# Eco-Innovations in Textiles: Agro-Waste Based Fragrance and Functional Finishes

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***Abstract*— Fragrance finishing has become a creative technique to improve both the functional and aesthetic qualities of textiles, especially in home furnishing products. In this study, a flower and leaves -based fragrance was applied to aloe vera–treated cotton fabrics using the exhaust method along with a non-ionic binder. The treated fabrics were then tested to evaluate fragrance durability, fabric performance, and their ability to withstand repeated washing. To understand their practical use, the finished fabrics were further developed into decorative wall hangings, and their impact on the indoor environment was assessed through sensory observations and functional evaluation. The findings showed that the exhaust method provided effective fragrance retention without causing any significant change in the fabric's original properties. The lavender aroma continued to release a pleasant scent even after several washing cycles, indicating strong binding efficiency. Overall, the study suggests that fragrance finishes derived from natural essential oils can serve as sustainable and user-friendly alternatives to synthetic fragrances. These fragranced textiles can be successfully used in various home textile products such as wall hangings, table linens, upholstery fabrics, and carpets, helping to create a more pleasant and comfortable indoor atmosphere. [1-2,17].**

***Index Terms*—Agro-waste, Bio-fragrance, Eco-friendly finishing, home textiles, Natural dye, Sustainable textiles**

## I. INTRODUCTION

Growing awareness about environmental protection has encouraged researchers to explore eco-friendly antimicrobial agents from natural sources for textile applications. At the same time, consumers are becoming more conscious about hygiene and the harmful effects of microbial growth on fabrics, which has increased the demand for antimicrobial clothing and household textiles. Plant-based extracts that naturally possess antibacterial properties are now being considered effective substitutes for synthetic chemicals. These extracts can be applied to fabrics directly in their natural form or through techniques such as microencapsulation, which improves durability and allows the gradual release of active compounds. As the demand for cleaner and safer textiles continues to grow, antimicrobial finishing is gaining greater importance in the textile industry. Therefore, current research focuses on developing antimicrobial treatments that are effective, environmentally friendly, and safe for consumers while meeting existing environmental standards. [5-12].

Another growing environmental concern is the large amount of agro-horticultural waste generated from households, local markets, and food processing industries. Fruit and vegetable peels are often discarded as by-products, and when they are not properly managed, they can create both environmental and economic problems. Poor waste management practices, including improper segregation and disposal, further worsen the situation and contribute to environmental pollution. The continuous accumulation of organic waste also increases carbon emissions, which can lead to higher pollution levels and long-term ecological imbalance. Food waste, particularly from fruits and vegetables, forms a

significant portion of this problem because of its highly perishable nature.[9].

## II. MATERIALS AND METHODS:

Sources of Essential Oils

Across the world, nearly 400,000 plant species are known for their aromatic and medicinal properties. Among them, about 2,000 species from nearly 60 botanical families are recognized as important sources of essential oils. These plants are not limited to a single botanical group but are distributed across many different plant classifications. Essential oils can be extracted from various parts of plants depending on the species. For example, flowers and inflorescences such as chamomile, lavender, rose, and ylang-ylang are widely used for oil extraction. Leaves of plants like basil, lemongrass, peppermint, rosemary, and laurel also serve as significant sources. In addition, oils can be obtained from fruits such as black pepper and nutmeg, as well as from citrus peels including orange, lemon, bergamot, and tangerine. Seeds like anise, cumin, fennel, and cardamom; berries such as juniper and allspice; bark from trees like cinnamon and cassia; and woods such as sandalwood and cedarwood are also important sources. Furthermore, roots and rhizomes including ginger, turmeric, and vetiver, along with plant resins like myrrh and frankincense, contribute significantly to the production of essential oils. [4-15].

## III. COMMON SOURCES INCLUDE

| | | |
|---|---|---|
| Leaves | 1) Maruthu<br>Scientific Name: Terminalia arjuna |  |
| | 2) Marikolunthu<br>Scientific Name: Davanam Artemisia pallen |  |
| Flower | 3) Rose<br>Scientific Name: Rosa damascena |  |
| | 4) Samanthi<br>Scientific Name: Tagetes |  |

Table 1. Common sources of Essential Oils

The use of agricultural and food-processing waste as extract sources supports waste valorization and reduces environmental burden.

