Vol. 15(1), pp. 1-10, January-March, 2020
DOI: 10.5897/SRE2019.6649
Article Number: FEC1AE762643
ISSN 1992-2248

http://www.academicjournals.org/SRE

ACADEMIC JOURNALS
expand your knowledge

Scientific Research and Essays

Full Length Research Paper

Preparation of Laundry Soap from Used Cooking Oils: Getting value out of waste

Legesse Adane

Department of Chemistry, College of Natural and Computational Sciences, Hawassa University, Ethiopia

Received 16 August, 2019; Accepted 14 October, 2019

Palm oil is commonly used to prepare laundry soap by treating it with alkaline solutions. However, using it for this purpose is becoming expensive as palm oil is imported from few major exerting countries. Moreover, it is used for biodiesel production. Therefore, looking for alternative raw material that substitutes palm oil for soap production is imperative. Used cooking oils (UCOs) are good candidates in this regard. In the present study, laundry soaps were prepared using UCOs and sodium hydroxide solution. The cleaning actions and physicochemical properties were evaluated and compared with that commercial soaps purchased from local market. The pH, moisture content, free caustic alkali, % chloride and total alkali content values of the prepared soap materials were found to be in range of 9.31 to 10.56, 6.67 to 14.47%, 0.19 to 0.22%, 0.12 to 0.21%, 0.78 to 1.09%, 75.42 to 88.53%, 70.35 to 84.68%, 0.98 to 1.52%, and 0.28 to 0.67%, respectively. The results obtained in this study were comparable with the physicochemical properties of the commercial soap products used in the study. Moreover, the observed data were comparable with similar data reported in literature and East African Standards (EAS) suggesting that UCOs can be used as raw materials to prepare good quality laundry soap by replacing imported palm oil.

Key words: Laundry soap, used cooking oil, saponification, physicochemical properties, saponification.

INTRODUCTION

Soap is the sodium (Na) or potassium (K) salt of a long chain fatty acid (at least 12 carbons hydrocarbon chain and linked with carboxylic acid functional group). Soaps could be solid and liquid depending on ingredients used for preparation. For instance, solid soaps typically consist of sodium salts of fatty acids and liquid soaps consist of potassium salts of fatty acids (Schuman and Siekman, 2005; Gunstone et al., 1986; Head et al., 1995). Their cleansing action can be attributed to the presence of long hydrocarbon chains attached to a carboxyl group (carboxylate anion). The hydrocarbon chain has an affinity for grease (dirt) and the carboxyl group for water. In this way, the dirt is dissolved in the alkyl groups of the soap molecules while the ionic end allows it to be dissolved in water. This process, ultimately, results in removal of dirt from clothes and skins of human body (Gunstone et al., 1986; Phansteil et al., 1998; Okeke, 2009; Mao et al., 2015; Silva et al., 2014). The general saponification reaction used in soap preparation is shown below (Figure 1).

Most of the modern or commercial soap preparation methods that are being used today have evolved from

E-mail: adanelegesse@gmail.com. Tel: 00251916395678.

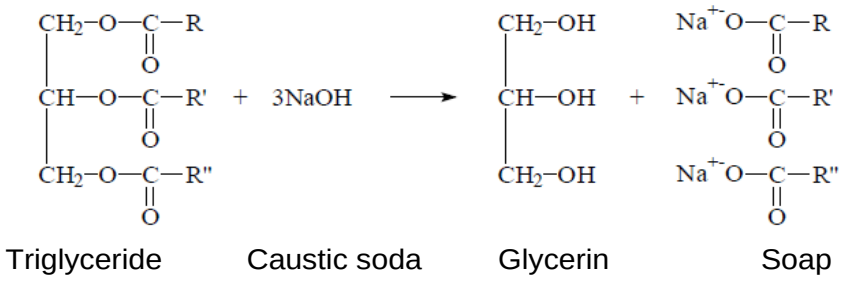

Figure 1. A general scheme of soap preparation (or saponification) processes

ancient methods with some modifications through times. The methods involve treatment of raw material such as lard and tallow (from animal sources), coconut, palm and olive oils (from vegetable sources) with alkaline solutions such as NaOH or KOH (Pavila et al., 1982; Donkor, 1986; Mabrouk, 2005; Sani and Hassan, 2007; Oghome et al., 2012).

It is well known that almost all soap making process involves use of oils from plant sources (mainly palm oil) and animal fats (e.g., tallow). Palm oil is imported by soap manufacturing industries of many countries mainly from two major exporting Asian countries (namely, Malaysia and Indonesia) (Bazmi et al., 2011; Sonja and Nathalie, 2006). Current trends are showing that these raw materials are being used for other competitive purposes such as biodiesel production by developed countries of the western world (Tincliffe and Webber, 2012; Arifin, 2009; Grain, 2007; Rudy, 2006). These completive uses of palm oil and animal fats are expected to create severe scarcity of raw materials for soap industries. Therefore, in the near future, their continuous and sufficient supply may be difficult to soap manufacturing industries. This fact made looking for alternative raw materials for soap production to be an urgent issue. Used cooking oils (UCOs) could be good candidates in this regard (Peters et al., 2013; Araujo et al., 2013).

