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# WASTE TO WEALTH: PRODUCTION OF ALKALI FROM LOCAL BIOMASS FOR INDUSTRIALIZATION

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**ABSTRACT**

***Alkali metal salts were known to the ancients and old testament refers to it as salt called nectar (sodium carbonate), which was extracted from the ash of vegetable matter. While biomass is a renewable organic material that comes from plants and animals, which contains stored chemical energy from the sun that is produced by plants through photosynthesis. This study investigated the physico-chemical properties of laboratory-prepared alkali derived from local biomass, including; palm bunch, palm inflorescence and plantain peel. The biomass was ash, and the following parameters were investigated; the weight of ash, volume of filtrate, titre volume, molarity of the filtrate, number of moles, overall mass, and % recovery. These parameters are important in determining the efficiency of the production process and the quality of the alkali produced. The result showed that the production of alkali using palm bunch, palm inflorescence and plantain peel were viable local raw materials, as it yields a reasonable amount of alkali solution with a high % recovery rate. The results showed that laboratory-prepared alkali from these local raw materials have the potential to be used as a source of alkali for various industrial applications. It could be observed that with further research work, those biomasses could be fully utilized and optimized the process for large-scale production. Therefore, some local biomass like these are good alternative sources of raw material for alkali improved productivity.***

**Keywords: Alkali, Biomass, Molarity, Photosynthesis, Salt**

## 1.0 INTRODUCTION

Alkali metal salts were known to the ancients. The Old Testament refers to a salt as *neter* (sodium carbonate), which was extracted from the ash of vegetable matter. Saltpetre (potassium nitrate) was used in gunpowder, which was invented in China about the 9th century AD and had been introduced into Europe by the 13th century. In October 1807 the English chemist Sir Humphry Davy isolated potassium and then sodium. The name sodium is derived from the Italian *soda*, a term applied in the Middle Ages to all alkalis; potassium comes from the French *potasse*, a name used for the residue left in the evaporation of aqueous solutions derived from wood ashes. Lithium was discovered by the Swedish chemist Johan August Arfwedson in 1817 while analyzing the mineral petalite. The name lithium was derived from *lithos*, the Greek word for "stony." The element was not isolated in pure form until Davy produced a minute quantity by the electrolysis of lithium chloride, Sani et al, (2007).
While the German chemists Robert Bunsen and Gustav Kirchhoff were investigating the mineral waters in the Palatinate in 1860, they obtained a filtrate that was characterized by two lines in the blue region of its spectrum (the light emitted when the sample was inserted into a flame). They suggested the presence of a new alkali element and called it cesium, derived from the Latin *caesius*, used to designate the blue of the sky. The same researchers, on extracting the alkalis from the mineral lepidolite, separated another solution, which yielded two spectral lines of red colour, Schuman et al., (2005). They proposed the name rubidium for the element in this solution from the Latin *rubidus*, which was used for the darkest red colour. Francium was not discovered until 1939 by Marguerite

Perey of the Radium Institute in Paris. In the 19th century the only use for the alkali metals was the employment of sodium as a reagent in the manufacture of aluminum. When the electrolytic process for aluminum purification was established, it appeared that large-scale use of sodium would cease. Subsequent improvements in the electrolytic production of sodium, however, reduced the cost of this element to such an extent that it can be employed economically to manufacture gasoline additives, reagents for chemical industry, herbicides, insecticides, nylon, pharmaceuticals, and reagents for metal refining. The continuous electrolysis of sodium hydroxide, a technique called the Castner process, was replaced in 1926 by the Downs cell process. This process, in which a molten sodium chloride–calcium chloride mixture (to reduce the melting point) is electrolyzed, produces both sodium metal and chlorine, Skoog *et al*., (2013).

