MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 5 No. 2 (2024) 87-92
https://publisher.uthm.edu.my/periodicals/index.php/mari

Green Eco-Soap Hand Wash

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DOI: https://doi.org/10.30880/mari.2024.05.02.013

Article Info

Received: 01 December 2023
Accepted: 30 April 2024
Available online: 30 June 2024

Keywords

Brine, Geen Product, Saponification, Waste Cooking Oil

Abstract

Improper disposal and management of waste cooking oil (WCO) will cause various environmental, economic, and health problems. The development of eco-soap hand wash not only serves as a green replacement to traditional goods, but it also helps decrease the environmental effect associated with inappropriate WCO discharge. The main focus of this project is to produce high-quality eco-hand soap using WCO as major raw material with additions of other ready ingredients. The technique used for this purpose was saponification using sodium chloride (NaCl), sodium hydroxide (NaOH) and potassium hydroxide (KOH) at different concentrations. The best liquid soap produced through this project was sample A_2B_2 where the proportion of NaCl and KOH in the soap are 10% and 60%, respectively. The sample A_1C_1 contain the best proportion of NaCl and NaOH in solid soap production where the concentration of NaCl is 5% while NaOH is 20%.

1. Introduction

Cooking oil or edible oil is mostly derived from vegetable, animal, or synthetic liquid fats used in cooking such as frying, baking, and other culinary purposes [1]. In addition, cooking oil acts as a carrier of heat transmission in food preparation and food seasoning. Cooking oil is difficult and challenging to dispose of due to the various characteristics that factor into it. Their characteristics such as sticky and greasy qualities may allow them to cling to surfaces and be difficult to remove if carelessly thrown into a trash can or any other container. Untreated waste cooking oil (WCO) can now harm the environment and public health in a variety of ways. As in nature, improperly disposed of WCO can harm aquatic life. When oil is dumped into a body of water, such as a lake or river, it covers the surface of the water. As a result of this condition, the oil layer will block the water surface and inhibit oxygen from diffusing [1]. Cooking oil is also known as non-biodegradable which means it will not degrade spontaneously over time [2]. This makes it more difficult to dispose of because it could contaminate nearby soil and groundwater [3]. The purpose of this project is to produce high-quality eco-soap using low-cost materials such as waste cooking oil. This project is to facilitate an eco-soap at college, especially the cafeteria workers as well as staff and student of Universiti Tun Hussein Onn Malaysia (UTHM), Pagoh Campus. Furthermore, this project has the potential to minimize pollution caused by discarded WCO in the future. Since Malaysia have countless restaurants, stalls, and food industries that produce WCO, the manufacture of soap is the best idea for the government to decrease pollution caused by WCO as well as to maintain healthy surrounding and reduce the production of synthetic soap.

1.1 Green product of WCO

Instead of disposing of this oil, it may be gathered and repurposed for a variety of purposes, giving both environmental and financial advantages using special techniques to help reduce these difficulties. Hence, the purpose of this project was to create a practical, inexpensive, and high-quality eco-soap using WCO as a raw material. The main focus of this project is to produce high-quality eco-hand soap using WCO as major raw material with additions of other ready ingredients. Furthermore, WCO can produce a variety of industrial products that may be utilized in the manufacturing of plastics, lubricants, and other industrial materials, as well as biogas production as a sustainable energy source for heating, power production, or car fuel [4]. On the other hand, WCO may be used to make environmentally friendly soap for personal hygiene or cleaning.

Soap is a mixture of salt and fatty acids. Chemically, soap composition involves two main components: fatty acid and alkali. According to previous research, soap is a product of natural oil or fatty acids, or stearic acid, with a mixture of either sodium or potassium hydroxide, which has $Na+$ or $K+$, or any strong alkali, and added scent such as essential oil [5]. Based on the previous study by Hartini et al [1], the study attempts to increase the number of items priced using WCO as a basic material and use three different concentrations of potassium hydroxide (KOH) which are 25%, 30%, and 35% that eventually produces a liquid soap. KOH generates soap almost watery texture that is ideal for producing liquid soap and the finest choice for soaps that must eliminate greasy oils [6].

