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# SUSTAINABLE HAIR WIGS AND EXTENSIONS FROM BANANA AND SILK FIBRES: A REVIEW USING PRISMA METHODOLOGY

**KOITUMET Joel Sabore[1, 2], MWASIAGI Josphat Igadwa[1], OCHOLA Jerry[1], AQSA Imran[3], NZILA Charles[1]**

[1]Moi University, School of Engineering, Department of Manufacturing, Industrial and Textile Engineering, P.O Box 3900-30100 Eldoret, Kenya, E-mail: igadwa@mu.ac.ke

[2]Technical University of Mombasa, School of Engineering and Technology, Department of Medical Engineering, P.O Box 90420-80100 Mombasa, Kenya, E-mail: info@tum.ac.ke

[3]National Textile University, Department of Textile Engineering, Sheikhupura Road, Faisalabad - 37610, Pakistan E-mail: info@ntu.edu.pk

Corresponding author: Koitumet, Joel Sabore, E-mail: jsabore@yahoo.com

***Abstract:*** *Petroleum-based synthetic fibers and chemically processed human hair, both linked to excessive resource consumption, microplastic pollution, and hazardous chemical exposure during dyeing and finishing, dominate the global wig and hair extension market. These products are linked to carbon emissions, plastic waste, and environmental problems at the end of their useful lives. Although natural fibers like banana and silk offer renewable and biodegradable alternatives, their use in wig and extension systems is still understudied. This study conducts a systematic review of the literature on sustainable hair substitutes made from silk and banana fibers. The Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) methodology was used to synthesize peer-reviewed studies on fiber production, extraction, characterization, textile processing, performance evaluation, and consumer acceptance. Results show that while silk offers better lustre, flexibility, and tactile qualities, banana fiber offers high tensile strength and is readily available as an agricultural waste. Nevertheless, there is a scarcity of empirical research that specifically examines their incorporation into hair wig systems. There are notable research gaps in consumer acceptance studies, durability benchmarking, thermal styling performance, and lifecycle assessment. The review concludes that while banana/silk hybridization is technically feasible and beneficial for the environment, it needs multidisciplinary validation through materials engineering and market research.*

***Key words:*** *Banana fiber, Hair extensions, Hair wigs, Prisma, Silk fiber.*

## 1. INTRODUCTION

The global market for wigs and hair extensions has grown dramatically as a result of protective hairstyling techniques, medical hair loss treatment, and fashion trends. According to [1]; [2]; [3], conventional wigs and extensions are primarily made from petroleum-based synthetics or chemically processed human hair, both of which are linked to high energy consumption, chemical loads, and end-of-life microplastic, all of which will have an impact on landfills. Figure 1 shows hair extension made of synthetic material. In general, the textile industry is a significant polluter,

contributing to persistent waste, greenhouse gas emissions, and contamination of water and soil [4]; [2]. Figure 2 shows circular economy of material for sustainability.

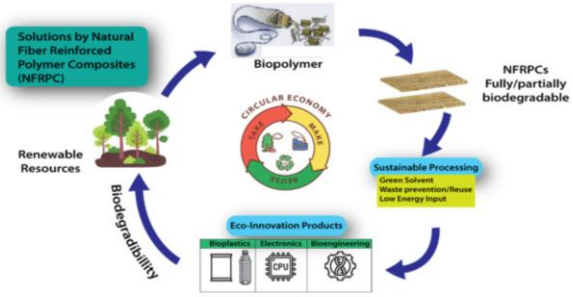


***Fig. 1.*** *Synthetic hair extension [5]* ***Fig. 2.*** *Circular economy of material for sustainability [6]*

As a result, the textile industry has embraced sustainable material paradigms that are in line with institutionally promoted circular economy frameworks. The circular economy 5Rs (Refuse, Reduce, Reuse, Repurpose and Recycle) are key strategies to waste minimization and optimal resource use. The approaches create a hierarchy which first prevent consumption and moving towards material recovery to enhance materials and products longevity, reducing pollution and embracing conservation of resources for sustainable growth. Systematic reviews of textile sustainability highlight the need for bio-based, circular materials and eco-design to reduce microfiber release, effluent impacts, and waste generation [7]; [8]; [9]; [10].

