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Production of Soap Utilizing Banana and Orange Peel Ash as Alkaline Sources

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Abstract

This study has addressed the environmental problem of managing agricultural wastes by producing soap from banana and orange peels ash, which serve as alternative sources of alkaline. The experimental design details the saponification of palm oil using an alkaline solution produced by ash derived from peels of banana and orange plants. The banana and orange peels were sourced from vendors, then dried and thoroughly burned to obtain the ashes. The ashes were then mixed with water and filtered. Palm oil was added to the filtrate and heated until soap formed. The soap was analyzed for pH, foamability, and total fatty matter (TFM). The soap was found to have medium to good hardness with a fine-grained texture. The pH value accounted for 9.98, while that of TFM read 44.61 %. It thus indicated a fair cleaning quality. Further research is required for the optimization of these processes and to improve the quality of soap produced.

1. Introduction

Soap is significant in our everyday life for personal hygiene and public health. Soap can be easily defined as salt, a product of fatty acid by the reaction of some strong base with fat of animal or vegetable origin [1]. The cleansing action of soaps lies in their containing negative ions arrayed in combination with a long hydrocarbon chain attached to a carboxyl group. The hydrocarbon chain has an affinity for grease and oil, while the carboxyl group has an affinity for water. That is why soaps are used mainly with water, whether for bathing, washing, or cleaning purposes. Making soap from vegetable matter has been an age-old craft; however, what was made during that period was soft, black, smelled terrible, and corrosive to hands [2]. In contrast, its utilization has vastly differed over time and culture

Agricultural waste is highly consists of the residues of activities such as animal waste and plant remains. Recently, the last 50 years have flourished in agricultural output by nearly 300 percent, but improper management of residues yields some environmental complications such as water pollution, land destruction, and production of harmful greenhouse gases which disturb the ecosystems adversely [3]. Reducing food wastage at this stage is mandatory for the rejected fruits and vegetables in the prevailing trend to allow room for supply that can meet the increasing demand. Concerns raised by the public about hunger, food security, pollution, and socioeconomic issues have underscored the intensification of research regarding how to better use natural resources.

Since fruit and vegetable wastes are good sources of starch, cellulose, and hemicelluloses, hydrolyzing these materials to sugars followed by fermentation to produce hydrogen and ethanol is an advantageous way to add value to these materials [4]. Bananas and orange peels are rich in potassium and salt and may form promising alkaline sources for saponification. The study showed that banana peels contain potassium hydroxide, and orange peels contain sodium hydroxide; therefore, both can be sources of soap formulations [5].

Traditional technologies use non-renewable chemicals like sodium hydroxide and are incredibly intensive in energy consumption. Furthermore, heaps of food industry waste contribute to environmental pollution, such as peelings from bananas and oranges [6].

Green chemistry is associated with using agricultural wastes, mitigating environmental effects, and employing sustainable practices. Bananas and orange peels are low-cost sources of alkalis. Various research works have shown soap-making from non-conventional sources of alkali to be viable [7]. Rare work is conducted on utilizing the previously listed peel ash in soap making. The current project emphasizes the application of agricultural waste by-products for the commonly found potential of alkali for the formation of soap by integrating conventional methods with the principles of green chemistry using advanced sustainable resource utilization.

An ash from which an alkali solution can be obtained is obtained by drying banana and orange peels. An alkaline solution, mixed with fats or oils used in soap, is then manufactured. The objectives of this study are to produce soap using banana and orange peels ash and to characterize the soap produces from banana and orange peels ash.

2. Materials and Method

The materials and method used in this project are discussed in the following sub-topics including the sample preparation and analysis.

2.1 Collection of Materials

Banana and orange peels were obtained from vendors around Universiti Tun Hussein Onn Malaysia (UTHM), Pagoh Campus. Meanwhile, palm oil was purchased from a local mart near UTHM Campus Pagoh.

2.2 Preparation of Ashes

The banana and orange peels were removed using a sharp knife. The banana and orange peels were cleaned, and oven dried at 100 °C for 24 hours. The dried peels were crushed using mortar and pestle to change it physical state into finer particles. Next, the crushed peels were sieved before heated in a muffle furnace at 600 °C for 3 hours. The ashes were stored in a clean airtight container.

2.3 Fourier Transform Infrared Spectroscopy (FTIR) Analysis of Banana and Orange Peel Ash

Both banana and orange peels ash were analyzed using FTIR. The analysis was run on wave number (cm^{-1}) of 4500 to 500 for both ashes.

2.4 Potash Determination of Ash using Titration Method

Two beakers were each filled with 100 ml of distilled water. Approximately 5 g of banana peel ash and orange peel ash were added to the respective beakers and stirred thoroughly. The solutions were then boiled briefly and allowed to cool. After cooling, each solution was filtered separately using filter paper. Next, 25 ml of HCl was measured with a burette, and 2 ml of the filtered ash solution was transferred to a clean conical flask. A drop of methyl orange was added as an indicator for the base concentration in the solution. The solution was titrated with HCl until a color change occurred. The appearance of a pink color indicated a high potassium hydroxide (KOH) content.

