PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (5) 1393-1406 May 2024

Assessment of Physicochemical Properties of Laundry Soaps Prepared From Mango and Avocado Seed Oils and Their Blends: Giving Attention to Fruit Left Overs

***LEGESSE, A; MENGISTEAB, M**

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

**Corresponding Author Email: adanelegesse@gmail.com*
**ORCID: https://orcid.org/0000-0001-5153-6946*
**Tel: +00251916395678*

Co-Author Email: mengisteabmathewos@gmail.com

ABSTRACT: It is a common practice to use oils extracted from fruits seeds for soap making. The oils are non-edible to avoid food competition. The objective of the present study was to assess the possibility of preparing a soap of acceptable quality from oils extracted from seeds of Avocado and Mango. The ground Avocado and Mango seeds were subjected to Soxhlet extraction technique using n-hexane as an organic solvent. The oil yield of 2.43% and 1.32% were obtained for Avocado seed and Mango seed samples, respectively. The analyses of the physicochemical properties such as saponification value, acid value, percent free fatty acid, and relative density were found to be 25.245 and 84.15, 30.86 and 30.85, 6.26 and 6.26, 0.87 and 0.83, respectively, and the data were in favor of utilization of the oils in soap making. Moreover, the blends of extracted Avocado and Mango seed oils in a 1:1, 3:1 and 1:3 ratios (by mass) revealed Saponification values of 151.47, 162.69, 214.62, respectively; total fatty matter contents of 59±1.41, 63 ± 1.41, 67±1.41, respectively; total alkali contents of 1.44 ± 0.03, 1.715 ± 0.08, 1.77 ± 0.13, respectively. The pH values of soaps prepared from the two oils and their blends were found to be in the range of 9.6-10.15. The data are comparable to commercial soaps and also suggest that the prepared soaps from the extracted oils can be used for cleaning purpose without any harm on human skin.

DOI: https://dx.doi.org/10.4314/jasem.v28i5.9

Cite this Article as: LEGESSE, A; MENGISTEAB, M. (2024). Assessment of Physicochemical Properties of Laundry Soaps Prepared From Mango and Avocado Seed Oils and Their Blends: Giving Attention to Fruit Left Overs. *J. Appl. Sci. Environ. Manage.* 28 (5) 1393-1406

Dates: Received: 21 February 2024; Revised: 22 March 2024; Accepted: 20 April 2024 Published: 19 May 2024

Keywords: Saponification; Avocado Seed Oil; Mango Seed Oil; Saponification Value; Total Fatty Matter

Soap is one of the commonly used products that are used in human day to day life to clean and wash skin and clothing. It is prepared by a process called saponification reaction. The process involves heating of animal fat ((lard and tallow) or vegetable oils (e.g., coconut oil, palm oil and olive oil) with alkali solutions (of KOH or NaOH) in alcohol (e.g., ethanol) that results in salt (soap) and glycerol (Hassan *et al*., 2015; Peter *et al*., 2015; Warra, 2013). As mentioned above, raw animal fats are used to prepare soaps (Peter *et al*., 2015; Warra, 2013). However, the use of these raw materials is becoming difficult for several reasons. Some of the reasons are (a) they are used for biodiesel in developed countries to satisfy their energy demand (Thoenes, 2006; Rudy, 2006; Fiedel *et al*., 2020) (b) animal fats/soaps from such fats cannot be stored for a long time because they easily oxidized when exposed to air and give bad smell (Flavia *et al*., 2014); (c) getting certificate from regulatory agencies for qualities of such fats is a big problem (Heena *et al*., 2013) and (d) fats produce offensive odors in soap manufacturing factories and the surrounding community where the factory is established (Jerome, 1961). Oils obtained from fruits/seeds of plants are also used as alternative inputs for soap preparations in soap industries. Some of the examples are olive oil,

**Corresponding Author Email: adanelegesse@gmail.com*
**ORCID: https://orcid.org/0000-0001-5153-6946*
**Tel: +00251916395678*

coconut oil, palm oil, castor seed oil soap, Jatropha seed oil soap, Neem seed oil, etc.(Peter *et al*., 2015; Warra, 2013; Warra *et al*., 2014). Among the aforementioned oils, palm oil has been widely used as fatty raw material in the manufacture of soap (Warra, 2013). However, palm oil could not be used sustainably in the near future unless some alternative vegetable oils are found today. Some of the factors are (i) increasing demand of palm oil (75 million tons/year by 2050 (for biodiesel in developed countries in their energy sectors (Grain, 2007; Tincliffe and Webber, 2012http://www.intracen.org/uploadedFiles/intracenorg/Content/About_ITC/Where_are_we_working/Multicountry_programmes/Pact_II/Palm%20Oil%20Report%202012.pdf; Helena *et al*., 2019; https://news.mongabay.com/2013/09/europe-importing-more-palm-oil-for-biofuels-raising-risks-for-rainforests); (ii) use of for cooking to prepare healthier foods that competes its use for soap preparation (Hakimah *et al*., 2022) and (iii) only two countries Malaysia and Indonesia export 87% palm oil to the world market (Murphy, 2015; Murphy, 2014; Bazmi *et al*., 2011; https://www.innovhub-ssi.it/kdocs/1990284/animal_fats_for_non-food_uses._a_review_of_technology_and_critical_points.pdf;). Such factor resulted in the decline of the use of palm oil in soap manufacturing industries. It is important to note that continuous supply of the oil from the exporting countries cannot be taken for granted as economic or political situations may lead to interruption of the importation of the oils from exporting countries. So, the risk of importing countries to be economic and political dependent on those exporters is quite high in the future unless alternatives are considered in advance. Ethiopia is one of palm oil importer countries for its soap industries and other uses. For instance, the country has imported 222,142 tonnes by 2010 from Indonesia and Malaysia (Ethiopian Investment Agency, 2012), and recent reports revealed that the annual import has increased to about 350 million tonnes (https://snv.org/update/bridging-gap-between-demand-and-supply-edible-oil-ethiopia). These data also showed that the quantity and price of palm oil being imported is increasing from time to time imposing a huge budget allocation to the limited economy of the country. Thus, it is a must to look for alternative vegetable oil sources (such as Mango seed oil, Avocado seed oil) for soap preparation. Though there are few reports on the extraction and characterization of Mango and Avocado seed oils as well as use of Mango seed oils as components of home-made soap products, there are no reports on the use of Avocado and Mango seed oil blends in soap making from Ethiopia. Moreover, similar to elsewhere in the world (1 million tonne mango seed discarded)(Arogba, 1997), in different cities of the Ethiopia Avocado and Mango seeds are discarded to environment as wastes after using these fruits for making juices. Thus, this study was initiated to carry out extraction; characterization of oils and preparation of laundry soap from the oils and blends of the oils extracted from seeds of Avocado and Mango varieties of Ethiopia where these fruits are available in abundance or produced in large quantities (Messay and Shimelis, 2012; Takele, 2014; Berhanu, 2013; Edossa, 1997; Zekarias, 2010; Abduselam, 2016).

MATERIALS AND METHODS

Chemicals and reagents: The following are the chemicals and reagents used for the study. These are n-hexane (AR), Potassium hydroxide (AR), Phenolphthalein indicator solution, hydrochloric acid (AR), glacial acetic acid, ethyl alcohol, sodium hydroxide (AR), Potassium dichromate (AR), Chloroform (AR), Nitric acid, Methyl Orange indicator solution.