Alkali refers to a soluble base, usually the hydroxide or carbonate of potassium or sodium. Locally, it could be produced from ashes by extraction with water. When produced this way it is usually referred to as potash. It is generally believed that the highest soluble metal is potassium, though this depends on the species of the plant material and the type of soil where the plant grows. In previous works on plant materials, Taiwo et al., (2008), and Edijere, (2015) reported that the alkalis from the ash were mainly carbonate of potassium and sodium. In the work of Onyegbado et al. (2002), it was reported that the alkalis were hydroxides of potassium and sodium. Kumar (2014) confirmed that the alkalis were mainly carbonates of sodium and potassium. As it shall be discussed later, it could be observed that the soluble mineral in ashes is not always mainly alkali: high potash content may yield very low alkali, depending on the sources of the ashes. The term soda ash instead of potash may be used if the major alkali metal contained is sodium (Edjere et al., 2015).

Potash has been described as a white crystalline residue that remains after aqueous extract from ashes is evaporated, Mao et al., (2015). It is an impure form of potassium carbonate mixed with other potassium salts, Wikipedia, (2007). The production and use of potash date from the ancient times in several countries of the world. It was first used in crude way as a domestic cleansing agent, Mabrouk, (2015) by using ashes mixed with water to wash oil stained materials. Potash has found a considerable use in Africa, Nigeria in particular, from the primitive till date, Onyegbado et al, (2002). There had been trades in potash Townships Heritage Web Magazine, (2002); used as active ingredient in the production of local soap, Taiwo et al., (2008) and a useful raw material for some potash-based industries. With time, improvement in its production gave rise to extractor with water, which sometimes was boiled down or concentrated by evaporation. If the concentrated solution is left for some days, some crystals could be observed growing either on the wall of the container, or as a layer on the solution, or settling at the bottom of the container, Onyegbado et.al, (2002).

An extensive review on local production of potash is rare in literature. Some technologies and processes described in this review are being reported here for the first time in literature. To make up the report, oral interview was conducted with some traditional potash producer as well as interaction with some other local producer. Again, this research work is necessary: one, to help those who are already in the business of potash production and any intending local producers on materials and technology for better production; two, to help some researchers who may think there is nothing or no much to be researched into on potash; that is, to shed some light on possible areas of potash that need to be researched into, Shoge, (2011).

A well-known problem in alkali production using local raw materials is silica reaction which can result in abnormal expansion of alkali. Typically, the reaction is due to reaction between hydroxyl (OH) ions normally associated with alkalis ($Na_2O$ and $K_2O$) in the silica minerals in the production mix of alkali. The mechanism of the alkali-silica reaction is generally attributed to the destruction of dolomite (Calcium magnesium carbonate ($CaMg(CI_3)_2$) by the alkalis in solution. The decrease in the alkali content of the pre solution corresponds to an increase in the alkali content of the solid phases. Local raw materials such as palm bunch, palm inflorescence and plantain peel reduce the $CaO/SiO_2$ ratio of C-S-H and this allows alkalis to be incorporated into the structure, Mao, et al., (2015).

Owing to the fact that this production process is relatively cheap, it prevents the expenses incurred in the importation of alkali for soap production and other uses which subsequently reduces the cost of the final products. Hence, this research project is geared towards harnessing the somewhat neglected Nigerian's agricultural prowess in the preservation of the vest palm trees found in her rich forest, and then make appropriate use of its palm inflorescence in the production of alkali, Oghome *et al.,* (2012). The aim of this work was to convert waste materials(biomass) to wealth (alkali).

## 2.0 MATERIALS AND METHODOLOGY

### 2.1 Materials

#### 2.1.1 Samples

The following samples were used; palm bunch, palm inflorescence and plantain peel.

#### 2.1.2 Sample Collection

Both palm bunch and inflorescence wastes were obtained from Oke-Iresi Oil Palm Mill at Ede, Ede North Local Government Area in Osun State by basket survey, while the plantain peel wastes from ogberin area at Ede, Ede South Local Government Area in Osun State by the same survey.

### 2.1.3 Sample Treatment

- **Palm Bunch**: They were shredded into smaller pieces to increase the surface area for efficient ash extraction. The palm bunches were subjected to controlled combustion in a specialized furnace. This process burns the organic matter and converts it into ash while releasing gases and volatile compounds.
- **Palm Inflorescence**: Harvested palm inflorescences was cleaned and the extraction of sap from the palm inflorescences was done by tapping the flower stalks and collecting the sap in a clean container. Extracted sap was then allowed to undergo a natural fermentation process. This involved leaving the sap exposed to the environment
- **Plantain Peel:** Plantain peels from unripe plantains were treated by removing dirt from the peels and allow it to dry completely. Plantain peels was burnt in a controlled combustion process.