UCOs are left overs of oils and fats that have been used for cooking/frying in food processing industries, restaurants, fast food making institutions and at a consumer (household) level. They are usually disposed to environment as wastes after repeated uses for cooking/frying. When disposed to environment, they cause many environmental problems such as sanitary sewer over flowing as a result of blockade of sanitary sewer systems in cities, clog sewer and septic system, and also unnecessarily increased organic load on water bodies. They also contaminate water and land resources (Arjun et al., 2008; Gomez and Machado, 2015; Babatunde and Bello, 2016). UCOs have also been reported to cause serious human health hazards such as heart diseases, stroke, Parkinson's disease, Alzheimer's disease, liver disease, gastrointestinal disorders and even mutagenesis in human body (Potgieter et al., 2004; Riera et al., 2000). With the increasing numbers of fast food processing industries, hotels and restaurants in the present modern world, it is expected that considerable amounts of UCOs are discarded into human environment and cause pollution. Therefore, proper collection and reusing them for other purposes such as biofuel and soap making (Khalisanni et al., 2008; Panadare and Rathod, 2015; Hazwani et al., 2013; Alemayehu and Abile, 2014; Kazuo and Kasukabe, 1989; https://www.changemakers.com/discussions/entries/) is a very important option in order minimize environmental pollution caused by UCOs as well as extending the finite natural resources through reusing these wastes for other (new) purposes.

Similar to elsewhere in developing world/countries, UCOs are treated as wastes in Ethiopia, and disposed into environment without any concern by users or concerning authorities. Thus, this study was initiated to prepare laundry soap materials by treating UCO samples with sodium hydroxide, and to evaluate their physicochemical properties and cleaning powers, and also to see the possibility this approach to minimize pollution of UCOs in the environment. The re-use of UCOs as raw materials for soap production is expected to have two advantages; the first is its use as substitute for palm oil and animal fat for ecofriendly laundry soap production, and secondly used as disposal options or to avoid environmental problems (Dimple et al., 2017). They are also easy to collect from food processing industries, street food venders, restaurants and hotels. Moreover, they are relatively cheaper than other oils (refine oils). However, before using the collected UCOs directly for soap making, their suitability (quality) need to be evaluated.

MATERIALS AND METHODS

Collection and pre-treatment of UCOs

The UCOs samples were collected from restaurants, hotels and street food venders from Addis Ababa in the month of August 2017. Literature reported procedures were employed to do the pre-treatment on the collected UCOs in order to remove solid, inorganic material and other contaminants. It was carried out, first, by heating

Figure 2. UCO samples obtained from hotel, restaurant and street food vender.

them at 60 °C. The hot oil samples were then allowed to cool to room temperature. Suction filtration was also used to remove the above mentioned impurities and to make UCOs suitable for soap preparation (Dennis and Kevin, 1988; Bernard et al., 1990; Pocknell and Venni, 2010; Araújo et al., 2013) (Figure 2).

Analyses of physicochemical properties of UCOs

Though there are several parameter to evaluate qualities of oils [Kumar, 2014), the two important parameters namely iodine and Saponification values were considered in this experiment to assess the properties of the collected UCOs for soap making.

Determination of iodine value

Iodine value (iodine number) is the amount (in g) of iodine absorbed by 100 g of the oil or fat. The value gives an idea of the average degree of unsaturation of an oil/fat or number of carbon-carbon double bonds. Thus, the higher the iodine value, the greater the number of C=C double bonds and also reflects susceptibility oil to oxidation or low stability as oil fats with a greater number of double bonds provide more sites for oxidation (Akinhanmi et al., 2008; Nelson, 1994; Odoom an Edusei, 2015). One gram of oil sample was weighed in a 250 ml beaker, and 10 ml of carbon tetrachloride was added to the oil. Then, 20 ml of Wijs solution was added and allowed to stand in the dark for 30 min. After 30 min, 15 ml of (10%) potassium iodide and 100 ml of water was added. The resulting mixture was then titrated with 0.1 mol/ml thiosulphate solution using starch as indicator just before the end point. A blank was also prepared alongside the oil samples. The iodine value was obtained using the following equation (Eq. 1) (Nawal et al., 2014)).

$$\text{Iodine Value} = \frac{(B-S) \times M \times 12.69}{W} \quad (1)$$

Where, B and S are titre values of blank and sample, respectively. M is the molarity of $Na_2S_2O_3$, 12.69 is the conversion factor from Meq $Na_2S_2O_3$ to gram iodine molecular weight of iodine and W is the weight of oil.

