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# Development of Eco-Friendly Beeswax Food Wraps using Natural Fabric

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## Abstract

*This study examines the technical development and functional performance of eco-friendly beeswax-coated cotton food wraps as a sustainable alternative to conventional plastic wraps. The project focuses on creating a natural, biodegradable, and reusable food storage solution that combines the protective properties of beeswax with the flexibility of coconut oil, applied to cotton fabric as the base material. Cotton was chosen for its widespread availability, food safety, and natural fiber structure, which allows efficient absorption and adherence of the wax-oil coating. The preparation process involved melting beeswax and blending it with coconut oil to achieve a homogenous mixture, which was then evenly applied onto the cotton fabric. The coated fabric was allowed to cool and solidify, forming a flexible sheet capable of covering food items of various shapes and sizes. The combination of beeswax and coconut oil provides a protective barrier that reduces moisture loss, prevents direct contact with air, and maintains freshness, while the cotton base ensures breathability and easy handling. The wraps are designed to be reusable, washable with cold water, and biodegradable, making them environmentally responsible. Throughout the study, observations and measurements were conducted to evaluate key performance parameters, including flexibility, usability, and adherence to various food containers. Essentially, the developed wraps can cycle through multiple uses, maintaining their functional properties and demonstrating durability in daily food storage. The mixture of beeswax and coconut oil was systematically optimized to achieve moderate adhesion, allowing the wraps to conform effectively around different food items while remaining securely in place. This research helps in developing better sustainable food storage options by showing that a simple, natural mixture can work well in everyday use while being safe for the environment, also contributes to the growing interest in sustainable living and highlights the role of natural materials in reducing dependency on single-use plastics offering a practical model for home-based or small-scale fabrication of sustainable food wraps.*

**Keywords:** Eco-Friendly, Beeswax, Cotton Fabric, Coconut Oil, Food Wrap, Biodegradable, Reusable

## Introduction

The use of single-use plastics has become one of the biggest environmental concerns of the modern era. Plastic wraps and packaging are widely used in kitchens for food storage because they are cheap, convenient, and easily available. However, their non- biodegradable nature ends up polluting landfills and oceans, where they take hundreds of years to decompose. This

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not only harms wildlife but also affects soil and water quality, creating a long-term ecological problem. As awareness about these harmful effects grows, there is a strong need for eco-friendly, sustainable alternatives that are safe, reusable, and biodegradable.

To overcome these challenges, beeswax-coated food wraps have been introduced as an excellent replacement for plastic wraps. Beeswax wraps are flexible sheets made by coating a natural fabric with a mixture of beeswax and plant-based oil. Because the wraps are breathable, they allow a small amount of airflow that prevents food from becoming soggy while still reducing moisture loss, keeping fruits, vegetables, and baked goods fresh for longer and can be molded over bowls, plates, or directly around food items to keep them fresh. These wraps are washable, reusable, and completely biodegradable, making them an ideal solution for reducing household plastic waste. This research focuses on creating simple, low-cost beeswax-coated cotton wraps using just two key ingredients - beeswax and coconut oil and compares them with commercial beeswax wraps.

Most commercial wraps include pine resin, jojoba oil, or gum rosin to improve stickiness and softness, but these can sometimes cause allergic reactions, are not always easily available, and make the process slightly more expensive. By avoiding these additives, this project demonstrates that a simpler, two-ingredient formula can still produce a functional and sustainable product.

Beeswax is the key ingredient used in this study, chosen for its protective properties, water resistant property, mild antibacterial nature, and biodegradability. Ethically sourced beeswax ensures that bees are not harmed during collection and that sustainable beekeeping practices are supported.

Beeswax is available in different forms, and the most common types include:

- **Yellow Beeswax:** The most natural and least processed form, retaining its natural color, aroma, and antibacterial properties.
- **White Beeswax:** Bleached or filtered beeswax, lighter in color, usually used for cosmetics but still food safe.
- **Beeswax Pellets:** Small, easy-to-melt pellets, convenient for uniform melting and measuring during projects.
- **Beeswax Blocks:** Large solid chunks, slightly harder to cut but ideal for bulk preparation.