For the purpose of producing a liquid eco-soap, a treated WCO is stirred with NaCl at separated concentrations of 5% and 10%. Later, the mixtures are added with KOH at concentrations of 20% and 60%, separately. In order to produce a solid eco-soap from WCO, two different concentrations of NaCl are used during a saponification process; that are 5% and 10%, respectively. Besides, NaOH is added to the mixture of WCO and NaCl at concentrations of 20% and 60%, respectively.

2. Methodology

2.1 Materials and Apparatus

The main material that will be used in this project is WCO. In addition, KOH and NaCl will also be used for the bleaching and saponification procedure. Other apparatus that is needed for this purpose are a hot plate and stirrer, magnetic bar, 1000 mL beaker, 500 mL beaker, filter cloth, thermometer, volumetric flask, measuring cylinder, pH meter, molds, and essential oil. Then, after the soap was achieving the maturity period, analysis of the chemical compound using Fourier Transform Infrared Spectroscopy (FTIR).

2.2 Methods

Technically, there are three main procedures in producing an eco-soap in this project that are filtration, decolorization, and saponification. Firstly, approximately 500 mL of WCO was filtered using a filter cloth to ensure that there is no solid contaminant that can damage the soap quality. Then, the filtered WCO was heated at a temperature of 100°C before being allowed to cool until it reaches a temperature of 60°C to 70°C. Later, the sample was separated into two different beakers. NaCl solution at temperature of 90°C with concentrations 5% and 10% were added into the beakers and labelled as A_1 and A_2. NaCl or also known as brine, was used to remove the yellowish color from the WCO, as shown in Fig. 1. Each sample was placed on the hot plate and stirred for one hour.

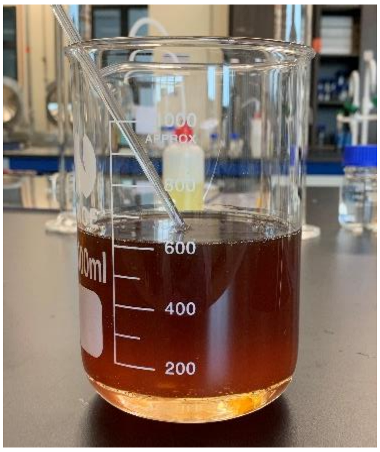


Fig. 1 *Mixture of WCO with NaCl solution*

2.2.1 Saponification procedure

The saponification procedure started by adding approximately 100mL of NaOH at a temperature of 60°C into the sample A_1 and A_2 at two different concentrations which are 20% and 60%, respectively. The mixture was stirred for 60 minutes, until the mixture became slightly thickened. By adding NaOH to saponify the mixture, the sample will become hardened. A similar procedure is repeated using 100ml of KOH at a temperature of 60°C that is added into the WCO to produce liquid soap. Soap made with KOH does not crystallize in the same way as NaOH, so it does not become solid or opaque [7].

2.2.2 Essential Oil

Next, the essential oil was added to the mixing solution. A few fragrances will be used such as lavender, rose, and orange essence. The mixture was stirred for 5 minutes before being poured into a desired mold and left for 48 hours to two weeks before it can be used in order to complete the maturation process. Fig. 2 summarizes the project flow on eco-soap production while Fig. 3 shows some of the eco-soap produced at the end of the procedure.

