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Production of Soap from Soya Bean (Glycine max) Oil with Lye from Borassus aethiopum Leaf Ash

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ABSTRACT

Industrial soap production normally employs energy-intensive synthetic alkalis. The aim of this research was to identify a more sustainable and environment-friendly soap production method that exploits soya bean (Glycine max) oil and lye made from Borassus aethiopum leaf ash. The lye was produced by firstly drying leaves derived from B. aethiopum; calcining them to 600°C; then extracting the chemical with distilled water to obtain lye. Soap was then produced through the hot process method that involves the reaction between soya bean oil and chemical lye within (80-90°C). The resultant product was then aged for two weeks prior to rigorous analysis through standard AOCS analysis. The results showed that the soap product was superior in quality to meet more stringent industrial standards demanded in the production of laundry soap. The product had pH level 9.9 that was safe alkaline; moisture levels were low (12.6%), making the product more durable. Notably, its Total Fatty Matter (TFM) was recorded to be 75.2% that was significantly higher above the standard 60% set to ensure cleanliness in domestic cleaning. The free caustic alkali was also lower to 0.18%, indicating full saponification that was safe to the user. This study therefore confirms the efficacy and use potentiality derived from B. aethiopum leaf residues to fully replace synthetic chemicals in the soap production.

1. Introduction

Saponification is the essential chemical reaction used in the creation of soap. It is a process in which a fat or oil (a triglyceride) is treated with a strong alkali, or base, resulting in two main products: glycerol and a fatty acid salt, which is the "soap" itself (Alum, 2024) This reaction is a classic example of base-catalyzed hydrolysis (McMurry, 2018). In this process, the strong base (like sodium hydroxide) attacks the ester bonds of the triglyceride, breaking the fat molecule apart into its components (McMurry, 2018).

The choice of alkali is critical as it determines the nature of the final product. Sodium Hydroxide (NaOH), commonly known as caustic soda or lye, is used to produce hard, solid bar soaps (sodium soaps). In contrast, Potassium Hydroxide (KOH$), or potash, is used to create softer, often liquid soaps (potassium soaps) (Gunstone, 2004).

The characteristics of the final soap, such as its hardness, cleansing power, and lather, depend heavily on the specific types of fatty acids present in the original oils (Gunstone, 2004). For example, oils rich in lauric acid (like coconut oil) produce a very hard, cleansing soap with a bubbly lather, while oils rich in oleic acid (like olive oil) result in a softer, more conditioning bar. Soap-makers must use precise calculations, known as the saponification value, to determine the exact amount of alkali needed to completely convert a specific quantity of oil into soap. This calculation is vital to ensure no caustic alkali remains in the final product, making it safe for use (Warra, 2013).

Soya bean (Glycine max) oil is one of the most important types of vegetable oils for industrial uses, like making soap with good cleansing and lathering properties because it is widely available, inexpensive, and has a well-defined fatty acid profile that is high in linoleic, oleic, and palmitic acids (Akoh & Min, 2008). Most of the time, sodium hydroxide (NaOH) or potassium hydroxide (KOH) are used to saponify soya bean oil. These are made at factories that use a lot of energy, such the chloralkali process (O'Brien, 2005).

These synthetic alkalis function well, but using them causes a lot of complications, particularly when it comes to sustainable development and providing people in the region greater power over their own economies. Making NaOH takes a lot of energy, which is hazardous for the environment (Schmittinger, 2000).

The ash from Potassium and sodium carbonates are found in the ashes of many plants. When they are combined with When mixed with water, they form a strong alkaline solution that may turn fats and oils into soap (Warra et al., 2011). Even though people have been using lye from certain plants to make soap for a long time, there has not been much study on how to make it better and explain it for current usage.

The African fan palm, Borassus aethiopum, is a plant that grows across all of tropical Africa. It is a highly strong plant that has been used for food, construction and crafts for a long time time (Arkcoll, 1988). But its leaves, which are abundant as agricultural waste, have not been extensively looked into for usage in industry.

Utilization of B. aethiopum leaf ash as an alkali source for saponification remains poorly understood. This work aims to fill the current research gap by looking into the synthesis of soap from the soybean oil using lye prepared from the leaves ash of B.

aethiopum. The primary objective is to prepare soap through this new plant-based alkali and subsequently perform a physicochemical characterization to determine if it complies with industry quality standards. This study aims to demonstrate this method to be a good, enduring, and affordable means of producing soap in place of the traditional methods.

2. Literature Review

2.1. Methods

The laboratory procedure was designed to be systematic and reproducible, ensuring the results were accurate. There were four primary processes to the procedure: obtaining the materials, making the plant lye, the reaction of saponification, and the physicochemical analysis of the finished soap product.