Determination of saponification value

The saponification number (value) is defined as the milligrammes of potassium hydroxide (KOH) required to saponify 1g of fat or oil [Odoom and Edusei, 2015; Nielson, 1994]. Two grams of the oil sample was weighed into a clean dried conical flask and 25 ml of alcoholic potassium hydroxide (KOH) was added. The flask was heated for an hour with frequent shaking. 1 ml of 1% phenolphthalein indicator was added and the hot excess alkali was titrated with 0.5 mol/L hydrochloric acid (HCl) until it reached the end point where it turned colorless. A blank titration was carried out at the same time and under the same condition (Nkafamiya et al., 2010). The saponification value was calculated using Equation 2.

$$\text{Saponification Value} = \frac{(S-B) \times M \times 56.1}{W} \quad (2)$$

B and S are titre values of blank and sample, respectively, M is the Molarity of HCl and 56.1 is the molecular weight of KOH.

Preparation of laundry soap

60 mL of UCO samples (Figure 2) was heated to 40°C in separate flasks. Then 90 ml of 20% sodium hydroxide solution was diluted with distilled water and mixed with hot UCOs in separate flasks. The mixtures were stirred using magnetic stirrer. The mixtures were continuously stirred until foam was subsided in each flask. Then saturated sodium chloride solution was added, followed by filtration and drying in oven at 60°C for 24 h to get yellowish soap bars. All the experiments were done in triplicates.

Physicochemical tests/experimental details

The physicochemical characteristic of soap depends on several factors such physicochemical characteristics including pH, moisture content, free caustic alkalinity and total fat matter (TFM) (Atiku et al., 2014). The physico-chemical properties of the soap samples were analyzed using standard procedures reported in literatures al., (Hautfenne, 1982; AOCS, 1997; Onyegbado et al., 2002; Vivian et

2014). The experiments were carried out in triplicates.

Determination of pH

pH values (or acidity and basicity) refer to the degree of acidity or basicity of a given solution (Pure Appl. Chem., 2002). The powder of commercial soap bars (10 g) were weighed and dissolved in distilled water. The solution was made up to 100 mL to prepare 10% soap solution. The pH meter was calibrated using a buffer solution of pH 7 and 10 before measuring the pH of the soap solutions. The meter used for pH determination was Hanna pH-211 microprocessor pH meter. Two grams of each of prepared soap was dissolved in 10 mL of distilled water and retained till sample dissolved, and their pH values were determined with the same instrument.

Determination of moisture content

The moisture content (MC) of soaps is the quantity of water present in soap. It is determined by heating soap samples at 103±2°C until constant mass was observed. 5 g of each soap material was put in clean and dried dish and dried in an oven for 2 h and temperature of 101°C. The heating was repeated until a constant weight was reached. The % moisture was calculated using Equation 3:

$$\% \text{ moisture} = \frac{C_S - C_L}{C_S - C_W} \times 100 \quad (3)$$

Where, C_W = weight of crucible, C_S = weight of crucible + sample, C_L = weight of crucible + sample after floating

Determination of free caustic alkali

The key to make good soap is to ensure that there is no free or excessive alkali. Free caustic alkali was determined by the method described by Milwidsky and Gabriel (Carlos et al., 2011). The free caustic alkali content of sodium soaps of ordinary quality is the quantity of free caustic alkali, expressed as a percentage (rn/n) of sodium hydroxide (Hautfenne, 1982). It is one of the parameters that determine the abrasiveness of any given soap materials. This mostly results from improper or incomplete saponification (Onyekwere, 1996). 5 grams of finished soap was weighed and dissolved in 30 mL of ethanol. Few drops of phenolphthalein indicator and 10 mL of 20 % $BaCl_2$ were added into the soap solution. The resulting solution was then titrated against 0.05 M H_2SO_4 (aq) till the solution becomes colorless. For free caustic alkali the volume of the acid obtained was calculated using Equation 4 (Carlos et al., 2011):

$$\text{FCA} = \frac{0.31}{W} \times V_A \quad (4)$$

Where, V_A = Volume of acid added in the experiment, W = Weight of soap used in the experiment

