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FINAL YEAR PROJECT ON THE “PRODUCTION OF LIQUID DETERGENT FROM CASTOR SEED”

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"PRODUCTION OF LIQUID DETERGENT FROM CASTOR SEED"

Approval

The undersigned certify that they have read and here by recommend to the **Wolkite University** to accept **the thesis** submitted by Angasa Niguse, Behailu Yadesa, Mekdes Getabalewu, Cherasa Tola and and Gemechu Geremew, and entitled **"Production liquid detergent from castor seed"** in partial fulfillment of the requirements for the award of a B.Sc Degree in Chemical Engineering

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Declaration

We, the undersigned, declare that this **thesis** is our original work and that all sources of materials used for the **thesis** have been duly acknowledged. We, further confirm that the thesis has been submitted in partial fulfillment of the requirements for the advanced BSc degree in Chemical engineering/ChEg/ at Wolkite university. Quotations from this **thesis** are allowed without any permission provided that appropriate acknowledgment of source is made in all other case, however, permission must be obtained from the author.

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Abstract

Non-biodegradability process and non-solubility of mineral oil soap and liquid detergent products cause to pollute fresh tap water. To overcome this problem, replacing of the raw material of mineral oil by vegetable oil is the possible solution. Castor plant is a locally available and cheapest material which is non -edible crop and does not compete with food crops. It is rich in oil which is used for many industrial purposes. The main use of castor oil is in the production of detergents. Therefore; this project work was to carry out with the objective of extraction of oil from castor seeds and its utilization to produce liquid detergent. The detergent production was obtained from castor beans by using pretreatment of castor seed, extraction of castor oil, neutralization and sulphation methods. The oil was extracted via soxhlet extractor using hexane as solvent. Solvent extraction method was employed in extracting the oil and the total percent oil yield was found to be 33.33%. The research also revealed some properties of castor oil in terms of values obtained by the determination of saponification value of 183.93 mg NaOH/g of oil which is in the range of standard saponification value of 176-187 mg NaOH/g of oil, free fatty acid 92%, and acid value (AV) was 1.84 also these values were between the ranges of values specified by ASTM. The soap produced gave a pH of (10.69), foam height (2.57cm) and moisture content (1.785%). The color, scent and efficiency of the detergent were improved with the addition of bleaching agent and perfume. However, as this paper use of only two ingredients is not enough for good quality of detergents. Hence using other ingredients like optical brightness and enzymes was recommended for more good quality of liquid detergents. The fixed capital investment for the project is 38,837,233.33 birr with a payback period of 1 year. So, this project relies that the castor oil can substitute the expensive detergent base materials and it is a simple way of production which can be done at small scale industries and feasible.

Key Words: *Detergent, Castor oil, Castor seed, neutralization, sulphation, extraction*

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Abbreviations and Acronyms

LABS	Linear alkylbenzenesulfonates
POC	Plant Overhead Cost
TCI	Total Capital Investment
FCI	Fixed Capital Investment
PBP	Payback Period
ROR	Rate of Return
WC	Working Capital
POC	Plant Overhead cost
FC	Fixed Charges
TPC	Total Product Cost
NaOH	Sodium Hydroxide
H_2SO_4	Sulfuric acid
H_2O_2	Hydrogen Peroxide

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Castor plant, Ricinus communis L., is a specie of flowering plant in the spurge family, Euphorbiaceae. Its seed is the castor been, despite its name, is not a true been. Castor plant is indigenous to the southeastern Mediterranean Basin, Eastern Africa, and India, but is widespread throughout tropical regions (10).This plant grows optimally in tropical summer rainfall areas. It rows well from the wet tropics to the subtropical dry regions with an optimum temperature of 20^0C-25 ^{0}C. Castor been is cultivated for the seeds which yield viscous, pale yellow non-volatile and non-drying oil. It has been used for industrial and medicinal purposes (11).

The high content of the oil in the seeds can be attributed to the warm climate conditions, but temperatures over 38^0C can lead to poor seed setting. Additionally, temperature's low enough to induce the formation of forest is known to kill the plant (1).

Castor oil is one of the few naturally occurring glycerides with high purity, since the fatty acid portion is nearly 90% of ricinoleic (3). The crude oil has district odor but can easily be deodorized in the refining process like any other vegetable oil. This oil has an advantage over other mineral oils in that it is biodegradable, eco-friendly and renewable resource (4). The presence of ricinoleic acids, oleic acid, palmitic acid, steric acid and dihydroxylystearic acid in castor seed oil is an indication of good quality that can be utilized for use in cosmetics and soap industries. Compared with the common vegetable oils, Castor oil is more viscous, less soluble in hexane, more soluble in ethanol, all as a consequence of the presence of the hydroxyl acid (5).

Apart from soap, it is the earliest anionic surfactant (6). One of it's uses in the manufacture of transport soaps (7). Its major fatty acids are the unsaturated fatty acid, hydroxylated 12-hydroxy, 9-octadecenic acid known familiarly as the ricinuleic acid (RNA). The fatty acid composition of a typical castor oil contains between 87-90% ricinuleic acid. Thus, the oil can be used in the production of vanishes, lacquers, protective coatings, lubricants, soaps, paints, inks and it is a primary raw material for the production of nylon and other synthetic resins (27).

The washing industry, usually known as soap industry has, roots over 2000 years, a soap factory having been found in the pomp excavation. However, among the many chemical process industries, none has experienced such a fundamental change in a raw material as have the washing industry. Soap itself was never actually "discovered", but instead gradually evolved from crude mixture of alkaline and fatty acid (12).

Scientifically, the term detergent covers both soap and synthetic detergent, "syndets" but it is widely used to indicate synthetic cleaning compounds as distinguished from soap. Detergent differs from soap in their action in hard water. Although soaps are excellent cleaners, they do have disadvantages. As salts of week acids, they are converted by mineral acids in free fatty acids. These fatty acids are less soluble than the sodium or potassium salts and form precipitate or soap scum. Because of these, soaps are ineffective in acidic water. Also, soaps form insoluble salts in hard water such as water containing magnesium, calcium or iron. The insoluble salts from bath rub rings, leave film that reduce hair luster, and gray/roughen textiles after repeated washings. Synthetic detergents, however, may be soluble in both acid and alkaline solutions and do not form insoluble precipitate in hard water (13).

The detergent and soap making industries are no exceptions, for while they provide us with cleansing agents, their processing and by-products are also cause of public nuisance. For instance, detergents, unlike soaps, have proved very effective cleansing agents in hard and cool water whereas soap is often wholly ineffective under such condition (14).

This project work is primarily aimed at studying the replacement made to the non-biodegradable detergents. Production of environmentally friendly liquid detergents (soft detergents) from castor oil has the dual advantage of using locally sourced raw material, they make economically friendly for our country because it's locally available and cheapest material.

1.2 Problem of statement

Liquid detergents are used for washing textiles, cleaning household items, vehicles and equipment. In addition, in the industry they facilitate technological processes in the bleaching and dyeing of fabrics, furs and skins. And also many mineral detergents were neither soluble nor biodegradable, that is they were so stable that when they flow into the soil in laundry sewage water and they remain unchanged, resisting conversion in to less complex and more soluble substance. They create suds and foams in fresh tap water, naturally occurring ground and surface waters.

Today, many detergents are produced from petroleum by-products which may result in depletion of non-renewable resources and causes environmental damage. In our country there are small-scale factories they produce and supply liquid detergents for the society, but they do not meet the need of the society. In order to meet their need, it's imported from abroad countries which may affect the economy of our society that result in economy of the country.

To correct those the above odds, require that environmental issues be considered at the initial stages of conceptualization and development of better search for alternative cheapest and eco-friendly materials. Due to all this purposes, vegetable (Castor oil) detergent is better than the other mineral detergents.(10) This is the reason why the project was proposed for production of environmental-friendly detergent from castor oil.

