PHYSIOCHEMICAL QUALITY OF SOAP PRODUCE FROM BLEND OF PALM OIL AND PALM KERNEL OIL

BY

ILALOKHOIN AARON OHIFUEMHE

PSC1908744

DEPARTMENT OF CHEMISTRY, FACULTY OF PHYSICAL SCIENCES,

UNIVERSITY OF BENIN,

BENIN CITY

APRIL, 2024

PHYSIOCHEMICAL QUALITY OF SOAP PRODUCE FROM BLEND OF PALM OIL AND PALM KERNEL OIL

BY

ILALOKHOIN AARON OHIFUEMHE

PSC1908744

A PROJECT SUBMITTED TO THE DEPARTMENT OF CHEMISTRY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) UNIVERSITY OF BENIN, BENIN CITY.

APRIL, 2024

CERTIFICATION

This is to certify that this work was carried out by **ILALOKHOIN AARON OHIFUEMHE** of the Chemistry Department, Faculty of Physical Sciences, University of Benin.

Dr. (Mrs.) I. G. Okunzuwa **Date**

(Project Supervisor)

Prof. J. U. Iyasele **Date**

(Head of Department).

Ilalokhoin Aaron Ohifuemhe **Date**

DEDICATION

This project work is dedicated to Almighty God for who has kept me alive, for his abundant grace in my life and for seeing me through my academic pursuit and aspirations throughout the duration of my degree. Also, I want to dedicate this project to my family and friends for the love and encouragement they have shown towards me all through, thank you and God bless you.

ACKNOWLEDGEMENT

I express deep gratitude to God, who provided unwavering guidance and protection throughout my four-year journey at the University of Benin.

I extend sincere appreciation to my project Supervisor, Dr. (Mrs.) I. G. Okunzuwa, for her invaluable guidance, constructive criticism, and encouragement during the course of this work, as well as the invaluable knowledge she imparted through her lectures.

I also wish to convey my gratitude to the Head of Department, Prof. J. U. Iyasele, for the motivating words during my studies.

Special recognition goes to my course adviser, Dr. Ogbeide, for his tireless corrections and advice, as well as my lecturers and classmates for their commendable efforts.

A heartfelt thank you is also reserved for my parents, Mr. and Mrs Ilalokhoin and my Brother Benjamin, My aunt, Mrs. Iriaye and her children for their immense support, both financially and spiritually, in every aspect of my journey.

Lastly, I am immensely thankful to my friends who shared the journey at the University of Benin with me experiencing and enduring every moment together, be it failures, successes, laughter, late-night study sessions, mosquito bites, jokes, or football debates. Precious-gift, Vegas, Omolola, Catoka, Royal, Victor, Blessing, Raymond, you have all become an integral part of my life. Thank you.

TABLE OF CONTENT

ABSTRACT

This study focuses on investigating the physiochemical properties of soap derived from blends of palm kernel and palm oil. The oils underwent an initial analysis to determine their saponification and acid values using established methods. Subsequently, the oils were mixed in various ratios: palm kernel to palm oil (100:0, 0:100, 50:50, 70:30, and 30:70). Each blend was used to produce soap using the hot method approach, followed by the analysis of the resulting soaps for moisture content, pH, hardness, harshness, cleaning properties, and foamability. The results indicated the saponification and acid values for palm kernel oil were 283.305 mgKOH/g and 4.488 mgKOH/g, respectively, while for palm oil, they were 221.595 mgKOH/g and 6.732 mgKOH/g, respectively. The moisture content, pH, hardness, cleaning properties, and foamability of the various blends were as follows: moisture content (35%, 33.5%, 36%, 39.5%, 30.5%), pH (8.95, 8.57, 8.81, 8.99, 9.34), hardness 4.0, 2.8, 3.6, 3.8, 3.4 cm, harshness (all soaps were mild and gentle to the skin and hands), cleaning property (more effective, effective, more effective, more effective, most effective), and foamability 7.3, 11.4, 12.6, 9.8, and 13.3 cm, respectively. The results demonstrate that soap produced from the 30:70 blend exhibited superior physiochemical and functional properties. Consequently, it is recommended that this particular oil blend be employed for soap production with sodium hydroxide using the hot method.

CHAPTER ONE

1.0 INTRODUCTION AND LITERATURE REVIEW

Introduction

Soap is a salt (sodium or potassium salt) of fatty acid (Ndiokwere and Ukhun, 2001). In addition, Soap may be defined as a chemical compound or mixture of chemical compounds resulting from the interaction of fatty acids or fatty glycerides with a metal radical or organic base (Kirk-Othman, 1963). Soaps are mainly used as surfactants for washing, bathing, and cleaning, but they are also used in textile spinning and are important components of lubricants. Soaps for cleansing are obtained by treating vegetable or animal oils and fats with a strongly alkaline solution. Fats and oils are composed of triglycerides; three molecules of fatty acids are attached to a single molecule of glycerol (Cavitch and Miller, 1994). The alkaline solution which is often called lye (although the term "lye soap" refers almost exclusively to soaps made with sodium hydroxide) brings about a chemical reaction known as saponification. The metals commonly used in soap making are sodium and potassium, which produce water-soluble soaps that are used for laundry and cleaning purposes (Kuntom *et al*., 1994). The qualities of soap are usually determined by the amount and composition of the component fatty acids in the starting oil.

Blends of oils can be used in both the hot and cold soap production methods. Vegetable oil blends could be obtained by mixing different vegetable oils such as the mixture of coconut oil, groundnut oil, Shea butter, palm oil, and palm kernel oil in different proportions and soaps of desirable quality can be produced (Kuntom *et al*., 1996).

1.1 Statement of Research Problem

There is heavy dependence on palm oil as source of fatty acids for the production of soaps by soap producers. Exploring palm oil blends would go a long way in reducing the total dependence on palm oil. Blending at the different percentage could go a long way in the production of quality soaps for laundry, bathing and general cleaning purpose.

1.2 Justification

Nature offers two primary sources of oil for soap production: vegetable oil derived from plants and tallow extracted from animal fat. While vegetable oil possesses the unique ability to create lather in water, its drawback lies in its inability to solidify effectively. Conversely, animal fat solidifies well but doesn't readily produce lather. Considering this, there's a gap in knowledge regarding the utilization of blends like palm oil (PO) and palm kernel oil (PKO) in soap making. Therefore, it's essential to investigate the potential of blending these oils to create a soap that lathers effectively in both soft and hard water conditions.