Preparation of plant material and oil extraction: The 5-6 kg (each) of Avocado and Mango seeds were collected from cafes and restaurants. The seeds were air dried at room temperature in shade without exposing to direct sun light. The dried seeds were crushed using mortar and pestle and grinder (Starlux sl-1304, 220v 200W coffee grinder) to reduce the size of the sample in order to make it suitable for the oil extraction of the seeds. The oil extraction was done using n-hexane as solvent employing Soxhlet extraction technique (Extractor Soxhlet B50/42 8sec 200/63). Finally, the solvent was removed from the extracted oils under reduced pressure using rotary evaporator and the remaining solvent residues were removed by heating the oil extract in a water bath at 40^0C for 2 hrs. The extracted oil samples were stored in a refrigerator at ≤ 4^0C until used for subsequent physicochemical analyses and soap preparation (Warra, *et al*., 2014).

Study of physicochemical properties of the seed oils

Determination of saponification value: The oil samples were filtered through a filter paper to remove any impurities and the last traces of moisture. The oil samples were dried, and were mixed thoroughly. 2.0 g of each dry plant material was weighed and transferred into a 250 ml Erlenmeyer flask. Then 25 ml of alcoholic potassium hydroxide solution was pipetted into the flask. A blank determination was conducted in parallel. The flasks containing the oil samples and the blank were connected with reflex condensers, keeping on the water bath. The flasks were boiled gently but steadily until saponification was completed, as was indicated by absence of any oily matter and appearance of clear solution. After the flask and condenser have cooled, the inside of the condenser was washed down with 10 ml of hot ethyl alcohol neutral to phenolphthalein. The excess potassium hydroxide was titrated with 0.5N hydrochloric acid, using about 1.0 ml phenolphthalein indicator (AOAC, 2000).

$$SV = \frac{5.81\,(B - S)N}{W} \quad (1)$$

Where, SV = saponification value; B = Volume in ml of standard hydrochloric acid required for the blank. S = Volume in ml of standard hydrochloric acid required for the sample, N = Normality of the standard hydrochloric acid and W = Weight in gm of the oil taken for the test.

Determination of acid value: A 0.5 g of the cold oil sample was put into a 250 ml conical flask and then100 ml of freshly neutralized hot ethyl alcohol and about 1ml of phenolphthalein indicator solution were added into the flask that contain the oil sample. The mixture was boiled for 5-6 minutes and it was titrated while hot against 0.5 N standardized potassium hydroxide solutions shaking vigorously during the titration until the pink color disappeared (ISO660, 1996).

$$Acidic\ Value = \frac{56.1\ \mathrm{VN}}{W} \quad (2)$$

Where, V = Volume in ml of standard potassium hydroxide used; N = Normality of the potassium hydroxide solution and W = Weight in g of the sample. The acidity is frequently expressed as free fatty acid (Eqn. 3)

Acid value = Percent fatty acid (as oleic) x 1.99.

$$FFA\ (\%) = \frac{28.2\ VN}{W} \quad (3)$$

Where FFA = fatty acid as oleic acid

Determination of relative density of the extracted oils: About 10.0 ml of oil sample was taken in a measuring cylinder of a known weight. The weights of both the oils and the cylinder were also measured. The weight of the oil was obtained by subtracting the weight of the cylinder from the weight of both the oil and measuring cylinder, and its density was determined (John, 2003).

$$\text{Density of the Oil} = \frac{W1 - Wo}{Vo} \quad (4)$$

Where, W1= weight of measuring cylinder and the oil, W0= weight of measuring cylinder, and V0= volume of the oil sample used in the experiment.

GC-MS analysis of composition of the extracted oils: The GC-MS analyses of the extracted seed oils, obtained from the Ethiopian Mango and Avocado varieties, were done at The Department of Chemistry, Addis Ababa University, Ethiopia. The data were compared with literature reports on percent yields of oil extracts of Avocado and Mango seed varieties outside Ethiopia. The oil samples were first, subjected to transesterification using methanol and standard procedures reported in literature (Atilla, *et al*., 2015) in order to determine their chemical compositions using GC-MS analyzer. The transesterification reaction was carried out in a 250ml flat-bottomed flask, equipped with a magnetic stirrer heater, thermometer and spiral reflux condenser. Before starting the reaction, a 0.75g of sodium hydroxide (NaOH) according to chosen catalyst concentration was dissolved in a 30ml of methanol. In the flat bottomed flask, this alcoholic solution was added to the 50g oil that was formerly warmed to about 80^0C in a beaker. These reactants were mixed at 80^0C for about 40minutes with stirring speed of 500 rpm by means of the magnetic stirrer heater. At the end of the reaction, the resulting product mixture was transferred to a separatory funnel. After a day, two phases occurred in the separatory funnel. The upper phase consists of methyl esters (oil) while the lower one consists of glycerol, excess methanol and the remaining catalyst together with soap. The two layers were separated and then the upper layer (oil) was washed with warm distilled water. The washed oil was heated up to about 100^0C to remove methanol and water residuals (Atilla, *et al*., 2015) GC-MS analyses of the Avocado and Mango seed oils, obtained from the Ethiopian varieties, were done and compared with literature reports about chemical compositions of Avocado and Mango seed oil varieties of outside Ethiopia.

Soap preparation: Soaps were prepared using Avocado oil, Mango oil and blends of the two oils in different ratios (1:3, 1:1 and 3:1 by mass) by heating the oils with sodium hydroxide (NaOH) and solvent ethanol following standard procedure of soap preparation reported in literature (Hassan, *et al*., 2015). Similar procedure was used to prepare soap from palm oil for the sake of comparison. The oils sample (10g) was into a 250ml beaker. A 30 ml of ethanol and 30 mL of 20 % NaOH were added to the beaker containing the oil. A small magnetic stir bar was added to the beaker and the mixture was heated and stirred on a magnetic stirrer-hotplate. The mixture was heated (with constant stirring) for 30 minutes, until the solution no longer had two separate layers. The solution became transparent at this point. In order to make sure that the volume does not decrease too much, the 5 mL portions of a mixture containing equal volumes of ethanol and water was added to the beaker. When the saponification was completed, the beaker was carefully removed from the heat. The soap solution was poured into the beaker containing the 50ml saturated salt solution and was then stirred with a stirring rod. This process is called "salting out". It increases the density of the solution and causes the soap to precipitate and float on the surface of the solution. The beaker was placed in an ice water bath until it reached the approximate temperature of the bath. In a separate container, 20 mL of distilled water was chilled to rinse the solid collected in the funnel. The soap curds were collected by vacuum filtration with an aspirator.