1.3 Objectives

1.3.1 General Objective

The general objective of this research is to develop the process of extraction of castor oil from castor seed for the production of liquid detergent.

1.3.2 Specific objective

- To characterize castor oil extracted from castor seed.
- To characterize detergent produced from castor oil.
- To perform techno-economic study.

1.4 Scope of the study

This paper generally deals with the production of detergents from castor seed which includes and explains about raw materials, production process, equipment design and economic analysis of the process.

1.5 Significance of the study

This paper is aimed at the replacement of mineral detergent which makes precipitate in hard water with liquid detergent from castor oil, which have better important for textile, fabrics and toilet washes. For the country like Ethiopia in which 85% of it's people follow agriculture based way of life, such type of project is going to upgrade the society economic status. By doing so the first beneficial will be farmers who are going to be prepare a farm of this plant. This is because they will be raw material suppliers for the industries that are engaged in the production of castor seed based liquid detergent.

The relevance of the production and use of synthetic detergents have the following advantages: -

- Production of liquid detergent is based on a cheap raw material which is consistently obtained with a simple production process. This will play an important role in decreasing cost of detergents.
- Synthetic detergents do not interact with the salts of hard water or the reaction yields products which are easily removed from the fabric.
- They increase the number of industries in our country and create job opportunities since it can be implemented at small scale factories.
- Finally, revealed for researchers to see this very cheap locally available materials for other investigation.

CHAPTER TWO

2. LITRATURE REVIEW

2.1 General Description of Detergents

Detergent is a cleaning agent that helps to remove dirt and grease from porous surfaces such as fabrics, clothes, and/or non-porous surface such as metal plastics. All detergents are made principally of soap or surfactants. But after a time, different technologies are applies for the production of detergent among these are vegetable oil, like olive oil, palm oil, coconut oil and castor oil are basic raw materials for the production of detergent. Among these vegetable oil castor beans is a fast growing ever-green shrub that produces seeds with high oil content up to 55%. (15).

Detergents are anionic surfactants used in conjunction with water for washing and cleaning, but they are also used in textile spinning and are important components of lubricants. Detergents for cleansing are obtained by treating vegetable or animal oils and fats with strongly alkaline solution. Fats and oils are composed of triglycerides; three molecules of fatty acids are attached to a single molecule of glycerol. It consists of sodium or potassium salts of fatty acids and is obtained by reacting common oils or fats with a strong alkaline solution in a process known as saponification. Soap belongs to the family of detergents which is a substance which improves the cleaning properties of water. (9)

2.1.1 The development of detergent industry

The first synthetic detergents were created in Germany during the First World War, due to a large deficit of dietary fat, and after the war the liquid detergents industry flourished in the United States, Japan and some European countries. In different countries, liquid detergents were produced from various raw materials. For example, in the United States sodium oleyl taurate began to be actively used, Germany aliphatic sulfates (sulfates of fatty alcohols), in the United Kingdom - a secondary olefin sulfate, derived from petrochemical sources, which is released in England in large quantities. (10).

Thus, liquid detergents finally were established on the market. So, in the years 1940-1972 the demand for synthetic detergents in the United States increased 1000-fold to 4.5 million tons per year. Production of detergents in the world was developed due to both a displacement of fatty soaps, and due to the increase of the total consumption of detergents. Currently, the world production of liquid detergents amounts to tens of millions of tons per year. However, most of them (70%) are consumed only by residents of the most developed countries, constituting about 20% of the population. The most widely used are detergents in a powdered form, in particular those for domestic use. During the last decade, the release of liquid detergents increased significantly, mainly for industrial applications. This is due to the fact that during the use and storage of detergents in liquid form their drying is excluded, liquid compositions do not give up dust, they are easily dispensed, can be quickly and easily mixed with water. A range of cleaning agents includes cleaners for dish washing, cleaners for bathrooms, toilets, glass, household and specialty cleaners. (10).

2.1.2 Use of additives in detergent industry

A liquid detergent composition generally comprises six groups of substances: surfactants, builders, enzymes, bleaching agents, fillers and other minor additives such as dispersing agents, fabric softening clay, dye-transfer inhibiting ingredient, and optical brighteners.

A) Surfactants

Surfactant is an abbreviation for surface active agent, which literally means active at a surface (16). Surfactants are the single most important ingredients in laundry and household cleaning products, comprising from 15% to 40% of the total detergent formulation. (17). According to the polar head group, surfactants used in detergent formulations can be classified into four groups: anionics, non-ionics, cationics, and zwitterionics.

i) **Anionic Surfactants**: It's where the head of the detergent particle contains a negatively-charged ion. They are used in greater volume than any other groups due to their ease and low cost of manufacture. The first surfactant is soap, which is made from a fatty acid such as animal fat or vegetable oil that is allowed to react with an alkali. It's where the head of the detergent particle contains a negatively-charged ion.

ii) **Cationic surfactants**: - It's where the head of the detergent particle contains a positively charged ion. The majority of cationic surfactants used in detergent compositions are based on the nitrogen atom carrying positive charge. In general, the preferred solubilizing anion is a halide or methosulfate ion. It's where the head of the detergent particle contains a positively charged ion.

iii) **Nonionic surfactants**: - It's where there is no charged ion on the head of the detergent particle. They have been extensively used in the area of the laundry detergents and personal-care formulations in combination with anionic surfactants. The non-ionic surfactants are represented mostly by linear alcohol ethoxylates, with the alcohols being derived from either petro-chemical raw materials or natural resources.

iv) **Zwitterionic surfactants**: - They contain two charged groups of different signs under normal conditions. One main type of zwitterionic surfactants is the amphoteric surfactant, which can be either cationic, zwitterionic, or anionic, depending on pH of the solution.

B) Detergency Builders

Surfactant efficiency is greatly reduced in hard water and surfactants do not show good performance even in softer water. Furthermore, large amounts of surfactants in detergents not only significantly increase biological demand in water but also impose heavy load on sewage works and, on the environment, due to their eco-toxicity. To remove Ca^{+2} and Mg^{+2} ions existing in hard water and in soils, and thus to lower the content of surfactants in the detergent formulations, detergency builders are often used in conjunction with surfactants. A potential builder should satisfy a large number of requirements including sequestering ability, alkalinity, buffer capacity, bleach compatibility, soil deflocculation, oral toxicity, skin absorption, eye irritation, effects on fish and other aquatic animals, and other environmental and economic practicability. (18).

C) Bleaching agents: - Dissolves and bleaches organic deposits. Oxygen-based bleaching agents are often used. Until a few years ago chlorine or per-chlorates were normally used but due to their environmental properties other products like per-carbonates are often used.

D) **Optical brighteners**: - Improve the apparent (whiteness) of the clothes by absorbing invisible UV light and giving off a blue fluorescence.

