

Development of Herbal Paper Soap Using Natural Polymers and Pomegranate Peel Extract

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Abstract—Paper soap is a thin, lightweight sheet of soap that can be carried in a small box or pouch and used with water. It can be handy when travelling or when a regular soap bar is difficult to carry. For paper soap to work well, the sheet must be flexible enough to handle and should release its cleansing ingredients when wet. Natural polymers such as starch, sodium alginate, chitosan and cellulose derivatives may be used to make these sheets because each has different film-forming properties. [10, 11, 9]

This project also looks at pomegranate peel, which is usually thrown away after the fruit is eaten or processed. The peel contains plant compounds, including tannins and other polyphenols, that have been studied for their antioxidant and other biological activities. Reusing the peel in a paper-soap formulation could help make use of this waste material. Still, its benefits in the final product cannot be assumed; they need to be checked through experiments. [1, 2, 3, 4, 5, 6, 7, 8]

The project proposes making paper soap with a suitable natural polymer, a cleansing agent and pomegranate peel extract. The sheets can then be checked for flexibility, strength, pH, behaviour in water, cleansing performance, storage stability and safety. The results would show whether the formulation is worth developing further. [1, 2, 3, 4, 5, 6, 7, 8]

I. INTRODUCTION

Soap helps remove dirt and excess oil from the skin. Although soap bars and liquid soaps are commonly used, they are not always convenient to carry when travelling or spending time outdoors. Paper soap is one possible alternative because the sheets are light, compact and can be used with water when needed. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

Paper soap is made by spreading a mixture of film-forming material and cleansing ingredients into a thin layer and allowing it to dry. The sheet should not crack easily during handling, but it should also soften or release its ingredients when water is added. These

features depend on the polymer, the amount of cleansing agent and whether a plasticiser or another ingredient is included. Studies of biodegradable films show that the formulation can affect flexibility, strength and sensitivity to moisture. [13, 16, 9]

Pomegranate (*Punica granatum* L.) peel is usually discarded after the fruit is eaten or processed. It contains plant compounds such as tannins and other polyphenols, which have been studied in scientific research. Using an extract from the peel in paper soap may be a practical way to reuse this by-product. Still, the presence of these compounds does not by itself prove that the finished soap offers extra skin benefits, so the final formulation would need to be tested. [1, 2, 3, 4, 5, 6, 7, 8]

Natural polymers can form the thin sheet needed for paper soap, but they do not all behave in the same way. A film may become brittle after drying, absorb moisture during storage or soften too quickly in water. For this reason, the polymer should be chosen carefully and tested with the cleansing agent and pomegranate peel extract before a final formulation is selected. [1, 2, 3, 4, 5, 6, 7, 8]

II. AIM

To prepare and evaluate herbal paper soap made with a natural polymer and pomegranate peel extract, and to study its physical properties and cleansing performance. [1, 2, 3, 4, 5, 6, 7, 8]

III. OBJECTIVES

1. To study the chemical composition and reported biological properties of pomegranate peel. [1, 2, 3, 4, 5, 6, 7, 8]
2. To understand the film-forming properties of natural polymers such as starch, sodium alginate, chitosan, and cellulose derivatives. [10, 11, 9]

- To study how the polymer, cleansing agent, plasticiser, and pomegranate peel extract work together in the formulation. [1, 2, 3, 4, 5, 6, 7, 8]
- To prepare paper soap sheets and evaluate their appearance, flexibility, strength, pH, and response to water. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- To assess the cleansing performance, stability, and safety of the prepared formulation. [20, 21, 22, 23, 24, 9, 15]
- To identify the possible advantages and limitations of using pomegranate peel extract and natural polymers in paper soap. [1, 2, 3, 4, 5, 6, 7, 8]

IV. BOTANICAL OVERVIEW OF POMEGRANATE PEEL

Pomegranate (*Punica granatum* L.) is valued as a food and has also been studied for its traditional uses. The outer peel is normally removed and discarded, but it contains naturally occurring compounds that have attracted interest in food science and plant-extract research. [1, 2, 3, 4, 5, 6, 7, 8]

The composition of pomegranate peel is not always the same. It can change with the fruit variety, growing conditions, ripeness, storage and extraction method. To make the study more consistent, the source of the peel, drying conditions, extraction steps and amount of extract obtained should be recorded. [1, 2, 3, 4, 5, 6, 7, 8]