For this project, yellow beeswax blocks were chosen because it is minimally processed and retains its natural properties, making it most suitable for food-contact applications.



**Figure Natural Beeswax Blocks**

Along with beeswax, organic cold-pressed coconut oil was used in this project because it retains more nutrients and has a natural aroma, unlike refined or processed oils. It helps soften the beeswax layer, making the wrap flexible and easy to mold around food items or containers. The oil also prevents the wax coating from becoming too brittle and cracking after repeated use. In addition, coconut oil provides mild antimicrobial benefits, contributing to better food preservation and extending the usability of the wraps and is considered safer for food contact.

The choice of fabric is equally important in making food wraps. Pure cotton fabric was selected as the base material in this project due to its breathability, food safety, and ability to absorb the wax mixture evenly. Cotton is widely available, biodegradable, and soft to handle, making the final product easy to use and comfortable while wrapping. Together, these ingredients make the wrap not only eco-friendly but also cost-effective and replicable at a small scale or in a household setting.

## Objectives

- To prepare beeswax-coated cotton wraps using a blend of beeswax and coconut oil.
- To test the flexibility, adhesion, and usability of the prepared wraps.
- To document the coating process for easy replication at home or small scale.
- To check durability and washability after multiple uses.
- To promote an eco-friendly alternative to single-use plastic wraps.

## Methodology



## Material Collection

Organic cotton fabric was chosen as the base because it is natural, safe for food, and easily available. Plain and Azo free printed fabrics were chosen. Beeswax was used as the main coating for its protective and biodegradable properties, while coconut oil was added to make the wraps flexible and prevent them from becoming brittle. Only these three natural ingredients were used to ensure the wraps remained eco-friendly and safe. A photograph of the collected materials was taken for documentation.



**Plate 3.1 Materials used for preparing beeswax-coated cotton food wraps - (a) Coconut Oil, (b) Organic Cotton Fabric (125 GSM), (c) Pure Beeswax.**

**Equipment Setup**

After collecting the materials, the next step involved setting up all the necessary equipment for preparing the beeswax-coated cotton food wraps. A bowl was used to melt the beeswax safely using double boiler method, and trays covered with aluminum foil were arranged to prevent mess and make cleanup easier. A heat-resistant container was used to mix the melted beeswax with coconut oil, while spatulas and tongs were kept on hand for handling the hot mixture and applying it onto the fabric. Drying racks were also set up to allow the coated fabric to solidify evenly. Proper arrangement of all equipment ensured safe handling of hot materials and smooth execution of the process, while maintaining the quality and consistency of the wraps.



**Plate 3.2 Equipment used for preparing beeswax-coated cotton food wraps, foil-covered trays, heat-resistant container, spatulas and tongs.**

**Preparation of Beeswax–Coconut Oil Mixture****Adding Coconut Oil**

After the beeswax was completely melted, coconut oil was gradually added to the mixture to improve flexibility and prevent the coating from becoming brittle once cooled. A ratio of 20 parts beeswax to 5 parts coconut oil (20:5) by weight was used, which was found to provide an optimal balance between firmness and flexibility. The mixture was stirred continuously to ensure thorough blending and a uniform consistency. This proportion can be represented by the formula:

$$\text{Total Mixture} = \text{Beeswax (g)} + \text{Coconut Oil (g)}$$

$$\text{Beeswax : Coconut Oil} = 20:5$$

Using this ratio ensures that the final mixture remains smooth, spreads evenly on the cotton fabric, and retains the natural protective properties of beeswax while gaining the desired flexibility from the coconut oil.

**Mixing**

The mixture was stirred continuously using a spatula to ensure even blending and smooth consistency.