Banana fiber, obtained from banana pseudostem agro-waste, is increasingly recognised as a biodegradable, low-impact textile resource with good tensile strength, breathability, and potential to substitute synthetic fibres in fashion applications [1]; [2]; [4]; [11]. Figure 3 shows banana fibers extracts from three different extraction methods. Silk remains a high-value natural protein fibre prized for lustre and drape; blending silk with other sustainable fibres is being explored to improve functionality and reduce dependence on any single resource [12]; [13]. Figure 4 shows silk fiber and cocoons. Table 1 shows the main attributes of banana and silk fibers. Developing research on silk and banana blended textiles using natural dyes and bio-mordants reveals environmentally friendly coloring and finishing techniques [13].


***Fig. 3.*** *Extracted banana fibers (a) Water retting, (b) Boiling in water (c) Caustic soda aqueous solution [14]*


***Fig. 4.*** *(a) Silk cocoon and (b) silk fiber [15]*

***Table 1*** *Key attributes of banana and silk fibers attribute*

| Characteristic | Banana fiber | Silk fiber | References |
|---|---|---|---|
| Resource base | Agro-waste (pseudostem, leaves) | Sericulture by-product or waste silk | [1]; [2]; [16]; [17]; [18]; [19]; [20]; [21]. |
| Biodegradability | High; lignocellulosic | Protein-based, biodegradable | [1]; [2]; [16]; [19]; [20]. |
| Sustainability | Waste valorization, reduced burning/landfill | Upcycling of textile waste, high strength alternative to nylon/Kevlar | [1]; [2]; [17]; [18]; [19]; [20]; [21]. |
| Mechanical profile | Good tensile strength, moderate stiffness | Very high strength/toughness (esp. engineered spider silk) | [1]; [12]; [16]; [17]; [19]; [20]; [21]. |

Natural fibers have become more popular in clothing and composite materials because they are biodegradable, renewable, and have lower embodied carbon. Nevertheless, there is still little scholarly research on their use in hair wig and extension systems. Although there isn't a study that specifically assesses banana or silk fibers in wigs and extensions, evidence from textiles, circular fashion, and PRISMA-based sustainability reviews enables the creation of a methodical, PRISMA-aligned overview of their potential as sustainable hair product substitutes. There is increasing pressure to switch to circular, renewable, and biodegradable fiber systems in place of these materials [1-3], [18].

## 2. MATERIALS AND METHODS

This review employed the PRISMA methodology framework, which ensures a careful search strategy, screening, suitability assessment, and synthesis. The Preferred reporting items for systematic reviews and meta-analyses, is a guideline designed to improve the reporting of systematic reviews. It is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses which provides authors with guidance and examples of how to completely report why a systematic review was done, what methods were used, and what results were found.

A systematic search was conducted across major scholarly databases for interdisciplinary coverage of materials science, textile engineering, sustainability, and consumer studies. Searches were restricted to peer-reviewed articles published between 2000 and 2025. The PRISMA process involved an initial retrieval of 1,243 articles where 312 duplicates were removed leaving 931

articles. Abstract screening excluded 701 unrelated studies and 230 full-text articles met inclusion criteria. This is demonstrated by Figure 5. The databases that were used are Scopus, google Scholar, Web of Science, Science Direct and PubMed. Keywords combined with Boolean operators were used as follows; “banana fibre” OR “Musa fibre” OR “banana pseudostem” AND “sustainable” OR “eco-friendly” OR “biodegradable” OR “life cycle” “silk fibre” OR “sericin” OR “natural silk” OR “silk textile”. The analysis was exclusively for banana and silk fibers application in hair wigs and extensions.