2.1.3 Properties of detergents

Table 1:- Properties of Liquid Detergent

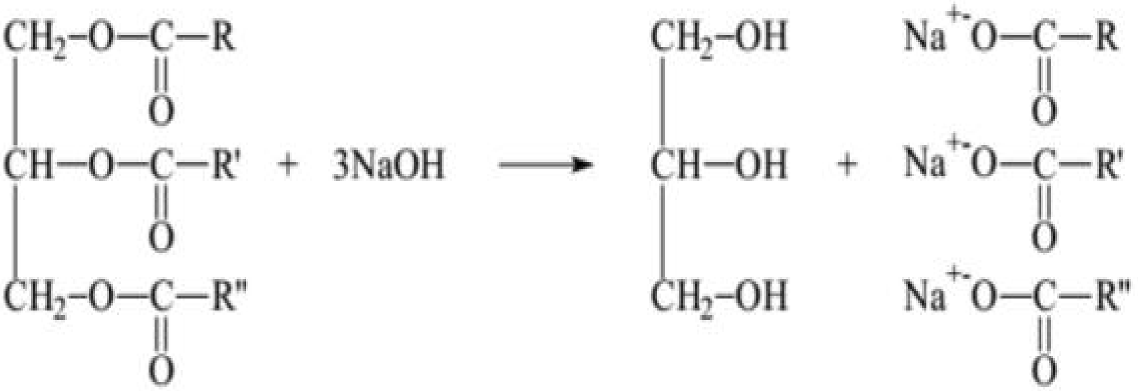
Property	**Description**
PH	8-12.5
Specific gravity@25^0C	1.26
Boiling point	247 ^{0}C
Melting point	11-13 ^{0}C
Density	0.932g/cm^3

2.1.4 Chemistry of detergents

A detergent is any compound that can be used as a cleaning agent. Although soap is a detergent, this term is generally used to refer to liquid substitutes of soap. Detergents have structural characteristics similar to soaps, polar region and a non-polar long chain and act basically the same way. However, chemical characteristics of the detergent are different and do not precipitate in hard water or acidic solutions, such as soaps. (19)

Detergents are the product of the reaction between a fat/oil and sodium hydroxide:

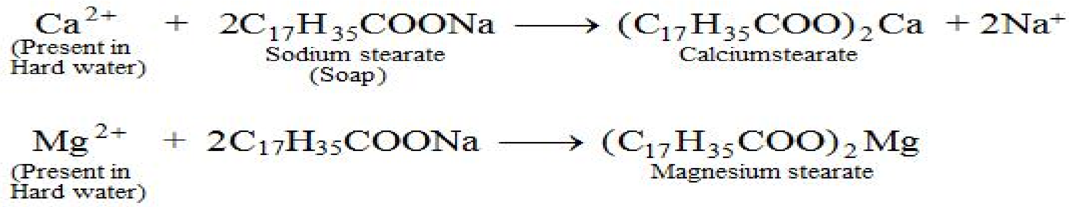
Fat/oil +3NaOH → glycerine + 3 soap/detergents



Triglyceride Caustic soda Glycerine Soap/Detergent

2.1.5 Advantages of detergents over soap

Soaps does not work well with hard water containing Ca^{2+} or Mg^{2+}. It reacts with Ca^{2+} and Mg^{2+} to form white precipitate which is called scum and soap goes waste. The reaction which takes place is as follows. Thus, soap solution forms less lather with hard water.



$$\underset{\substack{\text{(Present in}\\\text{Hard water)}}}{Ca^{2+}} + \underset{\substack{\text{Sodium stearate}\\\text{(Soap)}}}{2C_{17}H_{35}COONa} \longrightarrow \underset{\text{Calciumstearate}}{(C_{17}H_{35}COO)_2Ca} + 2Na^{+}$$

$$\underset{\substack{\text{(Present in}\\\text{Hard water)}}}{Mg^{2+}} + 2C_{17}H_{35}COONa \longrightarrow \underset{\text{Magnesium stearate}}{(C_{17}H_{35}COO)_2Mg}$$

In addition to this they are not suitable for washing woolen garments because it is basic in nature and woolen garments have acidic dyes. And also, they are less effective in saline water and acidic water. However, detergents does not form precipitate and are more soluble than soaps.

2.1.6 Detergent Fomability

Foams are usually formed in systematic hexagonal texture as a result of gas dispersion through a continuous surfactant solution**.** They are generally described in terms of their foamability defined as the capacity of the surfactants to form foam irrespective of the special foam properties, and foam stability describing the variations of foam height or volume with time, immediately after foam generation, it takes as standard of 2.6 cm for 2 minute. (19)

2.2 General Description of castor Plant

Castor plant is mostly agreed to be a native to Africa, by cultivation it has been distributed through not only all tropical and subtropical regions, but also in many of the temperate countries of the globe. They varies greatly in its growth and appearance also in growth habit, colour of foliage, stems, seed size and colour, and oil content, so that varieties often bear little resemblance to one another. Castor may be large perennials often developing into small trees, others behave as short-lived dwarf annuals and every gradation between these extremes can be found. The tree and short-internodes types are commonly referred to as giant and dwarf castor types respectively. (20).

Castor plant (Ricinus communis), from which castor beans and oil are native to the Ethiopian region of east Africa, is now grown in tropical and warm temperate regions throughout the world and is becoming an abundant weed in the south western united states .(21). In Ethiopia the castor plant found in Easter and Western Oromiya, Amahara, Arba Minch, Harar, Gambella and Tigray with different varieties (i.e. in color; red, brown, and white). (10).

Castor can produce flowers over a long period, especially under natural condition when climatic condition is favorable. Castor is naturally a cross-pollinated plant and wind is the major agent of pollination. The castor flowers are borne on inflorescences, which forms a pyramidal raceme also known as spikes, terminally on main and lateral branches. The flowers may be monoecious (male and female), pistillate (female only) or interspersed (arranged intersperse) on the inflorescence. (22)

Castor fruit is a globular spiny capsule which becomes hard and brittle when ripe. The Castor fruit is usually a schizocarp, typical regma; a capsular fruit with three cells each of which splits open at maturity into separate parts and then breaks away explosively, shattering the seeds. However, some castor varieties produce capsules with rudimentary spines, some produce soft, flexible and non-irritant spiny capsules while other produce spiny irritant capsules. After fertilization, the formation of capsule commenced 3 to 7 days. (23).

The capsule contains three seeds which may be elongated, oval or square in shape. The seed has a tiny and brittle testa (seed coat) enclosing a white kernel. The seeds may be colored white, dark brownish-red, brown, dark chocolate, red or black but usually several colours occur as very attractive mottle on the testa. The seeds vary greatly in size, from a few millimeters to nearly 250mm long and in breadth from 5 to 16mm. (24).

2.3 General Description of castor oil

(21) reported that castor beans contains about 30-35% oil which can be extracted by variety of processes such as cold press and solvent extraction. Also, (25) reported that the castor bean contains 35-55% oil by weight for high yield breed types and has one of the highest viscosities among vegetable oils, with a molecular weight of 298. Castor oil is one of the few naturally occurring triglycerides that approach being a pure compound, since the fatty acid portion is nearly nine-tenths ricinoleic. (26). It’s crude form is a pale straw colour that turns colourless or slightly yellowish after refining and bleaching.

The structure of castor oil is made up of triglycerides that lack glycerin. The triglyceride molecule has a long 18-carbon chain with a double bond. (27). Its chemistry is based mainly on the ricinoleic acid structure, carboxyl group, hydroxyl group, and a single point of unsaturation. (28). The carboxylic group in castor oil molecule allows production of a wide range of esterification products. The hydroxyl (-OH) group on the 12th carbon can be acetylated or eliminated through a dehydration process to upsurge the unsaturation to give a semi-drying oil. (29).

It contains triglycerides, which chemically is a glycerol molecule with each of the three hydroxyl groups esterified with long chain fatty acids. Their major fatty acid is the unsaturated fatty, hydroxylated 12- hydroxy, 9-octadecenic acid, known familiarly as the ricinoleic acid. (30),containing between 87- 90% ricinoleic acid (Rial et al, 1999; Conceicao et al, 2007). The presence of a hydroxyl group at C12 of the recinoleic acid, the ester linkages, double bonds and hydroxyl groups provide reaction sites that makes it usually polar, which provide sites for the production of a wide range of natural and synthetic resins, waxes, polymers and elastomers. It also has excellent emollient and lubricating properties, a marked ability to wet and disperse dyes, pigments and fillers (31) as well as several medicinal values. (32).