Study of physicochemical properties of prepared soaps: The physicochemical properties of soaps determine their quality as well as their efficiency and cleansing properties. Thus, the physicochemical properties (total fatty matter content, total alkali content, pH, lathering and cleaning abilities) of the prepared soaps were carried out following standard procedures reported in literature (Hassan, *et al*., 2015; Betsy, *et al*., 2013; Warra *et al*., 2012; Warra *et al*., 2010)

Determination of the Total Fatty Matter: Five (5) g of soap sample was dissolved in 100ml hot water and 40ml of 0.5N HNO_3 was added to make it acidic. The mixture was heated until fatty acids were floating as a layer above the solution. It was cooled in ice water to solidify the fatty acids. The fatty acids were separated and the aqueous solution was treated with 50ml chloroform to remove the remaining fatty acids from the aqueous phase. The separated fatty matter was mixed together, solvent was evaporated and the yield was noted (Betsy *et al*, 2013). The total fatty matter was determined.

$$\%Fatty\ Matter = \frac{(Y - X) * 100}{\text{Weight of } soap\ sample} \quad (5)$$

Where x = Weight of the china dish; y = Weight of china dish + Soap after drying; and Weight of soap sample = 5 g

Determination of the Total Alkali Content: The 5 g of soap sample was dissolved in 100 ml hot water. Then 40 ml of 0.5N HNO_3 was added to make mixture acidic. The mixture was heated until fatty acids were floating as a layer above the solution. It was cooled in ice water to solidify the fatty acids. The fatty acids were separated from the aqueous phase and the aqueous solution was treated with 50ml chloroform to remove the remaining fatty acids. The aqueous solution was measured and 10ml of it was titrated against 0.5N NaOH using methyl orange as indicator. The total alkali content was calculated from the titer value using equation 6 in the method of Betsy *et al*, 2013 to obtain percent alkalinity.

$$\text{\% of alkalinity} = \frac{(Y\ x100)}{w} \quad (6)$$

pH determination: The pH of the prepared soap was determined using a pH meter (Model; PHS-3C DC-6V 300mA) employing standard procedure (Warra *et al*., 2012). The 5 g of the soap shavings were weighed and dissolved in distilled water in a $100cm^3$ volumetric flask. The electrode of the pH meter was inserted into the solution and the reading was recorded.

Foam -ability test: The 2 g of the soap (shavings) were added to a $500cm^3$ measuring cylinder containing $100cm^3$ of distilled water. The mixture was shaken vigorously so as to generate foams. After shaking for about 2 minutes, the cylinder was allowed to stand for about 10 minutes. The height of the foam in the solution was measured and recorded (Warra *et al*., 2012)

Test for effectiveness in cleaning: To determine cleaning property of the prepared soap, a drop of grease oil was placed on four separate strips of filter paper. These filter papers were then immersed in a separate test tube containing soap solution (2 g of soap sample in 100 ml distilled water). Each test tube was shaken vigorously for 1 minute. The filter papers were removed and rinsed with distilled water, and then the extent degree of cleanliness in each filter paper was observed (Hassan, *et al*., 2015).

RESULTS AND DISCUSSION

Oil extraction and determination of oil contents: It has been reported that seed oil extraction using Soxhlet extraction technique to be standard method. Its advantage is that the sample (the plant material) is repeatedly brought into contact with the fresh portions of the solvent. This repeated contact, thus, increases ability of the solvent to overcome forces that bind lipids within the sample matrix, and ultimately increasing the yield of oil (Lumley and Colwell, 1991). Moreover, n-hexane is recommended as an organic solvent in such a method as it is evaporated easily from the extracted oil, and giving good quality oil. The percentage yields (Table 1) of the oils obtained from the Mango and Avocado seeds were determined by dividing total mass of oil from each seed type by total mass of seeds used for extraction (in a batch).

$$Oil\ content\ (\%) = \frac{Weight\ of\ oil}{\text{Weight of sample}} * 100 \quad (7)$$

It is a fact that determination of oil content in seeds is very important as it helps to predict the potential of a particular seed as sources of oil (or oil seed). High oil content in seeds implies that processing it for oil production would be economically viable (Ikhuoria *et al*, 2008). The oil yields obtained in the present study from Avocado and Mango seed oils were 2.41% and 1.35%, respectively (Table 1). The Mango oil yield obtained in this study is lower than 8.10 ± 0.07% reported for persea Americana seed oil (Banji, *et al*., 2016) but comparable to the oil yield reported for persea Americana (Evwierhoma and Ekop, 2016).

Table 1. The oil yields of Avocado and Mango seeds obtained in the present study

Sample	Weight of Sample (g) used	Weight of oil (g)	Percent Yield (%)
Avocado seeds	2264.88	54.5	2.41
Mango Seeds	4420.75	59.75	1.35

The oil content of agricultural products such as fruits and seeds determines largely whether oil can be industrially processed from them or not (Bwade, *et al*., 2013). According to FAO, seeds that contain oil yield greater than 17% are considered as oil seeds (Akinoso and Raji, 2010). The Avocado seed and the Mango seeds are, therefore, not recommended for the purpose of edible oil generation and biodiesel production due to the very low oil yield.

Table 2. The physical characteristics of extracted Mango and Avocado seed oils

Parameters	Mango seed oil	Avocado seed oil
Color	Yellow	Brown-red
Odor	Fruity	Fruity
Physical state	Liquid	Liquid

Physicochemical analysis of the extracted seed oils: The physicochemical analysis of the extracted seed oils as well as their blends (in different proportions) were carried out following standard methods reported in literature (AOAC, 2000; ISO660, 1996; John 2003) in order to assess their qualities. The analyzed physicochemical properties were saponification values, acid values, % free fatty acids and densities (Table 3).

Saponification value: The saponification value is an index of mean molecular weight of the fatty acids of glycerides comprising a fat. It is the number of mg of potassium hydroxide required to saponify 1 gram of oil/fat (AOAC, 2000). This value gives information concerning the character of the fatty acids of the fat/oil. The long chain (higher molecular weight) fatty acids found in fats have low saponification value because they have a relatively fewer number of carboxylic functional groups per unit mass of the fat. Oils with high saponification values such as coconut oil (257.0 mg KOH/g) and palm oil (199.1 mg KOH/g) are better used in soap making. Soap manufacturers blend their oils with coconut oil because of its high saponification value. When it is blended with castor oil, then saponification number of the blend is higher than castor oil. The higher saponification value justifies the usage of particular oil product for soap production (Debesh, 2013). In the present study, the saponification value of Mango seed oil was found to be 84.15±2.11mg KOH/g (Table 3) which is higher than the seed oil reported for *Mangifera Indica* (71.52 mg KOH/g) (Taiwo *et al*., 2008) The data indicated that Mango seed oil had high enough saponification value, and could be utilized industrially for soap production if extracted in large scale. On the other hand, the saponification value of Avocado seed oil (in this study) was found to be 25.25±1.06mg KOH/g. The value was lower than reported for sheanut fat (36.32±1.9 mg KOH/g) and *Jatropha curcat* L (122.49 ± 2.6 mg KOH/g) (Taiwo *et al*., 2014). The relatively low saponification value of this oil may imply its poor suitability for the production of soaps (if used alone).

Acid value: The acid value is the number of milligrams of potassium hydroxide required to neutralize free fatty acids present in one gram of fat or oil (ISO660, 1996). It is a relative measure of rancidity as free fatty acids are normally formed during decomposition/hydrolysis of oil glycerides due to the action of moisture, temperature or heat and/or lypolytic enzyme lipase (ISO660, 1996). This value can also be expressed as percent of free fatty acids calculated as oleic acid.