1.3 Scope of Research Work

This work covered the procurement of some selected vegetable oils such as palm oil and palm kernel oil from Benin City, Edo Sate, Nigeria. These oils were blended together at different percentage and each blend was used to produce soap. Each soap produced from these various oils were analyzed for their physicochemical parameters, although, other fat/oils exist but this work is only limited to just these two oils.

1.4 Aim

The aim of the research work is to thoroughly investigate the physiochemical quality of soap manufactured from a blend of palm oil and palm kernel oil. This involves delving into various aspects such as the chemical composition, physical properties, and overall quality characteristics of the soap produced using this blend..

1.5 Objectives

I. blend Palm oil and palm kernel oil
II. determine the physicochemical parameters of the blended oils
III. produce soaps from the individual blends (saponification) and
IV. Determine the quality parameters of the produced soap.

1.2.0 LITERATURE REVIEW

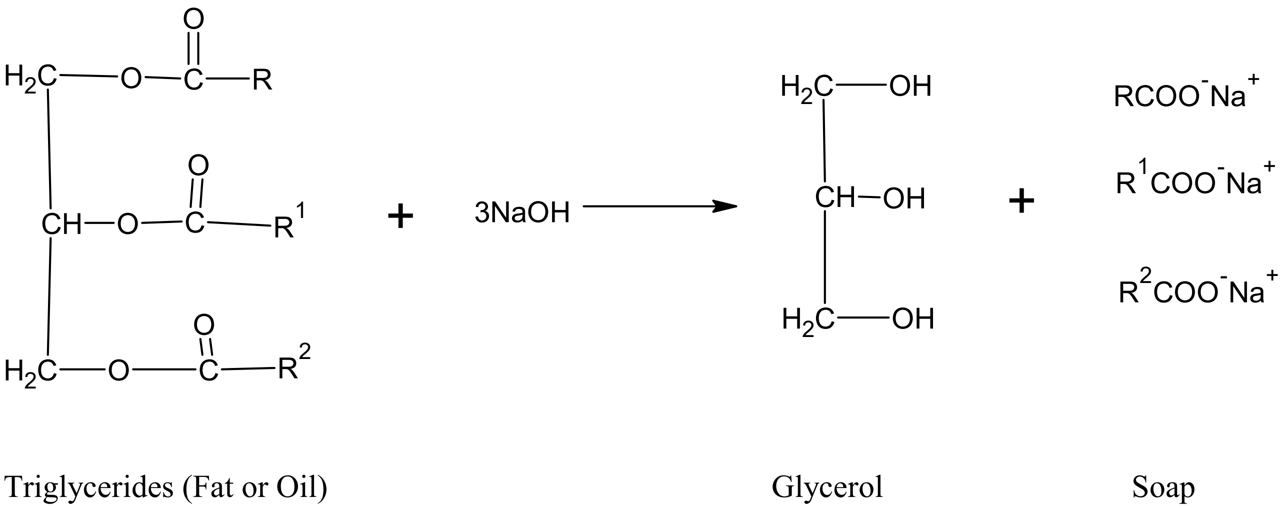
Soaps for cleansing are made by treating vegetable or animal oils and lipids with a highly alkaline solution. Saponification is the process by which ordinary oils or fats react with a strong alkaline solution to produce sodium or potassium salts of fatty acids. Soap is a detergent, which means it improves the cleaning capabilities of water. During saponification, fats are first degraded into free fatty acids, which subsequently mix with alkali to make crude soap. Glycerol (glycerin) is freed and either left in or washed out and recovered as a useful byproduct, depending on the technique used (Cavitch and Miller, 1994).

Fats and oils are composed of triglycerides; three molecules of fatty acids are attached to a single molecule of glycerol (Kirk-Othman, 1963). The fatty acids, such as stearic acid, palmitic acid, myristic acid, lauric acid, and oleic acid, contribute to the lathering and washing properties of the soaps (Ainie et al., 1996). Fats are solid esters of fatty acids and glycerin, while oils are the liquid glycerol esters of fatty acids at room temperature. During saponification reaction of glycerides with alkalis, NaOH is used for solid or bar soaps and KOH is used for soft soaps (Shoge, 2011). These are characteristically different from soaps made from divalent metals such as calcium, magnesium, iron, or aluminum, which are not water-soluble (Chalmers and Bathe, 1978). Coconut oil is a source of lauric acid (12 carbons) which can be made into sodium laurate. This soap is very soluble and will lather easily even in seawater. Fatty acids with only 10 or fewer carbons are not used in soaps because they irritate the skin and have objectionable odors (Chalmers and Bathe, 1978). For centuries, soap was the only cleansing substance available. Shortage of some raw materials makes soap to be highly priced and only wealthy people could afford it (Viorica et al., 2011).

It became affordable to other people only after the manufacture of sodium carbonate came in handy during the manufacture of soap (Viorica *et al*., 2011). At the end of the 19th century, the first soap powder for laundry was made using sodium silicate as a binder (Viorica *et al*, 2011). Though, the use of sodium or potassium carbonate leads to a hard or soft soap respectively, the chemical nature of the lipophilic part of soap plays the largest role in determining the performance of finished soap (Viorica *et al*., 2011).

1.2.1 Saponification

Saponification is the chemical process of making soap that involves an exothermic reaction between sodium hydroxide (lye) and a fat (usually oils). A simple saponification reaction is as shown in Figure 2.1:



Scheme1.2.1: Saponification Reaction of Triglycerides

1.2.2 Raw Materials Used in Soap making

Some of the raw materials used in soap making are:

1.2.2.1 Fats and oils

Panduranga *et al* (1971) reported that soap making oils and fats are found in animal and vegetable fats and oil (such as beef tallow, grease, coconut oil, palm oil, palm kernel oil, linseed oil, rubber seed oil, soybean oil, and corn oil), among others. These fats and oils contain various properties of the fatty acid usually having 6-22 carbon atoms in the paraffin chain. These include caprylic acid ($C_8H_{16}O_3$) lauric acid ($C_{14}H_{32}O_2$), stearic acid ($C_{18}H_{36}O_2$), and linoleic acid ($C_{18}H_{32}O_2$).