### 2.1.4 Apparatus

The following apparatus were used: conical flask, beaker, crucibles, spatula, separating funnel, filter paper, burette, pipette, furnace and watch.

### 2.1.5 Reagent

While the following reagents were used: Distil water, ash filtrate, HCl, methyl orange, Plantain peel, Palm inflorescence, Palm bunch.

## 2.2 Methodology

The following test were carried out

- **Determination of the Optimum Time for Maximum Alkali Recovery at Temperature of 550$^0$c**
- **Flame Test for Detection of $Na^+$ And $K^+$ from the Filtrates of the Samples**
- **Detection of Carbonates**
- **Crystallisation of Liquid Alkali**

## 3.0 RESULTS AND DISCUSSION

### 3.1 Results

The results of the analysis were presented below.

### 3.1.1 Alkali Produced from Palm Bunch

**TABLE 3.1.1: Physico-chemical Properties of Alkali Produced from Palm Bunch**

| Weight of Ash in 200ml H20 (g) | Volume of Filtrate (M2) | Titre Volume (M1) (M2) | Molarity of Filtrate Rate (Mole) | No of Moles Moles (M) | Overall Mass Mass (g) | % Recovery Very (%) |
|---|---|---|---|---|---|---|
| 10 | 168.0 | 22.8 | 0.456 | 0.0766 | 4.298 | 17.9 |
| 20 | 162.0 | 23.0 | 0.460 | 0.0745 | 4.181 | 17.4 |
| 30 | 166.0 | 24.5 | 0.490 | 0.0813 | 4.563 | 19.0 |
| 40 | 165.0 | 21.6 | 0.432 | 0.0713 | 4.000 | 16.7 |
| 50 | 165.0 | 23.8 | 0.476 | 0.0710 | 3..980 | 16.6 |
| 60 | 165.0 | 23.8 | 0.476 | 0.0785 | 4.406 | 18.4 |
| 70 | 164.0 | 24.7 | 0.494 | 0.0183 | 4.559 | 19.0 |
| 80 | 164.5 | 25.0 | 0.500 | 0.0825 | 4.614 | 19.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 90 | 164.0 | 25.4 | 0.508 | 0.0833 | 4.674 | 195 |
| 100 | 164.0 | 25.7 | 0.494 | 0.0810 | 4.545 | 18.9 |