It can be determined directly by titrating the oil in an alcoholic medium against standard potassium hydroxide/sodium hydroxide solution. The lower the acid value of oil, the fewer free fatty acids it contains which makes it less susceptible to rancidity. The acid values obtained in this study for Avocado and Mango seed oils were 30.855 mg KOH/g and 30.860 mg KOH/g, respectively (Table 3). These values are higher than the acid value reported for Avocado pear oil (16.80 mgKOH/g) (Akubugwo *et al*., 2008) and 17.82±0.22 mg KOH/g) (Oluwole *et al.,* 2013)**..**

Table 3. Physicochemical characteristics of the extracted Avocado and Mango seed oils

Types of oil	Saponification value (mg KOH/g)	Acid value	% Free fatty acid (as oleic acid)	Density (g/ml)
Avocado seed oil	25.25±1.06	30.86±1.15	15.08±0.58	0.87±0
Mango seed oil	84.15±2.11	30.86±1.89	14.82±0.95	0.83±0

Reports also showed that an oil with the lower acid content to be more appealing oil and suitable for consumption (Coenen, 1976; Orthoefer and List, 2007). However, the acid values obtained for both the Avocado and Mango seed oils suggest that these oils cannot be used for edible purpose (as acid values are greater than 0.1 mg KOH/g) (Orthoefer and List, 2007) and could be easily get rancid. But they can be used as raw materials (vegetable oil feedstock) for chemical industries such as biodiesel, soap, fatty acids, surfactants and detergents (Evwierhoma and Ekop, 2016). The percentage free fatty acid (FFA) value of an oil is also a crucial parameter in determination its quality. This is because the lower the FFA, the higher the quality of the oil especially in terms of its edibility (Banji *et al*., 2016). The percentage FFA obtained in this study for Avocado and Mango seed oils (Table 3) were lower than reported for breadfruit seed oil (38.85±3.34) (Akubugwo *et al*., 2008) but higher than reported (2.26±0.08) for Avocado seed oil (Banji *et al*., 2016). This suggests that such oils cannot be used as edible oils and also get rancid easily, and hence their storage needs precaution to minimize rancidity.

Density of the oils: Generally, oils are lighter than water. But there are some oil types denser than water, especially those oils that contain larger amounts of oxygenated constituents of the aromatic series. Most popular seed oils have specific gravity ranging from 0.91 to 0.94. Literature reports also revealed that specific gravity value of 0.92 to be considered a good number for any edible oil (Evwierhoma and Ekop, 2016). The relative densities obtained in this study for Avocado and Mango seed oils were 0.87 and 0.83 g/ml, respectively (Table 3). The relative density of the Avocado seed oil is 0.87 g/ml which was found to be comparable to the value (0.91±0.02 g/ml) reported for *Persea Americana* seed oil (Banji *et al*., 2016). The relative density of the Mango seed oil (0.83 g/ml) was found to be lower than reported value (1.995 ± 0.05 g/ml) of oils extracted from Mango (Olagunju, 2013). The results implied that Avocado and Mango seed oils are less dense than water, and could, therefore, be useful in cream production as this will make the oil spread easily on the skin.

Analysis of physicochemical properties of oil blends: The production of oils for specific applications has been commonly achieved by mixing of various plant oils (Sakurai and Pokorny, 2003). Mixing of Jatropha oil and coconut oil accompanied by heating causes the breaking of the carbon bond around the double bond. This happens because the electrons in the double bond move more freely, so the double bonds are more unstable and more easily to react (Wardana *et al.,* 2018). The properties of the Avocado and Mango seed oils can be improved by blending and heating the two oils together. The two oils were taken and different blends were prepared taking the two oils at a time in different proportions. The blended oil samples were analyzed for saponification value, acid value and free fatty acid (as Oleic acid) by varying the weight of the two oils taken keeping the weight of the mixture constant (Table 6). Analysis of saponification values revealed that the Avocado and Mango seed oil blends in 1:1, 1:3, 3:1 ratio to have saponification values of 151.47, 214.62 and 162.69 mg KOH/g), respectively (Table 5). Moreover, the data revealed that the oil blends have higher saponification values than the individual oils of Avocado and Mango seed oils which have 25.25 and 84.15 mg KOH/g, respectively (Table 5). This might be due to the formation of short chain fatty acids from long chain polyunsaturated fatty acids while mixing and heating the two oils together. Among the mixtures (blends), the one with Avocado and Mango in a 1:3 ratio (by mass) have higher saponification value than the 1:1 and the 3:1 ratio. The saponification values obtained in this study for the two oil blends showed that the values are comparable with the saponification value of Palm oil (126.22mgKOH/g) reported in literature (Ekop *et.al*., 2007). The saponification value of the palm oil was

126.22mgKOH/g. When the carrot, paw paw, lime and dye were mixed with different samples of the oil, the saponification value was increased to 126.88 mgKOH/g, 134.64 mgKOH/g, 131.86 mgKOH/g and 141.62 mgKOH/g, respectively. There was a significant difference between the saponification value of pure palm oil and when it is blended with lime, Carrot, Parrot and dye, respectively (Ekop *et al*., 2007). The saponification value of the oil blends revealed that the oil blends can be better used in soap production than using the individual oils**.**

Table 4. Physicochemical properties of the oil blends

Types of oil	Ratio of oils (by mass)	Saponification value	Acid value	%Free fatty acid as Oleic acid
Avocado + Mango seed oils	1:1	150.86±0.86	31.94±2.44	16.03±1.22
Avocado+ Mango seed oils	1:3	212.56±2.91	22.36±0.06	11.22±0.03
Avocado + Mango seed oils	3:1	161.99±0.99	22.48±1.53	11.30±0.79

The acid values of the blends were also analyzed. The results/data from the study revealed that the acid values to be 33.66, 22.40, 23.56 mg KOH/g for Avocado and Mango seed oil blends in a 1:1,1:3 and 3:1 ratio, respectively (Table 4). The observed data for the oil blends indicated that the acid values are higher than the acceptable limit of edible oil but are useful in soap production.

The low acid value signifies a maximum purity and makes it suitable for soap production (Hassan *et al*., 2015). The acid value obtained for the 1:3 and 3:1 blends (Table 4) are lower than the acid value obtained for Avocado and Mango seed oils (Table 4). But the 1:1 oil ratio of Avocado and Mango (Table 4) revealed higher acid value than the Avocado and Mango seed oils (Table 4), and also higher than the other two oil blends which imply that the 1:1 ratio is less appealing in soap production as compared to the other ratios.

GC-MS Analysis: The analysis of the fatty acids in the extracted Avocado and Mango seed oils (Ethiopian varieties of the fruits) samples were carried out using the GC-MS analyzer (Agilent) in order to detect their fatty acid compositions. The GC-MS analysis data (Table 5) revealed that Avocado seed oil consist of some important fatty acids. These include lauric acid (1.32%), myristic acid (3.24%), palmitic acid, methyl palmitate (15.65%), oleic acid (29.39%), linoleic acid (34.98%), linolenic acid (2.14) and eicosanoic acid (4.22%). These values are comparable to that of fatty acid composition of Avocado seed oil (reported in literature) which consists of linoleic acid (12%), oleic acid (58%), palmitic acid (20%), and stearic acid, (2%) and also comparable with palm oil (linoleic acid 10%, oleic acid 39%, palmitic acid 44% and stearic acid 5%) (Peter *et al*., 2015).

Table 5. The major fatty acids derived from hexane extract of Avocado seed oil

S.No	Name of the fatty acid	MF	MW	RT	SI %	Content (%)
1	Lauric acid	$C_{13}H_{26}O_2$	214.34	8.326	98	1.32
2	myristic acid ,methyl ester	$C_{14}H_{34}O_2$	270.45	9.886	98	3.24
3	palmitic acid, methyl palmitate	$C_{17}H_{34}O_2$	270.45	11.488	89	15.65
4	palmitic acid, ethyl palmitate	$C_{18}H_{36}O_2$	284.48	12.08	99	2.02
5	Oleic acid methyl ester	$C_{19}H_{36}O_2$	296.49	13.412	99	29.39
6	Linoleic acid	$C_{19}H_{34}O_2$	294.47	13.493	99	34.98
7	Linolenic acid	$C_{19}H_{32}O_2$	292.46	13.654	99	2.14
8	Eicosanoic acid, methyl ester	$C_{21}H_{40}O_2$	324.54	16.211	99	4.22

M.F.=Molecular formula, M.W. = Molecular weight, RI= Retention time, SI% = Similarity index.

