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A comprehensive review on banana fibres for sustainable applications

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Abstract

In the context of growing environmental concerns and the urgent need for sustainable resource utilization, the textile industry is undergoing a significant transformation toward eco-friendly materials and processes. Conventional fibres such as cotton, polyester, and viscose are associated with high water consumption, chemical usage, and environmental degradation, necessitating the exploration of sustainable alternatives. This study highlights the potential of nonconventional and organic fibres, with a particular focus on banana fibre as a viable and sustainable textile resource. Derived from the pseudostem of the banana plant, an agricultural byproduct, banana fibre embodies the principles of circular economy by converting waste into value-added material. The paper reviews the historical significance, extraction techniques—including manual, mechanical, and chemical methods—and key physical and chemical properties of banana fibres. Special emphasis is placed on chemical extraction processes, where controlled alkali treatments facilitate the removal of lignin, hemicellulose, and other non-cellulosic components, thereby enhancing fibre quality and performance. The study also discusses the fibre's mechanical strength, biodegradability, moisture absorbency, and its compatibility in blending with natural and synthetic fibres for diversified textile applications. Additionally, the scope of banana fibre in dyeing, product development, and market acceptability is examined. The findings suggest that banana fibre possesses considerable potential to reduce the ecological footprint of the textile sector while supporting sustainable livelihoods and promoting green innovation.

Keywords: Banana fibre, sustainable textiles, chemical extraction, nonconventional fibres, eco-friendly materials, circular economy, textile innovation

Introduction

In an era of rising environmental concerns and heightened awareness of our planet's finite resources, sustainability has become a crucial concept guiding industries worldwide. From manufacturing to fashion, the need for sustainable practices has never been more urgent. A key aspect of this movement is the reassessment of materials, especially in textiles, where traditional resource use has led to significant ecological challenges. Unconventional fibers have surfaced as a promising way to reduce the environmental effects of textile manufacturing. Among these, organic fibers like banana fiber stand out as sustainable alternatives, addressing the ecological issues inherent in the textile industry.

The traditional textile industry, which relies on fibers such as cotton, polyester, and viscose, has long been associated with environmental harm. These conventional fibers require a huge amount of water, chemicals, & energy, leading to deforestation, pollution and biodiversity loss. Intensive agricultural practices for fiber cultivation exacerbate soil degradation and water scarcity, further increasing their ecological footprint. In response, the search for sustainable alternatives has driven innovation, leading to the exploration

of nonconventional fibers from renewable sources.

Nonconventional fibers include materials from agricultural byproducts, recycled substances, and unconventional sources like marine algae. These fibers help reduce the environmental burdens of traditional textile production by utilizing waste materials and adopting low-impact cultivation methods. They often possess properties that rival or exceed those of conventional fibers, making a strong case for their adoption on both ecological and functional grounds.

Organic fibers are particularly notable for their sustainability. Grown without synthetic pesticides, herbicides, or GMOs, they reduce the negative environmental and health impacts of conventional agriculture. Organic farming prioritizes soil health and biodiversity, promoting long-term sustainability. Within this context, banana fiber obtained from the stalks of banana (Fig 1.) has gained attention as a versatile, eco-friendly alternative with significant potential to transform the textile industry.

Banana fiber, derived from the stalks of banana plants post-harvest, epitomizes sustainability and circularity. As an



Fig 1: Banana tree (Source:

https://neist.res.in/stiner/banna_fibre_extraction_and_product_development.php)

agricultural byproduct, it repurposes waste material, reducing environmental pollution and resource depletion. Banana cultivation is inherently sustainable, requiring minimal water and chemical inputs compared to traditional crops. Additionally, banana plants thrive in diverse agro-ecological conditions, providing economic opportunities for smallholder farmers in tropical regions. Promoting banana fiber not only reduces the textile industry's ecological footprint but also supports sustainable livelihoods and community development.

The rise of sustainable clothing is increasingly popular, with consumers seeking eco-friendly fashion despite its higher production costs. Given the limited availability of natural fibers, banana fiber presents a highly accessible and sustainable alternative to meet consumer demand, potentially replacing cotton fiber. Recognized for its eco-friendly qualities and excellent characteristics, banana fiber is set to be a key player in the future of sustainable textiles.

History of Banana Textiles

The earliest documented use of banana stems for fiber dates back to the thirteenth century. Banana fibres were treasured in Japan as a silk substitute and were traditionally fashioned into ceremonial clothing for the wealthy ^[1].