**Cutting and Preparing Fabric**

Once the beeswax–coconut oil mixture was ready, the cotton fabric was prepared for coating. The organic cotton was first washed and dried to remove any impurities and ensure a clean surface for better adhesion of the wax mixture. The fabric was then measured and cut into the required sizes, depending on the intended use of the wraps, such as small squares for sandwiches or larger sheets for covering bowls. Care was taken to cut the fabric evenly, maintaining straight edges to facilitate uniform coating. Preparing the fabric properly is essential to ensure that the wax mixture adheres smoothly and consistently, resulting in high-quality, reusable wraps.



**Plate 3.4 Cotton fabric cut into required sizes for coating.**

### **Coating the Cotton Fabric**

The prepared cotton pieces were coated with the beeswax–coconut oil mixture using a brush to ensure even coverage. Each piece of fabric was placed on the aluminum foil–lined trays to prevent mess and allow easy handling. The mixture was spread carefully across the entire surface of the fabric, ensuring that all areas were covered without excess accumulation, which could make the wrap stiff. Gentle brushing helped the mixture penetrate the fibers of the cotton for better adhesion.



**Plate 3.5: Applying the beeswax–coconut oil mixture evenly onto the cotton fabric.**

### **Drying and Solidification**

After coating, the fabric pieces were left to cool and solidify on the aluminum foil–lined trays. This allowed the wax–oil mixture to set properly, forming a flexible sheet that could wrap food items of various shapes and sizes. Proper drying ensures the coating adheres well and prevents stickiness or uneven surfaces.

### **Inspection and Pre-Test Quality Check**

Before sending the wraps for testing, each piece was carefully inspected for uniform coating, proper drying, and any defects such as thin spots or uneven surfaces. The wraps were checked to ensure flexibility, smooth texture, and that the wax–oil mixture had adhered properly to the cotton fabric. This step ensured that only well-prepared wraps were evaluated during testing, maintaining consistency and reliability in the results.



**Plate 3.7 Inspection of coated cotton wraps for uniformity and even ness.**

**Testing and Evaluation**

The coated cotton wraps were evaluated to determine their functional performance, including flexibility, adhesion, and usability. Tests were conducted by wrapping different food items such as fruits, vegetables, and bowls to check how well the wraps conformed to various shapes and sizes. Observations included how effectively the wraps-maintained freshness, prevented moisture loss, and adhered to the surfaces without slipping. The evaluation also assessed reusability, by washing some wraps with cold water and observing any changes in texture or coating integrity. This step provided critical information on the durability and practicality of the wraps in everyday use.

**Preservation and Handling**

After testing, the beeswax-coated cotton wraps were stored properly to maintain their quality and usability. The wraps were kept in a cool, dry place away from direct sunlight to prevent melting or deformation of the wax coating. They were folded neatly and placed in clean cover to avoid dust or contamination.



**Plate 3.9 Proper storage of beeswax-coated cotton wraps to maintain clean usability.**

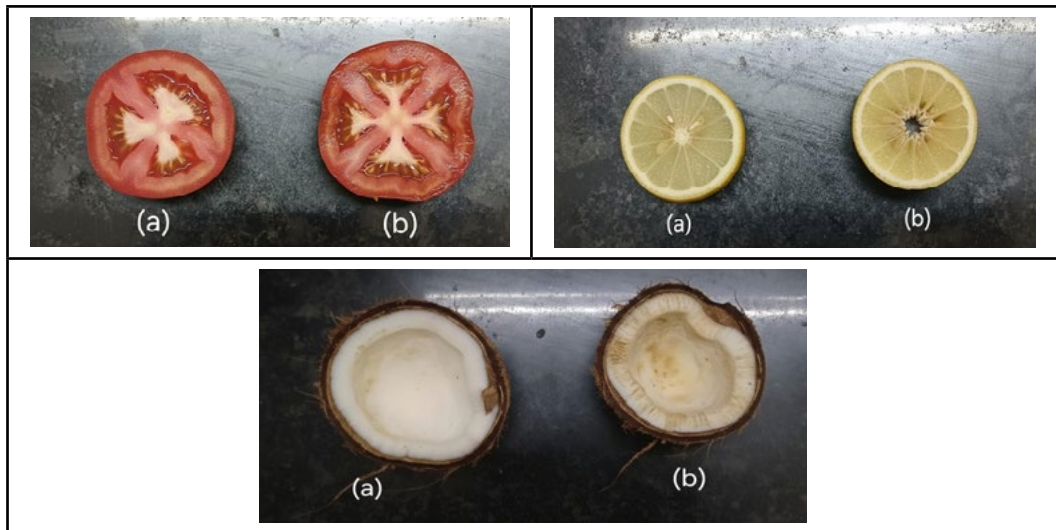
**Final Product Preparation and Presentation**