All animal fats and vegetable oils intended for soap making should be as free as possible from unsaponifiable matter, of a good colour and appearance, and in a sweet, fresh condition (Simmons and Appleton, 2007). Fats and oils used to make soap come from animal or vegetable sources. Oil derived from another sources such as mineral oil, cannot be used. Soap can be made by using only one kind of fat or oil, by blending animal and vegetable oil or blending more than one vegetable oil. Other oils that can be used are olive, cottonseed, maize, soybean, groundnut, safflower, sesame and linseed. Coconut and palm oils are very good for soap making. The animal or hard fats are generally used to make soap are tallow and lard. Tallow is the fat from beef or lamb. Lard is the fat from hogs. Butterfat from cow milk is acceptable. However, chicken fat is not a hard fat, and is regarded as oil (Francioni and Callings, 2002). Some other vegetable oils are very rich in minerals and Vitamins that are good for the skin. Vegetable oils such as Almond Oil, Aloe Vera Butter, Aloe Vera Oil, Apricot Kernel Oil, Avocado Butter, Avocado Oil, Babassu Nut Oil, Beeswax Animal, Borage Oil, Candelilla Wax, Canola Oil, Castor Bean Oil, Cherry Kernel Oil, Cocoa Butter, Coconut Oil, Jojoba Seed Oil, Neem Tree Oil, Olive Oil, Palm Kernel Oil, Peanut Oil, Pumpkin Seed Oil and Soybean Oil, among several others. These oils, when used in bathing soap nourish the skin, and cure many skin infections and diseases.

1.2.2.2 Olive oil

Olive oil is made from pressing the olive fruit. This oil is an excellent moisturizer because it attracts external moisture, holds the moisture close to the skin, and forms a breathable film to prevent loss of internal moisture. It is also known for healing properties (Kenam and Melek, 2014).

1.2.2.3 Palm oil

Palm oil is known for moisturizing with a creamy rich lather. It is so important to use sustainable palm oil as it saves the environment (Kenam and Melek, 2014).

1.2.2.4 Coconut oil

Coconut oil is considered a gift. Its discovery has contributed to higher grade soaps in addition to its rich, moisturizing lather. If used in too high of portions it can be dried. Many of these natural oils have replaced lard in high quality soaps (Kenam and Melek, 2014).

1.2.2.5 Shea butter

This is a byproduct of nuts obtained from shea tree also known as *Vitellaria Paradoxa* (Maranza *et al*., 2004*)* or *Butyrospermum parkii* which belongs to the *Sapotaceae* family. It constitutes an important source of fat in food and cosmetics (Okollu *et al*., 2010) Its fatty matter has been used for years in Africa for different purposes, ranging from food and soap processing, to healthcare and other medicinal uses (Coulibaly *et al*., 2010) Global interest in the product stems from its use as a cocoa butter equivalent in the pharmaceutical and cosmetics industries (Elias *et al*., 2006) It is also used as an unguent for the skin and has anti-microbial and soothing properties, which give it a place in herbal medicine. It is also used as an important raw material and/or a precursor for the manufacture of candles (Adomako, 1985). The fat obtained from the shea kernel is referred to as shea butter and it is the most valued product from the shea tree (Hall *et al*., 1996).

Shea Butter is from the nut of the Shea Tree, also known as "The Tree of Life". The Shea tree (locally known as ori in Yoruba Language) only grows in the savannah region of Africa. It grows up to 60 feet and can live up to 200 years. The Shea Tree produces its fruits once a year. The nut in the center of the fruit when crushed and traditionally processed by boiling and extracting the oil, is what yields the vegetable fat known as Shea Butter. Shea butter contains vitamins A, E, and F, and fatty acids, which provide healing abilities superior to cocoa butter. This natural butter has proven cell regenerative, moisturizing, and anti-aging properties, which restore shine and beauty to skin and hair. Effective in preventing stretch marks, wrinkles, inflammation, eczema, and dryness from razor irritation. Shea butter has been used for centuries in Africa for cooking, and also as skin treatment for its amazing ability to renew, repair and protect the skin against harsh climates. African healers and beauties like Cleopatra have known about shear butter for thousands of years. Shea butter is also called "women‟s gold", because extracting the butter from the nuts gives income to hundreds of thousands of rural African women.

1.2.2.6 Cocoa butter

Cocoa butter is obtained from the same bean as chocolate and cocoa. Cocoa butter lays down protective layer that holds moisture to the skin, making it a good skin softener (Kenam and Melek, 2014).

1.2.3 Alkali

Alkalis are basic (high pH) substances that cause the desired chemical reaction. Common alkalis used are caustic soda (sodium hydroxide) and potash (potassium hydroxide). The alkalis use in soap making can be from two sources:

I. Lye, caustic soda, or potash, purchased at the market: or

II. Lye obtained by leaching or washing water through the ashes of plants.

1.2.4 Other soap ingredients

Borax, soda, ammonia, kerosene, naphtha, and resin are sometimes added to increase the quantity of suds and improve the appearance of the soap, however they may not be necessary. Perfumes are added to make soap smell more pleasant. Either essential oils or artificial perfumes can be used. Some essential oils commonly used are lavender, geranium, winter green, citronella, cloverlemon, rose, almond, caraway, and banana. The oil or perfume is stirred into the soap just before the soap is poured into molds. The quantity of perfume used depends on the size of the batch of soap being produced, the intensity of the perfuming agent, and the strength of the desired final scent. The amount used can vary from a few drops to 15 grams or more. Coloring matter can alsobe added. For example, vegetable or aniline dyes can be used to make soap. They are stirred evenly into the soap mixture before pouring it into molds. The color obtained from aniline dyes has a tendency to fade slightly when soap is exposed to bright light (Francioni and Callings, 2002).

1.3 Fatty Acids and Soap Making.

Soap is a chemical substance, created by combining fatty acids, an alkali and heat in a water medium. Fatty acids are chemical components of oils ("oils" includes fats and butters). There are various fatty acid varieties, each differing in molecular composition. When used in soap making, each fatty acid variety will make a soap that has its own unique characteristics. Different oils used in soap making have differing proportions of these various fatty acids. Therefore, chosen "recipe" combinations of specific oils mixed together in soap making can result in combined fatty acids compositions tailored to make soaps with desired characteristics. An understanding of this ability to tailor the oils mix and thereby control the fatty acids mix is essential in designing successful soap recipe formulas.