V. PHYTOCHEMICAL CONSTITUENTS OF POMEGRANATE PEEL

5.1 Hydrolysable Tannins

Pomegranate peel contains hydrolysable tannins, including punicalagin and punicalin. Researchers study these compounds because of their chemical properties and possible biological activities. The

amount found in an extract can vary with the quality of the peel and the solvent, temperature and time used for extraction. [1, 2, 3, 4, 5, 6, 7, 8]

Tannins can bind to proteins, which makes them relevant to several biological and material studies. Still, their presence in the extract does not guarantee that they will remain stable or active after mixing with the polymer and cleansing agent. Their behaviour in the final paper soap would need to be tested. [1, 2, 3, 4, 5, 6, 7, 8]

5.2 Ellagic Acid and Other Phenolic Compounds

Pomegranate peel has also been reported to contain ellagic acid and other phenolic compounds. These compounds are studied in part because they can show antioxidant activity in laboratory tests. [1, 2, 3, 4, 5, 6, 7, 8]

The number of phenolic compounds recovered depends on the peel and the extraction method. If the laboratory has the required equipment, high-performance liquid chromatography (HPLC) can be used to identify and measure selected compounds. This would help describe the extract more clearly. [1, 2, 3, 4, 5, 6, 7, 8]

5.3 Flavonoids and Other Plant Compounds

Flavonoids and other plant compounds may also be present in pomegranate peel. Together, these substances contribute to the extract's chemical makeup and may affect its colour and other physical features. [1, 2, 3, 4, 5, 6, 7, 8]

Adding the extract may change the colour, smell or appearance of the paper-soap sheets. These changes should be noted for each formulation. Preparing the extract in the same way each time will also make it easier to compare batches. [1, 2, 3, 4, 5, 6, 7, 8]

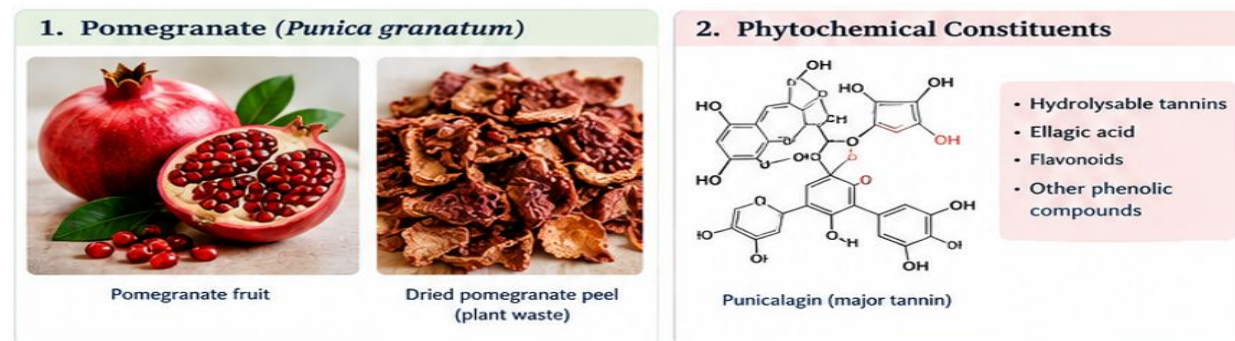


Figure 1. Pomegranate fruit, dried peel and selected phytochemical constituents.

VI. BIOLOGICAL PROPERTIES OF POMEGRANATE PEEL

6.1 Antioxidant Activity

Pomegranate peel extracts have been examined in laboratory tests for antioxidant activity. The results can differ according to the extract concentration, how it was prepared and which test was used. [1, 2, 3, 4, 5, 6, 7, 8]

A positive result in an antioxidant test does not automatically mean that the finished paper soap will have the same effect on skin. Other ingredients may change the extract's behaviour, and the extract's colour may affect some test readings. Suitable controls are therefore important when testing the final formulation. [1, 2, 3, 4, 5, 6, 7, 8]

6.2 Antimicrobial Activity

Some research has tested pomegranate peel extracts against selected microorganisms. The results are not always the same because they depend on the extract, its concentration, the microorganism and the test method. [1, 2, 3, 4, 5, 6, 7, 8]

The paper soap should not be called antibacterial or a disinfectant just because it contains pomegranate peel extract. The finished product must be tested with an appropriate microbiological method. Controls, such as the soap base without the extract, can help show whether the extract makes a measurable difference. [1, 2, 3, 4, 5, 6, 7, 8]

