforced Plastics and Composites,* 42(15-16), pp. 776-789. Available at: https://doi.org/10.1177/07316844221140350.

[29] Kink, J. et al. (2023) 'Structural Mechanics Analysis of Woven Web Reinforced Membranes in Proton Exchange Membrane Water Electrolysis', *Journal of The Electrochemical Society*, 170(11), p. 114513. Available at: https://doi.org/10.1149/1945-7111/ad0663.

[30] Kaewpirom, S. and Worrarat, C. (2014) 'Preparation and properties of pineapple leaf fiber reinforced poly(lactic acid) green composites', *Fibers and Polymers,* 15(7), pp. 1469-1477. Available at: https://doi.org/10.1007/s12221-014-1469-0.

[31] Kacem, M.A. et al. (2024) 'Assessing Extraction Methods and Mechanical and Physicochemical Properties of Algerian Yucca Fibers for Sustainable Composite Reinforcement', *Macromolecular Materials and Engineering*, 2400082, pp. 1-13. Available at: https://doi.org/10.1002/mame.202400082.

[32] Lotfi, A. et al. (2021) 'Natural fiber – reinforced composites: A review on material, manufacturing, and machinability', *Journal of Thermoplastic Composite Materials*, 34(2), pp. 238-284. Available at: https://doi.org/10.1177/0892705719844546.

[33] Aruchamy, K. et al. (2020) 'Study on mechanical characteristics of woven cotton/bamboo hybrid reinforced composite laminates', *Journal of Materials Research and Technology*, 9(1), pp. 718-726. Available at: https://doi.org/10.1016/j.jmrt.2019.11.013.

[34] Gao, X. et al. (2022) 'Structural and mechanical properties of bamboo fiber bundle and fiber/bundle reinforced composites: a review', *Journal of Materials Research and Technology*, 19, pp. 1162-1190. Available at: https://doi.org/10.1016/j.jmrt.2022.05.077.

[35] S. Garriba, H. Siddhi Jailani, Extraction and characterization of natural cellulosic fiber from Mariscus ligularis plant as potential reinforcement in composites, *Int. J. Biol. Macromol*. 253 (2023) 127609. https://doi.org/https://doi.org/10.1016/j.ijbiomac.2023.127609.

[36] Storm, S.L.S. et al. (2024) 'Investigation of native cellulose under high pressure using microfocused synchrotron radiation', *Cellulose*, 31(5), pp. 2705-2712. Available at: https://doi.org/10.1007/s10570-023-05581-2.

[37] Nazir, M.H. et al. (2023) 'The potential of adopting natural fibers reinforcements for fused deposition modeling: Characterization and implications', Heliyon, 9(4), p. e15023. Available at: https://doi.org/10.1016/j.heliyon.2023.e15023.

[38] Wang, Y. et al. (2023) 'Strain-induced crystallization behavior and tensile properties of natural rubber with different vulcanization bond types', *Polymer Testing*, 129(September), p. 108289. Available at: https://doi.org/10.1016/j.polymertesting.2023.108289.

Johanis Manuel Ramandey
Universitas Satya Wiyata Mandala
Nabire, Indonesia
e-mail: jmramandey@gmail.com

Wardhana Wahyu Dharsono
Universitas Satya Wiyata Mandala
Nabire, Indonesia
e-mail: wardhana.wd@gmail.com

Nugroho Mamayu Hayuning Bawono
Department of Technology Management
Institut Hukum dan Pembangunan Papua
Jl. Karya ABRI No.2, Manokwari
West Papua 98312, Indonesia
e-mail: nugrohomhb@outlook.com

Suryadi
Universitas Satya Wiyata Mandala
Nabire, Indonesia
e-mail: suryadi.uswim@gmail.com

Paulus Wisnu Anggoro (corresponding authors)
Universitas Atma Jaya Yogyakarta
Yogyakarta, Indonesia
e-mail: wisnu.anggoro@uajy.ac.id;
wisnuanggoro@gmail.com