

Development of Herbal Antimicrobial Reusable Baby Diaper Fabric Using *Moringa oleifera* Extract

Priya Dharshini . I.K.¹, Alcin Sveda.C², Afrin Defani .N³, Asheeni A⁴

^{1,2,3}*B.Sc. Student, Department of Costume Design and Fashion Holy Cross College [Autonomous]
Nagercoil – 629 004*

⁴*Assistant Professor, Department of Costume Design and Fashion Holy Cross College [Autonomous]
Nagercoil – 629 004*

Abstract—Reusable baby diapers are being considered as an alternative to disposable diapers because they can be washed and used multiple times, which may help reduce textile waste. However, the moisture present in diaper fabrics can create suitable conditions for microbial growth and may lead to hygiene concerns. This study focuses on developing a reusable baby diaper fabric using *moringa oleifera* leaf extract as a natural antimicrobial treatment. In this study, moringa leaves will be cleaned, dried, and processed to obtain an aqueous extract. A suitable textile fabric will then be treated with different concentrations of the extract using an appropriate finishing technique. [15] The treated and untreated fabrics will be compared to determine their antimicrobial activity and selected textile properties, including absorbency, comfort, and durability after washing. The antimicrobial activity of the treated fabrics will be evaluated against selected bacterial strains using a suitable microbiological testing method. The study aims to examine the potential of *moringa oleifera* leaf extract as a plant-based finishing agent for developing a hygienic and reusable baby diaper fabric. The research may contribute to the development of sustainable textile products using naturally derived functional materials.[19]

Index Terms—*moringa oleifera*, herbal antimicrobial, reusable baby diaper, cotton fabric, natural textile finish, antibacterial textile, sustainable textile

I. INTRODUCTION

Baby diapers are commonly used in infant care to provide comfort, absorb body fluids, maintain hygiene, and protect the baby's skin. Disposable diapers are popular because they are convenient and easy to use. However, since they are discarded after a

single use, they contribute to a large amount of waste and raise concerns about environmental sustainability. This has encouraged interest in reusable fabric diaper products. Reusable diapers can be washed and used several times, which may help reduce the amount of waste produced from single-use diapers. Cotton and other natural fibres are often considered suitable for these products because they are soft, absorbent, breathable, and comfortable. At the same time, diaper fabrics are regularly exposed to moisture and body fluids. If moisture remains in the fabric for longer periods, it can provide suitable conditions for the growth of microorganisms. Therefore, maintaining hygiene is an important aspect of developing reusable diaper fabrics.[17]

Antimicrobial treatment can be used to improve the hygienic properties of textile materials. In recent years, there has been growing interest in using natural plant extracts instead of conventional synthetic treatments. *Moringa oleifera* is one such plant that contains several naturally occurring compounds, including phenolic compounds and flavonoids. These compounds have been studied for their possible antimicrobial activity. Earlier research has investigated the use of *Moringa oleifera* extracts as functional treatments for textile materials, including cotton fabrics. [1] This provides a basis for exploring *Moringa* extract in reusable diaper applications. Therefore, the proposed study focuses on developing a reusable baby diaper fabric treated with *Moringa oleifera* extract as a natural herbal antimicrobial agent. The proposed research brings together reusable textile development and plant-based textile finishing. It aims to explore the possibility of developing a more

sustainable and hygienic fabric for baby diaper applications. The actual effectiveness and other properties of the developed fabric will be established through experimental testing.[4]

II. MATERIALS AND METHODS

2.1 Moringa Plant and Source of Herbal Extract

Moringa oleifera is a medicinal and nutritional plant belonging to the family Moringaceae. It is commonly known as the drumstick tree and is widely cultivated in India. Different parts of the plant, including the leaves, pods and seeds, are used for various traditional and functional purposes. The leaves are particularly important because they contain naturally occurring bioactive compounds such as flavonoids, phenolic compounds and other phytochemicals. For this study, fresh and healthy Moringa oleifera leaves were selected for the preparation of the herbal extract. The leaves were examined carefully, and damaged or discoloured portions were removed. The selected leaves were washed thoroughly with clean water to remove dust and other surface impurities. They were then dried under suitable conditions before being used for extraction.[5]

Moringa leaves were selected because of their reported antimicrobial and antioxidant potential. The prepared extract was used as a natural treatment for reusable baby diaper fabric. This approach aims to introduce functional antimicrobial properties into the fabric using a plant-based material instead of relying completely on conventional chemical treatments.[3]