6.3 Skin Safety Considerations

A natural ingredient is not automatically safe for every skin type. Skin compatibility may depend on the extract concentration, the other ingredients, the product's pH and any impurities present. [1, 2, 3, 4, 5, 6, 7, 8]

Before the product is considered suitable for regular skin use, its formulation and safety need proper assessment. Any skin-compatibility testing must follow suitable safety and ethical procedures. Claims about soothing, protecting or improving the skin should only be made when there is evidence to support them. [20, 21, 22, 23, 24, 9, 15]

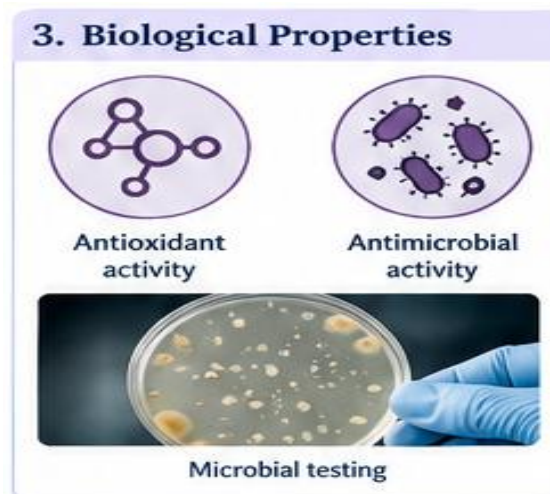


Figure 2. Biological properties that may be investigated in laboratory studies.

VII. NATURAL POLYMERS USED IN PAPER SOAP

In paper soap, the polymer forms the thin sheet that holds the cleansing ingredients together. The type of polymer affects how easily the sheet can be prepared, how strong it is after drying and how it behaves in water. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]



Figure 3. Examples of natural polymers that may be considered for film formation.

No single polymer will necessarily work best for every formulation. The amount used, drying conditions, plasticiser and other ingredients can all change the film's properties, so the final sheet needs to be tested. [13, 16, 9]

7.1 Starch

Starch is a natural polymer that can be used to prepare films. It is widely studied because it is available from plant sources and can form films under suitable preparation conditions. [14, 13, 9]

Still, starch films may become brittle after drying, and their strength and moisture resistance can change depending on the starch source and formulation. A plasticiser may help improve flexibility, but the amount used needs to be tested. In paper soap, the sheet should be flexible enough to handle while still responding properly to water. [14, 13, 9]

7.2 Sodium Alginate

Sodium alginate is a natural polysaccharide obtained mainly from brown seaweeds. It is used in different applications because it can form films and gels under suitable conditions. [12, 9]

Its film-forming behaviour makes it a possible option for paper soap. Still, the final properties will depend on the concentration, preparation method, and interaction with the other ingredients. The formulation should be tested to determine whether the resulting sheet has sufficient flexibility and suitable water response. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

7.3 Chitosan

Chitosan is a natural polymer produced by processing chitin, which is found in sources such as crustacean shells. It has been studied for film formation and several other applications. Its properties depend on factors such as molecular weight and degree of deacetylation. [10, 11, 9]

Chitosan may be considered for paper soap, but its suitability depends on how it behaves with the cleansing agent, extract, and other formulation ingredients. Its solubility and film properties should be checked before selecting it. Although chitosan is discussed in antimicrobial research, antimicrobial activity should not be assumed for the finished paper soap without testing. [1, 2, 3, 4, 5, 6, 7, 8]

7.4 Cellulose Derivatives

Cellulose derivatives are used in different film-forming and formulation applications. Their properties vary according to the type of derivative, including its solubility, viscosity, and ability to form a uniform film. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

For paper soap, the specific cellulose derivative should be clearly identified rather than referring to all cellulose-based materials as the same. Its compatibility with the cleansing agent and pomegranate peel extract should also be checked. [1, 2, 3, 4, 5, 6, 7, 8]

7.5 Role of Plasticisers

Plasticisers are added to some polymer formulations to improve flexibility and reduce brittleness. They can help a dried film bend more easily instead of cracking during handling. [13, 16, 9]

Still, adding more plasticiser does not always improve the product. It may also affect the film's strength, moisture absorption, drying behaviour, and response to water. For this reason, the type and amount of plasticiser should be selected through preliminary trials. [13, 16, 9]