2.5 Determination of pH of Ash Solution

20 ml of distilled water was measured and poured into a beaker. Approximately 1 g of banana peel and orange peels ash were then added to the beaker and stirred thoroughly. The solution was briefly boiled and subsequently allowed to cool. After cooling, the solution was filtered separately using filter paper. The pH of the ashes was measured using a calibrated pH meter set to 7, and the readings were recorded.

2.6 Production of Soap

Approximately 22 g of ash was combined with 100ml of water to create lye for the soap. Next, 25 ml of palm oil was heated on a hotplate stirrer for a few minutes. The 18ml of lye and 25 g of beeswax were then gradually added to the oil and stirred until the mixture thickened. Finally, three drops of fragrance oil were added to the solution.

2.7 Test of Soap Acceptability

The acceptability of the soap was analysed through its physical properties testing, total fatty matter (FTM), and pH value testing.

2.7.1 Physical Properties

The soap was evaluated by examining its colour, texture, and foam size. To assess foamability, the shredded sample was mixed with water in a separate test tube and allowed to dissolve. The solution was then shaken until foam formed in the test tube

2.7.2 Total Fatty Matter (TFM)

The TFM content was evaluated by reacting soap with acid in the presence of hot water and measuring the resulting fatty acid. Approximately 10g of the finished soap was weighed and placed in a 250 cm^3 beaker, followed by 100 cm^3 of distilled water. The mixture was heated in a water bath until it melted. Next, 10 cm^3 of 20% H_2SO_4 was added, and the mixture was heated until it became transparent. To solidify the fatty acids on the surface, 5g of beeswax was added, and the mixture was heated until the wax melted. The contents were then allowed to cool to room temperature, forming a solid cake. This cake was removed, wiped dry, and weighed to calculate the total fatty matter using the equation (1).

$$\%TFM = \frac{\text{Weight of the obtained cake - Weight of the wax}}{\text{Weight of the soap}} \times 100 \quad (1)$$

2.7.3 pH Value

The shredded lab-made soap will be dissolved in distilled water for a few minutes, then the solution will be transferred into a 50 ml beaker before dipping with pH meter anode. Then, pH was recorded. The normal pH range for soap is 9 to 11 [8].

3. Results and Discussion

The physical and chemical analysis of the soap were discussed as in the following sub-topics.

3.1 Potash Determination of Ashes using Titration Method

Table 1 displays the concentration of potassium hydroxide (KOH) for two different types of peels which are orange peels and banana peels.

Table 1 *Concentration of potassium hydroxide (KOH)*

Sample	Concentration of KOH (g/dm^3)
Orange peels	10.66
Banana peels	7.476

The concentration of KOH in orange peels is 10.66 g/dm^3, which is higher than that in banana peels, where the concentration is 7.476 g/dm^3. This indicates that orange peels have a higher potassium hydroxide content compared to banana peels. The higher concentration of KOH in orange peels compared to banana peels can be attributed to the differences in their chemical composition and ash content. Studies indicate that the organic content and cellulose structure of fruit peels, like those of oranges, are more conducive to producing alkaline substances, such as KOH, during the ash conversion process [9]-[12]. This can be linked to the higher potassium content and the efficiency of conversion from organic material to ash in orange peels, as compared to banana peels.

3.2 FTIR Analysis of Banana and Orange Peel Ash

From Fig. 1 below, a broad peak can be seen at 3112 cm^{-1} and a small peak at 3148 cm^{-1} at both spectrums. This is caused by O-H Stretching from alcohol and carboxylic acid [13]. A sharp peak at wavenumber 2312 $cm^{-1}$and 2098 cm^{-1} for orange peel ash and 2314cm^{-1} and 2312 cm^{-1} is a presence of C≡C. Meanwhile, A peak at 1555 cm^{-1} and 1645 could be prescribed by C=C vibration stretch [13].