In the Philippines, abaca (banana) has been used in traditional textiles, particularly warp ikat textiles ^[2]. It has been used in light weight, delicate fabric along with pineapple for catholic religious garments which were decorated with embroidery ^[3].

In Japan, banana fiber has been used since the Edo period to create traditional garments such as kimonos and kamishimos. Its lightweight and comfortable nature makes it suitable for swimwear, as well as for curtains, bags, and tablecloths ^[4].

Banana fabric is a lovely, non- animal product that mimics the shine of real silk and is a fantastic option for eco-friendly and sustainable textile ^[5]. Banana fibre, often referred to as musa fibre, is a biodegradable natural fibre that is obtained from the bark of the banana plant. It is made of cellulose, hemicelluloses, and lignin and is among the strongest natural fibres. The part of banana plant from which fibres are extracted, determines the quality of the fibre. The outer sheaths yield the thicker, more durable strands, whereas the core sheath yields the softer fibres. Banana fibre is made of thick-walled cell tissue that is bound together by natural gums, much like natural bamboo

fibre, but it has superior tensile strength, fineness, and spinability ^[2].

Evidence suggests that banana fibres have been used in Japan since the early 13th century, but due to demand, traditional fibres like cotton and silk from China and India are becoming more and more popular. This fibre has recently become more important in all conceivable industries, including packaging (tea bags), transportation technology (car tyres), textile technology (saris), and even currency (Japanese yen) ^[6].

A typical 37 kg banana stem yields approximately 1 kg of high-quality fiber. The yield of dry fibre is between 1% and 1.5%. The plant's central core produces fibers of lower quality. Depending on the species and technique of extraction, the fresh banana plant produces approximately 0.61.0% of fibre. The coarsest fibre is produced by the outer sheaths. They frequently break with the least jerk since they are so fragile. Two or three of the outer sheaths are often rejected. Due to the amount of pulpy material they contain, the outer two or three sheaths are also disregarded. For the purpose of fibres, only the intermediate sheaths are utilised ^[7].

Banana fibre was formerly harvested manually, which was laborious and time-consuming. A metal scrapper is used to remove the stem covering, and the fibre is then separated. An anaerobic (without oxygen) procedure was developed by the National Institute for Inter-disciplinary Science and Technology (NIIST) in India to extract banana fibre. To separate the fibres, an anaerobic reactor produces enzymes. Once the separation process is finished, the fibers are washed and sun-dried. The fibre that is produced in this way is completely white. As per NIIST, this method is cost-effective, environmentally friendly, and preserves the fibers. The banana fibre extraction device will be advertised to small-scale rural business owners and disadvantaged farmers ^[5].

Banana fibres have a low elongation and are lightweight but robust. The fibre is particularly quick in both absorbing and releasing moisture. Due to its shine, affordability, and environmental friendliness, banana cloth is a favourite among designers and manufacturers ^[8]. Banana fabric is one of the few materials in the textile industry that can be made inexpensively and utilised for fire-resistant garments. The stem can be used to make a variety of fabrics since the grade of the fibre it contains varies. The stem's interior fibres are exceptionally smooth and delicate, and they have a pleasant sheen. They serve to create the smoothest T₅.

Table 1: Physical Properties of Banana Fibres (Pandit, 2020)

Tenacity	29.98 g/denier
Fineness	17.15
Moisture Regain	13.00%
Elongation	6.54
Tensile Strength (Mpa)	529-914
Specific Tensile Strength (Mpa)	392-677
Young's Modulus (Gpa)	27-32
Specific Young's Modulus (Gpa)	20-24
Failure Strain (%)	1-3
Density (Kg/m)	750-950

The white inner, weaker strands are most suited for value-added fancy products, the stronger fibres are ideal for

cordages. They are made in Kerala, India, and exported there. The fibre can be used to create thread for shipbuilding as well as strings, ropes, cords, and cables. Sacks, packing materials, mats, and carpets can all be made out of it. Its application in the paper industry, including tissue, filters, specialty nonwoven products, documents, printing, surgical and hygiene uses, coffee bags, and meat casings, has been noted because of its high cellulose and low lignin content. Additionally, curtains, bags, sofa coverings, neck ties, and other items are made from banana fibre. Bananas that have been bleached and dried are used to make hand-knotted banana silk fibre rugs in Nepal ^[7].

Extraction of Banana Fibres

Extraction refers to the process of separating fibres from the pseudostem sheaths. Banana fibre extraction can be carried out using various methods, including manual extraction, mechanical extraction, chemical retting, microbial retting, and enzymatic retting. Each technique has its own advantages and limitations in terms of fibre yield, quality, and the properties of the resulting fibre bundles ^[9].