2.2 Common Herbal Sources

The following herbal materials are commonly considered for antimicrobial and skin-related textile applications:

S. No	Herbal Source	Scientific Name	Main Application
1	Moringa	Moringa oleifera	Antimicrobial fabric treatment
2	Neem	Azadirachta indica	Natural antimicrobial treatment
3	Tulsi	Ocimum tenuiflorum	Herbal antimicrobial application

4	Aloe vera	Aloe barbadensis	Skin-friendly textile treatment
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Table 1: Common Herbal Sources Used for Antimicrobial Textile Applications

Among these herbal sources, Moringa oleifera was selected for the present research. The selection was based on its availability, natural bioactive constituents and reported antimicrobial potential. The use of moringa extract in textile treatment may help improve the functional performance of reusable baby diaper fabric.[6]

2.3 Preparation of Raw Materials

The major raw materials used in this study were Moringa oleifera leaves and cotton fabric. Cotton was selected as the base material for the reusable baby diaper because of its softness, breathability, comfort and moisture-absorbing ability. These properties are important for textile materials that come into direct and prolonged contact with a baby's skin. The collected moringa leaves were initially cleaned and dried. After drying, the leaves were cut into small pieces or processed into a suitable form for extraction. The herbal extract was then prepared using an appropriate extraction method and filtered to remove unwanted plant particles. [14]

Before applying the herbal treatment, the cotton fabric was washed and dried to remove dust, impurities and any processing residues. The prepared Moringa oleifera extract was then applied to the fabric using a suitable textile finishing technique. After treatment, the fabric was dried and conditioned before further testing. The treated fabric was evaluated for properties relevant to reusable baby diaper applications. The evaluation included moisture absorption, liquid retention, drying behaviour, fabric thickness, air permeability, tensile strength, dimensional stability, fabric pH, washing durability and antimicrobial activity. The developed fabric was intended to combine the comfort and absorbency of cotton with the functional properties of Moringa oleifera extract. The use of reusable fabric and a plant-based antimicrobial treatment may provide a more sustainable approach to baby diaper textile development.[17]

III. EXTRACTION PROCESS

Fresh *Moringa oleifera* leaves were collected and washed thoroughly with clean water to remove dust, dirt and other unwanted materials. The leaves were then dried under suitable conditions until the moisture content was reduced. After drying, the leaves were cut into small pieces and prepared for extraction. The prepared moringa leaves were soaked in a suitable extraction medium for a specific period. This process helped to release the naturally occurring bioactive compounds from the leaves into the extraction medium. After the extraction period, the mixture was filtered using suitable filter material to separate the leaf residues from the liquid extract.[5]

The filtered moringa extract was collected and used for treating the selected reusable baby diaper fabric. The extract was applied to the fabric using a suitable textile finishing method. After treatment, the fabric samples were dried and conditioned before carrying out further testing. The treated fabric was evaluated for properties such as absorbency, moisture management, softness, thickness, air permeability, tensile strength, dimensional stability, pH, wash durability and antimicrobial activity. These tests were carried out to determine the suitability of the developed fabric for reusable baby diaper applications.[12]

II. COMMON EXTRACTION METHODS

S.No.	Extraction Method	Description
1	Water-Based Extraction	Water is used as the extraction medium to obtain water-soluble compounds present in <i>Moringa oleifera</i> leaves.
2	Soaking Method	The cleaned and prepared moringa leaves are immersed in the extraction medium for a specific period to allow the desired compounds to dissolve into the liquid.
3	Hot Water Extraction	Warm or hot water is used to improve the release of suitable soluble compounds

		from the moringa leaves into the extraction medium.
4	Maceration	Dried or powdered moringa leaves are soaked in the selected extraction medium for a longer period to obtain the herbal extract.