The GC-MS analysis of Mango seed oil of the Ethiopian variety revealed the fatty acid composition to be lauric acid (1.17%), myristic acid (2.79%), palmitic acid, methyl palmitate (13.67%), oleic acid (29.53%), linoleic acid (30.85%), linolenic acid (1.90), phthalic acid (7.10%) and eicosanoic acid (3.8%) (Table 6). It has been reported that Mango seed oils consist of major fatty acids that include stearic

(37.73%), palmitic acid (6.43%), oleic (46.22%), linoleic (7.33%) and linolenic acids (2.30%). The types of fatty acids compositions of Mango seed oil extracted from Ethiopian variety were found to be comparable with that of Mango seed oil and palm oil reported in literature (Joosten, 2007; Peter *et al*., 2015; Kittiphoom and Sutasinee, 2013). The data, thus, suggest that the oils can be used for preparation of soap products.

Table 6. The major fatty acids derived from hexane extract of Mango seed oil.

S.No	Name of the fatty acid	MF	MW	RT	SI %	Content (%)
1	Lauric acid	$C_{13}H_{26}O_2$	214.34	8.312	98	1.17
2	myristic acid ,methyl ester	$C_{14}H_{34}O_2$	270.45	9.873	98	2.79
3	palmitic acid, methyl palmitate	$C_{17}H_{34}O_2$	270.45	11.474	89	13.67
4	palmitic acid, ethyl palmitate	$C_{18}H_{36}O_2$	284.48	12.05	99	1.74
5	Oleic acid methyl ester	$C_{19}H_{36}O_2$	296.49	13.385	99	29.53
6	Linoleic acid	$C_{19}H_{34}O_2$	294.47	13.466	98	30.85
7	Linolenic acid	$C_{19}H_{32}O_2$	292.46	13.627	99	1.90
8	Phthalic acid ,di(2propylpentyl) ester	$C_{24}H_{38}O_4$	390.56	14.831	91	7.10
9	Eicosanoic acid, methyl ester	$C_{21}H_{40}O_2$	324.54	16.184	99	3.80

Note: M.F.=Molecular formula,M.W.= Molecular weight, RI= Retention time, SI% = Similarity index.

The fatty acid type and compositions data of Avocado and Mango seed oils of the Ethiopian variety can also be compared using graph. The oils have comparable oleic acid contents of 29.39% (Avocado oil) and 29.53% (Mango oil). The Lauric acid, myristic acid, palmitic acid, Linoleic acid, Linolenic acid contents were found to be 1.32% and 1.17%, 3.24% and 2.79%, 15.65% and 13.67%, 34.98% and 30.85% and, 2.14% and 1.90%, respectively, for Avocado and Mango seed oils (Table 6). The value obtained for the major fatty acid compositions revealed that Avocado seed oils have higher fatty acid composition (with higher molecular mass) than the fatty acid compositions obtained for Mango seed oils of the Ethiopian variety. This could imply that the relatively higher molecular mass composition of Avocado seed oils than that of Mango seed oils made it to have lower saponification value than Mango seed oils.

Preparation of Soaps and assessment of their properties: Soap preparation: Soap is sodium or potassium salt of fatty acids that is prepared by a process known as saponification. It can be prepared by treatment of fat/oil with a solution of sodium hydroxide or potassium hydroxide. The oils could be obtained from oil-rich fruits (seeds) such as coconut, palm oil and olive oil. In line with this fact, oils (and their blends) extracted from Avocado and Mango varieties of Ethiopia were used to prepare laundry soaps. They were prepared by using Avocado seed oil (Figure 1A) and Mango seed oil (Fig 1B), blends of Avocado and Mango seed oils in a 1:1 ratio by mass (Fig 1C), 1:3 ratio by mass (Fig 1D), 3:1 ratio by mass (Fig 1E) using the procedure mentioned in the Experimental Section.

The physicochemical properties of prepared soaps: The physicochemical properties of soaps determine their quality as well as their efficiency and cleansing properties. Thus, the physicochemical properties (total fatty matter content, total alkali content, pH, lathering and cleaning abilities) of the prepared soaps were carried out following standard procedures/protocols reported in literature (Hassan, *et al*., 2015; Betsy *et al*., 2013; Warra *et al*., 2012; Warra *et al.*, 2010; Lumley and Colwell, 1991; Ikhuoria *et al*., 2008).

Total fatty matter of soap materials: The total fatty matter (TFM) is one of the most important characteristics describing the quality of soap and it is always specified in commercial transactions. It 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. TFM serves as one of the parameters used to grade soap products as it is good indicator of hardness of such products. TFM values of soaps can be as low as 50%. Soaps with TFM values less than 50% are usually associated with hardness and lower quality (Lumley and Colwell,1991; EAS, 2013) whereas a soap product with minimum TFM value of 75% referred as Grade1 and that value of 65% minimum as Grade 2 (Betsy *et al*., 2013). The TFM values for the soaps prepared (in this study) from Avocado and Mango seed oils and their blends in various proportions were determined (Table 7).

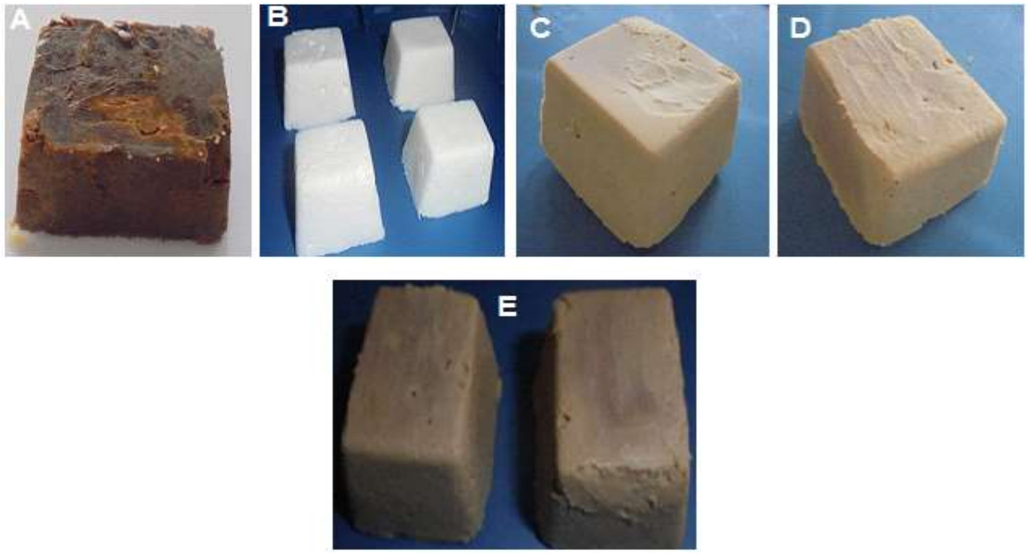

Fig 1. Soaps prepared using Mango seed oil (**A**); Soap from Avocado seed oil (**B**); Soap from blends of Avocado and Mango seed oils (1:1) (**C**); Soap from blends of Avocado and Mango seed oils (1:3) (**D**); Soap from blends of Avocado and Mango seed oils (3:1)(**E**). **(Photo**: Mengisteab M., April, 2018)

The TFM values of the prepared soaps were found to be 43.0±1.41, 52±2.82, 59±1.41, 63 ± 1.41 and 67 ± 1.41, respectively, for Avocado seed oil, Mango seed oils, Avocado and Mango seed oil blends (1:1), Avocado and Mango seed oil blends (3:1) and Avocado and Mango seed oil blends in (1:3) (Table 7).