1.3.2 Some fatty acids and their resulting soap characteristics

Lauric Acid ($C_{12}H_{24}O_2$): Hard bar, excellent cleansing, lots of fluffy lather, can be drying to skin

Linoleic Acid ($C_{18}H_{32}O_2$): Conditioning, silky feel.

Myristic Acid ($C_{14}H_{28}O_2$): Hard bar, cleansing, fluffy lather.

Oleic Acid ($C_{18}H_{24}O_2$): Conditioning, slippery feel, stingy lather, kind to skin

Palmitic Acid ($C_{16}H_{32}O_2$): Hard bar, cleansing, stable lather.

Riconoleic Acid ($C_{18}H_{34}O_3$): Softer bar, conditioning, moisturizing, lots of fluffy, stable lather, kind to skin.

Stearic Acid ($C_{18}H_{36}O_2$): Hard, long-lasting bar, stable lather.

1.4 Types of Soap Based on Process, Properties and Compositions

1.4.1 Hard and soft soaps

Often, hardness is achieved through the addition of hardening agents, so many natural soaps tend to be softer. Hard soap can be produced by repeat regrinding and reforming, known as triple milling. Keeping the moisture content low helps the hardness of the soap, but this is often achieved by accelerated curing in very low humidity conditions. Glycerin is a normally produced during the soap making process. Glycerin is humectants, which means it attracts water. Therefore, soaps which contain glycerin in them tend to make the skin feel moister. At the same time glycerin soaps tend to have more water in them and attract water from the atmosphere, therefore 'sweating' in humid conditions (DMBB, 2013).

1.4.2 Transparent soap

This soap uses slightly different components and usually some form of alcohol to alter the process. The process is also conducted at higher temperatures. All these facts (alcohol and higher temperature) change the process and hence the resulting product. Not all transparent soaps are glycerine soaps. Sugar syrup (sugar in distilled water) is an alternative ingredient to replace alcohol but not as effective as alcohol. Some of the soap producer use already made soap base to make their transparent soap.

1.4.3 Liquid soaps

Liquid soaps are actually quite difficult to make and many of the commercial liquid soaps are just in fact detergents. They are in liquid state. Making liquid soap is more complicated than bar soap. Liquid soaps are usually made with the hot process method. It becomes liquid form due to a different type of lye (potassium hydroxide instead of sodium hydroxide) used in the making process and also due to more water added during the soap making process.

1.4.4 Tablet or bar soaps

These are generally solid soaps.

1.5.1 Types of Soap Based on Usage

Based on the ingredients used by the manufacturer or producer soap can be used for different purposes, which include cleaning, washing to bathing. The types of soap based on usage are:

1.5.2 Antiseptic soaps and bathing soaps

Antiseptic soap, sometimes called antibacterial soap or antifungal soap, is regular soap in liquid or solid form that contains some kind of ingredient that reduces the chance of infection when applied to the skin. These products also have antimicrobial properties, meaning they kill or inhibit the growth of microbes like bacteria, virus, or fungi. Alcohol, triclosan, and tetrasodium ethylenediaminetetraacetic acid are three antiseptics commonly used in soap, and they are all examples of antibacterial antiseptics. Other antiseptics have antiviral properties, and some are antifungal and can be used to treat or prevent fungal infections like athlete's foot, ringworm, or vaginal yeast infections. Many antiseptics have a combination of these various properties. Some essential oils, such as tea tree oil, contain naturally occurring antiseptics called terpenes that have antibacterial, antifungal, and antiviral properties. These various kinds of antiseptic ingredients are also used in soap (WiseGEEK, 2013). Some scientists and medical professionals are critical of the increasing use of antiseptic soaps and the addition of antibacterial ingredients to so many cleaning products. They believe that this practice might lead to more strains of bacteria becoming resistant to antibacterial agents, eventually causing antibiotic medications to become less effective. This could make it more difficult to treat serious medical conditions caused by bacteria, like staph infections and pneumonia. For example, many microorganisms are already resistant to triclosan, meaning that even though it is a proven antibacterial agent, it may not be as effective as stated by some soap manufacturers because many strains of bacteria are immune to it (WiseGEEK, 2013).

1.6 Soap Making Processes

There are several different soap making processes that allow easy production of soap products. These are briefly described in sections 2.7.1-2.7.4:

1.6.1 Cold process soap making

The cold process uses just enough heat (45-50^{0}C) to ensure that all the fat is melted prior to reacting it with the base. The cold process gets its name from the general low temperatures that are used to mill this type of soap (Anne-Marie, 2002). Even in the cold soap making process, some heat is usually required; the temperature is usually raised to a point sufficient to ensure complete melting of the fat being used. The batch may also be kept warm for some time after mixing to ensure the alkali (hydroxide) is completely used up. This soap is safe to use after about 12–48 hours, but is not at its peak quality for use for several weeks.

Cold-process soap making requires exact measurements of lye and fat amounts and computing their ratio, using saponification charts to ensure the finished product does not contain any excess hydroxide or too much free unreacted fat. Saponification charts should also be used in hot processes, but are not necessary for the "fully boiled hot-process" soaping.

Historically, lye used in the cold process was made from scratch using rainwater and ashes. Soap makers deemed the lye solution ready for use when an egg would float in it. Home-made lye making for this process was unpredictable and therefore eventually led to the discovery of sodium hydroxide by English chemist Sir Humphrey Davy in the early 1800s.

A cold-process soap makers first looks up the saponification value for each unique fat on an oil specification sheet. Oil specification sheets contain laboratory test results for each fat, including the precise saponification value of the fat. The saponification value for a specific fat will vary by season and by specimen species (QLOEPA, 2012). This value is used to calculate the exact amount of sodium hydroxide to react with the fat to form soap. The saponification value must be converted into an equivalent sodium hydroxide value for use in cold process soapmaking. Excess unreacted lye in the soap will result in a very high pH and can burn or irritate skin; not enough lye leaves the soap greasy. Most soap makers formulate their recipes with a 2–5% deficit of lye, to account for the unknown deviation of saponification value between their oil batch and laboratory averages.