Through caustic fusion and high-temperature pyrolysis, the reactive site of the hydroxyl group can be splited to generate useful products with shorter chains. (27). In addition, the hydroxyl group provides more strength to the structure to prevent the formation of hydro peroxides. (34). The double bond in the structure can be modified through the process of carboxylation, epoxidation or hydrogenation. (33). Lastly, the single point of unsaturation can be altered through the process of epoxidation and hydrogenation. Hydrogenated castor oil, which is a wax-like substance, can be obtained from the oil via hydrogen reduction. (27).

According to (35), Castor oil pale amber viscous liquid derived from the seeds of the plant Ricinus communis is sometimes known as ricinus oil. Castor oil is one of the few naturally occurring glycerides that approach being a pure compound, since the fatty acid portion is nearly nineteenths ricinoleic acid. (36). Crude castor seed oil is pale straw colour which turns colourless or yellowish after refining and bleaching. (37). The crude oil has a distinct odour, but it can easily be deodorized in the refining process like any other vegetable oils .(21).

Castor oil has excellent solubility in methanol and hence theoretically an ideal oil for Extraction. Transesterification to biodiesel (38), requiring a minimum amount of catalyst and heating which can reduce cost for production. The extraction and commercialization of oils from castor seeds have been carried out extensively, relating its properties to the geographical origin and the method of extraction from oil bearing material. (39). The functional group causes ricinoleic acid to be unusually polar, and also allows chemical derivatization that is not practical with most other seed oils. It is this hydroxyl group which makes castor oil ricinoleic acid valuable as chemical feed stocks. (40)

Thus, the oil can be used in the production of vanishes, lacquers, protective coatings, lubricants, soaps, cosmetics, paints, inks, and it is a primary raw material for the production of nylon and other synthetic resins and fibers and a basic ingredient in racing motor oil for high-performance automobile motorcycle engines. (41). The castor meal or cake is mainly used as fertilizer; this is because it is unsuitable as an animal feed because of the presence of toxic protein called ricin and toxic allergen often referred to as castor bean allergen (CBA). However, it is not worthy that none of the toxic components is carried into the oil (42).

Castor oil extracted from the seed mostly using n-hexane is very versatile. Thus, it is utilized in several sectors such as agricultural, pharmaceutical, and industrial sectors. Products of castor oil include; ointments, nylon, varnishes, airplane engine lubricants, hydraulic fluids, dyes, detergents, plastics, synthetic leather, cosmetics, and perfumes. (43).

The leading castor oil producers are Brazil, China and India with India accounts for 90 % exporter. (27). The major consumers of castor oil are US, Europe and China. The oil contains 4 % linoleic acid, 3 % oleic acid, 1 % steric acid, and about 1 % linolenic acid (44). Annual consumption of castor oil is measured by hundreds of thousands of gallons, where that of either cotton-seed oil or linseed oil amounts to tens of millions. (45).

Table 2:- Composition of castor oil

Acid name	**Average percentage range (%)**
Ricinoleic acid	85-95
Oleic acid	2-6
Linoleic acid	1-5
Alpha-linolenic acid	0.5-1
Stearic acid	0.5-1
Palmitic acid	0.5-1
Dihydroxystearic acid	0.3-0.5
Others	0.2-0.5

Table 3:- Properties of castor oil

Property	**Information**
Density	(800 – 900) kg/m^3
Boiling point	313 ^{0}c
Melting point	-2 to -5 ^{0}c
Specific gravity	0.8 – 1.0
Viscosity	889.3 CS
PH	6.0 - 8.1
Acid Value	0.14 – 1.97
Saponification Value	176 -187
Color	Colorless to very pale-yellow liquid

2.3.1 Products derivable from Castor seed oil

i. Cosmetics

The highest concentrations of castor oil in cosmetic products are found in lipsticks, which in some cases may be over 80% castor oil. (44). Castor oil is rich in ricin oleic acid, a mono-unsaturated fatty acid which act as humectants and can be used to moisturize the skin. Humectants retain moisture by preventing water loss through the outer layer of the skin. It is often used in cosmetics to promote hydration and often added to products like lotions, makeup and cleansers. Castor oil and ricin oleic acid are thought to increase absorption in the skin and are sometimes used in the treatment of various skin conditions, including dermatosis, psoriasis, and acne. (46)

ii. Medicine

Castor oil is a known purgative, cure of rheumatism, lumbago, skin affections, cramps, colds, and a host of other illnesses. It was used to regulate digestive health in olden days (47). Both castor oil and ricin oleic acid have demonstrated anti-inflammatory properties which make them useful for treating irritated skin.

iii. Oleo-chemicals and Polymers

Because of hydroxyl functionality in its structure, the oil is suitable for use to make polyurethane millable, polyurethane elastomers, adhesives and coatings. Polyurethane casting resins, fluid for automobiles, trucks and machinery are the other applications of castor oil. (48).

iv. Fuel

Castor oil, like currently less expensive vegetable oils, can be used as feedstock in the production of biodiesel. Castor is considered to be one of the most promising non-edible oil crops for biofuel production. (27), reported that methyl esters of castor oil can be used as a biodiesel. The resulting fuel is superior for cold winters.

v. Dyeing and Printing Industries

The demand for castor oil by dyeing and printing industries has increased tremendously due to supplantment of aniline dyes. (45) reported that, the popular red, formerly known as Adrianople red, but now commonly as known Turkey red oil, famous for the permanency, intensity, and beauty of its colour, owes its quality of exceptional fastness to castor oil.

vi. Pesticides

The use of pesticides is still the main strategy employed in the control and prevention of agricultural pests, aiming at greater productivity allied to lower costs.

2.3.2 Principles of Extraction of castor oil

Commercially, there are three methods used for the production of castor oils: batch hydraulic pressing, continuous mechanical pressing and solvent extraction. The first step of the process, common to all technologies, is the preparation of raw material. And scaling, cleaning, dehulling (or decorticating), cracking, drying, conditioning (or cooking), and flaking respectively are discussed below.

I. **Scaling**:- Initially the oil seeds are weighed and sent to the cleaning step.

II. **Cleaning**:- A good quality oilseed has around 2% of impurities when it comes from the field. These foreign materials are removed when the oilseeds reach the storage unit and also before starting the extraction of oil. Some examples of foreign materials are a combination of weed seeds, sticks, pods, dust, soil, sand, stones, and tramp metal.

III. **Drying:-** Due to the high oil content in its composition, oilseeds must have a low moisture content in order to prevent deterioration during storage and also to ensure that down stream unit operations are efficient. This operation is conducted in a dryer. The main goal of size reduction operation is to increase surface area to facilitate oil removal from the seed inside. This operation must be conducted at proper moisture content. If the moisture level is too low, the seeds are "conditioned" with water or steam to raise the moisture to about 11%. A solvent extraction operation is going to have a higher yield if the flakes are about 2.03 to 4.3 mm. Thinner flakes tend to disintegrate during the solvent extraction process and reduce the miscella percolation rate. (49)

IV. **Cracking:-** Cracking mill is the equipment used to crack oilseeds. This equipment consists of two sets of cylindrical corrugated rolls in series, operating at differential speeds to assist in breaking the oleaginous materials apart.

V. **Dehulling:-** Another unit operation is dehulling because some oilseeds present outer seed coat known as hull, rich in fiber and poor in oil and protein. The removal of these hulls will produce a better cake with high protein content by weight. Another problem observed with hulled seeds is that the hull will reduce the total yield of oil by absorbing and retaining oil in the cake.

VI. **Flaking**

The equipment that performed flaking operation is named flaking mill. Two large diameter rolls in parallel, turning in opposing direction at approximately 250 to 300 rpm, and forced together by hydraulic cylinders. As the oilseeds are pulled through, they are stretched and flattened, forming flakes, in the range of 0.3 to 0.4 mm thick and 8 to 18 mm in diameter.