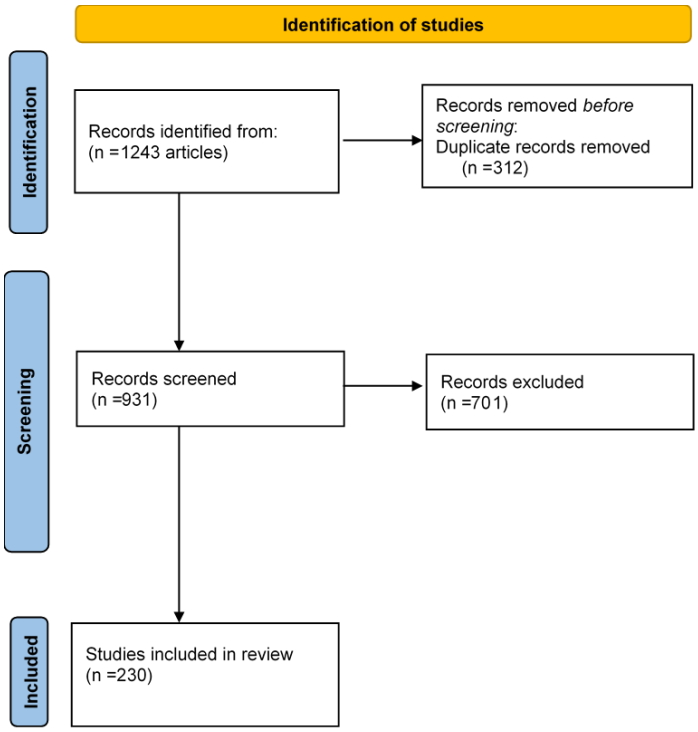


***Fig. 5:*** *Systemic Literature review stages using PRISMA methodology*

Inclusion eligibility criteria for the search involved empirical or review studies on banana or silk fiber production and characterization, studies on natural fiber textile applications research on sustainability assessments (LCA, carbon footprint) and the consumer behavior studies on sustainable fashion. The exclusion criterion was based on on-peer reviewed articles, studies unrelated to textile or fiber applications and exclusive biomedical silk research not applicable to textiles.

## 3. DISCUSSION

The global wig and hair extension market is dominated by petroleum-based synthetic fibers and chemically processed human hair, which are associated with high resource use, microplastic pollution, and toxic chemical exposure throughout processing procedures. Synthetic materials, often produced from modacrylic and polyethylene terephthalate fibers, are not neither ecofriendly nor sustainable. The literature consistently identifies synthetic wig fibers as environmentally burdensome due to high carbon emissions, end of life environmental burden, petrochemical

dependency, and non-biodegradability. Lifecycle assessments of polyester and acrylic textiles reveal significant energy consumption and greenhouse gas emissions during polymerization and extrusion processes. Microplastic release and landfill accumulation are made worse by end-of-life disposal of these synthetic fibers. Natural fibers such as banana and silk present biodegradable and renewable alternatives, yet their application in wig and extension systems remains underexplored.

Natural fiber substitutes have less impact on the environment, especially when they come from agricultural waste streams like banana pseudostems. Banana-producing nations in Asia and Africa have an abundance of banana fiber. High banana production volumes in sub-Saharan Africa are confirmed by reports from the Food and Agriculture Organization, indicating the availability of raw materials. Mechanical research shows high moisture regain, good biodegradability, and tensile strengths between 400 and 600 MPa. However, applications needing a fine hair-like texture face difficulties due to the fiber inherent coarseness and diameter variability. Alkali treatment increases surface smoothness and flexibility, but if effluent management is poorly done, then environmental challenges might overshadow the beneficial effects of the treatment.

In contrast, silk, a protein based biodegradable fiber has remarkable elongation capacity, tensile strength, sheen and excellent moisture management the properties that makes the fiber desirable for luxury textiles and biomedical applications. Silk fiber is sustainable evidence by mulberry cultivation as well as degumming/finishing chemistry, where waste silk can be recycled providing a circular route. Wet spinning of waste silk into regenerated silk fibroin fibres allows structural control of the fiber (circular, bean-shaped, U-shaped, lumen-containing) via coagulation conditions [20]. The morphology of degummed silk fibers demonstrate is softness when compared to human hair. Suitability for moderate styling conditions is improved by thermal resistance up to about 140 up to 160°C. Sericulture inputs, however, continue to make silk production resource-intensive. Silk has a significant attribute of been protein-based and biodegradable, but sustainability discussions raise concerns about labour intensity and land use.