Manual extraction

Banana fibre extracted manually is regarded as superior in quality compared to fibres obtained through other methods. In the manual extraction process, each leaf sheath is detached from the pseudostem and sliced into strips measuring 6-10 cm in width ^[10].

A stainless-steel scraper is used for extraction of fibers initially from the inner side of the sheath and in the later stage, it is done in the outer side. The fibres obtained from the scrapping method are smooth, silky, whitish and comparatively stiff to that of mechanically extracted fibre ^[11].

In Philippines, the undressing process of banana pseudostem is known as Tuxying and the ribbons are called as Tuxies. Two methods of taxiing are employed: Bacnis Process and Loenit Process. The Bacnis Process uses simple stripping process in which trunks are pulled apart and sheath is undressed. The fiber is obtained by removing pulpy and pulling away the ribbons (tuxy) while in Loenit Process a knife or any sharp pointed tool is used for obtaining ribbons. Ribbons are obtained from one sheath at a time. 20-25 kg of fiber is dried, cleaned and bundled ^[12].

This technique produces good quality fiber, without much debris on the fiber surface; however, it is laborious and production is very low. It is common in villages and rural areas ^[13].



Fig 2: Responder Machine. (source: CSIR-NEIST. 2025. banana fibre extraction & product development, https://neist.res.in/stiner/banna_fibre_extraction_and_product_development.php)

Mechanical extraction

Mechanical extraction of fibre is done with the help of a commercial Responder machine. Banana sheaths after removing from the stem can be used directly to the responder machine or can be used after removing of excess water by pressing through two roll crusher. The fibres extracted by mechanical process are smooth, uniform and whitish in color ^[11].

The machine operator holds one end of the long sheaths of pseudostem and inserts it inside the machine. The machine consists of a high-speed rotating drum. Due to high-speed mechanical beating action, the debris associated with the pseudostem is removed and the fibers are getting separated ^[13] (Figure 2).

In general, manual extraction produces superior quality of fiber than machine extraction, since mechanical extraction may cause severe damage to the fibers due to high-speed mechanical beating. Although the quality of the fiber is marginally inferior to the manual method, it is well accepted in terms of its high production capacity ^[13].

Chemical Extraction

Table 2: Chemical composition of banana fibres (Jagadeesh *et al.*, 2015)

S. No.	Constitutions	Banana fibers
1	Cellulose	64
2	Hemicellulose	19
3	Lignin	5
4	Moisture	11

In chemical extraction, plant stalks are exposed to various aqueous chemicals for a few hours, often at elevated temperatures, resulting in the dissolution of gums and loosening of bast fibers. Extraction conditions, such as alkali concentration, duration, and temperature should be selected modestly, as overly harsh conditions may hydrolyze cellulose, compromising the properties of the extracted fibers ^[14].

Chemical extraction using alkali treatment like NaOH facilitate fibrillation, where the composite fibre bundle is broken down into smaller fibres ^[15].

The alkali (sodium hydroxide (NaOH)) reduces the fibre roughness and results in good quality fibre. In addition, sulphuric acid, hydrogen peroxide, protease and sodium citrate can also be used for chemical extraction ^[16].

Properties of Banana Fibres

Banana fiber is classified as a bast fiber derived from the banana plant's pseudostem, exhibiting excellent mechanical properties such as high strength, effective moisture absorption, and biodegradability ^[17]. Banana fiber is lightweight, has strong moisture absorption, and low elongation. It holds significant potential as a sustainable raw material for the textile industry as it shifts towards green technology ^[18]. Some important properties of banana fibres has depicted in Table 1.

Chemical Composition of Banana Fibres

Natural fibers have their botanical compositions in their structures. The chemical composition of banana fibers varies with alkali treatment The chemical properties of

banana fiber ^[19] was shown in Table 2.

The SEM morphology revealed a regular structure with distinct net fibrils, where hemicelluloses, lignin, and wax contribute to the uniform morphology of the natural composite. It is also observed and seen that on alkali treatment the soluble components like hemicelluloses, lignin and wax were partially removed ^[20].