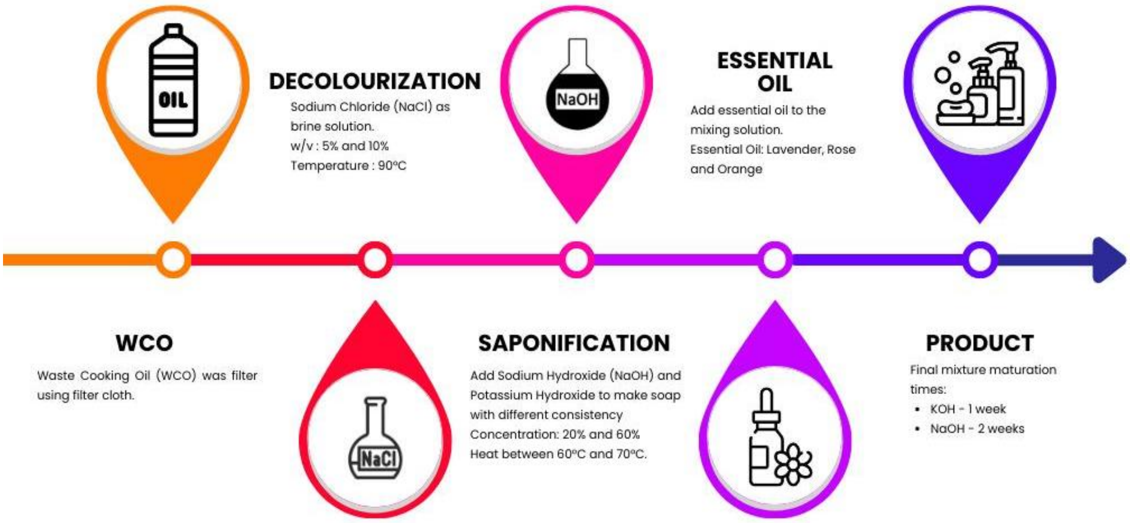
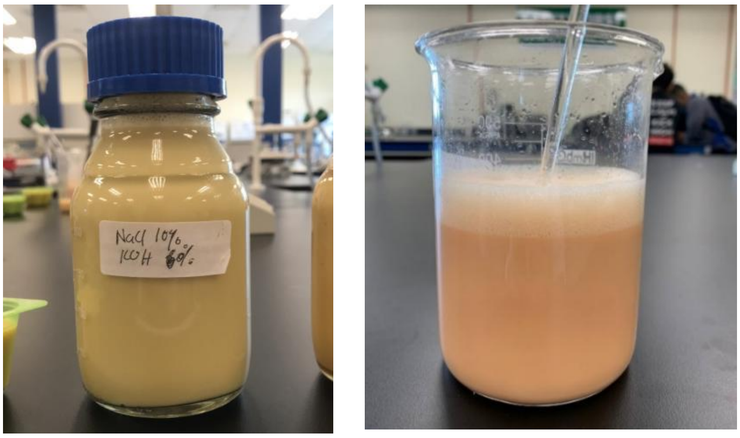


Fig. 2 *Project flowchart to produce a lab-scale eco-soap*



(a) (b)

Fig. 3 *End product of saponification process of WCO*

2.2.3 Physical and Chemical Properties analysis

Several analyses have been done to study the physical properties of the eco-soap such as sample's texture, scent and colour, and lathering and cleaning ability. Besides, the chemical properties were analyzed using pH testing paper and FTIR.

2.2.4 Physical analysis

Physical analysis that was analyzed to determine and specify the best soap among 8 different mixtures are scent, color, lathering ability and cleaning ability. As for color and scent of soap determination, a hands-on analysis has been performed. This analysis was performed with helps of 20 participants excluding project researchers. The best soap in terms of color and scent was chosen based on majority vote from participants.

Lathering ability was conducted by soap sample with 100mL of water in a bottle. This analysis was conducted by taking matured soap samples in a small amount and put it in water contained bottle. The bottle was then closed with its cap and shaken to observe which soap produce the most foam. For cleaning ability, a container was smudged with makeup cosmetics are used where soaps that cleans the smudge was chosen as the best soap. Cleaning ability was chosen based on few criteria. The same pressure was applied which is by using the same person for this analysis. The first criteria that need to be fulfil is soap must wash away all smudge without leaving any small traces. Second criteria are the soap should not leave any oily traces left behind after rinsing with water.