III. CONCEPT OF HERBAL PAPER SOAP

The proposed paper soap has three main components: a natural polymer, a cleansing agent and pomegranate peel extract. Each has a separate role in the formulation. [1, 2, 3, 4, 5, 6, 7, 8]

- Natural polymer: Forms the thin sheet and helps hold the ingredients together. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Cleansing agent: Helps remove dirt and oil when the sheet is used with water. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Pomegranate peel extract: Adds plant-derived compounds that can be studied for their properties and compatibility with the formulation. [1, 2, 3, 4, 5, 6, 7, 8]

The main challenge is to make a sheet that is easy to handle without becoming brittle, sticky or weak. It should also remain stable during storage and respond properly to water. These qualities need to be confirmed by testing rather than assumed from the ingredients alone. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]



Figure 4. Main components proposed for the herbal paper-soap formulation.

IX. PROPOSED METHODOLOGY FOR FORMULATION

9.1 Collection and Preparation of Pomegranate Peel

Pomegranate peels can be collected from a clean and suitable source. Wash them to remove visible dirt, dry them under controlled conditions and grind them into powder. Keep the powder in a clean, dry and labelled container until it is used. [1, 2, 3, 4, 5, 6, 7, 8]

Record where the peels came from, how they were dried and how long they were stored, because these details may affect the material's composition. [9, 20]

9.2 Preparation of Pomegranate Peel Extract

The powdered peel can be extracted with a suitable solvent, such as water or a water-based alcohol mixture, depending on the laboratory procedure. Use consistent amounts of peel and solvent, and keep the extraction time and temperature the same for each batch. [1, 2, 3, 4, 5, 6, 7, 8]

Filter the mixture to remove solid particles, then label and store the extract under suitable conditions. Recording the amount of extract obtained and measuring total phenolic content if facilities are available can help compare batches. [1, 2, 3, 4, 5, 6, 7, 8]

9.3 Preparation of the Polymer Solution

Mix the chosen polymer with the appropriate solvent using a method suitable for that material. Stir carefully to reduce lumps and obtain an even mixture. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

Record the polymer concentration and check that the solution has no obvious clumps. If more than one polymer is being compared, document the preparation steps for each one so the results can be compared fairly. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

9.4 Addition of Cleansing Agent and Extract

Measure the cleansing agent and pomegranate peel extract and add them to the polymer solution. Stir until the mixture looks even, while trying not to introduce too many air bubbles. [1, 2, 3, 4, 5, 6, 7, 8]

Different amounts of extract can be tested to see how they affect the sheet's colour, smell, flexibility and behaviour in water. Adding more extract is not always better, as a high amount may affect the film or its stability. [1, 2, 3, 4, 5, 6, 7, 8]

A control formulation without pomegranate peel extract would be useful for comparing the effect of the extract on the finished paper soap. [1, 2, 3, 4, 5, 6, 7, 8]

9.5 Casting and Drying

Pour the mixture onto a clean, level surface or casting plate and spread it into an even layer. Keeping the layer uniform will help produce sheets of a similar thickness. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

Dry the films under controlled conditions. Once dry, remove them carefully, cut them into equal-sized pieces and store them in suitable packaging. Protecting the sheets from moisture is important because some natural polymer films change when they absorb water from the air. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

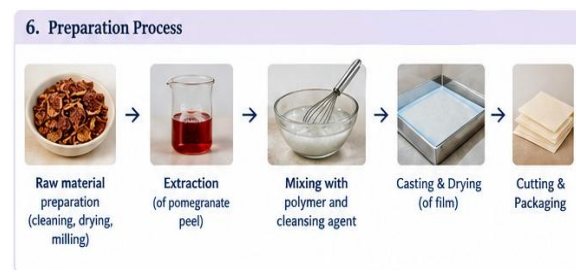


Figure 5. Suggested preparation steps, from peel processing to casting, drying and packaging.

