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Utilization of Coleus scutellarioides Leaf Extract as an Antimicrobial Active Ingredient in the Production of Solid Soap from Used Cooking Oil

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Abstract. Soap is the result of a chemical reaction between fatty acids (triglycerides) and alkali, producing soap and glycerol. One of the common sources of triglycerides in our surroundings is used cooking oil. While used cooking oil can be utilized as a raw material for soap production, it has a drawback namely, a high content of free fatty acids. Therefore, an adsorption process is required to reduce the free fatty acid content before the oil can be used in soap making. The aim of this study is to examine the effect of adsorbent concentration specifically using sugarcane bagasse and adsorption duration on the quality of used cooking oil. The variables in this study include the concentration of sugarcane bagasse adsorbent ranging from 0% to 10%, and the duration of the adsorption process from 0 to 96 hours, both aimed at reducing the free fatty acid content in the used oil. Additionally, the study evaluates the effectiveness of Coleus atropurpureus (Jawer Kotok) leaf extract, which has been separated from ethanol solvent using a rotary evaporator, as an antimicrobial agent in soap, with varying concentrations from 0% to 2%. The results indicate that the optimal adsorbent concentration for reducing free fatty acid content is 7%, with an optimal adsorption duration of 72 hours. The optimum concentration of Coleus atropurpureus extract for antimicrobial effectiveness in soap formulation is 2%.

Keywords: Adsorbent, Coleus atropurpureus, Used cooking oil, Soap

INTRODUCTION

In the post-COVID-19 era, the demand for soap remains high due to increasing public awareness of the risks associated with physical contact, which may lead to the transmission of diseases through dirt, sweat, and bacteria on the skin. The quality of soap is significantly influenced by the raw materials used in its production. One highly potential raw material for soap-making is used cooking oil (commonly known as jelantah oil in Indonesia), considering its widespread availability due to extensive daily consumption of cooking oil in the country.

However, not many people consider or choose soap made from used cooking oil, as it is often perceived as having no remaining function or beneficial properties. Therefore, an adsorption process using sugarcane bagasse is needed to improve the quality of used cooking oil. The use of sugarcane bagasse as an adsorbent is expected to reduce the free fatty acid (FFA) content in the oil, making it suitable for soap production (Chusnana, 2016).

Soap is a compound formed from a reaction between sodium (alkali) and fatty acids, commonly used as a body cleanser in solid form, foamy, with or without additional ingredients, and should not cause skin irritation (Pangestika et al., 2016). The process of soap-making is referred to as saponification (Jalaludin Aji, 2018), which is a chemical reaction between fats or oils and an alkali, producing soap and glycerol as a by-product. Soap generally contains fatty acids such as C12 and C16 and carboxylic acids.

The main function of soap is to cleanse the skin surface from germs and potential diseases. Given the skin's sensitivity and susceptibility to irritation, proper skincare is essential. Therefore, this research aims to develop a soap formulation from used cooking oil combined with a natural active antimicrobial agent. The extract of Coleus atropurpureus (locally known as Jawer Kotok)

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is selected due to its abundance and antibacterial properties. The extract is then saponified with NaOH solution to form fatty acid salts. Further analysis of the soap's quality was conducted in accordance with the Indonesian National Standard (SNI No. 3532-2016) (Jalaluddin & Nuriani, 2018).

The soap-making process produces two main products: soap and glycerin. Glycerin is a polar organic compound composed of three carbon atoms, each bonded to a hydroxyl group (-OH). These hydroxyl groups are reactive and can be esterified by fatty acids (Christine, 2017). Technically, soap is the result of a chemical reaction between fatty acids (typically from animal or vegetable fats) and an alkali. Used cooking oil is a viable fat source for this purpose due to its high availability from everyday frying activities.

Sugarcane bagasse is a by-product of sugar production and is commonly used as boiler fuel, fertilizer, animal feed, or paper mixture (Chusnana, 2016). In this study, sugarcane bagasse is utilized as an adsorbent to reduce the FFA content in used cooking oil. This not only improves the quality of the oil but also adds value by repurposing agricultural waste. Adsorption is a process in which fluids (liquid or gas) are bound to the surface of a solid or liquid adsorbent, forming a thin layer (Diaz et al., 2022). It is considered a simple and cost-effective method, especially when using natural adsorbents from biomass (Rohmat et al., 2020; Rizna et al., 2017). Previous studies have shown that FFA reduction is influenced by two main variables: the concentration of sugarcane bagasse and the adsorption duration. A longer soaking period generally results in a lower FFA content (Erna et al., 2016).