3. Results and Discussion

The objectives to produce eco-soap from WCO are successfully achieved where production of soap shows great results. There are eight samples of eco-soap that are produced from this project, with different proportions of NaCl to NaOH and KOH. The proportion of the catalyst are labeled and tabulated in Table 1. Two types of eco-soaps which are solid and liquid with the most preferable proportion of NaOH and KOH were chosen out of total eight samples produced. The best soap was selected based on its physical and chemical characteristics as discussed below.

Table 1 *The proportion of NaCl with KOH and NaOH*

Material	NaCl		KOH		NaOH	
Label	A_1	A_2	B_1	B_2	C_1	C_2
Concentration %	5	10	20	60	20	60

3.1 Liquid Eco-soap

The soap molecules are formed when potassium hydroxide combines with fatty acids to generate potassium carboxylates or potassium salts of fatty acids. These soap molecules have both hydrophilic and hydrophobic heads and tails. They create micelles in which the hydrophobic tails cluster together to form the core and the hydrophilic heads face outward to interact with water. In comparison to sodium soap made from NaOH, potassium soap formed from KOH has a greater water solubility. This distinction emerges because potassium salts are more water soluble than sodium salts. Because potassium soap is more soluble in water, it remains liquid even at larger concentrations. Because of this feature, KOH is a good choice for making liquid soap.

Table 2 shows the result of physical testing properties of liquid eco-soap. From the result, the best liquid soap is A_2B_2 with the proportion concentration of 10% NaCl and 60% KOH. This soap shows the best result where it produces more foam compared to others and shows the best cleansing power without leaving any small smudge at all. Moreover, this soap has smooth and soft textures to hands without leaving any oily feels on skin.

Table 2 *Physical properties of the liquid soap*

Sample	Texture	Scent	Color	Lathering ability	Cleaning ability
A_1B_1	Highly concentrated and smooth	Unpleasant	Yellow	Non-foam	Leaves traces of oil
A_1B_2	Highly concentrated and smooth	Slightly unpleasant	Blue ocean	Less foam	Remove the lip matte
A_2B_1	Highly concentrated and smooth	Unpleasant	Yellow	Foam	Leaves traces of oil
A_2B_2	Highly concentrated and smooth	Pleasant	Sage Green	Foam	Remove the lip matte

Table 3 *The pH value of liquid soap and the chemical compound present in each sample*

Sample	pH	Chemical compound (FTIR)
A_1B_1	10	Non-alcohol
A_1B_2	12	Primary alcohol
A_2B_1	11	Primary alcohol
A_2B_2	13	Secondary alcohol

The A_1B_1 soap is known as non-alcohol due to its chemical compound found in FTIR. Besides, A_1B_2 and A_2B_1 soap are known as primary alcohol. The primary alcohol is the one that is attached to the primary carbon atom in the hydrocarbon. The A_2B_2 soap is known as secondary alcohol. Secondary alcohol is the alcohol which is connected to the hydrocarbon's secondary carbon atom. According to Madhu (2018)'s research study [8], primary alcohol is more acidic than secondary alcohol. This is since the strength of the alcohol as an acid is proportional to the strength of its conjugate base, the alkoxide ion.

Therefore, the A_2B_2 was chosen as the best among the rest. Even though the pH is high compared to other soaps, it is included as a safe product. Based on Botanie Soap, despite the pH of soap is an important aspect of cosmetics, it has no direct link with how harsh or gentle that item is. pH should not be used to determine whether a soap or other cosmetic product is irritating to the skin unless it has an excessively acidic or alkaline pH that might cause harm [9].

3.2 Solid Eco-soap

The chemical characteristics of NaOH that allow the sample to solidify during saponification are principally related to the production of soap molecules in micelles and subsequent solidification. The soap molecules, which are sodium salts of fatty acids, exhibit both hydrophilic and hydrophobic characteristics. The hydrophilic head interacts with water, but the hydrophobic tail does not. This characteristic allows soap molecules to organize themselves so that they may form micelles, with the hydrophobic tails concealed within and the hydrophilic heads interacting with water. The water evaporates as the soap solution cools and dries, and the soap molecules become densely packed together. The hydrophobic tails of the soap molecules align, resulting in a solid structure.