Table 2. Common Extraction Methods Used for *Moringa oleifera* Leaf Extract

After completing the extraction process, the mixture was filtered carefully to remove the remaining leaf particles. The filtered moringa extract was collected and used for treating the reusable baby diaper fabric. The treated fabric samples were then dried under suitable conditions and prepared for further evaluation. The developed fabric was tested to determine its antimicrobial effectiveness and other important textile properties. The overall process was intended to develop a reusable baby diaper fabric with natural antimicrobial functionality using *Moringa oleifera* extract.[13]

IV. CONCENTRATION AND STABILIZATION OF MORINGA EXTRACT

After the extraction and filtration process, the obtained *Moringa oleifera* extract can be concentrated by removing excess moisture under suitable conditions. Concentration helps to obtain an extract containing an appropriate amount of plant-based compounds for textile treatment. Excessive heating and direct exposure to sunlight should be avoided because they may affect the quality of the herbal extract.[8] The concentrated extract should be transferred into a clean and closed container and stored properly until it is used for fabric treatment. Suitable storage conditions help to maintain the quality and stability of the extract. The prepared *Moringa oleifera* extract is then used for treating the selected fabric intended for reusable baby diaper production.[11]

V. INFUSION / APPLICATION METHODS

The prepared *Moringa oleifera* leaf extract is applied to the selected diaper fabric using a suitable textile treatment method. Before treatment, the fabric is washed properly to remove dust, dirt, oils and other impurities present on the fabric surface. The cleaned

fabric is then immersed or brought into contact with the *Moringa oleifera* extract to allow the herbal compounds to penetrate and deposit onto the textile material. Padding, soaking or direct application methods can be used depending on the required treatment condition.[13]

After the fabric has absorbed the extract, excess solution is removed carefully. The treated fabric is then dried under suitable conditions. Uniform application of the extract is important to obtain consistent treatment throughout the fabric. The treated fabric is further tested to determine its antimicrobial activity, absorbency, moisture management, softness and other properties required for reusable baby diaper applications.[9]

VI. DRYING AND CURING

After applying the *Moringa oleifera* extract, the treated fabric is carefully dried to remove excess moisture. The fabric should be spread evenly during drying to obtain uniform drying throughout the material. Excessive temperature should be avoided because high heat may affect some of the naturally occurring bioactive compounds present in the *Moringa* extract. After drying, the fabric may be allowed to condition or cure for a suitable period so that the herbal treatment can become properly established on the fabric.[5]

Depending on the selected treatment method, the fabric may be gently washed or rinsed to remove loosely attached extract material. The fabric is then dried again under suitable conditions. Proper drying and curing help to maintain the softness, appearance, absorbency and overall performance of the fabric. After completing this process, the treated material is ready for antimicrobial and textile performance testing.[6]

VII. ADVANTAGES OF MORINGA EXTRACT INFUSION

The application of *Moringa oleifera* extract to reusable diaper fabric provides several potential benefits. *Moringa* is a naturally available plant containing various bioactive compounds. Using *Moringa* leaf extract as a textile treatment provides a plant-based approach for developing antimicrobial functionality in reusable diaper fabrics. The herbal treatment can be incorporated into the fabric while maintaining the

basic requirements of a reusable diaper. When combined with a suitable absorbent textile structure, the treatment may provide additional functional benefits.[1]

The use of *Moringa* extract also encourages the utilization of renewable plant resources in textile development. However, the final treated fabric should be tested properly to confirm its antimicrobial performance, safety, durability and suitability for baby-care applications.[6]

7.1 ECO-FRIENDLY AND RENEWABLE MATERIAL

Moringa oleifera is a renewable plant resource that can be cultivated in many tropical and subtropical regions. The use of *Moringa* leaves as a source of herbal extract provides an opportunity to develop textile treatments using naturally available plant materials.[5]

The reusable nature of the diaper fabric can also help reduce the continuous disposal of single-use diaper products. Combining reusable textile materials with plant-based treatment supports the development of more environmentally conscious baby-care products.[18]

7.2 REDUCED DEPENDENCE ON SYNTHETIC FINISHING AGENTS

Moringa oleifera extract provides an opportunity to introduce antimicrobial functionality through a naturally derived material. Plant-based textile treatments may reduce the dependence on certain synthetic finishing agents, depending on the treatment formulation and performance obtained.[12]

The extraction and application process can be carried out using relatively simple procedures and suitable textile-processing equipment. However, proper testing is required to determine whether the treated material provides sufficient antimicrobial activity and remains safe and comfortable for its intended use.[14]

7.3 MULTIFUNCTIONAL PERFORMANCE

The developed reusable baby diaper fabric is intended to provide more than antimicrobial functionality. The fabric should also have suitable absorbency, moisture management, softness, breathability and strength. The *Moringa oleifera* treatment is intended to provide antimicrobial properties, while the textile structure provides the physical properties required for diaper use.[15-16]

Therefore, the combination of suitable fabric construction and herbal treatment can help develop a multifunctional reusable baby diaper material with both comfort and functional characteristics.[16]