Determination of % chloride

The chloride content of commercial soaps is the quantity of sodium chloride or potassium chloride, expressed as a percentage by mass (rn/rn). The determination of percentage chloride in soap is a very important parameter (Hautfenne, 1982). This is because excess chloride causes soaps to crack. One cause of high chloride content in soaps could be use of chlorinated water to dissolve NaOH pellets for soap preparation (Taiwo et al., 2008). 10 grams of soap samples were dissolved in distilled water. The solution was made up to 100 mL by adding water and then heated to dissolve sample. The resulting solution was transferred into a 250 mL volumetric flask. 20 mL of 15% ($Ca(NO_3)_2$) solution was added to the mixture, and it was shaken to dissolve the soap completely. Distilled water was added to the solution up to the 250 mL mark. The solution was then filtered and methyl red was added to 100 mL of the filtrate. The solution was titrated against 10 N H_2SO_4 (aq) until a pink color was obtained. Finally, the resulting solution was titrated against 0.1 M $AgNO_3$ using $K_2Cr_2O_7$ as indicator till a brick red color is obtained. Equation 5 was used for calculating the % chloride:

$$\% \text{ Cl} = \frac{\text{Titre volume}}{\text{Weight of soap}} \times 0.585 \quad (5)$$

Determination of total alkali content

Total alkalinity is the total alkaline material present in soap. It is expressed as a percentage (n/rn) of sodium hydroxide or potassium hydroxide according to whether sodium or potassium soaps are concerned (Hautfenne, 1982). It was determined by titrating excess acid contained in aqueous phase with standard volumetric NaOH solution. 10 grams of soap samples were mixed with 100 mL of neutralized ethanol. 5 mL of 1 N H_2SO_4 (aq) solution was added to the mixture and was heated till the soap sample dissolved. The flask was gradually cooled to room temperature, and the remaining amount of sulphuric acid (after hydrolysis and neutralization of all alkaline components in soap) was estimated by back titrating test mixture with standard 1N NaOH using phenolphthalein as an indicator. The total alkali was obtained with Equation 6:

$$\% \text{ Total alkali} = \frac{V_A - V_B}{W} \times 3.1 \quad (6)$$

Where, V_A = volume of acid added in the experiment, V_B = volume of base at the end point, W = weight of soap used in the experiment.

Determination of total fatty matter

Total Fatty matter (TFM) is defined as total amount of fatty matter, mostly fatty acids, that can be separated from a sample after splitting with mineral acid, usually HCl (Betsy et al., 2013). TFM was one of the crucial characteristics describing quality and nature of soap. This is the reason why TFM is always specified in commercial soap. In the present study, determination of TFM was done following a method described in AOCS (ISO, 1975), with slight modifications. The tests were carried out by reacting soaps samples with acid in the presence of hot ethanol and measuring the fatty acids obtained. 10 grams of soap samples was mixed with 150 mL of warm neutralized ethanol, and was heated; the soap materials were dissolved. The dissolved solution was then filtered, and the residue was dried in oven at 110°C for 1 h and weighed again. The total fat matter was obtained using Equation 7 (AOCS, 1997):

$$\frac{100 - (\text{MC} + \text{MIA})}{1.085} \quad (7)$$

Where, MC = moisture content and MIA = matter insoluble in

Table 1. Iodine value and saponification value of UCOs

Type of UCOs	Iodine value (g I_2/g)	Saponification value (mg KOH/g)
UCOs obtained from hotel	31.03±0.45	201.33±0.58
UCOs obtained from restaurant	30.00±1.00	205.00±2.00
UCOs obtained from street food vender	32.30±0.62	196.60±0.53

alcohol.

Test of cleaning power and lather formation of the prepared soap materials

The cleaning power of the prepared soap bars was evaluated using pieces of cotton clothes that were stained with Chicken sauce (*Doro wot* in local language). Their lather foaming abilities were evaluated in distilled water by adding equal amount of soap solution in test tube and shaken vigorously by placing a stopper in the tube. For the sake of comparison, the same procedures were done with randomly selected threes commercial laundry soaps purchased from local market.

RESULTS AND DISCUSSION

Analysis of properties of UCOs

The greater the iodine value, the more the unsaturation and the higher the susceptibility to oxidation. Thus, the iodine values of the UCO samples were analyzed using procedure reported in literature (Anyasor et al., 2009**)**. The finding of the study showed that 30±1.00g I_2/g for UCOs was obtained from restaurants, 31.03± g I_2/g for UCOs was obtained from hotels and 32.3±0.62g I_2/g for UCOs was obtained from street food venders (Table 1). It has been reported that lowering the iodine value improves the stability and good yield of the liquid oil (Akinola et al., 2010). The values obtained from the analyses were lower as compared to the data reported values in literature (Akinyeye et al., 2011). Moreover, the observed iodine values of the oils were lower than reported iodine value of palm oil (53.87) (Adulkadir and Jimoh, 2013) suggesting that the UCOs can be used as suitable raw materials for soap making.