Table 7. Total fatty matter contents of soaps

S.No	Types of Soap	% of Fatty Matter*
1	Avocado	43.0±1.41
2	Mango	52.0±2.82
3	Avocado + Mango(1:1)	59.0±1.41
4	Avocado + Mango(3:1)	63.0 ± 1.41
5	Avocado + Mango(1:3)	67.0 ±1.41
6	Solar**	67.0 ±1.41
7	Infinity**	81.0±1.41
8	Pumpkin**	65.0±1.41
9	Palm	78.0 ±2.83

*The results are mean of duplicate determination ± SD
**Commercial soaps used as reference

The data showed that the TFM values of Avocado and Mango oil-made soaps to be generally lower than that of the soaps prepared from oil blends. Moreover, the value for Avocado oil soap was below the literature reported minimum value of 50% (EAS, 2013). This suggests that Avocado oil (if used alone) cannot be used in production of good quality soap whereas Mango oil and blends of Avocado and Mango oils (in any proportion) can be used to prepare soaps of acceptable quality. This is because their TFM are above the minimum TFM value (50%).

As shown above, the TFM content of the soaps prepared from blends of Avocado and Mango seed oils in different proportion were found to be higher than the soaps prepared from Mongo oil or Avocado oil alone. Moreover, the TFM values of soaps prepared from the oil blends are comparable to the TFM values of the commercial soaps (Table 7). But these values are lower than TFM values of commercial soap infinity (81.0±1.41%) and soap made from palm oil (78±2.83%) that was prepared using the same experimental conditions (for the sake of comparison) with that of Avocado and Mango seed oils.

Comparison of the data with literature reports showed that TFM values of all the prepared soaps to be higher than TFM value (36.66 ± 0.02%) of Canary melon L. seed oil-made soap (Taiwo *et al*., 2008). It is known that the best blended soap is selected mostly on the basis of TFM value (Debesh, 2013; Hosakatte *et al*., 2014). Thus, in the present study, the TFM value of a soap made from Avocado + Mango oil (1:3) showed the highest TFM value (67±1.41%) that falls in the range of TFM required for laundry soap (Table 7). Other soaps prepared from oil blends that showed appreciable TFM content were the oil blends of Avocado + Mango oil (3:1) with 63 ± 1.41. The oil blend of Avocado + Mango oil (1:1) also showed a closer TMF value (59±1.41) to the standard which makes it fit for laundry soaps. The data also revealed that soaps prepared from oil blends to be comparable to the Grade I pure laundry soap standard (TFM 62%) reported in literature (EAS, 2013).

Total alkali content of soap materials: The total free alkali content is the quantity of free caustic alkali and carbonated alkali expressed as a percentage (m/m) as either sodium hydroxide for sodium soaps or potassium hydroxide for potassium soaps. The composition of sodium or potassium carboxylates constituting soap depends on the percentage of fatty acids bonded to glycerol in the original triglycerides. Solid fats give mixture with higher proportion of sodium or potassium salts of higher fatty acids (palmitic acid, stearic acid) and give hard soaps. The vegetable oils give mixtures with a greater proportion of unsaturated fatty acids (oleic acid and linoleic acid) and give soft soaps. According to Bureau of Indian Standards (BIS), good quality soaps must have less than 5% of alkali content (BIS, 2013) whereas according to ISO specification, soaps should have only below 2% of alkali content (Betsy *et al*., 2013). The total alkali contents determined in this study for the prepared soaps and the commercial soaps are shown below (Table 8). Soaps with excess free caustic alkalis are known to cause skin itching and wearing out of clothes. The alkaline materials present in the finished soap include many alkaline components such as hydroxides, sodium (II) oxide Na_2O, carbonates and bicarbonates (EAS, 2013). The total alkali contents of the soaps prepared in this study were found to be 2.0 ± 0, 1.054 ± 0, 1.44 ± 0.03, 1.715 ± 0.08, 1.77 ± 0.13 for Avocado seed oil, Mango seed oils, Avocado and Mango seed oil blends (1:1), Avocado and Mango seed oil blends (3:1) and Avocado and Mango seed oil blends in (1:3), respectively (Table 8).

Table 8. Total Alkali Content in the Soap Samples

S.No	Soap made from	% Total alkali content*
1	Avocado	2.0 ± 0
2	Mango	1.054 ± 0
3	Avocado +Mango(1:1)	1.44 ± 0.03
4	Avocado +Mango(3:1)	1.715 ± 0.08
5	Avocado +Mango(1:3)	1.77 ± 0.13
6	Solar(CS.)	2.528 ± 0
7	Infinity(CS.)	2.15 ± 0.06
8	Pumpkin(CS.)	2.33 ± 0.09
9	Palm	1.78 ± 0.14

**The results are mean of duplicate determination ± SD, CS; Commercial Soap*

These values are lower as compared to the values for commercial soaps such as Solar (2.528 ± 0), Infinity (2.15 ± 0.06) and Pumpkin (2.33 ± 0.09) but comparable with the total alkali content of the soap prepared from palm oil (1.78 ± 0.14%) (Table 8). All the data obtained in the present study indicates that the low total alkali contents of the soaps prepared from the blended Mango and Avocado oils have total alkali contents that are within the acceptable range of reported standards of Bureau of Indian Standards (BIS) that states good quality soaps must have less than 5% of alkali content whereas according to ISO specification, soaps should have only below 2% of alkali content (ISO685, 1975; Hui, 1996).

The pH value, Foam stability and Cleaning ability of the soaps: The pH values of the prepared soaps were determined using a pH meter (Model; PHS-3C DC-6V 300mA). Soaps with pH range of 9 -11 or higher are considered to be harsh to skin. The pH values obtained for the prepared soaps were found to be in the pH range of 9-10 (Table 9). The finding of the study revealed that the pH values of the prepared and the commercial soaps are 10.15±0.07, 9.55 ± 0.07, 9.75 ± 0.07, 9.9± 0.00 ,9.75± 0.07, 9.60± 0.14, 9.65± 0.07, 9.7± 0.00, 9.6± 0.00 for Avocado, Mango, Avocado + Mango (1:1), Avocado + Mango (3:1), Avocado + Mango (1:3), Solar, Infinity, Pumpkin and Palm oil soaps, respectively (Table 9). Moreover, the data showed the pH values to be comparable to each other. All the values are lower than pH value (11.03± 0.02) of Canary melon seed oil soap reported in literature (Taiwo *et al*., 2008). National Agency for Food and Drug Administration and Control (NAFDAC) classified pH range 9-11 as higher level for any soap, and the pH range of 3-5 as low level. This could be attributed to the incomplete alkali hydrolysis resulting from the saponification process (Hui, 1996; Umar, 2002). Even though the pH values of the prepared soaps are higher than the skin friendly pH, their pH can be regulated during preparation by a process known as superfatting (Hassan, *et al*., 2015; Kuntom *et al*., 1999; Sylvia and Amir, 2019). This is a process that involves use of less lye (or more fat) than industry standards so that there's some leftover oil in the soap that's not bound to lye. This leaves behind more unsaponified fat, providing more moisturizing effect to soap products.