We procured refined soya bean oil (Glycine max) from an AgroCorp Ltd. of Jos, Nigeria. We purchased the hydrochloric acid, ethanol, and phenolphthalein required for titration and analysis from a Jos reputable vendor. The Borassus aethiopum leaves were also acquired from an assigned agricultural field located within Jos, Plateau State, Nigeria. These leaves were mature and were not infected or polluted.

2.2 Preparation of Lye from the Ashes of Borassus aethiopum Leaves

To make the alkaline solution, they had to boil and extract it in a regulated way.

The leaves were first rinsed with deionised water to get rid of debris on the surface.

Then, they were left outside in the sun for 72 hours to dry them out. After that, they were heated in a muffle furnace at 600 °C for four hours, which gave them a fine, greyish colour. The dried leaves were ground to powder using a pestle and mortar.

2.3 Extraction of Lye (Alkali) from B. aethiopum Ash

A 200g mass of the sieved leaf ash was mixed with 1000 mL of distilled water in a large beaker. The mixture was heated to boiling (100°C) and stirred continuously for 60 minutes to facilitate the leaching of soluble alkali (primarily potassium and sodium carbonates/hydroxides) into the water. After heating, the mixture was allowed to cool and filtered, first through a clean muslin cloth to remove large residues, and then through Whatman No. 1 filter paper to obtain a clear lye solution. This filtrate is the lye (alkali extract) to be used for the soap production.

2.4 Soap Preparation

Soap was prepared by using a hot-process saponification technique. A hot plate controlled by a thermostat was used to heat a 500 mL stainless steel beaker containing precisely 100 g of soya bean oil to 70 °C. 200 mL of the B. aethiopum lye was also heated to the same temperature in another beaker at the same time. The hot lye was then slowly and gently poured into the hot oil using a mechanical stirrer to mix the contents until it was level and preventing the mixture from boiling in one area. The mixture was constantly stirred and maintained at a low boil (around 80–90 °C). We could see how the saponification reaction was proceeding by checking the consistency of the mixture.

After the liquid had thickened to a smooth, sticky trail and a small amount poured into water failed to leave an oily residue, the reaction was finished. The entire process was around 45 minutes. The thick soap was then put into wooden moulds and allowed to cure at room temperature for two weeks. This was to allow all of the saponification to take place and for any excess water to evaporate.

2.5 Physicochemical Characterisation

We employed standard methods of the American Oil Chemists' Society (AOCS, 2017) to analyse the raw soya bean oil and the finished cured soap for a number of key physical and chemical properties.

This let us discover more about their quality and what they are like.

Soya Bean Oil: A Look The saponification value, which is a measure of the average molecular weight of the fatty acids in the oil, was discovered using AOCS Official.

We utilised AOCS Official Method Ca 5a-40 to obtain the acid value, which informs us how many free fatty acids are in the substance.

Examining the soap that was created. At 25 °C, we utilised a calibrated digital pH meter to determine the pH of a 1% solution of the soap in water. ASTM International (2014) notes that the moisture content was determined by putting a specified quantity of soap in an oven at 105°C and letting it dry until it ceased changing weight. We found out the Total Fatty Matter (TFM), which is a good way to tell how good soap is and how well it cleans, by dissolving a specified weight of soap in mineral acid and collecting the fatty acids that came out. We utilised a normal acid solution to titrate an alcoholic soap solution to find out how much free caustic alkali was in it. A graduated cylinder was used to shake a 1% soap solution to see how stable the foam was. The volume of the foam was measured before and after 5 minutes. We also looked at the samples to see how hard, soft, and colourful they were.

3. Results

The experimental inquiry effectively produced a lasting soap by the saponification of soybean oil with lye formed from B. ash from a leaf of an aethiopum. The cured soap was evaluated qualitatively and found to be light brown in colour, firm in texture, and smooth and even in consistency, which means that the soap matrix was well-structured. The quantitative findings from the physicochemical tests on the crude oil and the final soap are displayed clearly so that the two may be compared equitably. We learnt a lot about how saponification works by looking at the feedstock, soya bean oil, for the first time. The acid value was 2.1 mg KOH/g, while the saponification value was 192.5 mg KOH/g.

These numbers are in accord with what we know about commercial-grade soya bean oil, which demonstrates that the oil is excellent for creating soap.

The finished soap product's complete physicochemical characteristics were available after the two-week curing time. measured. The major results of these tests are shown in Table 1. The table offers a direct comparison between the qualities of the soap that was manufactured and the normal ranges for laundry-grade soap. This makes it simple to tell how good it is.