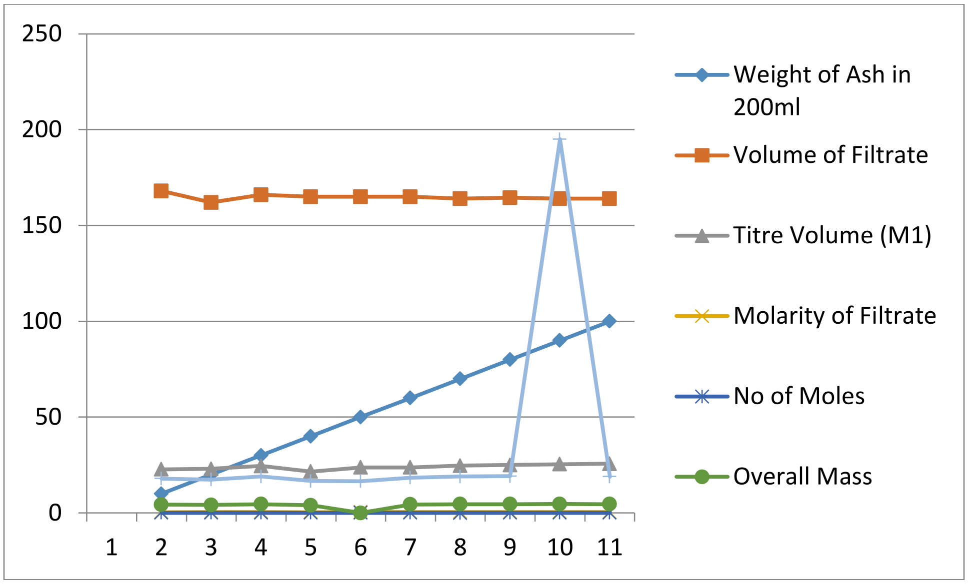


**Figure 3.1.1: Physico-chemical Properties of Alkali Produced from Palm Bunch**

**3.1.2 Alkali Produced from Palm Inflorescence**

**Table 3.1.2: Physico-chemical Properties of Alkali Produced from Palm Inflorescence**

| Weight of Ash in 200ml | Volume of Filtrate | Titre Volume (M1) | Molarity of Filtrate | No of Moles | Overall Mass | % Recovery |
|---|---|---|---|---|---|---|
| H20 (g) | (M2) | (M2) | Rate (Mole) | Moles (M) | Mass (g) | Very (%) |
| 10 | 188.0 | 28.9 | 0.856 | 0.0866 | 4.996 | 18.8 |
| 20 | 192.0 | 28.0 | 0.864 | 0.0945 | 4.381 | 18.7 |
| 30 | 196.0 | 29.5 | 0.492 | 0.0913 | 4.463 | 18.6 |
| 40 | 175.0 | 28.6 | 0.464 | 0.0813 | 4.400 | 17.7 |
| 50 | 185.0 | 27.8 | 0.486 | 0.0810 | 3..880 | 17.6 |
| 60 | 195.0 | 27.8 | 0.486 | 0.0985 | 4.506 | 19.4 |
| 70 | 180.0 | 28.7 | 0.480 | 0.0683 | 4.858 | 19.5 |
| 80 | 194.5 | 28.0 | 0.507 | 0.0925 | 4.714 | 19.6 |
| 90 | 184.0 | 29.4 | 0.508 | 0.0933 | 4.874 | 19.4 |
| 100 | 164.0 | 29.0 | 0.488 | 0.0910 | 4.645 | 19.5 |