Studies showed that high saponification values indicate oil samples/products are normal triglycerides and will be useful in the production of soap (Yourself et al., 2013; Tan et al., 2002). On the other hand, the lower the saponification value, the larger the molecular weight of fatty acids in the glycerides or the number of ester bonds is less (Musa et al., 2012). The saponification values of UCOs samples were also analyzed to evaluate their potential as substitute of palm oil (widely used raw material for soap production). The results obtained from the study showed that the saponification values to be 196.6±0.53 mg KOH/g, 201.33±0.58 mg KOH/g and 205±2.00 for UCOs obtained from street food venders, hotels and restaurants, respectively (Table 1). The saponification values of oil samples obtained from hotels and restaurants are relatively higher, and characterized by the presence of relatively high concentration of low molecular weight free fatty acid in their triglycerides as revealed. The observed values are lower than the reported saponification values of palm oil (191 mg KOH/g) (Adulkadir and Jimoh, 2013). The values are also in line with the standard guidelines set by NAFDAC and CODEX as well as some other literature reports (Wali et al., 2015; Nkafamiya et al., 2010; Musa et al., 2012; CODEX, 1969). It is reported that the larger the saponification number, the better the soap making ability of the oil (Nielson, 1994). Thus, the UCOs used in the study were found to possess comparable saponification values with that of palm oil suggesting that UCOs can be used as a substitute for palm oil in soap making.

Physicochemical properties of the prepared soaps

There are reports on the use of UCOs to soaps of low to medium grades by direct saponification method (Kazuo and Kasukabe, 1989). In the present study, laundry soaps were prepared, and their phyisco-chemical properties as well as cleaning abilities of the prepared soaps were also evaluated. The results were compared with literature reports and some standards.

pH

The observed pH values of the prepared laundry soaps were in the range of 9.31±0.81 to 10.56±0.44, and were also comparable to each other. In the case of commercial soap samples, the pH values were in the range of 10.34±0.11 to 11.41±0.21, and these values are comparable to each other but relatively higher than that of the prepared soap materials (Table 2). High pH values showed the presence of incomplete hydrolysis. It can be overcome by adding excess fat or oil or any other super fatting agent to reduce the harshness of soap (Wara et al., 2011). Superfatting also helps to prevent development of cracks in soap bars, produce better lathering properties and good hand feel. The observed data were consistent with the report by Shoge who stated that soaps whose pH values fall in the range of 9.0-11.0 are skin and fabric friendly (Shoge, 2011).

Table 2. The pH values of the prepared and commercial soaps used in the study.

Type of soap used	pH of the solutions prepared
Soap product prepared from	
UCOs obtained from hotels	9.86 ±0.53
UCOs obtained from restaurants	9.31±0.81
UCOs obtained from street food venders	10.56±0.44
Commercial soap	
Sky	10.34±0.11
Lia	11.41±0.21
Picolo	11.09±0.26

Table 3. The moisture contents of the prepared soap samples and some commercial laundry soaps.

Types of soap used	Moisture content (%)
Soap product prepared from	
UCOs obtained from hotel	6.67±0.95
UCOsobtainedfrom restaurant	10.73±0.34
UCOs obtained from street food vender	14.47±0.84
Commercial soap	
Sky	17.0±0.27
Lia	4.80±0.65
Picolo	7.60±0.52

Moreover, the data are comparable with the data obtained from commercial soap products (Table 1).

Moisture content

Reports showed that moisture content (MC) is a parameter that is used in assessing the shelf-life of a product. High MC values in soap would lead to reaction of excess water with unsaponified fat to give free fatty acid and glycerol (Victoria et al., 2011). The percentage of MCs of the prepared laundry soap samples was observed to be in the range of 6.67±0.95% to 14.47±0.84% whereas the percentages of MC for the commercial soap samples used in the study were 4.80±0.65% to 17±0.27% (Table 3). The analyses results in the study indicated that MC of the soap prepared from UCO obtained from hotel was lowest (6.67±0.95%) and that UCO from street food vender was the highest (14.47±0.84%). These differences could be due to differences in chemical compositions of the oils. The degree of heating and frequency of re-use of oils for frying or cooking may be different in hotels, restaurants and street food venders. The obtained data also showed that MC values of the prepared soaps are below permissible limits of EAS (30% for laundry soaps) (EAS, 2013).This suggests that the prepared soaps can be used for cleaning/washing purposes.

Free caustic alkali

The results from this study indicated that free caustic alkali contents of the laundry soaps prepared from the UCOs obtained from restaurant, hotel and street food vender were 0.22±0.03%, 0.20±0.02% and 0.19±0.03%, respectively (Table 4). These values are comparable to free caustic alkali contents of commercial soaps used in the experiment (Table 4). The data indicate the prepared soaps can be used for laundry purpose without any problems on human skins. Moreover, the data (values) are below or within permissible limit of free caustic alkali contents of laundry soaps proposed by EAS (0.2%) (EAS, 2013). This suggested that the prepared soaps will have no adverse effect on cloth or skin.