X. EVALUATION OF PREPARED PAPER SOAP

10.1 Appearance and Physical Characteristics

The prepared sheets should be observed for colour, smell, surface uniformity, cracks, bubbles, and any separation of ingredients. Their appearance should be recorded for each formulation. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

The weight, length, width, and thickness of the sheets can also be measured. These measurements help determine whether the preparation method produces reasonably uniform pieces. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

10.2 Flexibility and Mechanical Strength

Flexibility matters because the sheets should be easy to carry and handle without breaking. Use the same folding or handling procedure for each sample and record any cracks or visible damage. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

If suitable equipment is available, tensile strength and percentage elongation can also be measured. These tests would provide more reliable information about how the polymer and plasticiser affect the mechanical properties of the film. [13, 16, 9]

10.3 pH Measurement

Measure pH with a calibrated pH meter and a clearly described procedure. Since a dry sheet cannot be measured exactly like a liquid, state whether the pH is measured from a prepared solution or a dispersion of the paper soap. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

The method and dilution used should remain the same for all samples. The pH results can then be compared between formulations and considered as part of the overall product-safety assessment. [20, 21, 22, 23, 24, 9, 15]

10.4 Moisture Content

Moisture content can influence the storage life and handling properties of paper soap. Excess moisture may make the sheets sticky or weaken them, while very dry films may become brittle. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

The moisture content should be measured using a suitable laboratory method, if available. The results can help identify whether the drying conditions and packaging are appropriate for maintaining the quality of the sheets. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

10.5 Water Response and Dissolution

The sheet should respond to water in a predictable way. To compare samples, place equal-sized pieces in the same volume of water and record whether they soften, disperse or dissolve. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

Complete dissolution and dispersion are different, so record which one occurs. Keep the water volume, temperature, stirring and observation time the same for every sample. [9, 20]

10.6 Foam Formation and Cleansing Performance

Foam formation can be recorded, but more foam does not always mean better cleansing. [20, 21, 22, 23, 24, 9, 15]

To compare cleansing performance, use one consistent test method and include a suitable control. Keep the amount of cleansing agent and the test conditions the

same so the results can be compared fairly. [20, 21, 22, 23, 24, 9, 15]

10.7 Antioxidant Activity

If the project includes antioxidant testing, a suitable laboratory assay can be used to examine the activity of the pomegranate peel extract and the final formulation. [1, 2, 3, 4, 5, 6, 7, 8]

Appropriate controls are necessary because the polymer, cleansing agent, and colour of the extract may affect the results. Testing the extract separately and comparing it with the finished paper soap can help determine whether the measured activity changes after formulation. The results should be reported as laboratory findings and not as proof of a skin-related benefit. [1, 2, 3, 4, 5, 6, 7, 8]

10.8 Microbiological Evaluation

If antimicrobial activity is included as an objective, the testing should be carried out using an appropriate method and selected test microorganisms under suitable laboratory conditions. [1, 2, 3, 4, 5, 6, 7, 8]

The study should include suitable controls, such as the cleansing base without the extract and the extract tested separately. This comparison can help show whether any observed effect is associated with the extract or the complete formulation. The paper soap should not be described as antibacterial or disinfectant unless the results support that claim. [1, 2, 3, 4, 5, 6, 7, 8]

10.9 Stability Testing

Stability testing helps determine whether the paper soap retains its important properties during storage. Samples can be examined at planned intervals for changes in colour, smell, pH, moisture, flexibility, and response to water. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

The storage conditions, packaging type, testing intervals, and acceptance criteria should be decided before the study begins. Suitable stability procedures should be selected according to the type of product and the claims being considered. [20, 21, 22, 23, 24, 9, 15]

10.10 Safety and Skin Compatibility

Safety is an important part of developing any product intended for contact with the skin. The ingredients, formulation pH, possible contamination, and other relevant factors should be assessed before the product

is considered suitable for use. [20, 21, 22, 23, 24, 9, 15]

Any skin-compatibility study should follow the appropriate ethical requirements and safety procedures. The fact that the formulation contains natural polymers or a plant extract does not, by itself, establish that it is safe or non-irritating. [1, 2, 3, 4, 5, 6, 7, 8]



Figure 6. Examples of physical, performance, stability and safety evaluations for the prepared sheets.

XI. DISCUSSION

This project combines two ideas: making thin films from natural polymers and exploring pomegranate peel as a source of plant compounds. The polymers may help form portable soap sheets, while the peel offers a way to reuse a by-product that is often thrown away. [1, 2, 3, 4, 5, 6, 7, 8]

Making a useful paper soap is not just a matter of mixing the ingredients. The polymer needs to form a suitable film, the cleansing agent must work as intended and the extract must be compatible with the rest of the mixture. The sheet also needs acceptable flexibility, strength, water response and storage stability. These features can change with the formulation and the way the film is prepared. [1, 2, 3, 4, 5, 6, 7, 8]