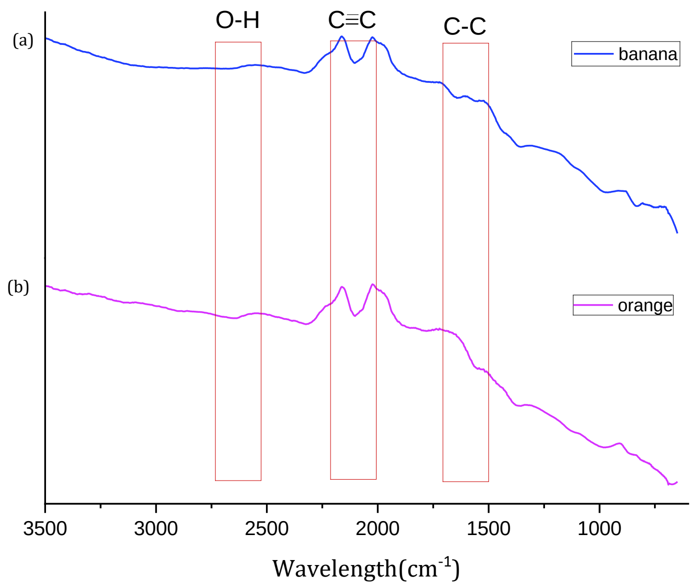

Fig. 1 *FTIR Analysis of (a)Orange peel ash; (b) and Banana peel ash*

3.3 Determination of pH of Ash Solution

The pH meter readings of the ash solution indicated that the solution was alkaline with a pH of 9.65 when the pH node is dipped into the ash solution. This solution is then used to make soap. pH of banana lye obtained from the experiment is in range of 10.04 to 11.31 which can be considered strong alkali [14]. Meanwhile, plantain peel has a pH value of 11.31 like banana peel lye [2].

3.4 Test of Soap Acceptability

3.4.1 Physical Properties

Table 2 shows a comparison of the physical properties between soap made from banana and orange peels and a hotel bar soap.

Table 2 *Physical properties of the soap*

Parameters	Banana and Orange Peels Soap	Hotel Bar Soap
Colour	Milky white	White
Texture	Hard	Hard
Foam	None	9.5cm

Based on Table 2, the soap produced from banana and orange peel ash has a hard texture and a milky white color. However, the soap made from banana and orange peel ash does not produce any bubbles. In contrast, the hotel bar soap is white, also has a hard texture, but produces foam measuring 9.5 cm in height. The absence of bubbles in the banana and orange peel soap is likely due to the specific combination of ingredients and the absence of lathering agents or sufficient fatty acids that contribute to foam production. Besides, the soap also retains a strong orange scent due to the fragrance oil added during its production.

3.4.2 Chemical Properties

Table 3 depicts the chemical analysis of the soap produced compared with soap base and coconut oi and hotel bar soap.

Table 3 Comparison of TFM and pH value

Type of soap	%TFM	pH
Banana & Orange Peel Ash and Palm Oil	44.61	9.98
Soap base and Coconut Oil	79.83	9.16
Hotel Bar Soap	50	9.8

From Table 3, banana and orange peels ash soap has the lowest TFM percentage, 44.61%, and the highest pH, 9.98. This indicates that it is more cleaning, nevertheless it may be harsher on the skin due to its higher alkalinity and lesser moisturizing content. The lower TFM percentage suggests that this soap may has fewer fatty acids content in plant ash and the potential for less efficient saponification. The high pH value might be due to the ash content from the banana and orange peels, which could introduce more alkaline substances. A local black soap made from cocoa pod ash and palm oil waste has 10.2 pH [15]. A soap made from plantain peel ash and mango peel ash produce a soap with pH of 10.02 [16].

In comparison, the average TFM of soap made from soap base and coconut oil is 79.83% [17] with a pH of 9.16, which is more pleasant and skin-friendly, while hotel bar soap has a TFM value of 50% and the pH level is slightly lower than the banana and orange peel soap but higher than the soap base and coconut oil soap which resulting in less moisturizing and potentially more drying to the skin.

4. Conclusion

The present research work showed the viability of soap production using banana and orange peel ash as alternative alkaline sources. Such a process uses agricultural wastes, thus contributing to waste management and sustainability. Saponification reactions of alkali obtained from banana and orange peel ash with palm oil gave soaps of satisfactory hardness and texture. The pH of the soap was 9.98, that is, alkaline, and the TFM was 44.61%, indicating a medium quality suitable for cleaning but with diminished moisturizing properties. Further research may be geared toward formulation, optimizing extraction and saponification processes that impact the quality and characteristics of soaps.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Ahmad Khairul Amirin Adnan, Mohamad Aiman Mohamad Jiwa, Muhammad Zulhelmy Mohd Hairuni, Norain Ahmad Nordin;* ***data collection:*** *Ahmad Khairul Amirin Adnan, Mohamad Aiman Mohamad Jiwa, Muhammad Zulhelmy Mohd Hairuni, Norain Ahmad Nordin;* ***analysis and interpretation of results:*** *Ahmad Khairul Amirin Adnan, Mohamad Aiman Mohamad Jiwa, Muhammad Zulhelmy Mohd Hairuni, Norain Ahmad Nordin;* ***draft manuscript preparation:*** *Ahmad Khairul Amirin Adnan, Mohamad Aiman Mohamad Jiwa, Muhammad Zulhelmy Mohd Hairuni, Norain Ahmad Nordin. All authors reviewed the results and approved the final version of the manuscript.*

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