Percentage of chloride

In his study, the percentage of chloride of the laundry soap prepared using UCOs is comparable to each other, and also with that of commercial soaps used in the study

Table 4. The free caustic alkali contents of the prepared soap materials and commercial soaps used in the study.

Types of soap used	Free caustic alkalinity (%)
Soap product prepared from	
UCOs obtained from hotel	0.20±0.02
UCOs obtained from restaurant	0.22±0.03
UCOs obtained from street food vender	0.19±0.03
Commercial soap	
Sky	0.12±0.005
Lia	0.16±0.008
Picolo	0.19±0.01

Table 5. The % of chloride of soap prepared from UCOs and commercial soaps used in the study.

Types of soap used	Percentage (%) chloride
Soap product prepared from	
UCOs obtained from hotel	0.20±0.03
UCOs obtained from restaurant	0.12±0.01
UCOs obtained from street food vender	0.18±0.01
Commercial soap	
Sky	0.15±0.02
Lia	0.15±0.05
Picolo	0.12±0.03

(Table 5). The data are also below the data reported in literature (1.15%) [50], and also below the limit set by EAS (1.5%) (I Hautfenne, 1982).

Total alkali content

The obtained data for the prepared laundry soaps indicated that the total alkali to be in the range of 0.78±0.02% to 1.09±0.05% and that of the commercial soaps used in the test were in the range of 0.47±0.01% to 0.78±0.01% (Table 6).The data obtained for all the prepared soaps are slightly higher than the values obtained from commercial soaps used in the experiment (Table 6). The results obtained in the current study are all below the value set by ISO specification that states for soaps should have only below 2% of alkali content (ISO, 1975).

Total fatty matter

The TFM values of the prepared laundry soap samples were observed to be in the range of 75.42±0.96% to 88.53±1.25% whereas the TFM data of commercial soap samples were found to be in the range of 82.10±0.81% to 88.42±1.12% (Table 7). All the data are comparable to each other, and also with ISO specifications of laundry soaps (76%) (ISO, 1975), indicating that the prepared soaps have good or acceptable quality.

Cleaning action and lather formation of the prepared soaps

Cleansing power, bubbly, hardness, conditioning, creamy and lather formation are the main characteristics commonly used to evaluate quality of laundry soaps. These characteristics can be explained based on the fatty acid compositions of the oils used in soap formulation. For instance, the presence of saturated fatty acids such as lauric acid and myristic acids is known to produce soap with fluffy lather and high cleansing power (Phansteil et al., 1998). The cleaning powers of the soaps prepared from UCOs (of different sources) were tested on cotton clothes stained with Chicken sauce (*Doro wot*). The results showed that the soap obtained from UCOs that were collected from hotel, restaurant and street food vender to be medium, good and excellent, respectively (Table 8).

Table 6. The total alkali contents of the prepared soaps and the commercial soaps used in the experiment

Types of soap used	Total alkali (%)
Soap product prepared from	
UCOs obtained from hotel	0.78±0.02
UCOs obtained from restaurant	0.93±0.03
UCOs obtained from street food vender	1.09±0.05
Commercial soap	
Sky	0.47±0.01
Lia	0.78±0.01
Picolo	0.62±0.03

Table 7. Total fatty matter of the soap samples prepared from UCOs and that of commercial soap samples used in the study.

Types of soap used	Total fatty matter (%)
Soap product prepared from	
UCOs obtained from hotel	82.52±0.83
UCOs obtained from restaurant	88.53±1.25
UCOs obtained from street food vender	75.42±0.96
Commercial soap	
Sky	82.10±0.81
Lia	86.92±0.88
Picolo	88.42±1.12

Table 8. Cleaning power and lather formation of the prepared and commercial laundry soaps.

Type of soap used	Cleansing power	Lathering formation
Soap product prepared from		
UCOs obtained from hotel	Medium	Medium
UCOs obtained from restaurant	Good	Medium
UCOs obtained from street food vender	High	Good
Commercial soap		
Sky	Medium	High
Lia	Poor	High
Picolo	Medium	Good

Moreover, the cleaning powers of the soaps were found to be relatively better than that of commercial soap samples (Sky, Lia and Picolo) included in study. However, the results showed that only the soap sample prepared from UCO collected from street food vender showed comparable lather formation with that of Picolo soap. In this regard, Sky and Lia soaps were found to produce very high lather as compared to the prepared soaps (Table 8). The observed difference could be attributed to the method used for soap preparation and also natures (types) of fatty acid composition of the oils used in the soap preparations; some commercial soaps also have foam stabilizer which helps the foam to stay longer. Thus, fatty acid compositions of the oils (UCOs) used to prepare soap materials need to be determined before soap preparations in order get adequate chemical information about soaps to be prepared. The observed properties of the soaps prepared from UCOs are comparable with that of commercial soap samples used in the study, suggesting such oils can be used to prepare

(a) **(b)** **(c)**

Figure 3. Soap bars prepared from the UCOs collected from restaurant (a), street food vender (b) and hotel (c).

good grade laundry soaps (Figure 3).