Preparation of Raw Materials

The plant materials are initially cleaned to eliminate dust, soil, and other impurities. After cleaning, they are carefully dried either under shade or at a controlled temperature to protect heat-sensitive compounds from damage. Once the drying process is complete, the materials are ground into a fine powder. This step helps to increase the surface area of the plant material, which enhances the efficiency of the extraction process.[16]

Preparation of Peel Extracts

Peels of onion, lemon, and potato were selected as the raw materials for preparing the extracts. Approximately 50 g of each peel sample was first washed thoroughly to remove dirt and impurities. The cleaned samples were then soaked in suitable solvents for extraction. Distilled water was used to prepare aqueous extracts, whereas ethanol was used to obtain alcoholic extracts. The peel–solvent mixtures were left undisturbed for about 48 hours to allow the bioactive compounds to dissolve effectively in the solvent. After this soaking period, the mixtures were gently heated for around 10 minutes to improve the extraction process. The solutions were then filtered to separate the solid residues, and the obtained extracts were collected and stored in sterile containers under dark conditions to avoid degradation before further use.[22] In addition to this method, lemon peels were also processed using the Soxhlet extraction technique with hexane as the solvent. The extraction was performed at a controlled temperature of about 60 °C for nearly 5 hours. After the extraction process was completed, the collected extract was placed on a rotary shaker to help remove any remaining solvent through evaporation. [10,11-17].

Extraction Process

Extraction is an important process in which beneficial bioactive substances are separated from plant materials using a suitable solvent. During this step, the active components present in the plant dissolve into the solvent, allowing them to be collected and used for further applications. The selection of the solvent mainly depends on the type of compounds that need to be extracted and the purpose for which the extract will be used.

## IV. COMMON EXTRACTION METHODS

| S. NO | Extracte process | Descript | Refer ence |
|---|---|---|---|
| 1 | Aqueous extraction | Uses water; suitable for eco-friendly and skin-contact applications | [16] |
| 2 | Solvent extraction | Uses ethanol or hydro-alcoholic mixtures for higher efficiency | [18] |
| 3 | Boiling or reflux method | Enhances extraction of heat-stable compounds | [19] |
| 4 | Soaking or maceration | Simple and cost-effective for small-scale applications | [20] |

Table 1. Common extraction methods of Agro-Waste Derived Bio-Compounds

After extraction, the solution is filtered to remove solid residues, yielding a clear extract rich in functional compounds.

Concentration and Stabilization

The extracted solution may be further concentrated to increase the amount and effectiveness of the active compounds. To maintain its quality and extend its shelf life, stabilization is often required to protect the extract from microbial spoilage and degradation. In some cases, natural binders, emulsifiers, or encapsulating agents are incorporated to improve the stability of the extract and ensure better compatibility with the material on which it will be applied. These additives also help in achieving a gradual and controlled release of the active components during use [14].

Infusion/Application Methods

The prepared extract is then applied to the selected material based on the specific requirements of its intended use. This infusion process allows the active components of the extract to be effectively incorporated into the substrate so that the desired functional properties can be achieved in the final product.

## V. COMMON INFUSION TECHNIQUES:

| S. NO | Infusion Techniques | Descript | Reference |
|---|---|---|---|
| 1 | Exhaust method | Ensure uniform absorption and better durability, widely used in textiles | [21] |
| 2 | Padding method | Suitable for continuous processing | [22] |
| 3 | Coating and spraying | Used for surface functionalization | [23] |
| 4 | Microencapsulation | Improves durability and slow release of active agents | [24] |

Table 3. Common infusion techniques of fragrance coating method

In textile applications, natural binders are often used to enhance adhesion between the extract and the fabric.

Drying and Curing

After natural extracts are applied, the treated material is subjected to drying and curing to ensure that the extract is properly fixed onto the surface. During the drying stage, the material is kept at a controlled temperature to remove excess moisture or solvent. This step must be done carefully so that the heat does not damage the fabric or the sensitive bioactive compounds present in the extract.

Once drying is completed, the material undergoes a curing process. In this stage, the fabric is maintained at a suitable temperature for a specific period to strengthen the bonding between the extract molecules and the material surface. Proper curing helps improve the durability of the functional properties, such as antimicrobial effectiveness, fragrance retention, and color stability, even after repeated washing or regular use.[21-22]

Maintaining the correct drying and curing conditions is very important to protect the structure of the fabric while achieving the desired functional performance. Excessively high temperatures or longer curing times may reduce the activity of the natural compounds or damage the material. Therefore, carefully optimized conditions are necessary to produce durable and effective materials treated with natural extracts.[6].

Advantages of Extract Infusion

Incorporating natural extracts into materials provides multiple benefits related to sustainability, improved functionality, and user safety. These extracts help enhance the performance of the material while also supporting environmentally friendly practices. The main advantages of using natural extracts are explained below.

Eco-Friendly and Biodegradable

The use of natural extracts in material infusion mainly involves plant-based substances or compounds obtained from agricultural waste, which are naturally biodegradable. In contrast to synthetic finishes, these natural extracts break down easily in the environment without producing harmful residues. This helps reduce environmental pollution and supports the development of more sustainable and eco-friendly products throughout their life cycle.

Reduced Reliance on Synthetic Chemicals

Using natural extracts reduces the dependence on synthetic chemicals that are usually added for fragrance, antimicrobial properties, and coloring. By replacing these artificial substances with natural alternatives, the level of chemical toxicity in production processes can be reduced. This approach also helps minimize environmental pollution and supports the adoption of environmentally responsible and sustainable manufacturing practices in line with modern global standards.[7].