Used cooking oil is derived from plant sources such as palm, corn, and coconut oil that have undergone frying processes (Erna et al., 2016). Both new and used vegetable oils are composed of triglycerides esters formed from glycerol and long-chain fatty acids (Christine, 2017). Fats and oils belong to a class of simple lipids made up of glycerol and fatty acid chains (Mulyani, 2018).

The primary difference between used and unused vegetable oil lies in their saturated and unsaturated fatty acid composition. Used oil tends to have a higher saturated fat content due to degradation of unsaturated bonds during frying. Chemically, used oil may contain carcinogenic compounds formed during high-temperature cooking. Repeated use of cooking oil leads to oxidative damage, forming peroxides and other harmful compounds (Nur Isna, 2021).

Carcinogenic substances may lead to various health issues, including cancer, heart disease, and developmental disorders in future generations. While the normal frying temperature ranges between 177–221°C, many users exceed this, reaching up to 300°C. At such high temperatures, unsaturated fatty acids break down and oxidize, forming peroxides and cyclic monomers, leaving behind mostly saturated fats. This increases the risk of elevated cholesterol levels and other health issues. Thus, the incorporation of Coleus atropurpureus extract with antibacterial properties into soap serves not only as an added value but also as a health-conscious innovation.

Coleus atropurpureus (commonly known as Jawer Kotok or Miana) is a plant widely used as both ornamental and medicinal (Yustina, 2017). Traditionally, the leaves are used to treat various ailments such as diarrhea, fever, post-partum recovery, menstrual disorders, abscesses, hemorrhoids, and diabetes mellitus. In the Philippines, it is commonly used as a carminative, headache reliever, and treatment for bruises, bleeding wounds, dyspepsia, sinusitis, and even as eye drops (Mida, 2019).

The plant contains flavonoids, tannins, triterpenoids, steroids, and essential oils all of which contribute to its antibacterial properties (Prataya, 2014). Therefore, Coleus atropurpureus leaf extract can be utilized as a bioactive ingredient in soap formulation. The extraction process involves dissolving the active compounds using a solvent suitable for fats and oils (Christine, 2017).

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METHODOLOGY

Based on a literature review, this study was conducted through several stages, consisting of: 1) preparation of the adsorbent, 2)adsorption process, 3)extraction process, and 4) soap formulation.

1) Adsorbent Preparation

In this study, the adsorbent used was sugarcane bagasse, which was first dried and then ground into a fine powder. The adsorbent was added in varying weight percentages ranging from 0% to 10% of the total weight of the used cooking oil to be adsorbed.

2) Adsorption Process

Prior to being used as a raw material for soap-making, the free fatty acid (FFA) content of the used cooking oil was analyzed. The oil then underwent an adsorption process using the prepared sugarcane bagasse. The adsorption was carried out in a closed container with varying durations ranging from 0 to 96 hours.

3) Extraction Process

As the active antimicrobial agent, Coleus atropurpureus (Jawer Kotok) leaves were used. A total of 50 grams of the leaves were extracted to obtain the bioactive compound. The resulting extract was collected and prepared for use in the soap formulation.

4) Soap Formulation

Soap was formulated using the purified used cooking oil and the obtained plant extract. The extract was added at varying concentrations from 0% to 2%. The resulting soap was then tested for moisture content, free fatty acid content, and antimicrobial effectiveness, in accordance with the Indonesian National Standard for soap (SNI No. 3532-2016).

RESULTS AND DISCUSSION

Free Fatty Acid (FFA) Content

Used cooking oil that had undergone adsorption with sugarcane bagasse (with adsorbent weight variations of 0%, 6%, 7%, 8%, 9%, and 10% of the oil weight) was tested for its free fatty acid (FFA) content. To determine the FFA level, 0.5 mL of 1% phenolphthalein indicator was added to the oil sample. If the solution remained colorless, it indicated an acidic environment. The sample was then titrated with a standard KOH solution until a stable pink color appeared, indicating a basic solution. If the sample was already alkaline (pink), it was titrated with standard HCl solution until the pink color disappeared, indicating a neutral point.