The lye is dissolved in water. Then, the oils are heated, or melted if they are solid at room temperature. Once the oils are liquefied and the lye is fully dissolved in water, they are combined. This lye-fat mixture is mixed until the two phases (oils and water) are fully emulsified. Emulsification is most easily identified visually when the soap exhibits some level of "trace", which is the thickening of the mixture. Many modern-day amateur soap makers often use a stick blender to speed up this process. There are varying levels of trace. Depending on how additives will affect trace, they may be added at light trace, medium trace, or heavy trace. After much stirring, the mixture turns to the consistency of a thin pudding. "Trace" corresponds roughly to viscosity. Essential oils and fragrance oils can be added with the initial soaping oils, but solid additives such as botanicals, herbs, oatmeal, or other additives are most commonly added at light trace, just as the mixture starts to thicken (QLOEPA, 2012)

The batch is then poured into molds, kept warm with towels or blankets, and left to continue saponification for 12 to 48 hours. (Milk soaps or other soaps with sugars added are the exception. They typically do not require insulation, as the presence of sugar increases the speed of the reaction and thus the production of heat.) During this time, it is normal for the soap to go through a "gel phase", wherein the opaque soap will turn somewhat transparent for several hours, before once again turning opaque.

After the insulation period, the soap is firm enough to be removed from the mold and cut into bars. At this time, it is safe to use the soap, since saponification is in essence complete. However, cold-process soaps are typically cured and hardened on a drying rack for 2–6 weeks before use. During this cure period, trace amounts of residual lye are consumed by saponification and excess water evaporates.

During the curing process, some molecules in the outer layer of the solid soap react with the carbon dioxide of the air and produce a dusty sheet of sodium carbonate. This reaction is more intense if the mass is exposed to wind or low temperatures.

1.6.2 Hot process soap making

This process is named for its boiling pot method of soap milling. This method uses heat to speed the reaction resulting in fully saponified soap by the time the soap is poured into molds (Anne-Marie, 2002). Hot-processed soaps are created by encouraging the saponification reaction by adding heat to speed up the reaction. In contrast with cold-pour soap which is poured into molds and for the most part only then saponifies, hot-process soaping for the most part saponifies the oils completely and only then is poured into molds.

In the hot process, the hydroxide and the fat are heated and mixed together at 80–100 °C, a little below boiling point, until saponification is complete, which, before modern scientific equipment, the soapmaker determined by taste (the sharp, distinctive taste of the hydroxide disappears after it is saponified) or by eye; the experienced eye can tell when gel stage and full saponification has occurred. Beginners can find this information through research and classes. Tasting soap for readiness is not recommended, as sodium and potassium hydroxides, when not saponified, are highly caustic.

An advantage of the fully boiled hot process in soap making is the exact amount of hydroxide required need not be known with great accuracy. They originated when the purity of the alkali hydroxides were unreliable, as these processes can use even naturally found alkalis, such as wood ashes and potash deposits. In the fully boiled process, the mix is actually boiled (100+ °C), and, after saponification has occurred, the "neat soap" is precipitated from the solution by adding common salt, and the excess liquid is drained off. This excess liquid carries away with it much of the impurities and color compounds in the fat, to leave a purer, whiter soap, and with practically all the glycerin removed. The hot, soft soap is then pumped into a mold. The spent hydroxide solution is processed for recovery of glycerin (Garzena and Tadiello, 2013).

1.6.3 Melt and pour soap making method

Out of all of the soap making methods this is perhaps the easiest for novice soap makers. It involves simply melting a soap base in a double boiler, adding in fragrance and dyes, and then placing the soap mixture into a mold (Anne-Marie, 2002).

CHAPTER TWO

2.0 MATERIALS AND METHODOLOGY

2.1 MATERIALS

2.1.1. **Reagents**

- Ethanol
- Fragrance
- Colour
- CMC(carboxymethyl cellulose)

.1.2 APPARATUS

- Thermometer
- Conical flask
- Beaker
- Erlenmeyer flask
- Burette
- Hot plate
- Measuring cylinder
- Weighing scale
- Hand gloves
- Plastic molds
- Funnel
- Separating funnel

- Nose mask
- Retort stand
- Stirrer
- Filter paper
- Water bath
- Micrometer screw gauge.

2.1 DETERMINATION OF SAPONIFICATION VALUES

Procedure

Weighing the oil sample:1 gram of the oil sample was carefully weighed and added to a 250 mL Erlenmeyer flask. This ensures that the amount of oil used in the experiment is accurately controlled.

Adding ethanolic potassium hydroxide solution: 25 mL of 0.5M ethanolic potassium hydroxide solution is poured into the Erlenmeyer flask containing the oil sample. This solution contains potassium hydroxide (KOH) dissolved in ethanol. The ethanol helps to dissolve both the oil and the KOH, facilitating the saponification reaction.

Attaching the reflux condenser and heating: A reflux condenser was connected to the mouth of the Erlenmeyer flask. This condenser is designed to allow volatile substances to evaporate but then condense back into the flask, preventing them from escaping. The mixture in the flask was heated for 30 minutes using a water bath. This prolonged heating ensured that the saponification reaction between the oil and the KOH is complete.

Cooling the mixture: After 30-minute heating period, the flask is removed from the water bath and was allowed to cool to room temperature. Cooling the mixture is necessary before proceeding to the titration step.

Titration with HCl: The cooled mixture was titrated with 0.5M hydrochloric acid (HCl) solution. Phenolphthalein indicator is added to the mixture before titration. Phenolphthalein is a colorless chemical that turns pink in the presence of excess base (in this case, KOH). The HCl reacted with any remaining KOH from the saponification reaction, neutralizing it. The titration continued until the pink color just disappears, which indicates that all the KOH has reacted.

Blank sample determination: Before starting the actual titration, a blank sample was prepared. This blank sample consists of all the reagents used in the experiment except for the oil sample. The blank sample was titrated in the same manner as the oil sample. The volume of HCl required to neutralize any residual KOH in the apparatus or reagents wa recorded as the blank titration volume.

Calculation;

The saponification value was calculated using the below formula;

$$\frac{\text{Tvblank - Tvsample x 28.05}}{\text{Weight of oil (1g).}}$$

Where;

Tvblank is the volume of HCl used for blank titration

Tvsample is the volume of HCl used for the sample titration.

2.2 Acid Value

Fifty milliliters of neutral ethyl alcohol was heated with 1 g of oil sample in a 250 mL beaker until the mixture began to boil. The heating was stopped and the solution titrated with 0. lM KOH solution using 2 drops of phenolthalein as indicator with consistent shaking of the solution for a permanent bright pink colour which was allowed to stand for 30 seconds as end point.