Multifunctional Performance

Natural extracts usually contain a variety of bioactive compounds, which allow them to deliver several functional benefits at the same time. A single extract can contribute antimicrobial properties, a pleasant aroma, antioxidant effects, and natural color. Because of these multiple functions, the overall performance of the product can be improved without the need for additional chemical treatments.[9]

Skin Safety and Environmental Sustainability

Materials finished with natural extracts are generally soft and skin-friendly, making them appropriate for products that stay in contact with the skin for extended periods, such as textiles and personal care items. Because these materials avoid the use of harsh synthetic chemicals, the possibility of skin irritation,

allergic reactions, or other health problems is greatly reduced. Moreover, they are environmentally safe since they do not release harmful substances during their usage or when they are discarded.[8].

Applications of Extract-Infused Materials

Materials infused with extracts obtained from natural sources and agricultural waste have attracted increasing interest because of their multiple functional benefits. These materials can provide properties such as antimicrobial protection, natural fragrance, coloration, and environmental friendliness. Due to these advantages, extract-infused materials are used in many different fields and industries, as explained below.

Antimicrobial and Fragrant Textiles

Natural extracts that contain bioactive compounds are now widely used in textiles to provide antimicrobial and deodorizing effects. When these extracts are applied to fabrics, they help control the growth of microorganisms that cause unpleasant odors and infections. As a result, the treated textiles offer improved hygiene and greater comfort for the wearer [.13]

Home Textiles and Upholstery

Plant-derived extracts rich in bioactive compounds are increasingly incorporated into textiles to provide antimicrobial and odor-control properties. When these natural substances are applied to fabrics, they help suppress the growth of bacteria and other microorganisms responsible for bad odors and potential infections. Consequently, textiles treated with such extracts promote better hygiene and enhance the overall comfort of the wearer.

Cosmetic and Personal Care Products

Materials infused with natural extracts are widely used in cosmetic and personal care products because of their gentle and beneficial effects on the skin. These extracts are added to items such as wet wipes, face masks, sanitary products, and cleansing pads to provide antibacterial protection, calming properties, and a pleasant natural fragrance.[3].

Medical and Hygienic Textiles

In healthcare settings, textiles treated with natural extracts are used where high levels of hygiene and safety are required. Items such as wound dressings, bandages, surgical gowns, masks, and hospital linens can benefit from the antimicrobial and soothing properties present in many plant-based extracts. These properties help reduce the growth of harmful microorganisms and support a cleaner and safer medical environment. [17 ,22].

Wellness and Lifestyle Products

Materials enriched with natural extracts are increasingly being used in wellness and lifestyle products because of their ability to promote relaxation and support overall well-being. These extracts often contain natural aromatic and therapeutic compounds that can create a calming and refreshing effect. When incorporated into products such as bedding, cushions, aromatherapy textiles, and relaxation accessories, they help improve the surrounding environment and enhance comfort. The natural fragrance and beneficial properties of these extracts can also contribute to stress relief and a more pleasant living experience. As consumers become more interested in natural and eco-friendly products, the use of extract-infused materials in the wellness sector continues to grow. [5-6]

## VI. CONCLUSION

The infusion of natural extracts into materials is considered a sustainable and effective method for creating functional products. By using extracts obtained from plants and agricultural waste, industries can make better use of natural resources and reduce the environmental impact caused by synthetic chemicals. This approach not only helps in minimizing waste but also supports eco-friendly production practices. Natural extracts often contain beneficial bioactive compounds that can provide properties such as antimicrobial protection, fragrance, antioxidant activity, and natural coloration. As a result, materials treated with these extracts can offer improved performance while remaining safe for both consumers and the environment. [1-12]

In addition, the use of plant-based and waste-derived extracts helps industries respond to the increasing consumer demand for natural, non-toxic, and value-added products. Many modern consumers prefer products that are sustainable and environmentally responsible, especially in sectors such as textiles, healthcare, cosmetics, and home furnishings. By

incorporating natural extracts, manufacturers can create products that are both functional and environmentally friendly.

Furthermore, ongoing research and technological developments in extraction techniques and infusion methods are helping to improve the efficiency and durability of these materials. Advanced methods such as microencapsulation, controlled release systems, and improved binding techniques can enhance the stability and long-lasting performance of natural extracts on different substrates. With continued innovation and research, extract-infused materials are expected to achieve greater durability, better functionality, and stronger commercial potential in the future. [2,24]

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Arorose Apciniya has assisted in literature collection, data organization, and initial and final drafting of the review.

M.Thogai Shri has conducted comprehensive literature review, synthesized findings, and prepared drafting the manuscript.

Dr Karpagam P has provided guidance on review framework, critically revised the manuscript, and approved the final version.

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