In the final step, the beeswax-coated cotton wraps were prepared for use or demonstration. Each wrap was carefully folded, labeled, and organized according to size for easy selection. The wraps were arranged neatly for presentation, highlighting their flexibility, smooth coating, and eco-friendly nature. This step ensured that the final product was ready for practical use, showcasing the quality and effectiveness of the beeswax-cotton wraps as a sustainable alternative to plastic food covers.

**Result and Discussion****Home Testing Results**

| S. No | Test Performed          | Particulars / method                    | Result Observed  | Satisfactory |
|-------|-------------------------|---|--|--------------|
| 1     | Flexibility Test        | Wrap was folded and unfolded repeatedly | No cracks, wrap remained soft and pliable              | Yes          |
| 2     | Adhesion Test           | Wrap applied to bowl surface            | Wrap adhered well and stayed in place without slipping | Yes          |
| 3     | Moisture Retention Test | Wrapped cut fruit and kept for 24 hours | Fruit remained fresh, no visible drying                | Yes          |

|   |                           |   |   |     |
|---|---------------------------|---|---|-----|
| 4 | Reusability Test          | Washed with cold water and reused 5 times | Coating intact, flexibility retained      | Yes |
| 5 | Smell/Contamination Check | Checked after 3 days of use               | No foul smell or microbial growth visible | Yes |
| 6 | Storage Durability        | Wraps stored for 2 weeks in cool place    | No melting, coating unchanged             | Yes |



**Plate 4.1 Testing of beeswax-coated cotton wraps on food items (Tomato, lemon, coconut);  
(a) Covered with bees wax food wraps, (b) left uncovered**

## Lab Testing Results

### Antimicrobial Activity

#### Preparation of the Bacterial Inoculum

Stock cultures were maintained at 4° C on slopes of nutrient agar and potato dextrose agar. Active culture for experiments were prepared by transferring a loop full of cells from stock cultures to test tubes of 50ml nutrient broth bacterial cultures were incubated with agitation for 24hours and at 37°c on shaking incubator and fungal cultures were incubated at 27°c for 3-5 days. Each suspension of test organism was subsequently stroke out on nutrient agar media and potato dextrose agar. Bacterial cultures then incubated at 37°c for 24 hours and fungal incubated at 27°c for 3-5 days. A single colony was transferred to nutrient agar media slants were incubated at 37°c for 24 hours and potato dextrose slant were incubated at 27°c for 3-5 days. These stock cultures were kept at 4°c. For use in experiments, a loop of each test organism was transferred into 50ml nutrient broth and incubated separately at 37°c for 18-20 hours for bacterial culture.