Foam ability has little to do with cleansing ability. It is of interesting importance to the consumer and is therefore considered as a parameter in evaluating soaps (Taiwo *et al*., 2008). The foam ability obtained for both groups of soaps (the prepared soaps and the commercial soaps) were 1.94±0.006, 11.23±0.390, 6.68±0.161, 5.75± 0.250, 15.23± 0.256, 14.08± 0.382, 19.38± 0.340, 19.23± 0.252, 18.37± 0.153 for soaps prepared from Avocado seed oil, Mango seed oils, Avocado and Mango seed oil blend (1:1), Avocado and Mango seed oil blend (3:1), Avocado and Mango seed oil blend (1:3), Solar, Infinity, Pumpkin and Palm oil soaps, respectively (Table 9). Soap prepared from Avocado seed oil was found to have the least foam height (1.94±0.006). The foam height obtained for the soap prepared from Avocado and Mango oil blends (1:3) was 15.23±0.256 which was found to be comparable with the commercial soaps and palm oil-made soap (Table 9).

Table 9. The pH values, Foam heights and Cleansing ability data of the prepared soaps and commercial soap products

S.No	Types of soap	pH value*	Foam height (cm)*	Cleansingability	Remark
1	Avocado	10.15±0.07	1.94±0.006	Poor	
2	Mango	9.55± 0.07	11.23±0.390	High	
3	Avocado +Mango(1:1)	9.75± 0.07	6.68±0.161	Good	
4	Avocado +Mango(3:1)	9.9± 0.00	5.75± 0.250	Good	
5	Avocado +Mango(1:3)	9.75± 0.07	15.23± 0.256	High	
6	Solar	9.60± 0.14	14.08± 0.382	High	Commercial
7	Infinity	9.65± 0.07	19.38± 0.34	High	Commercial
8	Pumpkin	9.7± 0.00	19.23± 0.252	High	Commercial
9	Palm	9.6± 0.00	18.37± 0.153	High	

**The results are mean of duplicate determination ± SD*

The cleaning ability of the soaps prepared from Avocado and Mango seed oils and also from their blends in various ratios were tested following a standard procedure reported in literature (Hassan *et.al*, 2015) and their cleaning abilities were compared with each other and with the randomly selected commercial soaps. Analysis of the prepared soaps and the commercial soaps revealed that the cleansing ability of the soap prepared from Avocado seed oil is poor and it cleanses less effectively than the soap prepared from Mango seed oil. The soap prepared by blending Avocado and Mango seed oils in (1:3 by mass) was found to have comparable cleansing ability with that of the commercial soaps and with the soap prepared from palm oil. It also cleanses more effectively than that of other combination of the two oil blends (Table 9).

Conclusions: The seeds Avocado and Mango seeds were collected from cafes and restaurants and oils were extracted by using solvent n-hexane applying Soxhlet extraction techniques. The oils were used in a separately or in a blended form to prepare laundry (bar) soaps. The physicochemical properties of the prepared soaps indicated that they have acceptable quality or comparable properties with the commercially available soaps. It can also be concluded that the soap prepared by blending of Avocado and Mango seed oils in a 1:3 ratio (by mass) was found to be the best quality soap among the prepared soaps. So, it can also be concluded that the blend of Mango and Avocado seed oils can be used as potential sources of oil for soap production.

Acknowledgements: MM kindly acknowledge Hawassa University for financial support.

REFERENCES

Abduselam, F (2016). Review on Avocado value chain in Ethiopia. *Ind. Eng. Let*. 6: 33-40.

Akinoso, R; Raji, AO (2010). Optimization of oil extraction from locust beans using response surface methodology. *Eur. J. Lip. Sci. Tech.* 113: 245-252,

Akubugwo, IE; Chinyere, GC; Ugbogu, AE (2008). Comparative studies on oils from some common plant seeds in Nigeria. *Pak. J. Nut.* 7: 570-573.

AOAC (2000). Saponification number of oils and fats, 17th edn, Official method 920.160

Arogba, SS (1997). Physical, chemical and functional properties of Nigeria mango (*Mangifera indica*) kernel and its processed flour**.** *J. Sci. Food Agric*. 73: 321-328.

Atilla, B; Mert, G; İhsan, K; Elif, N; Abdülvahap, C (2015). Determination of transesterification reaction parameters giving the lowest viscosity waste cooking oil biodiesel. *Soci. Behav. Sci.* 195: 2492 -2500.

Banji, A; Adebayo, O; Oluwatosin, S (2016). Physiochemical properties and antioxidant potential of *Persia Americana* seed oil. *Int. Sci. Org. Chem. Int*. 2; 168-175.

Bazmi, AA; Zahedi, G; Hashim, H (2011). Progress and challenges in utilization of palm oil biomass as fuel for decentralized electricity generation. *Ren. Sust. En. Rev.* 15: 574-583.

Berhanu, M (2013). The role of avocado production in coffee based farming systems of South Western Ethiopia: The case of Jimma zone. *Afr. J. Agri. Res*. 8: 2285-2296.

Betsy, KJ; Mary, J; Reshma, F; Jaya, TV (2013). Determination of alkali content & total fatty matter in cleansing agents. *Asian J. Sci. Appl. Technol*. 2*:*2249-0698.

Bureau of Indian Standards, DOC: CHD 20 (1861) C, 2011.

Bwade, KE; Aliyu, B; Kwaji, AM (2013). Physicochemical properties of pumpkin seed oil relevant to biodiesel production and other industrial applications. *Int. J. Eng. Bus. Ent. Appl.* 4: 72-78.

Coenen, JW (1976). Hydrogenation of edible oils. *J. Am. oil Chem. Soc*. 55: 338-339.

Debesh, M (2013). Preparation of soap using different types of oils and exploring thier properties. MSc thesis, National Institute of Technology, Rourkela, India.

East African Standard (2013); Laundry soap:-Specification, Second Edition, Arusha, Tanzania.

Edossa, E (1997). Selection of Avocado (*Persea americana* M.). Collection of desirable fruit characteristics and yield at Jimma, Proceedings of the 8th Annual Conference of the Crop Science Society of Ethiopia, Feb. 26-27, Addis Ababa. Ethiopia**.**

Ekop, SA; Etuk, BA; Eddy, NO (2007). Effect of some local additives on the chemical constituent of palm oil. *J. Appl. Sci. Environ. Manag*. 11: 85-89.

Ethiopian Investment Agency (2012), Investment opportunity profile for palm oil production.

Europe importing more palm oil for biofuels, raising risks for rainforests: https://news.mongabay.com/2013/09/europe-importing-more-palm-oil-for-biofuels-raising-risks-for-rainforests (Retrieved on 09, February 2023).

Evwierhoma, ET; Ekop, IE (2016). Extraction and characterization of oils from some local seeds. *Int. J. Sci. Eng. Res*. 5: 2229-5518

Fidel, TR; Leticia, M; Fidel T (2020). Trends in biodiesel production from animal fat waste. *Appl. Sci*. 10: 3644.

Flavia, P; Zorica, V; Delia, B (2014). Effects of temperature and storage time on the quality of alimentary animal fats. *Int. Food Res. J*. 21: 1507-1514.