Soap that was formulated with the addition of Coleus atropurpureus (Jawer Kotok) leaf extract as an antimicrobial agent was subsequently dissolved and tested for its effectiveness in inhibiting microbial growth through microbiological analysis.

The results obtained show the effect of sugarcane bagasse on the reduction of FFA levels in used cooking oil, which is influenced by the concentration of the adsorbent and the duration of the adsorption process. These factors directly impact the quality of the treated oil. Furthermore, the effectiveness of soap enriched with Coleus atropurpureus extract as an antimicrobial agent was evaluated.

It is important to note that the adsorbent concentration resulting in the lowest FFA content is not necessarily the most optimal. Rather, the most significant reduction in FFA levels should be considered when evaluating effectiveness. Moreover, a longer adsorption duration does not always guarantee better oil quality. Overextended contact time may lead to degradation of unsaturated bonds in the oil, thereby reducing its overall quality. Therefore, a comprehensive assessment of the data and graphical trends is required to determine the optimal conditions.

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The analysis of FFA content based on adsorbent concentration is presented in Table 1 and illustrated in Figure 1.

Table 1. Free Fatty Acid Content Based on Adsorbent Concentration

Jam/C	0	6	7	8	9	10
0	3,102 %	3,192 %	2,961 %	2,961 %	2,820 %	2,820 %
24	3,525%	1,692 %	1,128 %	0,987 %	0,846 %	0,987 %
48	3,384 %	2,256 %	1,128 %	1,128 %	1,128 %	1,128 %
72	3,525%	1,692 %	0,846 %	1,128 %	0,846 %	0,846 %
96	3,666%	1,410 %	0,846 %	0,987 %	0,846 %	0,846 %

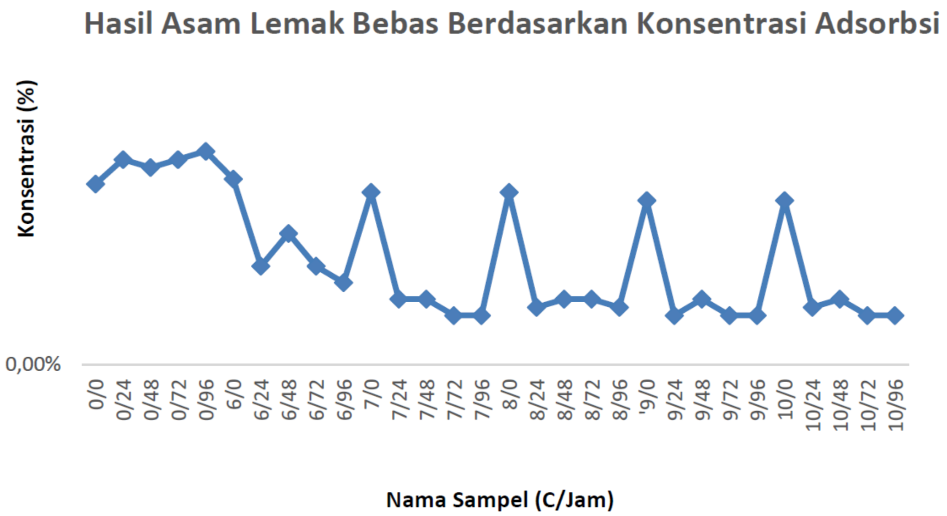

Figure 1. Free Fatty Acid Content Based on Adsorbent Concentration

From the graph shown in Figure 1, a fluctuating decrease in free fatty acid (FFA) levels was observed across the various trials; however, there was a consistent downward trend as the adsorbent concentration increased. This indicates that sugarcane bagasse can be effectively used as an adsorbent to reduce FFA levels in used cooking oil. In general, higher adsorbent concentrations result in greater reductions in FFA content.

At concentrations above 6% specifically at 7%, 8%, 9%, and 10% the FFA levels decreased at relatively similar rates. Among these, the 7% adsorbent concentration showed the most optimal reduction, both in terms of adsorbent efficiency and FFA reduction value, as it produced the most significant drop in FFA content. Although further increases in adsorbent concentration beyond 7% still led to reductions in FFA levels, the changes were no longer significant.