The formula for acid value determination according to the Pearson method is shown below;

$$\text{Acid value} = \frac{\text{Volume of KOH x5.611}}{\text{Weight of oil sample (w)}} \cdot$$

The results of the acid values is presented in a more simple way as

%FreeFatty Acid

The percentage free fatty acid follows the formula;

$$\%\text{FFA} = \frac{V \times M}{w \times 100}$$

Where V = volume of titrant (KOH) used
M = Molecular weight of dominant free fatty acid

W = weight of the oil sample in grams.

2.4 Preparation of caustic solution

2.4.1 3M sodium hydroxide in 250 mL

Thirty grams of sodium hydroxide was weighed using a weighing scale and then added to 250 mL distilled water inside a 250 mL volumetric flask. This solution was then stirred until it completely dissolves.

2.5 PREPARATION OF THE SOAP

2.5.1 Palm kernel soap (100%)

The method according to Woollatt, 1985, was modified and used for the preparation of different soap. One hundred and fifty milliliters of the palm kernel oil (PKO) was measured inside a beaker and then poured inside an aluminum pot and then heated until it gets to 60^0C mark. The temperature of the oil was monitored using a thermometer. 100 mL of 3M sodium hydroxide was then measured inside a 250 mL beaker and then slowly poured inside the aluminum pot containing the oil. On adding this lye solution, "saponification" occurs. This followed by heating the mixture using a hot plate along with continuous stirring of the mixture for 30minutes until a creamy mixture was achieved. The temperature of the mixture was the checked (90°C) and then allowed to cool to 70^0C. On cooling, 10g of sodium carbonate was added and stirred. 5g of sodium silicate was added, 2g of borax was also added, 5g of sodium sulphate was also added and then 10g of CMC (carboxymethyl cellulose) was added to the soap mixture and then stirred until proper mixture was attained. To the soap 20 mL of distilled water was added and heated for 5minutes to ensure a proper mixture off all the ingredients. 5g of color was added along with fragrance (for scent) and stirred until a uniform mixture was attained. Lastly, the soap mixture was then poured in a mold and left for 24hrs to set. After this period, the soap was unmolded and cut it into bars. The bars were placed on a rack in a cool, dry place to cure for 4-6 weeks. During this time, the soap hardened and its pH level was stabilized.

2.5.2 Palm oil soap (100%)

One hundred and fifty milliliters of the palm kernel oil (PKO) was measured inside a beaker and then poured inside an aluminum pot and then heated until it gets to 60^0C mark. The temperature of the oil was monitored using a thermometer. I00 mL of 3M sodium hydroxide was then measured inside a 250 mL beaker and then slowly poured inside the aluminum pot containing the oil. On adding this lye solution, "saponification" occurs. This followed by heating the mixture using a hot plate along with continuous stirring of the mixture for 30 minutes until a creamy mixture was achieved. The temperature of the mixture was the checked (90^0C) and then allowed to cool to 70^0C. On cooling, 10g of sodium carbonate was added and stirred .5 g of sodium silicate was added, 2 g of borax was also added, 5g of sodium sulphate was also added, **1**0 g of carboxymethyl cellulose (CMC) was added to the soap mixture and then stirred until proper mixture was attained. To the soap 20 mL of distilled water was added before heating for 5 minutes to ensure a proper mixing of all the ingredients. Subsequently, 5 g of colour was added along with fragrance (for scent) and stirred until a uniform mixture was attained. Finally, the soap mixture was then poured into a mold and left for 24 hours to set. After this period, the soap was unmolded and cut it into bars. The bars were placed on a rack in a cool, dry place to cure for 4-6 weeks. During this time, the soap hardened and its pH level was stabilized.

2.5.3 Palm kernel and palm oil soap blend (50%:50%)

75 mL of the palm kernel oil (PKO) was weighed and 75 mL of palm oil was measured inside a beaker and then poured inside an aluminum pot and then heated until it gets to 60 ^{0}C mark. The temperature of the oil was monitored using a thermometer. I00 mL of 3M sodium hydroxide was then measured inside a 250 mL beaker and then slowly poured inside the aluminum pot containing the oil. On adding this lye solution, "saponification" occurs. This followed by heating the mixture using a hot plate along with continuous stirring of the mixture for 30 minutes until a creamy mixture was achieved. The temperature of the mixture was the checked (90 ^{0}C) and then allowed to cool to 70^{0}C. On cooling, 10g of sodium carbonate was added and stirred 5g of sodium silicate was added, 2g of borax was also added, 5 g of sodium sulphate was also added and then 10g of CMC (carboxymethyl cellulose) was added to the soap mixture and then stirred until proper mixture was attained. To the soap 20 mL of distilled water was added before heating for 5minutes to ensure a proper mixing of all the ingredients. Subsequently, 5 g of colour was added along with fragrance (for scent) and stirred until a uniform mixture was attained. Finally, the soap mixture was then poured into a mold and left for 24 hours to set. After this period, the soap was unmolded and cut it into bars. The bars were placed on a rack in a cool, dry place to cure for 4-6 weeks. During this time, the soap hardened and its pH level was stabilized.

2.5.4 Palm kernel and palm oil soap blend (70%:30%)

Hundred and five milliliters of the palm kernel oil (PKO) was weighed and 45 mL of palm oil was measured inside a beaker and then poured inside a aluminum pot and then heated until it gets to 60^{0}C mark. The temperature of the oil was monitored using a thermometer. l 00 mL of 3M sodium hydroxide was then measured inside a 250 mL beaker and then slowly poured inside the aluminum pot containing the oil. On adding this lye solution, "saponification" occurs. This followed by heating the mixture using a hot plate along with continuous stirring of the mixture for 30 minutes until a creamy mixture was achieved. The temperature of the mixture was the checked (90^0C) and then allowed to cool to 70^0C. On cooling, 10 g of sodium carbonate was added and stirred .5 g of sodium silicate was added, 2g of borax was also added, 5 g of sodium sulphate was also added and then 10 g of CMC (carboxymethyl cellulose) was added to the soap mixture and then stirred until proper mixture was attained. To the soap 20ml of distilled water was added before heating for 5 minutes to ensure a proper mixing of all the ingredients. Subsequently, 5 g of colour was added along with fragrance (for scent) and stirred until a uniform mixture was attained. Finally, the soap mixture was then poured into a mould and left for 24 hours to set.