Figure 4a is relative to the raw fiber and shows the SEM morphology at an amplification of 5009. One can notice a regular structure with discrete net fibrils, where the presence of hemicelluloses, lignin, and wax contributes to a homogeneous morphology of the natural composite. For comparison, Fig. 4b shows the micrograph of the banana treated with NaOH 1% at the same amplification factor of the raw banana. After alkaline treatment, the soluble Figure 4a is relative to the raw fiber and shows the SEM morphology at an amplification of 5009. One can notice a regular structure with discrete net fibrils, where the presence of hemicelluloses, lignin, and wax contributes to a homogeneous morphology of the natural composite. For comparison, Fig. 4b shows the micrograph of the banana treated with NaOH 1% at the same amplification factor of the raw banana. After alkaline treatment, the soluble.

A scanning electron microscope (SEM) reveals various features, including surface morphology, cross-sectional views, fracture behavior, and the bonding between fibers and the resin matrix (Fig 3). SEM can also identify impurities, wax, and ash content on raw fibers, as well as the removal of these materials from treated fibers. It can display the presence of micropores on treated fibers. Banana fibers have elliptical-shaped holes in their cross-sectional structure. SEM analysis confirms that the elliptical cross-section enhances the tensile strength of banana fibers ^[19].

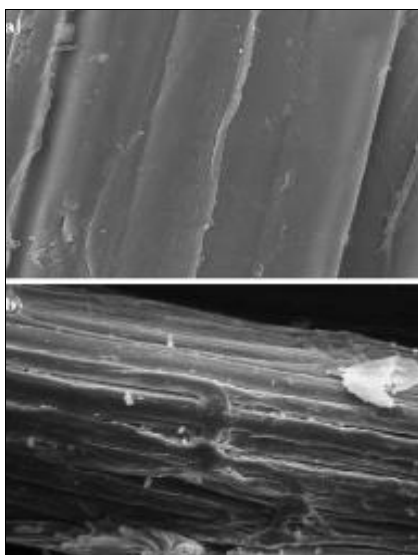


Fig 3: Sem analysis of untreated and alkali treated banana fibres (Barreto *etal.*, 2010)

Blending of Banana Fibre with Other Fibres

A banana fiber is one of those fibres that get blended easily with both natural and synthetic fibres. The 50:50 banana/cotton blend fabric had better strength as compared to 70:30 blended fabric ^[21]. Similarly, the banana/unbleached cotton fibre blended in the ratio 80:20 resulted in a lightweight, incredibly comfortable fabric that can be utilized both in clothing and interior decorating sectors. She also stated that Blending 50% banana and 50% bleached cotton fibres results in a thick and shiny, distinctive-looking fabric that could be a wonderful option for thick clothing and soft furnishings ^[22]. The fabric properties like tensile strength, elongation and yarn quality index of banana cotton blended fabric increased by increasing the percentage of banana fibre in the blended yarn ^[23]. The comfort properties such as air permeability, and water vapour permeability of blended fabric manufactured using banana/ cotton blended (50:50) weft yarn with satin 4 structure are better as compared to samples with banana/ cotton blend (25:75) in weft direction with plain 1/1 structure whereas in case of later higher rates of fabric stiffness were observed ^[24].

Banana fibre may be spun into yarns, with or without blending with other fibres, but the blend of banana fibre and wool would be the most ideal for commercial use ^[25]. Further, it was seen that the wool /banana blended fabric in a ratio of 50:50 results in a dense, warm fabric that is a fantastic alternative for winter clothing and outerwear ^[22].

Bleached banana fibres blended with jute fibre are excellent alternative for diverse value-added fashionable textiles ^[26]. According to researcher, the bleached jute/banana yarn blended in different proportions like 75:25, 50:50, and 25:75 exhibited higher tenacity as compared to grey fibres irrespective of the blend proportion ^[27]. Banana/ jute union fabrics can be used as home tech (floor mats, curtains, tablecloths, bedsheets, bags), cloth tech (winter wear, infants shoes) and agro tech (covering and fencing materials within the greenhouse) ^[28].

Banana fibre can also blend with different types of synthetic fibres. The Banana/PP yarn shows higher tenacity than flax/PP yarn and is more homogeneous ^[25]. Banana/ polyester blended yarn gives similar look as cotton blend ^[22]. Blending of banana fibres with other natural fibres like ramie improves the strength of blended yarn as compared to 100% pure banana yarn ^[29].

Dyeing and Printing of Banana Fibres and Fabrics

According to researcher's vat, reactive and basic dyes are suitable for bulk dyeing of the banana fibres, as the dyed fibres exhibit excellent rubbing and washing properties as compare to those dyed with direct dyes ^[30]. The banana fibres dyed with reactive dyes also showed excellent color with good to excellent washing fastness ^[18]. The banana fibres dyed with basic dyes showed promising result for colour fastness to light and rubbing and satisfactory result for colorfastness to perspiration and poor results for color fastness for washing ^[31].