Conclusions

Laundry soaps were prepared using UCOs obtained from hotel, restaurant and street food vender. The prepared soaps were found to show promising cleaning power and lather formation comparable to commercial soap samples purchased from local market. Analyses of physiochemical properties of the prepared soaps were comparable to those commercial soap samples and standards reported in literature. Comparability of the physicochemical properties (data) obtained for the prepared soaps and the commercial soap samples indicated that UCOs can be used to prepare laundry soaps of acceptable quality both in small and large scales. This has double advantage. One of the advantages is its use to minimize environmental pollution caused by UCOs; and the other one is replacing palm oil and animal fats in soap making which are going to be scarce (and expensive) in the near future because of their utilization as raw materials for biodiesel.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Adulkadir AG, Jimoh WLO (2013). Comparative analysis of physico-chemical properties of extracted and collected palm oil and tallow. ChemSearch Journal 4:44-54.

Akinhanmi TF, Atasie VN, Akintokun PO (2008) Chemical composition and physicochemical properties of cashew nut (*Anacardium occidentale*) oil and cashew nut shell liquid. Journal of Agriculture, Food and Environmental Science 2:11-10.

Akinola F, Oguntibeju O; Adisa W, Owojuyigbe S (2010). Physico-chemical properties of palm oil from different palm oil local factories in Nigeria. Journal of Food and Agriculture and Environment 8:264-269.

Akinyeye RO, Adeyeye EI, Fasakin O, Agboola A (2011). Physico-chemical properties and anti-nutritional factors of palm fruit products (Elaeis Guineensis Jacq.) from Ekiti State Nigeria. Electronic Journal of Environment, Agriculture and Food Chemistry 10:2190-2198.

Alemayehu G, Abile T (2014). Production of biodiesel from waste cooking oil and factors affecting its formation: A review. International Journal of Renewable and Sustainable Energy 3:92-98.

American Oil Chemists' Society (AOCS) (1997). Official and recommended practices of the AOCS. 7th Edition, AOCS Press Publication, Champaign.

Anyasor N, Ogunwenmo O, Oyelana A, Ajayi D, Dangana J (2009). Chemical analysis of groundnut oil. Pakistan Journal of Nutrition 8: 269-272.

Araujo CD, Andrade CC, Silva ES, Dupas FA (2013). Biodiesel production from used cooking oil: A review. Renew. Sustain. Energy Reviews 27:445-452.

Arifin SF (2009). Production of biodiesel from waste cooking oil and Rbd palm oil using batch transesterification process, University Malaysia Pahang, Thesis.

Arjun B; Chhetri K; Chris W, Rafiqul I (2008). Waste cooking oil as an alternate feedstock for biodiesel production. Energies 1:3-18.

Atiku FA, Fakai M, Kebbi, AB, Birnin-Yauri AU, Musa, MA (2014). Production of soap using locally available alkaline extract from Millet Stalk: A study on physical and chemical properties of soap. International Journal of Advanced Research in Chemical Science 1:1-7.

Babatunde OA, Bello GS (2016). Comparative assessment of some physicochemical properties of groundnut and palm oils sold within Kaduna metropolis, Nigeria. Journal of Applied Chemistry 9:26-30

Bazmi AA, Zahedi G, Hashim H (2011). Progress and challenges in utilization of palm oil biomass as fuel for decentralized electricity generation. Renewable and Sustainable Energy Reviews 15:574-583.

Bernard R, Gardner, John G (1990). Euro. Pat. 0381355 A2, Filter corp, Inc.

Betsy KJ, Mary J; Reshma F, Jaya TV (2013). Determination of alkali content and total fatty matter in cleansing agents. Asian Journal of Science and Applied Technology 2:8-12.

Carlos A, Guerrero F, Guerrero-Romero A, Fabio Sierra E (2011). Biodiesel Production from Waste Cooking Oil, Biodiesel - Feedstocks and Processing Technologies, Margarita Stoytcheva and Gisela Montero, IntechOpen, DOI: 10.5772/25313. Available from: https://www.intechopen.com/books/biodiesel-feedstocks-and processing-technologies/biodiesel-production-from-waste-cooking-oil.

CODEX (1969). Alimentarius Commission. Recommended international standards for edible Arachis oil. Food and Agricultural Organization of the United Nations. World Health Organization, Geneva-Switzerland.