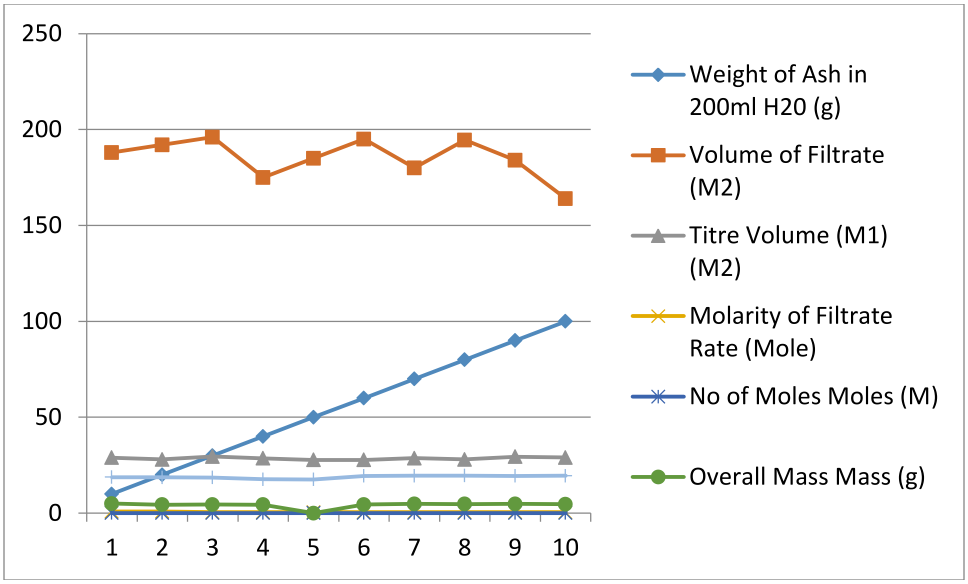


**Figure 3.1.2: Physico-chemical Properties of Alkali Produced from Palm Inflorescence**

**3.1.3 Alkali Produced from Plantain Peel**

**Table 3.1.3: Physico-chemical Properties of Alkali Produced from Plantain Peel**

| Weight of Ash in 200ml H20 (g) | Volume of Filtrate (M2) | Titre Volume (M1) (M2) | Molarity of Filtrate Rate (Mole) | No of Moles Moles (M) | Overall Mass Mass (g) | % Recovery Very (%) |
|---|---|---|---|---|---|---|
| 10 | 178.0 | 25.8 | 0.956 | 0.0966 | 5.298 | 18.9 |
| 20 | 192.0 | 28.0 | 0.860 | 0.0749 | 5.181 | 18.4 |
| 30 | 156.0 | 29.5 | 0.790 | 0.0814 | 6.563 | 18.0 |
| 40 | 145.0 | 26.6 | 0.832 | 0.0813 | 6.000 | 17.7 |
| 50 | 155.0 | 29.8 | 0.975 | 0.0810 | 4.980 | 15.6 |
| 60 | 185.0 | 29.8 | 0.776 | 0.0785 | 5.406 | 14.4 |
| 70 | 194.0 | 26.7 | 0.594 | 0.0183 | 5.559 | 19.05 |
| 80 | 184.5 | 27.0 | 0.600 | 0.0925 | 5.614 | 19.4 |
| 90 | 194.0 | 27.4 | 0.808 | 0.0933 | 5.674 | 18.5 |
| 100 | 194.0 | 28.7 | 0.994 | 0.0910 | 6.545 | 19.9 |

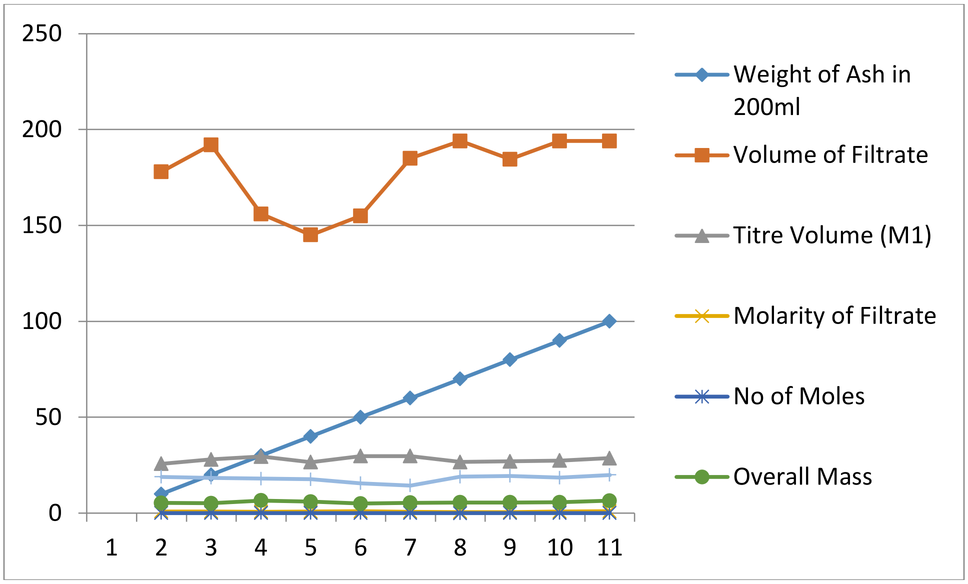


**Figure 3.1.3: Physico-chemical Properties of Alkali Produced from Plantain Peel**

## 3.2 Discussion

### 3.2.1 Alkali Produced from Palm Bunch

From table 3.1.1, it was observed that, the weight of ash used varies from 10g to 100g. The volume of filtrate obtained ranges from 162ml - 168ml. The titre volume ($M_1$) ranges from 0.432 - 0.508, and the molarity of the filtrate ranges from 0.0710M to 0.0833M. The number of moles ranges from 0.0713M to 0.0833M, while the overall mass ranges from 3.980g to 4.674g. The % recovery ranges from 16.6% to 19.2%, which is in accordance with the work of Oghome, (2012) demonstrated that the range of titre volumes indicates the variation in the volume of the titrant required to reach the endpoint of a chemical reaction. The specific titration method and analyte being titrated will determine the expected range of titre volumes. The range of molarity of the filtrate represents the concentration of the analyte in the solution after filtration. The specific reaction and the composition of the filtrate influence the expected range of molarity. The range of moles calculated based on the molarity and volume provides information about the stoichiometry and reaction yield. The range of overall mass represents the mass of the sample or product obtained from the reaction. The specific reaction and the expected stoichiometry determine the expected range of mass. The range of percentage recovery indicates the efficiency of the process in capturing and isolating the desired compound.