Further it was observed that the banana fibres dyed with myrobalan natural dye with mordant like Ferrous Sulphate, stannous Chloride exhibited good to excellent fastness properties ^[32].

Dyed samples of banana fiber with natural curcuma type of

dye showed better results for fastness against washing as compared to cotton fibers [33]. Banana-cotton union fabric also dyed with banana leave dye in presence of natural mordants extracted from onion skin and pomegranate rind. They claimed that fabric dyed in presence of pomegranate rind mordant shows better results and hence preferable to onion skin mordant [4].



Fig 4: Products made of Banana fibres, Source: <https://www.ncdc.in> [37]

Product Development of Banana Fabric [35]

According to researchers mechanically extracted banana fiber, which has significant market potential, can be used to create various decorative and everyday household items, including (Fig 4):

- Kitbags, tool bags, and luggage covers
- Lime brushes and cleaning brushes
- Strips for women's footwear
- Doormats and coarse carpets
- Table mats, flower vases, women's bags, dining mats, children's caps, wall hangings, and lampshades

Market Acceptability of Banana Products

The products made from cotton banana union fabric printed with hand blocks using eco friendly pigments were accepted among upper-middle and upper-economic class of the society [36].

Banana fibre is being used for many different things around the world. Over time, the fiber's commercial worth has increased. It is a fantastic accomplishment to turn garbage into things like useful fabric [1].

Conclusion

The increasing environmental challenges associated with conventional textile production have accelerated the search for sustainable and eco-friendly alternatives. Banana fibre, derived from the agricultural waste of banana pseudostems, emerges as a highly promising solution that aligns with the principles of sustainability and circular economy. Its utilization not only minimizes waste and environmental pollution but also adds economic value to agricultural byproducts, thereby supporting rural livelihoods.

The study highlights that banana fibre possesses excellent physical and mechanical properties such as high tensile strength, biodegradability, moisture absorbency, and lightweight nature, making it suitable for diverse textile and non-textile applications. Among the various extraction techniques, chemical extraction—particularly alkali treatment—plays a crucial role in improving fibre quality by removing lignin, hemicellulose, and other impurities. However, careful control of chemical concentration and processing conditions is essential to avoid fibre degradation. Furthermore, the adaptability of banana fibre in blending with natural and synthetic fibres enhances its commercial viability, while its compatibility with different dyeing

techniques supports its use in value-added textile products. Increasing consumer awareness and demand for sustainable fashion further strengthen the market potential of banana fibre-based products.

In conclusion, banana fibre stands out as an innovative, sustainable, and versatile material with the capacity to significantly reduce the ecological footprint of the textile industry. Future research and technological advancements in extraction, processing, and product development can further enhance its quality, scalability, and global acceptance, paving the way for a greener and more sustainable textile sector.

References

1. Kaur A. Banana fibre: a revolution in textiles. 2015.
2. Gillow J, Sentence B. World textiles: a visual guide to traditional techniques. Boston (MA): Bulfinch Press of Little, Brown and Company; 1999.
3. Harris J, editor. 5000 years of textiles. Washington (DC): Smithsonian Books; 2011.
4. Vigneswaran C, Pabitra V, Gayatri V, Mythili K. Banana fiber scope and value added product development. Journal of Textile and Apparel Technology and Management. 2015;9(2):1-7.
5. Fibre2Fashion. Banana fibre: green apparel of the future. 2015.
6. Hendriksz V. Sustainable textile innovations: banana fibres. 2017.
7. Desai AA. Unconventional textiles in India: banana fibres. 2008.
8. Pandit P. Characteristics and properties of banana fibers. 2020.
9. Balda S, Sharma A, Capalash N, Sharma P. Banana fibre: a natural and sustainable bioresource for ecofriendly applications. Clean Technologies and Environmental Policy. 2021;23(4):1389-1401.
10. Akhila BS, Manju PR, Simi S. A comprehensive review on banana fibre: extraction, degumming, and applications across industrial sectors. International Journal of Advanced Biochemistry Research. 2025;9(7):1359-1367.
11. CSIR-NEIST. Banana fibre extraction and product development. 2025.
12. Sheikh SA, Awate NP. A review paper on design and development of banana fiber extraction machine. International Journal of Engineering Sciences and Research Technology. 2016;5(3).
13. Badanayak P, Jose S, Bose G. Banana pseudostem fiber: a critical review on fiber extraction, characterization, and surface modification. Journal of Natural Fibers. 2023;20(1).
14. Koskelainen V. Chemical treatment for the separation of hemp bast fibers. 2024.
15. Abdul CSI, Mumthas GLD, Wickramasinghe USW, Gunasekera. Journal of Engineered Fibers and Fabrics. 2019.
16. Akubueze EU, Ezeanyanaso CS, Orekoya EO, *et al.* Extraction and production of agro sack from banana (*Musa sapientum*) and plantain (*Musa paradisiaca* L) fibres for packaging agricultural produce. International Journal of Agriculture and Crop Sciences. 2015;9(1):9-14.