The peel extract itself may vary from batch to batch because the fruit and extraction conditions can differ. Following the same preparation method and recording the extract yield would make the study more consistent. A control formulation without the extract

would help show what difference, if any, the extract makes. [1, 2, 3, 4, 5, 6, 7, 8]

Results should be explained carefully. Antioxidant activity in a laboratory test does not prove that the soap protects the skin, and antimicrobial activity in an extract does not automatically make the finished soap antibacterial. Any such property should be reported only if the relevant tests support it. [1, 2, 3, 4, 5, 6, 7, 8]

XII. ADVANTAGES OF HERBAL PAPER SOAP

- Easy to carry: Paper soap sheets are lightweight and can be carried in a small container or pouch. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Convenient to use: Individual sheets may make it easier to carry a measured amount of soap. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Use of fruit waste: Pomegranate peel provides an opportunity to reuse material that is often discarded after fruit processing. [1, 2, 5, 6, 8]
- Use of natural polymers: Selected natural polymers can form thin films and may offer useful alternatives for certain film applications. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Scope for formulation development: Different polymers, plasticisers, and extract concentrations can be compared to identify a suitable formulation. [1, 2, 3, 4, 5, 6, 7, 8]

These are possible advantages of the proposed product. Their actual value will depend on the formulation, test results, packaging, and intended use. [20, 21, 22, 23, 24, 9, 15]

XIII. LIMITATIONS OF THE STUDY

- Variation in extract composition: The composition of pomegranate peel extract may differ according to the source and extraction method. [1, 2, 3, 4, 5, 6, 7, 8]
- Film brittleness: Some natural polymer films may crack or break after drying. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Moisture sensitivity: The sheets may absorb moisture during storage and become sticky or weak. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]

- Compatibility problems: The extract, polymer, cleansing agent, and plasticiser may interact and affect the final properties. [1, 2, 3, 4, 5, 6, 7, 8]
- Changes in appearance: Pomegranate peel extract may affect the colour and smell of the finished paper soap. [1, 2, 3, 4, 5, 6, 7, 8]
- Storage challenges: Suitable packaging and storage conditions may be needed to maintain the quality of the sheets. [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
- Need for safety testing: The natural origin of the ingredients does not guarantee that the finished formulation is safe for skin use. [20, 21, 22, 23, 24, 9, 15]
- Need for supporting evidence: Antioxidant or antimicrobial properties should not be claimed for the finished product unless appropriate tests support those claims. [1, 2, 3, 4, 5, 6, 7, 8]

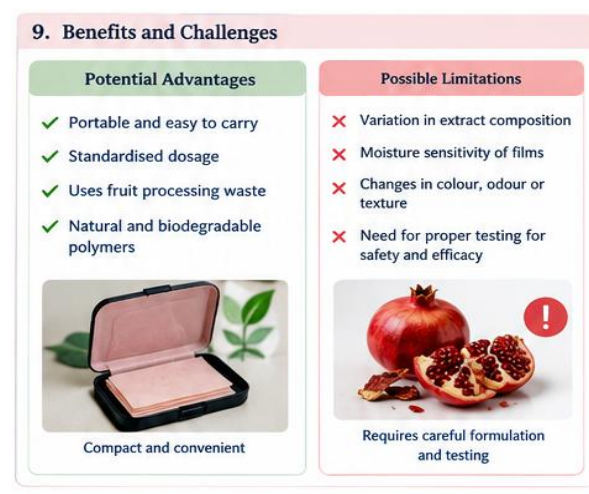


Figure 7. Possible benefits and development challenges for herbal paper soap.

XIV. CONCLUSION

This project explores the preparation of herbal paper soap using natural polymers and pomegranate peel extract. It brings together the idea of making portable cleansing sheets and reusing pomegranate peel, which is often discarded after fruit processing. [1, 2, 3, 4, 5, 6, 7, 8]

The final quality of the paper soap will depend on choosing a suitable polymer, using appropriate amounts of cleansing agent and extract, and producing a sheet that is flexible, strong and stable during storage. The sheet should also respond well to water

and provide acceptable cleansing performance. [1, 2, 3, 4, 5, 6, 7, 8]

More experiments are needed to compare formulations and check their physical properties, storage stability and safety. Antioxidant or antimicrobial claims should only be made if appropriate tests support them. Overall, the project provides a starting point for studying paper soap made with natural polymers and a plant-based by-product. [1, 2, 3, 4, 5, 6, 7, 8]



Figure 8. Illustrative appearance of thin herbal paper-soap sheets.

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