2.4 Methods of Extraction of castor oil

In many parts of the world, castor oils are mostly purchased in the form of cold-pressed oils. Research has revealed that castor oil can be extracted by pressing, solvent extraction technique mostly utilizing n-hexane, and super-critical carbon dioxide (SC-CO_2) (Danlami et al., 2015a, Guo et al., 2018). Before extraction, castor seeds are first cleaned to remove any unwanted material. The seed is then put into decorticating machines to dehull the shells leaving the kernels. The more efficient the decorticating the lighter the oil color.

2.4.1 Batch hydraulic pressing

In the late nineteenth century, oilseeds were processed in manual presses, where layers of grains were placed into the equipment, separated by filter cloths, filter press plates and force was applied via hydraulic cylinder. When the oil has stopped flowing, the workers opened the machine, removed the mass of crushed grain and put more fresh material. At the beginning of the twentieth century the vegetable oil industry worked basically with the hydraulic presses but even making use of a hydraulic cylinder, work with this type of equipment was considered labor intensive. With the emergence of the continuous screw-press, the only application that still requires the hydraulic press is the one that requires gentle handling, such as processing and production of cocoa butter. (50).

2.4.2 Continuous Mechanical pressing (Screw Press)

Among the physical processes for the extraction of castor oils, the continuous mechanical pressing emerges as the best technology to serve small farmers. That´s because this type of equipment associates both small scale and low cost when compared to the other methods cited. The operating principle of this equipment consists a helical screw which moves the material, compressing it, and at the same time, eliminating the oil and producing the cake.

In mechanical pressing, the seeds are crushed and then adjusted to low moisture content by warming in a steam-jacketed vessel. Then, the crushed seeds are loaded into a hydraulic press and pressed by mechanical means to extract oil. The resulting oil has a light colour and low free fatty acids.

Mechanical pressing only recovers about 45% of oil from the beans and the remainder in the cake can be recovered by solvent extraction. The crushed seeds are extracted with a solvent in a Soxhlet extractor or commercial extractor. (51). Solvents used for extraction include heptane, hexane and petroleum ethers. Refining is essential to remove impurities such as colloidal matter, free fatty acid, colouring matter and other undesirable constituents that make oil less resistance to deterioration during storage.

2.4.3 Supercritical CO_2 Extraction

A fluid is considered supercritical when it presents diffusivity similar to gas and density comparable to liquids. In the 1980's the use of supercritical CO_2 for the extraction of oilseeds such as soybean, cottonseed, corn germ, rapeseed, and sunflower. The oils obtained were shown to have similar quality compared with hexane extracts; they also had lighter color and lower iron and phospholipids content, resulting in a lower refining loss and reduction of subsequent refining steps. Despite the many advantages of $SCCO_2$ extraction and also the high volume of research carried out, commercial-scale $SCCO_2$ extraction of oilseeds was not readily accepted.

2.4.5 Solvent Extraction

Extraction with solvents is the most effective method for the recovery of oil (almost 98%), rather than the previous method. When performed at low temperature, the solvent extraction has another advantage over screw-pressing: better quality of oil produced. This is because during expelling a sudden heating of the oil can occur, changing some parameters of its quality. It is expected that residual oil in the meal to be less than 1 percent after commercial solvent extraction. The process known as pre-press is designed to prepare the high oil content raw material to the solvent extraction. Mechanical pressing reduces the oil by half to two thirds of its original level facilitating solvent extraction by reducing the amount of oil to be extracted, the size of extractor equipment and also the volume of solvent used.

The choice of solvent type is based on solubility of oil in the selected solvent, cost and safety. Hexane is primarily employed as an oil extraction solvent for vegetable and seed crops. It's used as a special-purpose solvent, a cleaning agent, and to extract edible oils from seeds and vegetables. Hexane (boiling point 146-156°F), heptanes (boiling point 194-210°F) and octane (boiling point 419-507°F) can be used for oil extraction. Currently hexane is widely used for commodity vegetable oil extraction.

Hence, this paper is focused on castor oil extraction using hexane for production of liquid detergent.

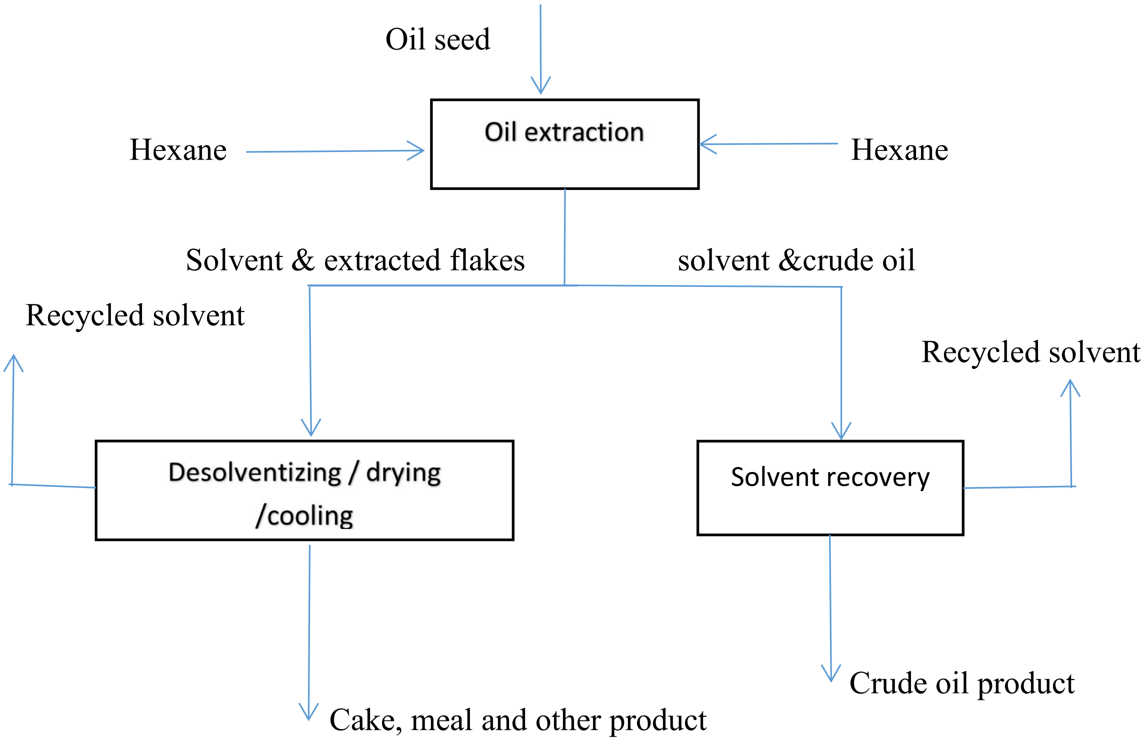


Figure 1: Simplified flow diagram of extraction process

2.5 Factors influencing the rate of castor oil extraction

Factors which affect the growing plants as leading to the variations in oil yield and composition, includes moisture contents, samples particle size, reaction time, solvent to sample ratio. The parameters are discussed in this paper as follows;

2.5.1 The Role and effect of Moisture in Oil Extraction

Water has a higher affinity and wets the surface of particles at a faster rate than oil due to its polarity and absorption ability. Research has proven that particles are selectively wetted by liquids with lower surface tension at the interface; hence water will tend to displace oil from the surface of particles. (52). Thus, moisture increases the flow of oil through the pores of the press cake, hence reducing the amount of oil entrained in the cake and increasing the oil yield mostly in mechanical expression. High moisture content stops oil flow possibly because the structures of the finely milled particles have been altered (high aggregation).