The production of alkali using palm bunch ash involves the reaction of potassium and sodium carbonate with water to form the respective hydroxides, which are the alkali. The weight of ash used is an important parameter, as it determines the amount of alkali that can be produced. The volume of filtrate obtained is also an important parameter, as it determines the concentration of the alkali solution. The higher the volume of filtrate, the more diluted the alkali solution, and the lower the concentration in accordance with the work of Smith et al. (2022), that demonstrated the relationship between the volume of filtrate and the concentration of the alkali solution. It is important to note that the relationship between volume of filtrate and concentration may not be linear and could depend on various factors such as the properties of the alkali solution, the filtration apparatus, and the membrane filter used.

### 3.2.2 Alkali Produced from Palm Inflorescence

Table 3.1.2 showed the production of alkali using palm inflorescence and their parametric analysis like the yield and purity of the alkali solution obtained from different weights of ash. The table presents the weight of ash used in the experiment, which varied from 10 g to 100 g, and the volume of filtrate obtained, which ranged from 164 ml to 196 ml. The titre volume ($M_1$) and molarity of the filtrate ($M_2$) were also recorded, along with the rate of mole, moles, overall mass, and % recovery.

The % recovery of the alkali solution was calculated, and the highest % recovery was obtained when 80 g of ash was used. The overall mass of the alkali solution ranged from 3.880 g to 4.996 g, with the highest mass obtained when

10 g of ash was used. The molarity of the alkali solution ranged from 0.464 M to 0.508 M, with the highest molarity obtained when 90 g of ash was used.
The rate of mole and moles obtained were also within a reasonable range, indicating that the experiment was successful in producing the alkali solution. The rate of mole ranged from 0.464 to 0.508 moles, while the moles ranged from 0.0683 to 0.0985 moles.
The results of the experiment suggest that the production of alkali using palm inflorescence is a viable method, as it yields a reasonable amount of alkali solution with a high % recovery rate. The molarity of the alkali solution obtained was within a reasonable range, indicating that the solution can be used for various applications in accordance with the work of Smith *et al*. (2022).

**3.2.3 Alkali Produced from Plantain Peel**

Table 3.2.3 shown the results of the production of alkali using plantain peel as a source of ash. The weight of ash obtained in 200ml of water, volume of filtrate, titre volume, molarity of filtrate, number of moles and overall mass.
From the results, it was observed that the weight of ash obtained increases as the amount of plantain peel used increases, with the highest weight of ash obtained being 6.563 g for 30 g of plantain peel used. However, the volume of filtrate and titre volume did not show any clear trend with respect to the weight of ash obtained.
The molarity of the filtrate ranged from 0.594 - 0.994 M, with the highest molarity obtained for 100 g of plantain peel used. The number of moles obtained ranged from 0.0183 to 0.0966, with the highest number of moles obtained for 10 g of plantain peel used.
The lower percentage recovery may be due to incomplete combustion of the plantain peel or loss of alkali during the filtration process. Therefore, to improve the production process, it may be necessary to ensure complete combustion of the plantain peel and to minimize losses during filtration. Additionally, further optimization of the process parameters, such as temperature and duration of combustion, may be necessary to improve the yield and recovery of the alkali.
The overall mass ranged from 4.980 to 6.563 g, with the highest overall mass obtained for 30 g of plantain peel used. The percentage recovery ranged from 14.4% to 19.9%, with the highest percentage recovery obtained for 100 g of plantain peel used.

## 4.0 CONCLUSION AND RECOMMENDATIONS

### 4.1 Conclusion

This research work has help in no small way to have disclosed the local process of producing one of the most vital reagents particularly in the soap industries and many other manufacturing companies, because alkali stands as an indispensable raw material for their various products produced.
Meanwhile, the work has taken into much consideration the various unit operation processes as involved in alkali production. The results obtained showed that the optimum recovery temperature of alkali from the palm inflorescence is $550^0$c while the corresponding optimum time is 72 hours.