2.5.5. Palm kernel and palm oil soap blend (30%:70%)

Forty five milliliters of the palm kernel oil (PKO) was weighed and 105 mL of palm oil was measured inside a beaker and then poured inside a aluminum pot and then heated until it gets to 60 ^{0}C mark. The temperature of the oil was monitored using a thermometer. I00 mL of 3M sodium hydroxide was then measured inside a 250 mL beaker and then slowly poured inside the aluminum pot containing the oil. On adding this lye solution, "saponification" occurs. This followed by heating the mixture using a hot plate along with continuous stirring of the mixture for 30 minutes until a creamy mixture was achieved. The temperature of the mixture was the checked (90 ^{0}C) and then allowed to cool to 70 ^{0}C.On cooling, 10g of sodium carbonate was added and stirred .5 g of sodium silicate was added, 2 g of borax was also added, 5g of sodium sulphate was also added and then 10 g of CMC (carboxymethyl cellulose) was added to the soap mixture and then stirred until proper mixture was attained. To the soap 20 mL of distilled water was added before heating for 5minutes to ensure a proper mixing of all the ingredients.

Subsequently, 5 g of colour was added along with fragrance (for scent) and stirred until a uniform mixture was attained. Finally, the soap mixture was then poured into a mold and left for 24 hours to set. After this period, the soap was unmolded and cut it into bars. The bars were placed on a rack in a cool, dry place to cure for 4-6 weeks. During this time, the soap hardened and its pH level was stabilized.

2.6 ANALYSIS OF THE SOAP

2.6.1 Moisture Content Determination

In determining the moisture content in the soap, a sample was initially taken and finely grinding or chopped into small, uniform pieces. Then, a precision balance was used to weigh an empty, clean, and dry moisture dish accurately, recording the weight meticulously. The moisture dish was filled with a portion of the chopped soap sample, ensuring even distribution without compaction. The moisture dish containing the sample was transferred to a oven set to a specific temperature (105-110°C) for drying until the sample's weight stops decreasing, indicating complete moisture removal. After drying, the dried sample was allowed to cool naturally to room temperature within a desiccator to prevent moisture reabsorption. Once cooled, the moisture dish was reweighed with the dried sample inside using the same balance, recording the weight was measured accurately. The moisture content was calculated using the provided formula below.

$$\text{Moisture Content (\%)} = \frac{\text{Weight before drying} - \text{Weight after drying}}{\text{Weight before drying}} \times 100\%$$

2.6.2 Foamability

Five grams of piece of the soap sample was cut uniformly, ensuring consistency across tests. Then, the soap sample was placed in the bottom of a graduated cylinder. 250mL of water was added to the cylinder or beaker. The mixture was agitated by shaking for a specific duration of one minute. The foam was allowed to stabilize for a short period of 30 seconds. Then the height of the foam formed was measured using the formula below.

$$\text{Foamablity (\%)} = \text{Formula: } \frac{\text{Volume or height of foam Volume of water}}{\text{Volume of Water}} \times 100\%$$

2.6.3 Test for pH

Five grams of the soap sample was weighed inside a beaker and then 50 mL of distilled water was added and stirred until the soap sample dissolves. The pH meter was then used to determine the pH of the soap.

2.6.4 Test for Harshness

The soap was tested by applying the soap with water to dry area of skin (forearm), then a stop watch was used to monitor the duration of contact between the soap and skin (2minutes), the soap was then washed away thoroughly from the skin using lukewarm water. The skin was allowed to dry naturally and then observed for any signs of irritation, such as redness, itching, or inflammation.

2.6.5 Hardness Test

To determine the hardness of the soap, a needle (6.4 cm in length; 1 mm in diameter) was attached to a weight (100g) and then lowered unto the soap, the distance into which the needle penetrates the soap, after 30 s, was recorded as a measure of its hardness. This was repeated thrice for each soap sample and the mean was taken.

2.6.6 Test for Effectiveness in Cleaning

To determine the cleaning property of the prepared soap, a drop of oil was placed on a filter paper. The filter paper with the oil spot was then immersed in a volumetric flask containing soap solution (2g soap and 100ml distilled water) and then shaken vigorously for one minutes. The filter paper was then removed and rinsed with distilled water and the degree of cleanliness in each of the filter paper was observed.

CHAPTER THREE

3.0 RESULTS AND DISCUSSION

The result of the chemical analysis carried in the oil is shown in Table 1

3.1 Chemical Analysis of the Oil

Table 3. 1: Saponification and Acid Value Analysis of the Oil

Oils	Saponification value(mgKOH/g)	Acid value(mgKOH/g)	% free fatty acid
Palm kernel oil (PKO)	283.305	4.488	1.600
Palm Oil(PO)	221.595	6.732	3.384

3.2 Moisture Content

Table 3. 2: **Moisture Content Analysis of the Oil**

Soaps	Moisture content (%)
PKO soap(100:0)	35.00
PO soap(0:100)	33.50
PKO and PO blend (50:50)	36.00
PKO and PO blend (70:30)	39.50
PKO and PO blend (30:70)	30.50

3.3 Foamability of the Soap

Table 3.3

Soap	**PKO(100:0)**	**PO(0:100)**	**PKO and PO (50:50)**	**PKO and PO (70:30)**	**PKO and PO (30:70)**
Soap solution + height (cm)	**7.30**	**11.40**	**12.60**	**9.80**	**13.30**

3.4 pH of the Soap Samples

Table 3. 4: pH of the Soap Samples

Soaps	**PKO(100:0)**	**PO(0:100)**	**PKO and PO (50:50)**	**PKO and PO (70:30)**	**PKO and PO (30:70)**
pH	**8.95**	**8.57**	**8.81**	**8.99**	**9.34**

3.5 Effectiveness in Cleaning

Table 3.5: **Cleaning Test**

Soap samples	Texture	lathering	Cleansing power	Uses
PKO(100:0)	Brittle	good	More effective	washing
PO(0:100)	Hard	Very good	Effective	washing
PKO and PO (50:50)	Hard	excellent	Most effective	Washing and bathing
PKO and PO (70:30)	Hard	Very good	More effective	washing
PKO and PO (30:70)	Hard	Excellent	Most effective	washing and bathing.

3.6 Discussion

From the above data obtained during the course of this work, showing information concerning the physiochemical analysis of the soap samples. The properties of the soaps obtained depend on the fats and oil used as well as the caustic alkali used for the preparation. Fatty acids containing 12, 14, 15 and 18 carbon atoms are mostly used for soap making. Different oil has different impact on soap.