2.5.2 The effects of temperature in oil extraction

Temperature plays an active role in the seed treatment for mechanical extraction and ensures an effective solvent process by heating the solvent which hastens the extraction process. At the right temperature and moisture content, the individual oil droplets unite to form a continuous phase and flow out maximizing oil yield. Better extraction is achieved by heating, which reduces the oil viscosity and releases oil from intact cells, and also reduces moisture in the cells. (53).

2.5.3 Effect of reaction times

If the oil extraction time of the solvents increase, the oil yield increase. Oil yield obtained (expressed in percent) was extraction time dependent. (54).

2.5.4 Effect of solvent to solid ratio

Solvent to solid ratio is another important parameter that affects oil extraction efficiency and recovery. The volume of the solvent should not be more than an optimized volume because the cost of the solvent recovery could be too high, there by increasing the total operational cost. (55).

2.5.5 Effect of particle size

Particle size plays a great role on the yield of castor seed oil. Smaller particle size gives high yield while samples with large particle size deliver low yield. That means less oil is extracted from the larger particles compared to the small size of the particles.

The reason is that larger particles with smaller contact surface area, have more resistant to solvent entrance and oil diffusion towards the solvent. Therefore, less amount of oil will be transferred from inside the larger particles to the surrounding solution in comparison with the smaller ones. Thus, an increase in particle size will decrease the oil yield. (56).

2.6 Properties of hexane

2.6.1 Chemical Identity

n-Hexane is a very volatile aliphatic hydrocarbon. It is a constituent in the paraffin fraction of crude oil and natural gas and is also used as an industrial chemical and laboratory reagent. Laboratory grade n-hexane contains approximately 99% n-hexane (57). “Hexane” or “hexanes” is a commercial and industrial product consisting of a mixture of hydrocarbons with six carbon atoms and includes n-hexane and its isomers 2-methylpentane and 3-methylpentane as well as small amounts of other hydrocarbons. (49).

Many commercial grades of n-hexane contain appreciable amounts of other hydrocarbons in addition to n-hexane (for instance, toluene or such solvents as acetone or methyl ethyl ketone). Where intended for specialized oil extraction or laboratory uses, the purity of the n-hexane products may be in the range of 95 - 99% n-hexane; for a variety of uses where purity is not as important, commercial n-hexane mixtures (in the range of 20 - 80% of n-hexane) may contain small amounts of chemicals such as acetone, methyl-ethyl ketone, dichloro-methane, and trichloroethylene, aromatics such as toluene, and other types of petroleum hydrocarbons. (58).

Table 4:- Chemical identity of n-hexane

Characteristics	**Information**
Chemical name	n-hexane
Synonym(s)	Hexane Hexyl hydride
Registered Trade name(s)	Skellysolve B Gettysolve-B
Chemical formula	C_6H_{14}
Chemical structure	$CH_3CH_2CH_2CH_2CH_2CH_3$

2.6.2 Physical and Chemical properties

The National Fire Protection Association (NFPA) has assigned n-hexane a health hazard identification code of 1 (slight) and flammability code of 3 (serious). n-Hexane is flammable and may be ignited by heat, sparks, and flames. Flammable vapor may spread away from a spill. The vapor may be an explosion hazard. n-Hexane can react vigorously with oxidizing materials such as liquid chlorine, concentrated oxygen, and sodium hypochlorite. n-Hexane will attack some forms of plastics, rubber, and coatings. (49).

Table 5:- physical and chemical properties of n-hexane

Properties	**Information**
Molecular weight	86.18
Physical state	Liquid
Melting Point	-95^0C
Boiling Point	69^0C
Density	0.6603 @ 23^0C
Odor	Faint, Peculiar odor
Solubility in water	Insoluble
Organic Solvents	Miscible in ethanol, chloroform, ether
Flash point	-22^0C
Flammability limits @ 25^0C	1.1-7.5 %
Explosive limits	1.1-7.5%

Source; www.wikipedia physical and chemical properties of n-hexane

2.7 Market study of detergent in Ethiopia

Today, detergent industry in our country use expensive raw materials like petroleum products which also imported from other countries. This may result in inflation of cost of detergents and also can affect the economy of our country. Although castor oil is an industrial raw material or intermediate input, there are no industries in Ethiopia which make use of it. Therefore, it has no market potential locally at present, and there is no indication that it will be demanded in meaningful quantity in the near future. Import statistics too show that negligible amount of it is imported annually.

Table 6 :- Import of castor oil (2000 - 2010)

Year	Imports (Tonne)
2000	4.2
2001	0.4
2002	7.1
2003	2.9
2004	3.1
2005	3.6
2006	3.3
2007	4.1
2008	4.7
2009	5.8
2010	6.7

Source: - Customs Authority, External Trade Statistics, Annual Issue.

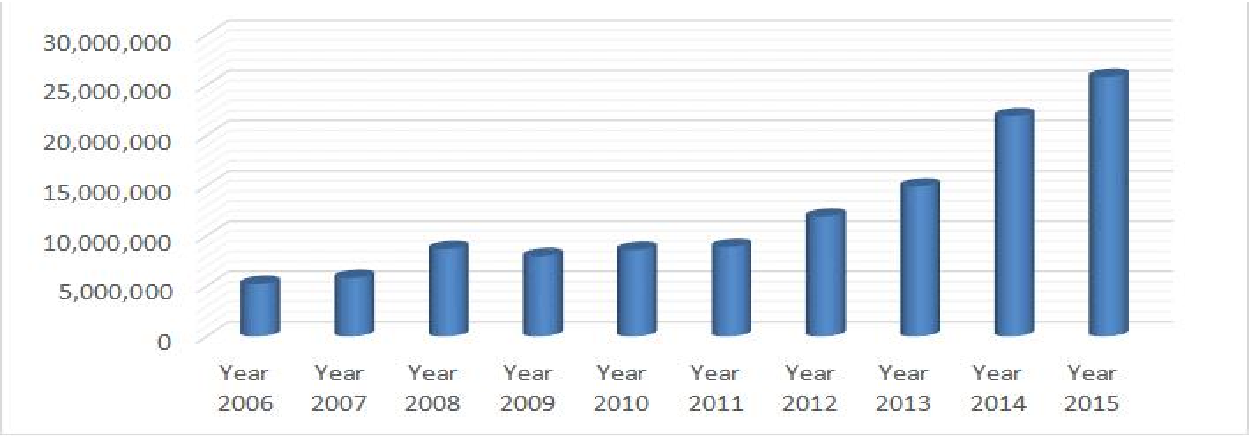


Figure 2: Import of liquid detergent data in Ethiopia

Source: https://trendeconomy.com/data/h2/Ethiopia/3401

CHAPTER THREE

3.MATERIALS AND METHODS

3.1 Materials, Raw Materials and Chemical Additives

Materials used were:

a. Analytical balance: used to measure the required amount of ingredient that used to produce the product.
b. Ball viscometer: used to measure the viscosity of the product.
c. Beaker: used to mix the ingredients.
d. Magnetic stirrer: used to heat and homogenize the solution
e. Measuring cylinder: to measure the liquid ingredients.
f. Mixer: used to mix the ingredients and reduced the amount of unconverted ingredient by producing perfect mixing.
g. PH meter: used to identify the pH media of the product weather it is acidic or basic.
h. Soxhlet extractor: used to extract the castor oil from castor bean.
i. Stand: used to carry the stirrer motor and separating funnel.
j. Test tubes: used to measure the liquid ingredients.
k. Thermometer: used to measure to the temperature.

Raw Materials used were:

a. Castor seed: as a raw material
b. Water and distilled water: used to dilute the ingredients and act as the reaction media.