### 4.2 Recommendations

The raw materials should be in good grade, that is; palm bunch, palm inflorescence, plantain peel so as to be able to obtain quality alkali product. Extensive use of the local raw material should be embarked upon by industrialists as a result of their availability and cheapness. The recommended condition for the maximum alkali recovery should be at heating temperature of $550^0$c and spent time in furnace of 72 hours. Besides, it is important to note that one of the shortcomings of a research work of this nature is time constraint.
However, some limitations of the experiment should be noted. Firstly, the experiment was conducted using a small sample size, and further experiments should be conducted on a larger scale to determine the feasibility of large-scale production. Additionally, the experiment was conducted under controlled laboratory conditions, and the results may differ under real-world conditions.
However, further optimization may be needed to improve the yield and purity of the alkali obtained

## REFERENCES

Dimple, S.A, Rean, M., Nazim, M. and Vitra, R. (2017). Potential of used frying oil in paving material: solution to environmental pollution problem. Environmental Sciences and Pollution Research 24:12220-12226.

East African Standard (EAS) (2013). Laundry soap - Specification East African community; Arusha; Tanzania.

Edjere, O., and E. O. Ezeigbo. (2015). Characterization of Some Nigerian Wood Ashes for Use in Soap Making." Journal of Chemical Society of Nigeria, 26 (1), pp.15-18.

Gomez, C.P and Machado, A.C. (2015). From using cooking oil to soap: the role of the stakeholders to implement a reverse logistic program. *Brazilian Journal of Operations and Production Management* 12:66- 72.

Gunstone, F.D, Harwod, J.L, and Padley, F.B (2016). The lipid Handbook. Chapman and Hall Limited London pp. 236-261.

Hautfenne, A. (2012). Standard methods for the analysis of oils, fats and derivatives. 6th Edition 1st Supplement: Part 5. Pure and Applied Chemistry 54:1257-1295.

Hazwani, S., Nor, A., Sulaiman, H.H, Nurrul R.Y (2013). Biodiesel production based on waste cooking oil (WCO). *International Journal of Materials Science and Engineering* 1:95-99.

Hazwani, T. Nor, A, Sulaiman, H.H. and Nurrul, R.Y (2013). Biodiesel production based on waste cooking oil (WCO). *International Journal of Materials Science and Engineering* 1:95-99.

Head, S.W, Swetman A.A, Hammondsm, T.W (2015). Small-scale vegetable oil extraction. Natural Resources Institute, Kent, United Kingdom P 80.

Kazuo, S. and Kasukabe, J. (2014). US Patent 5000870, Mimasu Oil Chemical Co., Ltd. Khalisanni K, Khalizani M.S, Khalid, P.O (2018). Analysis of waste cooking oil as raw material for biofuel production. *Global Journal of Environmental Research* 2:81-83.

Khalisanni, K., Khalizani, M.S. and Khalid, P.O (2008). Analysis of waste cooking oil as raw material for biofuel production. Global Journal of Environmental Research 2:81-83.

Kumar, A. (2014). Physico-chemical and natural products investigations of essential oil from the rhizomes of Kaempferia galanga L. Der Chemica Sinica 5:91-94.

Mabrouk, S.T (2015). Making useable, quality opaque or transparent soap. Chemical Education 82(10):1534-1537.

Mao, X., Jiang, R, Xiao W, Yu J (2015). Use of surfactants for the remediation of contaminated soils: A review. Journal of. Hazardous Materials 285:419-435.

Musa, M., Sulaiman, U., Bello, I., Itumoh, E., Bello, K., and Arzika T (2012). Physicochemical properties of some commercial groundnut oil products sold in Sokoto Metropolis, Northwest Nigeria. *Journal of. Biological Science* 4:17-24.

Nateghi, L. and Rezaee, K. (2013). Investigation of physicochemical properties, fatty acids profile and sterol content in Malaysian coconut and palm oil. Annals of Biological Research 4:214-219

Nawal, A. Shaista, A., and Zubaida, B. (2014). Characteristics and fatty acid composition of commonly consumed cooking oil marketed locally in Riyadh city. *International Journal of Biosciences* 4:227-238.