7.4 SKIN SAFETY AND ENVIRONMENTAL CONSIDERATIONS

Since the developed material is intended to come into prolonged contact with a baby's skin, skin compatibility is an important consideration. The selected fabric should have a soft surface, suitable pH, good breathability and adequate moisture management. After herbal treatment, suitable washing and finishing procedures should be followed to remove loosely attached materials from the fabric surface.[17]

The treated fabric should be evaluated using appropriate safety and performance tests before practical use. Wastewater produced during extraction and textile treatment should also be managed properly to reduce environmental impact.[13]

VIII. APPLICATIONS OF MORINGA EXTRACT-TREATED MATERIALS

Moringa oleifera extract-treated textiles can be considered for applications where naturally derived herbal functionality is required. In this project, Moringa extract is applied to fabric intended for reusable baby diaper production. [6] The treated material can be incorporated into different layers of the reusable diaper depending on the required function and construction method. It may be considered for suitable inner, absorbent or supporting textile layers after confirming its antimicrobial performance and skin compatibility.

Apart from baby-care textiles, plant-extract-treated fabrics may also have potential applications in selected healthcare, personal-care and household textile products. Each application requires separate testing according to its intended purpose.[14]

8.1 SUSTAINABLE HERBAL TEXTILE DEVELOPMENT

The development of herbal-treated reusable diaper fabric combines renewable plant resources with reusable textile materials. [19] Moringa oleifera leaves are used as the source of the herbal extract, while the

reusable textile structure is designed for repeated washing and use.

This approach supports sustainable textile development by encouraging the use of naturally derived materials. Proper extraction, fabric treatment, washing and wastewater-management practices are important to reduce the environmental impact of the overall process.[18]

8.2 MORINGA-TREATED REUSABLE BABY DIAPER FABRIC

The main application of the developed material is the production of reusable baby diaper fabric. A suitable cotton or cotton-blend fabric can be treated with Moringa oleifera extract and incorporated into the diaper construction.[9]

The treated fabric should provide a balance between absorbency, softness, moisture control, breathability and durability. The herbal treatment is intended to provide antimicrobial functionality without significantly affecting the comfort and basic performance of the diaper fabric.[17]

8.3 REUSABLE BABY DIAPER APPLICATIONS

The treated textile can be used in different sections of a reusable baby diaper depending on the design and construction. It may be incorporated into the absorbent layer, inner fabric layer or other suitable components. Reusable diapers can be designed using washable fabric layers, absorbent inserts and protective outer materials. Each layer should be selected according to its specific function, comfort and durability. The completed diaper should also be tested after repeated washing to determine whether its antimicrobial activity, absorbency, softness and other important properties are maintained.[16]

8.4 BABY COMFORT, HYGIENE AND SUSTAINABLE LIFESTYLE

The development of reusable baby diaper fabric using Moringa oleifera extract combines comfort, hygiene-related functionality and sustainable material selection. Soft and breathable fabrics are important for maintaining baby comfort during use.[19] Good absorbency and moisture management are also necessary for the functional performance of a diaper. The use of reusable textile materials can help reduce dependence on disposable baby-care products. The incorporation of a plant-derived treatment also

supports the concept of using renewable resources in everyday textile products.

Overall, the development of herbal antimicrobial reusable baby diaper fabric using *Moringa oleifera* extract aims to combine plant-based functionality with suitable textile performance. The final material should be evaluated for antimicrobial effectiveness, skin compatibility, absorbency, durability, comfort and performance after repeated washing before practical application.[17]

IX. CONCLUSION

The proposed research focuses on developing a herbal antimicrobial reusable baby diaper fabric using *Moringa oleifera* extract. It brings together herbal textile finishing, functional textile development, reusable product design, and sustainable textile concepts. Disposable diapers provide convenience but are discarded after use, resulting in repeated product waste. [17-19] Reusable textile diapers offer an area for exploring alternative product-development approaches. At the same time, antimicrobial functionality is an important consideration when developing reusable fabrics intended for hygiene-related applications.

Moringa oleifera is considered a suitable material for investigation because its leaves contain bioactive compounds and have been studied for their potential antimicrobial properties. Previous research on *Moringa*-based textile treatments provides a basis for further investigation. Therefore, the proposed study will explore the use of *Moringa oleifera* extract in reusable baby diaper fabric development. The research will establish the foundation for the experimental stage, where the developed textile can be evaluated for its antimicrobial activity and selected textile performance properties.[7]

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