Dennis RT, Kevin PG (1988). US Pat. 4735815, Harshaw/Filtrol.
Dimple SA, Rean M, Nazim M, 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.
Gomez CP, Machado APC (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.
Grain (2007). Corporate power: The palm-oil biodiesel nexus. https://www.grain.org/article/entries/611-corporate-power-the-palm-oil-biodiesel-nexus.
Gunstone FD, Harwod JL, Padley FB (1986). The lipid Handbook. Chapman and Hall Limited London pp. 236-261.
Hautfenne A (1982). Standard methods for the analysis of oils, fats and derivatives. 6th Edition 1st Supplement: Part 5. Pure and Applied Chemistry 54:1257-1295.
Head SW, Swetman AA, Hammonds TW (1995). Small-scale vegetable oil extraction. Natural Resources Institute, Kent, United Kingdom P 80. https://www.changemakers.com/discussions/entries/recycle-used-cooking-oil-eco-soaps-and-biodiesel Recycle used cooking oil into eco-soaps. (Downloaded on 30 August, 2019).
Nielson SS (1994). Introduction to the chemical analysis of foods. Chapman and Hall, New York pp. 93-207.
Kazuo S, Kasukabe J (1989). US Patent 5000870, Mimasu Oil Chemical Co., Ltd.
Khalisanni K, Khalizani MS, Khalid PO (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 ST (2005). 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, Arzika T (2012). Physicochemical properties of some commercial groundnut oil products sold in Sokoto Metropolis, Northwest Nigeria. Journal of. Biological Science 4:17-24.
Nawal A, Shaista A, 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.
Nkafamiya I, Maina M, Osemeahon A, Modibbo U (2010). Percentage oil yield and physiochemical properties of different groundnut species (*Arachis hypogaea*). African Journal of Food Science 4:418-421.
Hazwani Nor A, Sulaiman HH, Nurrul RMY (2013). Biodiesel production based on waste cooking oil (WCO). International Journal of Materials Science and Engineering 1:95-99.
Odoom W, Edusei VO (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 MU, Kamalu CIO (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 SU (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.
Onyekwere C (1996). 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
Panadare DC, Rathod VK (2015). Applications of waste cooking oil other than biodiesel: A Review. Iranian Journal of Chemical Engineering 12:55-76.
Pavila LD, Lapman GM, Krisz GS (1982). Introduction to organic laboratory techniques. 2nd Edition, Saunders College Publishers, England.
Peters D, Toop G, van den Bos A, Spöttle M (2013). Assessing the EC ILUC proposal "Dutch national ILUC Impact Assessment". ECOFYS Netherlands BV. Utrecht: ECOFYS Netherlands BV.
Phansteil ON, Dueno E, Xianghong WQ (1998). Synthesis of exotic soaps in the Chemistry laboratory. Journal of Chemical Education 75:612-614.
Pocknell TM, Venni AK (2010). US Patent. 20100313839 A1, Tony Michael Pocknell, Adrian Kurt Venni.
Potgieter H, Potgieter SS, Tona DD, Anelich L, Roux MP, Delport W (2004). A proposed alternative suggestion for the disposal of used cooking oil. Journal of Applied Science 4:313-316.
Riera JB, Rafael M, Guardiola F (2000). Recycled cooking oils: Assessment of risks for public health, European Parliament, Directorate General for Research Directorate A, The STOA Programme.
Rudy P (2006). Rendered fats and oils as a biodiesel feedstock Industry faces opportunities, challenges in sustaining growth. Biofuel 17:431-433.
Sani NA, Hassan LG (2007). Preparation and analysis of the physical and chemical properties of from *Lageneria siceraria* (bottle ground) seed oil, 2007.
Schuman K, Siekman K (2005). Soap in Ullmanna's. Encyclopedia of industrial Chemistry. Wiley-VCH, Weinheim.
Shoge MO (2011). Quality of soaps using different oil blends. Journal of Microbiology and Biotechnology Research 1:29-34
Silva RCFS, Almeida DG, Luna JM, Rufino RD, Santos VA, Sarubbo LA (2014). Applications of biosurfactants in the petroleum industry and the remediation of oil spills. International Journal of Molecular Science 15:12523-12542.
Sonja V, Nathalie G (2006). Towards better practice in smallholder palm oil production. International Institute Environment and Development.
Taiwo A, Oluwadare I, Shobo A, 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, ISO 685 (1975). https://www.complianceonline.com/analysis-of-soaps-determination-of-total-alkali-content-and-total-fatty-matter-content-standards-809484-prdp
Tincliffe H, Webber DO (2012). Deforestation and the problem of palm oil. The Chemical Engineering 858:24-25.
Vivian OP, Nathan O, Osano A, Mesopirr L, Omwoyo WN (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, 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, Atiku F (2011). Soap preparation from Soxhlet extracted Nigerian cotton seed oil. Pelagia Research Library 2:617-623.
Yourself M, Nateghi L, 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.