Table 1: Physicochemical Properties of the Produced Soap Compared to Standard Ranges

Parameter	Produced Soap Value	Standard Range for Laundry Soap
pH (1% solution)	9.9	9.0 – 11.0
Moisture Content (%)	12.6	< 20.0
Total Fatty Matter (TFM) (%)	75.2	> 60.0
Free Caustic Alkali (%)	0.18	< 0.25
Foam Height (initial, cm)	4.6	Not specified
Foam Stability (after 5 min, cm)	3.82	Not specified

The soap's pH level, which is a good way to tell how safe and gentle it is to use, was 9.9. This number is well within the safe alkaline range for laundry and all-purpose soaps. The moisture level was 12.6%, which is far lower than the limit for acceptable bar soaps. This signifies that the soap was cured properly and won't go too soft for a long time. The Total Fatty Matter (TFM) in soap is a key part of how effectively it cleans. The soap that was manufactured had a TFM level of 75.2%. This high number is substantially higher than the lowest level for laundry soap and is near to the level for toilet soap. This suggests that the product can clean a lot. It was also determined that the free caustic alkali concentration was 0.18%. This low number is extremely essential since it implies that the saponification process is nearly over and that the final product does not contain any additional alkali that hasn't reacted yet. This might be harsh or corrosive to skin and clothes. The soap generated lots of foam, which measured 4.6 cm tall and persisted for a while. It measured 3.82 cm tall after 5 minutes.

4. Discussion

The findings in this study provide strong evidence regarding the effectiveness of Borassus aethiopum leaf ash as an excellent source of alkali for soap-making. Successful saponification of soybean oil and excellence of the resulting soap product support the key hypothesis of the research. To be able to discuss the outcomes, we should look at the data in terms of established chemical principles and industry norms, compare them with our previous experience, and think about what this sustainable approach means to the future. Table 1 indicates that the soap that was created is great physically and chemically.

It is of utmost significance that the pH was 9.9. This pH level means that the lye that was created from the plant ash was concentrated enough to complete the saponification process, but the finished product isn't harsh.

This is a very significant balance in any soap, and it means that you can

You can create a regulated, efficient lye without industrial chemical synthesis. This is a result that is reinforced by research on other plant ash alternatives which have yielded soaps with a balanced pH value for everyday use (Ogunniyi & Odetoye, 2008).

The Total Fatty Matter (TFM) of 75.2% is perhaps the greatest method to assess how nice the soap is. TFM is the total quantity of fatty matter, usually fatty acids, that can be removed from a sample of soap. A higher TFM value suggests that the soap cleans better. The figure discovered in this research is substantially greater than the minimal guideline for laundry soap, which is normally approximately 60%. This suggests that the product works better at cleaning (Smulders, 2002). This high TFM suggests that B. Aethiopum lye is great for saponification and makes a lot of soap from soya bean oil.

There is just 0.18% free caustic alkali, which means that the process is over.

Presence of excess free alkali in soap is undesirable as it will ruin clothes and make the skin feel terrible. The reading is way below the permissible maximum level of 0.25% for laundry soaps, which means that the product is safe and of extremely high quality (ASTM International, 2014). This proves that one can use a homemade plant lye to the same extent as the commercial one to create a safe and properly finished product if oil-to-lye ratio and conditions of reaction are maintained under control.

The research findings have far-reaching effects on industrial activities in the region that are positive to the environment and the economy. Most people view B. Aethiopum leaves as waste, but they can be employed to transform low-value biomass into high-value chemical feedstock.

This is an approach that is underpinned by the principles of a circular economy, which focuses on leveraging local resources to enable things to be functional and on reducing waste. For regions where there is plenty of palm trees, this approach can be utilized in creating small, decentralized soap manufacturing enterprises. This would reduce the application of expensive imported chemicals and enable people to create own enterprises (Ejikeme et al., 2014).

You would do well to bear in mind that this study has some limitation, although the results seem positive. The study was conducted on laboratory scale, and for commercial production, the process would have to be scaled up; hence, the calcination and leaching have to be optimized further to ensure uniformity and highest concentration of lye. Furthermore, the chemical structure of the lye was not fully examined; further studies should utilize methods such as atomic absorption spectroscopy to determine the precise quantities of potassium and sodium salts.

This would let you make more accurate stoichiometric calculations and allow you greater control over how the saponification process operates. More study might also examine at the soap's effectiveness in more depth, such as how effectively it gets rid of various kinds of stains and how it affects different kinds of cloth.