Grain (2007). The palm-oil-biodiesel nexus. *Seedling: Biod., Rights and Livelihood.* pp16-17.

Hakimah NAH; Norlin, K; Zulkefly, AK; Muhamad, RK; Zainuddin, V (2022). Technical efficiency and export potential of the world palm oil market. *Agriculture* 12: 1-16.

Hassan, KJ; Zubairu, MS; Oyewole, RO (2015). Production of soap from neem seed oil and *Acacia nilotica* seed oil. *Int. J. Modern Org. Chem.* 4: 70-84.

Heena, S; Giriprasad, R; Meena G (2013). Animal fat-processing and its quality control. *J. Food Process Technol*. 4:8 DOI:10.4172/2157-7110.1000252

Helena, V; Adam T; Shofwan, ABC (2019). Palm oil intensification and expansion in Indonesia and Malaysia: Environmental and socio-political factors influencing policy. *Forest Policy Econ*. 92: 148-159.

Hosakatte, NM; Siragambi, HM; Poornananda, MN; Eun JL; Kee, YP(2014). Physicochemical characteristics and antioxidant activity of *Lavandula bipinnata* seed oil. *Int. Food. Res. J*. 21: 1473-1476.

https://snv.org/update/bridging-gap-between-demand-and-supply-edible-oil-ethiopia. Bridging the gap between the demand and supply of edible oil in Ethiopia. (Accessed on 10 April, 2023)

https://www.innovhub-ssi.it/kdocs/1990284/animal_fats_for_non-food_uses._a_review_of_technology_and_critical_points.pdf. About Palm Oil: http://www.rspo.org/files/pdf/Factsheet-RSPO. (Retrieved on 12 March, 2023)

Hui, HY (1996). *Soap. In: Bailey's Industrial Oil and Fat Products*. *A Wiley Int. Sci. Publ. John Wiley and Sons Inc*. NY, pp 93-98.

Ikhuoria, EU; Aiwonegbe, AE; Okoli, P; Idu, M (2008). Characteristics and composition of African oil bean seed. *J. Appl. Sci.* 8: 1337-1339.

ISO 660 (1996). Determination of acid value and acidity.Jerome, EM (1961). Control of odors from a continuous soap making process. *J. Air Pollution Control Assoc*. 11: 9-44.

John, K (2003). Analytical Chemistry for Technicians. 3rd Edn. Lewis Publishers, Kalyan Publisher, New Delhi, India, pp 432-433.

Joosten, F (2007). Development Strategy for export oriented horticulture in Ethiopia.

Kittiphoom, S; Sutasinee, S (2013). Mango seed kernel oil and its physicochemical properties. *Int. Food Res*. *J*. 20: 1145-1149

Kuntom, A; Ahmad, I; Kifli, H (1999). Effects of superfatting agents on cracking phenomena in toilet soap. *J Surfact Deterg*. 2: 325-329.

Legesse, A; Habtamu, A; Tegene, T (2020). Use of *Jatropha* seed oil and alkali solution obtained from its ash for soap making: An environmentally friendly and cost effective approach. *J. Appl. Sci. Environ. Manage*. 24: 2005-2015.

Lumley, ID; Colwell, RK (1991). Fats from fatty foods and determination of fat content in analysis of fat and fatty foods. Rossel, J. B. and Pritchard, J. L. R. (Eds), pp 238-247.

Messay, BL; Shimelis, AE (2012). Functional and physicochemical properties of mango seed kernels and wheat flour and their blends for biscuit production**.** *Afr. J. Food Sci. Technol*. 3:193-203.

Murphy, DJ (2014). The future of oil palm as a major global crop: opportunities and challenges. *J Oil Palm Res*. 26:1-24

Murphy, DJ (2015). What is the future for oil palm as a global crop? *World Agric*. 5: 24-34

Olagunju, EO (2013). Extraction and characterization of vegetable oil from Mango seed, *Mangifera indica*. *IOSR JAC*. 5: 2278-5736.

Oluwole, S; Yusuf, K; Fajana, O; Olaniyan, D (2013). Qualitative Studies on proximate analysis and characterization of oil from *Persea Americana* (Avocado Pear). *J. Nat. Sci. Res*. 3: 68-73

Orthoefer, FT; List, GR (2007). Initial quality of frying oil. *Oil Mil. Gaz.* **2007**, 113, 3-9.

Palm products global markets and developments http://www.intracen.org/uploadedFiles/intracenorg/Content/About_ITC/Where_are_we_working/Multicountry_programmes/Pact_II/Palm%20Oil%20Report%202012.pdf.(Retrieved on 05 April, 2023)

Peter, A; Marie, J; Dumont, MN (2015). Recent trends of biodiesel production from animal fat wastes and associated production techniques. Renewable. *Sust. Energy Rev*. 45: 574-588

Rudy, P (2006). Rendered fats and oils as a biodiesel feedstock Industry faces opportunities, challenges in sustaining growth. *Biofuel*. 17: 431-433.

Sakurai, H; Pokorny, J (2003). The development and application of novel vegetable oils tailor-made for specific human dietary needs. *Eur. J. Lipid Sci. Tech*. 105: 769-778.

Sylvia EB; Amir A (2019). Effect of superfatting agents on soaps properties. *J. Oil Palm Res*. 31: 304-314

Taiwo, AA; Oluwadare, I; Shobo, AO; Amolegbe, SA (2008). Extraction and potential application of caustic potash from kolanut husk, ugwu pod husk and plantain peels. *Sci. Res. Essay***.** *3*: 515-517.

Takele, H (2014). Review of mango value Chain in Ethiopia. *J. Biol. Agri. Healthcare*. 4:230-239.

The International Standard Specification for soaps, ISO 685: 1975.

Thoenes, P (2006). Biofuels and commodity markets–palm oil focus. *Food Agr. Org. UN*.

Tincliffe, H; Webber, D (2012). Deforestation and the problem of palm oil. *Chem. Eng*. 858: 24-25.

Umar, M (2002). Cosmetics, soap, detergents and NAFDAC regulatory requirements. A paper presented at a training workshop for small and medium scale enterprises organized by UNDP/JCSL and Ministry of Commerce and Industry, Maiduguri, Borno State, Nigeria, *2*: 3-5.

Wardana, IN; Agung, W; Widya, W (2018). Improving vegetable oil properties by transforming fatty acid chain length in jatropha oil and coconut oil blends. *Energies*. 11: 1-12.

Warra, AA (2013). A report on soap making in Nigeria using indigenous technology and raw materials. *Afr. J. Pure Appl. Chem.* 7:139-145.

Warra, AA; Babayemi, AW; Buga, ML (2014). Properties of soaps produced from selected seed Oils. *Int. Conf. Agr. Env. Biol. Sci*. Antalya (Turkey)

Warra, AA; Hassan, LG; Gunu, SY; Jega, SA (2010). Cold- Process synthesis and properties of soaps prepared from different triacylglycerol sources. *Nig. J. Bas. App. Sci*. 18: 315-321.

Warra, AA; Wawata, IG; Umar, RA; Gunu, SY (2012). Soxhlet extraction, physicochemical analysis and cold process saponification of Nigerian *Jatropha curcas* L. seed oil. *Canadian J. Pure and Appl. Sci*. 6: 1803-18019.

Zekarias, S (2010). Avocado production and marketing in South Western Ethiopia. *Trends Agr. Econ*. *3*: 190-206.