The best solid soap produced is sample A_1C_1 which are mixture of WCO with 5% NaCl and 20% NaOH. Soap A_1C_1 are chosen for some reason which one of them is the soap pH value. The first reason if the soap has pH differ from recommended range is the soap might be too dangerous for skin where it can cause skin irritation and skin peeling. Besides, lower range pH soap does not have cleansing power and produces no bubble which can be described as not a real soap. Selected soap has shown a great result where it cleans smudges on a container with good lathering ability and good number of bubbles.

Table 4 *Physical properties of the solid soap*

Sample	Texture	Scent	Color	Lathering Ability	Cleaning Ability
A_1C_1	Jelly-like	Pleasant	Average	Very good	Good
A_1C_2	Hard and firm	Pleasant	Average	Good	Poor
A_2C_1	Hard and oily	Slightly unpleasant	Good	Poor	Poor
A_2C_2	Hard and gritty	Unpleasant	Good	Poor	Good

Table 5 *The pH value of solid soap and the chemical compound present in each sample*

Sample	pH	Chemical compound (FTIR)
A_1C_1	10	Alcohol
A_1C_2	11	No alcohol
A_2C_1	12	No alcohol
A_2C_2	13	No alcohol

Other soaps are not selected due to some reasonable reason. For example, the scent of other soap is not quite pleasant as oil smell is left in soap with NaOH 60%. As for lathering ability, other soap does not show a good performance as no foam or single bubble are produced when it is mixed with water. The cleaning ability of other soap was not so good because dirty surfaces on the food container are proven to not disappear after washing. pH of soap other than A_1C_1 was higher than recommended range. When talking about soap, soap is one of most important items in every individual life for cleaning purposes that will be used on human skin. Thus, pH are the most important parameters to think about especially for someone that have sensitive skin. pH of soap is only recommended 8-10 because higher than that can cause irritation to skin. As for lower pH than 8, it may not have good lathering ability which can result to poor cleansing power for a soap. As for FTIR analysis, only soap A_1C_1 that displays presence of strong alcohol peaks in the graph. Alcohol in research by Jess, is one important substance that should be contained in soap, especially solid soap. Alcohol in soap is said to pop bubbles in the soap for smoother soap surfaces like a luxury soap bar. Alcohol is also substance that reduces oil scent in soap which are proven in this project [10]. As for aliphatic compounds, all soaps show an uncountable type of aliphatic which is a compound from sodium salt.

4. Conclusion

As a conclusion, production of green product from waste such as making eco-soap from waste cooking oil helps to minimize problems that the waste may cause. It is an answer to help both environment that were tightly related to human health itself and help government to minimize cost to repair clogging pipes systems. At the same time, production of eco-soap can help people in need because it can be sold at reasonable price. Thus, eco-soap yield is a viable and effective solution that should be expanded and more known to everyone. Further study on this project can be made to improve soap quality.

Acknowledgement

The authors would like to thank the Department of Science and Mathematics, Universiti Tun Hussein Onn Malaysia for its support and 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:*** *Anis Nur Syazwani Binti Azhar, Nur Sabrina Binti Mohd Safarin, Siti Noraiza Ab Razak;* ***data collection:*** *Anis Nur Syazwani Binti Azhar, Nur Sabrina Binti Mohd Safarin, Siti Noraiza Ab Razak;* ***analysis and interpretation of results:*** *Anis Nur Syazwani Binti Azhar, Nur Sabrina Binti Mohd Safarin, Siti Noraiza Ab Razak;* ***draft manuscript preparation:*** *Anis Nur Syazwani Binti Azhar, Nur Sabrina Binti Mohd Safarin, Siti Noraiza Ab Razak. All authors reviewed the results and approved the final version of the manuscript.*

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