This suggests that at 7% concentration, most of the free fatty acids in the oil had already been adsorbed by the sugarcane bagasse, indicating an effective saturation point for the adsorbent under these conditions.

The results regarding the effect of adsorption duration on FFA content are presented in Table 2 and visualized in Figure 2.

Table 2. Free Fatty Acid Content Based on Adsorption Duration

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C/Jam	0	24	48	72	96
0	3,102 %	3,525 %	3,948 %	3,948 %	4,23 %
6	3,102 %	2,397 %	1,692 %	1,410 %	2,256 %
7	2,961 %	1,128 %	1,692 %	0,846 %	1,128 %
8	2,961 %	1,128 %	1,128 %	0,846 %	1,269 %
9	2,820 %	1,269%	1,128 %	0,987 %	1,128 %
10	3,102 %	0,846 %	0,846 %	1,128 %	1,128 %

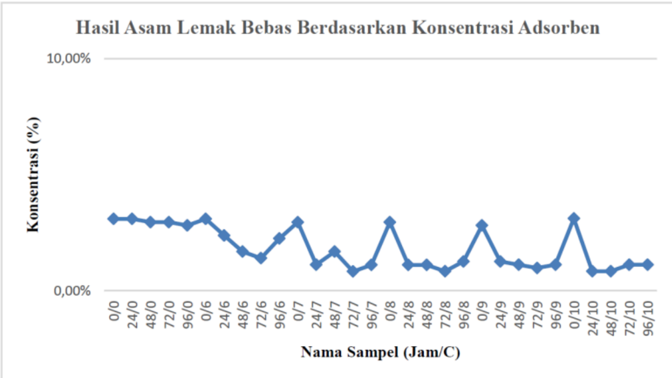

Figure 2. Free Fatty Acid Content Based on Adsorption Duration

The results of soap effectiveness based on extract concentration are presented in Table 3 and Figure 3.

Table 3. Soap Effectiveness Based on Extract Concentration

Konsentrasi (%)	Hasil Cfu/gr
0	TBUD
0.5	140
1	100
1.5	80
2	0

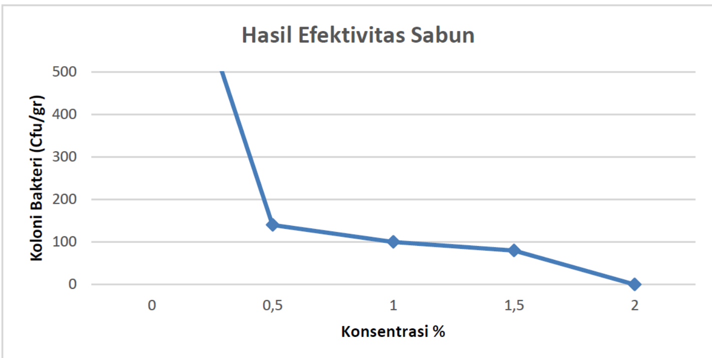

Figure 3. Soap Effectiveness Based on Extract Concentration

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From Table 3 and Figure 3, a consistent decrease in bacterial colony count was observed following the addition of Coleus atropurpureus extract. Notably, at a concentration of 2%, no bacterial colony growth was detected, indicating that this concentration is the most effective as an antimicrobial agent in the soap formulation used in this study.

This result aligns with the known antibacterial properties of Coleus atropurpureus leaf extract, which contains flavonoid compounds that function as natural antimicrobials. Therefore, it can be concluded that the higher the concentration of the extract added, the more effective the soap is in inhibiting microbial growth. However, since no bacterial growth was observed at the 2% concentration, increasing the extract beyond this level is unnecessary, and 2% can be considered the optimal concentration for effective antimicrobial activity in this formulation.

CONCLUSION

1. The analysis of free fatty acid reduction in used cooking oil based on the concentration of sugarcane bagasse as adsorbent showed that the optimal adsorbent concentration is 7%.
2. The analysis of free fatty acid reduction based on the duration of the adsorption process using sugarcane bagasse as adsorbent indicated that the optimal adsorption time is 72 hours.
3. Microbiological analysis revealed that soap with the addition of 2% Coleus atropurpureus leaf extract exhibited no microbial growth.

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