Chemical Additives were:

a. Hydrogen per oxide: used as bleaching agent.
b. N-hexane solvent: to extract the oil from the castor seed.
c. Perfume: used to give a good odor to the product.
d. Sodium chloride: is used to increase the brightness of the product and change the product to semi solid.
e. Sodium hydroxide: is a strong base used to neutralize and produce the detergent.
f. Sodium silicate: used to adjust the viscosity and pH of the product because it is strong basic chemical, and also used to increase the brightness of the product.

g. Sulfuric acid: used as active ingredient to produce the detergent and to sulphate the oil.

3.2 Methods

Castor seed must be processed in two key phases in order to produce liquid detergents. These include the production of detergent and the extraction of castor oil. Soxhlet extractor is used in the initial phase, followed by a heater evaporator. Then the neutralization process through sodium hydroxide takes place then treated with sulphuric acid. Following that, the preservation and perfumeing were completed.

3.2.1 Process Flow Description

Drying: is the first unit operation in the production of detergent from castor seed. First the castor seed is dried in order to reduce the moisture content of the seed. It can be done under a temperature of around 55-80 ^{0}C. It is used to reduce the amount of ricin present in the seed.

Grinding: the second one is grinder or crusher which is used to grind the seeds in order to reduce the size of the seed which helps to increase the surface contact between the seeds and solvent during extraction. The size of the raw material may affect the yield of the process.

Extraction: after the grinding there is extraction process which used to extract the oil for the next process. It can be done with solvents like hexane. The solvent is poured into the round bottom flask. Castor beans was placed in the thimble and inserted in the center of the soxhlet extractor. The extractor is heated when the solvent is boiling the vapor rises through the vertical tube into the condenser at the top. The liquid condensate drips into the filter paper thimble in the center which contains the solid sample to be extracted. The extract sips through the pores of the thimble and fills the siphon tube where it flows back down into the round bottom flask. After the oil extracted it under go separation process by rotary evaporator or distillation to recover the solvent. Now, the pure oil is obtained and can undergo for uses.

Neutralization: It takes place with the addition of strong base. After oil extracted neutralization process takes place. It is done with concentrated Sodium hydroxide. The base added to the oil with constant string at 300 rpm.

Sulphation: After neutralization the sulphation process takes place. It is done with concentrated sulfuric acid. The concentrated sulfuric acid is added to the solution with constant stirring by using the stirrer at 300 rpm. The reaction is exothermic. As different literature shows it can be done for

1-2 hrs and also the same procedure was done in this project. After sulphtation almost detergent is produced.

Then, it undergoes preservation, coloring, perfuming to improve the appearance and odor of the product. Preservation is used to avoid the product from the internal reaction. Coloring means the addition of different colorants to the product to give a good appearance of the product. But in our case we did not take colorant. Perfuming is used to improve the odor of the product and makes it more attractive.

3.3 Procedures

3.3.1. Pre-treatment of castor seeds

The pre-treatment of castor seed involved the preliminary preparations of the seeds in the following ways: The required raw material (700 g) of castor seed, was collected from the local market.

1. **Shelling**: this involves the removal of the shells to obtain the seeds. It will do manually.
2. **Clearing**: this involves the removal of foreign matter and dirt introduced during the sun drying and any unshelled seed. And which was separated by hand picking.
3. **Drying**: The beans were further dried in the oven at 55-80^{0}C for 1hrs to a constant weight in order to reduce its moisture content. The moisture content of the seed will reduce using the electric oven.
4. **Crusher**: Manually through covering shelled dry castor bean with Aluminum foil and then by using clean flatten stone reduce the sizes of the dry seeds so as to increase the interfacial area between the solvent and the seeds. This helps to weaken or rupture the cell walls to release castor fat for extraction.

3.3.2. Extraction of castor oil

First all the glass apparatus are rinsed by hexane and dried in the oven at 102°C and removed for cooling. Then each round bottom flask was filled with 30 ml of n-hexane. Castor beans weighing 10 g were put in each thimble and put in the center of the soxhlet extractor. The whole setting was placed on a heating mantle and the Soxhlet extractor is heated at 70^{0}C for heating solvent, and as it boiled, vapor rise through the vertical tube and into the condenser at the top. The liquid condensate drips into the filter paper thimble in the center which contains the solid sample to be extracted. The extract sips through the pores of the thimble and fills the siphon tube where it flows back down into the round bottom flask. This was allowed for 3 hours and then the sample was removed from the tube, cooled and weighed to determine the amount of oil extracted. The weight of oil extracted was determined for each 3 hours interval. At the end of the extraction, the resulting mixture (miscella) containing the oil was heated to evaporate solvent from the oil using heater evaporator at 70^0C.

The solvent free oil was then refined for further use. Further extraction was carried out repeatedly until the required amount of oil is obtained. There for experiment was repeated several times by placing the same amount of sample into the thimble at a temperature of 80^0C for 2 hours through the same value of hexane again.

Figure 3 ;Soxhlet extractor

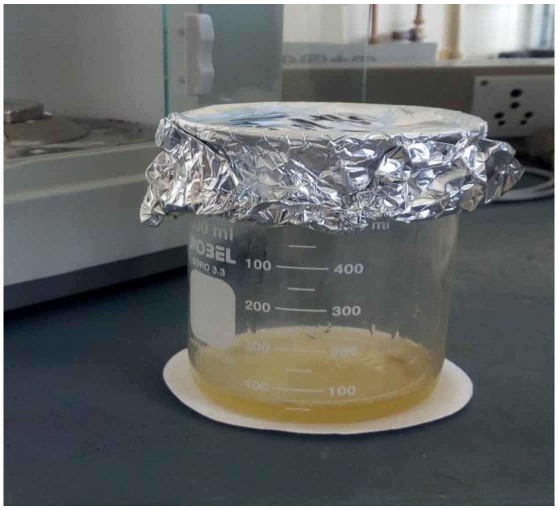


Figure 4 ;extracted castor oil

3.3.3. Refining of castor oil

Once the oil has been extracted from the seed, it is necessary to remove any impurities and gum from the extracted oil that makes it such an important commodity. The oil is essentially a pure triglyceride, and contains almost 90% of glycerol tricinoleate. It is the ricin oleic triglyceride that is needed in order to produce high quality castor oil that will be used for the chemical industry. Characterizing properties of castor oil include a higher density, viscosity, and reactivity than common triglycerides found in other vegetable oils. These properties are exploited when refining the oil from the impurities. The steps to refining the crude oil include settling and degumming of the oil, bleaching, neutralization, and deodorization of the oil. Common methods of oil refining are alkali refining and boiling of the oils. In this project boiling of the oils method was used.

It is done by:

a) Boiling water and add to the oil and the mixture stirred for 2 minutes and allowed to stand in the separating funnel or

b) Boiling the oil in half its volume of water for 2-4 hours depending on the amount of the oil volume. During the boiling process the steam from the oil-water mixture takes along with it some of the undesirable odor of the oil while the scenting materials give some scent (deodorize) to the oil. The aqueous layer is then removed. The procedure will repeated to ensure removal of most gums. The de-gummed oil collected and stored for use.