Although blended natural fiber systems are rarely used in wig applications, they are extensively researched in composite engineering. Combining plant and protein fibers can improve their structural and tactile qualities, according to research on natural fiber blending. Silk adds flexibility, lustre, and softness, while banana fibers provide structural integrity and tensile strength. Performance results are strongly influenced by fiber blending ratios. This clearly is a glaring research gap. Even so, there are no identified studies found that directly test banana or silk fibers in commercial wig structures.

According to comparative research, natural fibers besides been biodegradable, have a lower carbon footprint than synthetic ones. However, uniformity and durability often favor the synthetic fiber. From the lifecycle analyses, bio-based textiles use less energy than polyester, but occasionally more water. Therefore, cradle-to-grave evaluation, not just biodegradability, must be included in sustainability claims. Consumer research on sustainable fashion indicates that consumers are becoming more inclined to buy environmentally friendly goods, provided that the prices are comparable and the products are aesthetically pleasing. The literature on the theory of planned behavior shows that purchase intention is positively correlated with environmental concern, although this relationship is moderated by perceived performance and affordability. There is a substantial knowledge gap due to the scantiness of wig-specific research. Demand patterns are influenced, especially in African markets, by cultural considerations, fashion trends, and protective hairstyling norms.

The PRISMA methodology analysis demonstrate research gaps in regards to banana and silk fiber hair wigs and extensions which need to be addressed. Limited empirical studies as well as thermal styling performance data for natural fiber wig fabrication tops the list of gaps. Standardized

testing protocols for wig durability and comfort would add weight to application of banana and silk fiber for hair wigs and extensions. Scanty research on consumer acceptance that focus on natural hair products and the inadequate Lifecycle assessment that is very specific to wig application need substantial research attention.

## 4. CONCLUSIONS

This systematic review shows that silk and banana fibers have complementary mechanical, aesthetic, and environmental qualities that make them viable options for environmentally friendly hair extensions and wigs. The literature demonstrates strong potential for sustainable, high-performance materials that align with circular economy principles. Banana fiber offers structural strength and circular bio-economy benefits through agro-waste value addition, while silk contributes softness, elasticity, and visual appeal.

Nevertheless, the literature remains disjointed across cultivation, materials science, and sustainable fashion trends. No wide-ranging empirical research that currently validate banana and silk hybrid hair wigs and extensions under laboratory and consumer-use conditions. Although no studies yet directly target banana and silk fibers hair wigs and extensions, the underlying science strongly supports the feasibility in application of banana and silk fibersin hair products including the wigs and extensions as environmentally preferable alternatives to conventional synthetic hair. Additionally, literaturein has no clear address on sustainable alternatives to synthetic hair wigs and alternatives.

Consequently, a focused research agenda on aesthetic performance, durability under cosmetic use, and full life-cycle impacts is necesary to translate the feasibility into commercial, scalable sustainable hair products. It is also desirable that the future studies should integrate the optimization of protocols for banana and silk fiber extraction and eco friendly treatment, fiber blending and standardization of characterization for fiber properties. Life cycle assessment as well as market feasibility and market perception studies are equally reccomnded.

In conclusion, hair wigs and hair extensions synthesized from banana and silk fibers represent a technically conceivable pathway which is not only sustainable but is ecofriendly as well. Nevertheless, before commercial adoption of this product, a robust interdisciplinary experimental validation is essential. This review establishes a consolidated evidence base and classifies clear directions for advancing sustainable hair wig technologies within a circular bio-economy framework.

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### Orcid

Joel Sabore Koitumet https://orcid.org/0000-0001-5534-4714
Josphat Igadwa Mwasiagi https://orcid.org/0000-0002-9983-2573
Aqsa Imran https://orcid.org/0000-0001-5835-9882
Jerry Ochola https://orcid.org/0000-0002-5133-3636
Charles Nzila https://orcid.org/0000-0002-6285-5640

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