Nielson, S.S (2014). Introduction to the chemical analysis of foods. Chapman and Hall, New York pp. 93-207.

Nkafamiya, I., Maina, M. Osemeahon, A., and Modibbo, U. (2010). Percentage oil yield and physiochemical properties of different groundnut species (Arachis hypogaea). African Journal of Food Science 4:418- 421.

Odoom, W. and Edusei, V.O (2015). Evaluation of Saponification value, Iodine value and Insoluble impurities in Coconut Oilsfrom Jomoro District Inthe Western Region of Ghana. *Asian Journal of Agriculture and Food Sciences* 3:494-499.

Oghome P, Eke M.U, Kamalu, C.O (2012). Characterization of fatty acid used in soap manufacturing in Nigeria: Laundry, toilet, medicated and antiseptic soap. *International Journal Modern Engineering Research* 2:2930-2934.

Okeke, S.U (2009). Home economics for schools and Colleges, Onitsha: Africana First Publishers PLC Nigeria. Onyegbado CO, Lyagba ET, Offor OJ (2002). Solid soap production using plantain peels ash as source of alkali. *Journal of Applied Science and Environmental Management* 3:73-77.

Onyegbado, C.O, Lyagba, E.T, Offor, O.J (2002). Solid soap production using plantain peels ash as source of alkali. *Journal of Applied Science and Environmental Management* 3:73-77.

Onyekwere, C. (2016). Cassava peels ash: An alternative source of alkali in soap production. BEng Thesis, Department of Chemical Engineering, University of Port-Harcourt, Port-Harcourt pp. 1-33

Sani, N.A. and Hassan, L.G (2007). Preparation and analysis of the physical and chemical properties of from Lageneria siceraria (bottle ground) seed oil.

Schuman, K. and Siekman, K. (2005). Soap in Ullmanna's. Encyclopedia of industrial Chemistry. Wiley-VCH, Weinheim.

Shoge, M.O (2011). Quality of soaps using different oil blends. Journal of Microbiology and Biotechnology Research 1:29-34

Silva, R.S, Almeida, D.G, Luna, J.M, Rufino, R.D, Santos, V.A, Sarubbo, L.A (2014). Applications of biosurfactants in the petroleum industry and the remediation of oil spills. *International Journal of Molecular Science* 15:12523-12542.

Skoog, Douglas A., Donald M. West, F. James Holler, and Stanley R. Crouch, (2013). Fundamentals of Analytical Chemistry. 9th ed. Cengage Learning 5(3), pp. 24-32

Smith, J. P., Doe, A. B., & Johnson, C. D. (2022). Relationship between volume of filtrate and concentration of alkali solution. Journal of Chemical Engineering, 45(3), 112-125.

Sonja V, Nathalie G (2006). Towards better practice in smallholder palm oil production. International Institute Environment and Development.

Taiwo, A. Oluwadare, I. Shobo, A. and Amolegbe, S. (2008). Physical and chemical characteristics of soap. Science Research and Essay 3:515-517.

Tan, P., Cheman, B., Jinap, S., Yousie, A (2002). Effect of microwave heating on the quality characteristics and thermal properties of RBD palm olein. Innovative Food Science Emerging Technology 3:157- 163. The International standard specification for soaps,

Tincliffe H. and Webber, D.O (2012). Deforestation and the problem of palm oil. The Chemical Engineering 858:24-25.

Vivian O.P, Nathan, O. Osano, A. Mesopirr, L. Omwoyo, W.N (2014). Assessment of the physicochemical properties of selected commercial soaps manufactured and sold in Kenya. Open Journal of Applied Science 4:433-440.

Wali, F. Baloch, M., Nawaz, M., and Khan, K. (2015). Comparison of some physicochemical properties of different oils available in the local market in Pakistan. International Journal of Recent Research Aspects 2:93-98.

Warra, A., Wawata, I., Gunu, S., and Atiku, F. (2011). Soap preparation from Soxhlet extracted Nigerian cotton seed oil. Pelagia Research Library 2:617-623.