17. Gupta G, Bhatnagar RA. Review on composition and properties of bagasse fibers. *International Journal of Scientific and Engineering Research*. 2015;6(5):143-148.
18. Balakrishnan S, Wickramasinghe GLD, Wijayapala UGS. Study on dyeing behavior of banana fiber with reactive dyes. *Journal of Engineered Fibers and Fabrics*. 2019.
19. Jagadeesh D, Venkatachalam R, Nallakumarasamy G. Characterisation of banana fiber: a review. *Journal of Environment Nanotechnology*. 2015;4(2):23-26.
20. Barreto ACH, Costa MM, Sombra ASB, Rosa DS, Nascimento RF, Mazzetto SE, *et al*. Chemically modified banana fiber: structure, dielectrical properties and biodegradability. *Journal of Polymers and the Environment*. 2010;18:523-531.
21. Elayaperumal T. A preliminary study for improving the banana fibre fineness using various chemical treatments. *Global Journal for Research in Engineering*. 2016;16(3):17.
22. Bhanushali M. Banana fibres: the unknown green. 2021.
23. Khan A, Iftikhar K, Mohsin M, Ubaidullah M, Ali M, Mueen A. Banana agro-waste as an alternative to cotton fibre in textile applications: yarn to fabric: an ecofriendly approach. *Industrial Crops and Products*. 2022;189(1).
24. Hawas HS. A study on comfort properties of banana/cotton blend woven fabrics. *Journal of Design Sciences and Applied Arts*. 2021;2(1):96-105.
25. Orgeta Z, Moron M, Monzon MD, Badallo P, Paz R. Production of banana fiber yarns for technical textile reinforced composites. *Materials*. 2016;9(5).
26. Debnath S. Sustainable production of bast fibres. In: *Sustainable fibres and textiles*. Cambridge: Woodhead Publishing; 2017. p. 69-85.
27. Chattopadhyay SN, Pan NC, Roy AN, Samanta KK. Pretreatment of jute and banana fibre—its effect on blended yarn and fabric. *Journal of Natural Fibers*. 2018;17(1):1-9.
28. Hassan MN, Nayab-UI-Hossaina AKM, Hasan N, Rahman MI, Alam SMM. Physico-mechanical properties of naturally dyed jute-banana hybrid fabrics. *Journal of Natural Fibers*. 2021.
29. Soraisham LD, Mishra L, Basu G. Extraction and evaluation of properties of Indian banana fibre (*Musa domestica* var. balbisiana, BB group) and its processing with ramie. *Journal of Natural Fibers*. 2021;19(1):1-12.
30. Islam T, Karem MR, Barua P, Jayed HM, Roy M, Oslam S. Dyeing properties of banana fibre dyed with different dyes. *International Journal of Engineering and Advanced Technology*. 2019;9(1):1510-1514.
31. Brahma S, Arju SN. Calorimetric analysis and fastness properties of banana fibre dyed with basic dye. *IOSR Journal of Polymer and Textile Engineering*. 2022;9(1):1-7.
32. Singh PP, Sharma D. Dyeing of banana fiber using myrobalan natural dye. *International Journal of Home Science*. 2020;6(1):359-362.
33. Kamal MMM, Amaim YAEAMAE. Eco-friendly process for dyeing banana fabrics with curcuma natural dyes. 2021.
34. Amutha K, Annapoorani SG. Dyeing of banana/cotton union fabric with natural dye and mordants. *International Journal of Applied Research*. 2019;5(8):24-26.
35. STINER. Banana fibre extraction and product development. 2024.
36. Karolia A, Malhan S. Eco friendly printing on minor fibre fabrics (jute and banana). 2005.
37. Anonymous. Detailed project report (DPR): banana fibre extraction and weaving. National Cooperative Development Corporation.