5. Conclusion and Recommendations

5.1 Conclusion

This research effectively illustrated the development of an improved soap from soybean oil, using an innovative and sustainable

lye sourced from the ash of Borassus aethiopum plants. The thorough physicochemical analysis showed that the soap made meets or even exceeds the standards for laundry and all-purpose soaps.
The final output held a satisfactory pH value, not much moisture, high total fatty material, and low free caustic alkali. This validated the success and completion of the process of saponification.
The overall conclusion from this study is that B. Aethiopum leaf ash is an appropriate, environmentally friendly, and utilitarian replacement for commercially prepared alkalis during soap production. Results indicate that an old and new analytical tools-based strategy can construct a procedure that will stand the test of time.

5.2 Recommendations for Application and Commercialization

- Adoption and Training: It is recommended that local communities and small-scale entrepreneurs, particularly in regions where Borassus aethiopum is abundant, be trained in this soap-making method. This would promote a sustainable, eco-friendly, and cost-effective local industry.
- Economic Feasibility Study: A thorough cost-benefit analysis should be conducted to compare the production cost of this soap (including labor for ash collection and lye extraction) against soap made with commercial NaOH or KOH. This will determine its market viability.
- Sustainable Sourcing Protocol: Guidelines for the sustainable harvesting of Borassus aethiopum leaves should be developed. This will ensure that the raw material is not over-exploited, preventing ecological damage and ensuring the long-term viability of this method.

5.3 Recommendations for Further Research

- Product Diversification and Safety: The current soap was validated for laundry/all-purpose use. Further research should explore its suitability as a cosmetic or toilet soap. This would require additional testing, such as dermatological patch tests, to ensure it is safe and non-irritating for skin.
- Investigate Other Local Oils: This study successfully used soybean oil. Future research should test the efficacy of the B. aethiopum lye with other locally available and cost-effective oils or fats (such as shea butter, palm kernel oil, jatropha oil) to assess its versatility.
- Performance and Consumer Acceptance Studies: While the physicochemical properties are good, a comparative performance study against conventional commercial soaps should be conducted. This would measure its cleaning efficiency (launchness), lathering quality, and durability. Consumer acceptance studies should also be run to gather feedback on texture, scent, and overall satisfaction.
- Process Scale-Up and Optimization: The study should be replicated on a larger, pilot-scale level to identify any challenges in scaling up production. This would also allow for optimization of the lye-to-oil ratio and reaction conditions to maximize yield and consistency.

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References

[1] Akoh, C. C., & Min, D. B. (2008). Food lipids: Chemistry, nutrition, and biotechnology (3rd ed.). CRC Press.
[2] Alum, B. N (2024). Saponification Process and Soap Chemistry. INOSR Applied Sciences 12(2), 51-56
[3] American Oil Chemists' Society. (2017). Official methods and recommended practices of the AOCS (7th ed.). AOCS Press.
[4] Arkcoll, D. B. (1988). The production and marketing of babassu palm products. In G. T. Prance & M. J. Balick (Eds.), New York Botanical Garden's series of advances in economic botany (Vol. 6, pp. 91–103). New York Botanical Garden.
[5] ASTM International. (2014). Standard specification for solid soap for institutional use (D4955-94). ASTM International.
[6] Ejikeme, P. M., Anyaogu, I. D., & Ejikeme, C. L. (2014). Production and characterization of soap from Azadirachta indica seed oil. Journal of Chemical Engineering and Materials Science, 5(2), 16–21.https://doi.org/10.5897/JCEMS2013.0175
[7] Gunstone, F. D. (2004). The chemistry of oils and fats: Sources, composition, properties and uses. Blackwell Publishing.
[8] McMurry, J. (2018). Organic chemistry (9th ed.). Cengage Learning.
[9] O'Brien, T. F. (2005). Handbook of chlor-alkali technology. Springer.
[10] Ogunniyi, D. S., & Odetoye, T. E. (2008). Preparation and evaluation of soap from the oil of Jatropha curcas. Journal of Applied Sciences, 8(1), 162–165.
[11] Schmittinger, P. (2000). Chlor-alkali process. In Ullmann's encyclopedia of industrial chemistry. Wiley-VCH.
[12] Smulders, E. (2002). Laundry detergents. Wiley-VCH.
[13] Warra, A. A., Wawata, I. G., Gunu, S. Y., & Atiku, F. A. (2011). Soap preparation from Soxhlet extracted Nigerian cotton seed oil. Advances in Applied Science Research, 2(5), 535–541.
[14] Warra, A. A. (2013). A report on soap making in Nigeria using indigenous technology and raw materials. African Journal of Pure and Applied Chemistry, 7(4), 139-145