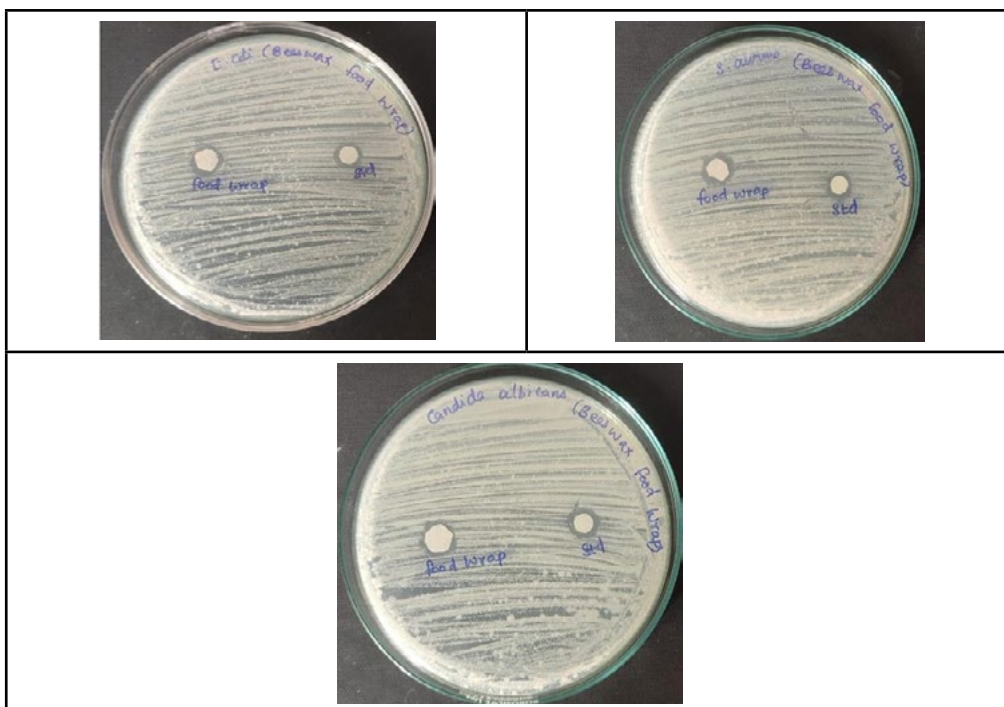
#### Disc Diffusion Method

Antibacterial activity was performed by agar diffusion method. Van der Watt et al., 2001. The stock culture of bacteria (*E.coli* and *Streptococcus* and *Candida albicans*) were received by inoculating in nutrient broth media and grown at 37 % for 18 hours. The agar plates of the above media were prepared. Each plates was inoculated with 18 hours old cultures the bacteria were swab in the sterile plates. Put the Materials into the agar plate. All the plates were incubated at 37oC for 24 hours and the diameter of inhibition zone was noted in mm.

| Organisms Concentration | E.Coli | S.aureus | Candida albicans |
|-------------------------|--------|----------|------------------|
| Film                    | 3 mm   | 3 mm     | 2.5 mm           |
| Standard                | 2 mm   | 2 mm     | 3 mm             |

## Report

The give Beeswax food wrap material shows the Antimicrobial activity against the Pathogenic Microorganisms like E.Coli and S.aureus and Candida albicans. food wrap shows good activity compare to the Standard drugs depending upon the size of the zone.



## Population of Bacterial Count



## Report

| Sample Name | No of colonies Preset | cfu               |
|-------------|-----------------------|-------------------|
| Bacterial   | 2                     | 2x10 <sup>2</sup> |

The given Beeswax food wrap material shows only two bacterial colony was observed. It is not affected to the food materials.

## Summary and Conclusion

This project focused on developing eco-friendly beeswax-coated cotton food wraps as a sustainable replacement for single-use plastic wraps. Organic cotton fabric was coated with a beeswax-coconut oil mixture prepared using the double boiler method, and the finished wraps were tested through both home-based evaluations and laboratory analysis. The results showed that the wraps were flexible, adhesive, reusable, and effective in reducing moisture loss while keeping food fresh. Laboratory tests confirmed antimicrobial activity against *E. coli*, *S. aureus*, and *Candida albicans*, along with minimal bacterial growth, proving that the wraps are safe for direct food contact. Additional observations of biodegradability and adhesion strength further established their practicality and environmental benefits, highlighting the potential of this product as an eco-friendly and sustainable alternative to plastic-based food packaging.

## Annexure

Final beeswax-coated cotton food wrap prepared during the study, laid flat on a table.



Beeswax-coated cotton wrap used to cover an avocado and a bowl, highlighting flexibility and effective sealing capacity.



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