From Table 2, (Saponification and free fatty acid of the oils) shows the saponification and acid value of the oil which is an importance parameter for soap production. The saponification value gives information concerning the character of the fatty acid present in the oil. The long chain fatty acid found in fat have low saponification value because they have relatively fewer number of carboxylic functional groups per unit mass of fat and therefore have high molecular weight. Oil with high saponification value such as palm oil and palm kernel oil is used in soap making and as a result soap manufacturers blend this oil with other oils because of its high saponification value. Also, the level of acidity or alkalinity present in soap is a very important parameter, as this can affect many bar characteristics including stability and irritancy. A high acid value indicates stale oil stored under improper condition. The acid value of both oils confirms for the minimum purity to get yield of better quality soap.

From table 3, we see that palm kernel oil foams but its foambility is not as high as the one produced from palm oil. The blend of palm kernel and palm oil of ratio 30:70 gives a higher forming ability when compared to palm kernel and palm oil soap blend of ratio 70:30.

From Table 4, the pH of soap samples has good pH range but the blend of the oils gives a slightly lower pH than the unblended. High pH in soap can cause skin bum and irritation.

From Table 5, it can be seen that the blend of both palm kernel oil and palm oil for the soap gave a good cleaning power when compared to the soap produced by the individual oil.

REFERENCES

Adomako D. (1985). Prospects for the development of the shea nut industry in Ghana. Cocoa.

Ainie, K., Hamirin, K. and Peang-Kean, L. (1996) Chemical and Physical Characteristics of Soap Made from Distilled Fatty Acids of Palm Oil and Palm Kernel Oil. *Journal of American Oil Chemists' Society,* 73, 105-108. http://dx.doi.org/10.1007/BF02523455

Anne-Marie Faiola, (2002). „Teach soap". Soap making recipes, tips and tutorials. Available online at http://soapqueen.com/?_e_pi=7%2CPAGE_ID10%2C3465923141

Chalmers, L. and Bathe, P. (1978) Chemical Specialist, Domestic and Industrial. 2nd Edition,

Coulibaly Y., Ouedraogo S., and Niculescu N. (2010). Experimental study of shea butter extractiondevelopment. 10: 2070-2084.

DMBB-(Desert Moon Bath & Body). (2013). Beneficial Properties of Oils, Butters, Minerals, and Botanical Extracts Used in Our Soap and Bath Products. Also available online at http://www.desertmoonbsthnbody.com/pages/learninglibrary.php [Accessed 3rd

Elias M., Bayala J., and Dianda, M. (2006). Impediments and innovations in knowledge sharing: The case of the African Shea sector. *KM4D Journal*. 2:52-67.

Francioni, J. B. and Callings, M. L. (2002)."Soap Making." Louisiana State Extension Circular http://ebookbrowse.com/gdoc.php?id=355456856&url=e36883294bb5b9bcd611ff0a00130aa [Accessed on 2nd January, 2017]

Garzena Patrizia, and Tadiello Marina (2013). *The Natural Soapmaking Handbook*. ISBN 978-0-9874995-0-9/George Godwin, UK, 1-15

Hall J.B., Aebischer D.P., Tomlinson H.F., Osei-Amaning E. and Hindle J.R. (1996). *Vitellaria* *paradoxa: A monograph;* School of Agricultural and Forest Sciences. University of Wales: Bangor, U.K. 8:105. Interscience, New York.

Kenam, Y. and Melek, A.K. (2014). A technical glance on some cosmetic oil. *European scientificjournal* /special edition/ edition vol.2 ISSN: 1857-7881 (print) e – ISSN:1857-7431.

Kirk-Othman (1963) Detergency, Soap and Surfactants. Encyclopedia of Chemical Technology.

Kuntom, A., Kifli, H., and Lim, P.K. (1996): Chemical and physical characteristics of soap made from distilled fatty acids of palm oil and palm kernel oil. *J. Am. Oil Chem Soc.* 73, 105-108.

Kuntom, A., Siew, W. L., and Tan, Y. A. (1994): Characterization of palm acid oil *J. Am.OilChemSoc,* 71, 525-528.

Maranz S., Kpikpi W., Wiesman Z., Saint Sauveur A., and Chapagain B. (2004). Nutritional values and indigenous preferences for shea fruits (*Vitellaria paradoxa)* in African agroforestryparklands. Economic Botany.58:588-600.

Ndiokwere and Ukhun (2001). University Organic Chemistry. Partiel Publishers, Benin City. Pp.243-246 November, 2016].

Okullo, J.B.L., Omujal, F., Agea, J.G., Vuzi, P.C., Namutebi, A., Okello, J.B.A. and Nyanzi, S.A., 2010. Physico-chemical characteristics of Shea butter (Vitellaria paradoxa CF Gaertn.) oil from the Shea district of Uganda. *African Journal of Food, Agriculture, Nutrition and Development*, *10*(1).

Panduranga, R., Thirumala S.D., and Reddy B.R. (1971). "The Storage Behaviour of Decorticated and Undecortieated Safflower Oil" Indian Oil Soap Journal. Vol. 36(3).

page. 233-238.

Quality Laboratory Oil Examination Procedures and Practices (QLOEPA)" (2012). *American Oil Chemists' Society*. Retrieved 17. Research Institute, Ghana, *Technical Bulletin.*11;8-10.

Shoge, M. (2011) Quality of Soaps Using Different Oil Blends. *Journal of Microbiology and Biotechnology Research, 1, 29-34.*

Simmons, W. H. and Appleton, H. A. (2007).“The Handbook of Soap Manufacture”.*The Oil and Colour Trades Journal.* London Scott, Greenwood & Son Offices 8 Broadway, Ludgate Hill, E.C.Also available online at http://www.gutenberg.org/files/21724/21724h/

Viorica, P., Alina, S. and Simona, D. (2011) Quality Control and Evaluation of Certain Properties for Soap Made in Romania. *Journal of Scientific Study and Research, Chemistry and Chemical Engineering, Biotechnology, Food Industry*, 12, 257-261.

WiseGEEK. (2013). How to make Soap, detergent soap, best antibacterial soap, soap making and handmade soap. Available online http://wisegeek.org/what-is-antiseptic-soap.htm. [Accessed 1st January, 2017]. 21724h.htm [Accessed on 2nd January, 2013]