3.3.4. Production of detergent

30 ml of castor oil was measured and placed on the electric heater as it was switched on and heated for about 5 min at 35^0C. Then 10 M of prepared Sodium hydroxide (NaOH) solution would be prepared by weighing 40g of NaOH Pellets into a beaker containing 100 ml of water and primarily shaking vigorously and stirred the mixture with a glass rod and added them on heated castor oil. Then they were placed on a magnetic stirrer that was adjusted at 35^0C and 300 rpm for about 1 hours. Then the mixture was again treated with 15 M Sulfuric acid (H_2SO_4) in order to make the oil linear by stirred using mixer at 300 rpm for 2 hours. The ratio of addition must be 1:2 according to the reaction or stoichiometric coefficients. Next the solution was allowed to cool at room temperature for about 12 min. Then the prepared solution of sodium silicate (0.8M) and sodium chloride (0.8M) was added and stirred until uniform solution was obtained. And the reaction allowed to completion after which20ml of hydrogen peroxide (Bleaching agent) is introduced in to the reaction mixture. Finally, 2ml of perfume was added to enhance it's aromatic properties and the system would allow stirred for 30 minutes at normal temperature. Then the liquid detergent formed was subjected to foam ability test to ensure the effectiveness of the process. The resulting liquid detergent formed was again collected and tested.

Figure 5 ; Produced liquid detergent

3.3.4.1 Effect of concentration on saponification process

1**.** During the implementation of this experiment we should protect our hands with gloves and with eye glasses and mouth mask.

2. Obtain two glass blenders or mixers and set the blenders properly.

3. Heat 60 ml of castor oil to 35°c and add 30 ml of the hot castor oil to each mixture, for blender 1 and 2 respectively.

4. 7.5 M and 12.5 M of sodium hydroxide solution prepared by weighing 30g and 50g of NaOH Pellets respectively in to a beaker containing 100 ml of water and shaking vigorously and then added them in to castor oil containing blender 1 and 2 respectively. Take almost 1 up to 1:30 hours for perfectly mixing process in mixer.

4.Then 15 M sulfuric acid solution filled a container with the ratio of addition must be 1:2 according to the reaction or stoichiometric coefficients. Takes 2 hours for perfectly mixing in mixer at 35^0C.

5. Then from 6gm and 7gm Sodium Silicate prepared with in 50ml of water then solution of sodium silicate (0.95M) and (1.1M) respectively was gained and added them in to blender 1 and 2 respectively. And, also from 2.5gm and 2.6gm Sodium chloride prepared with in 50ml of water

then solution of Sodium chloride (0.85M) and (0.88) was gained and added them in to blender 1 and 2 respectively. Stirred until uniform solution was obtained.

6.Next 15 ml of hydrogen peroxide and 1ml of perfume added in blender 1 and 25ml of hydrogen peroxide and perfume added in blender two and stirred them. And aloww the mixture to sit for hours.

7. Allow the mixture to sit for several hours. Finally, the resulting liquid detergent can be gained.

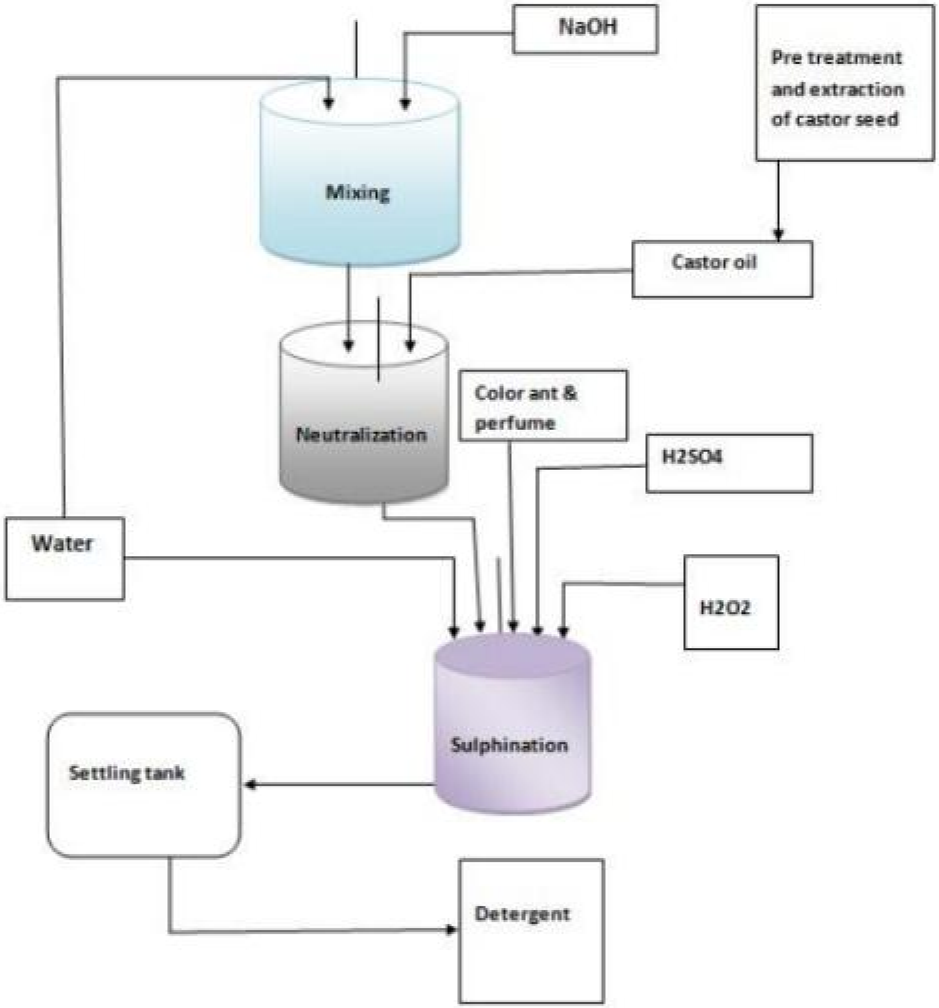


Figure 6 : Process flow diagram of detergent production from extracted castor oil

3.5. Characterization of products

3.5.1 Determination moisture content of castor seed

The moisture content of the sample can be calculated by

$$\boldsymbol{Moisture\ Content} = \frac{\boldsymbol{Initial\ mass\ of\ castor\ seed - Mass\ of\ dried\ sample}}{\boldsymbol{Initial\ mass\ of\ castor\ seed}} * \mathbf{100}$$

3.5.2 Characterization of Castor oil

3.5.2.1 Determination of the extraction oil (Yield)

Percentage of extracted oil can be calculated by:

$$Percentage\ of\ extracted\ oil = \frac{Weight\ of\ oil}{Weight\ of\ sample} * 100$$

3.5.2.2. Determination of specific gravity

Density bottle was used to determining the density of the oil. A clean and dry empty specific gravity bottle was weighed (Mc), castor oil was poured into the specific gravity bottle and was weighed to get (Mo). The oil was then substituted with water of the same volume and re-weighed to give Mw.

The specific gravity was determined by calculation using equation

$$specific\ gravity = \frac{weight\ of\ bottle\ with\ castor\ oil - weight\ of\ empty\ bottle}{weight\ of\ bottle\ with\ water - weight\ of\ empty\ bottle}$$

$$SG = \frac{Mo - Mc}{Mw - Mc}$$

3.5.2.3 Determination of PH value

The PH is measured by PH meter instrument.

3.5.2.4 Determination of oil solubility

The solubility of castor oil in water can be determined in laboratory**.**

3.5.2.5 Determination of free fatty acid Value

Procedure

1. 20ml of petroleum ether and 25ml of ethanol was mixed in a 250ml beaker which is V=16ml.
2. The resulting mixture was added to 10g of oil in a 250ml conical flask and 5 drops of phenolphthalein were added to the mixture.
3. The mixture was titrated with 0.1M NaOH to the end point by shaking for which a dark pink color was observed and the volume of 0.1M NaOH was noted as V_o=39ml.
4. Free Fatty Acid (FFA) was calculated as:

$$FFA = \frac{(vo - v) * Concentartion\ of\ NaOH * Molar\ mass\ of\ NaOH}{mass\ of\ sample} * 100$$

Where: vo:volume of NaOH at which dark pink color observed

v: volume of NaOH for the determination

Preparation of 0.1M NaOH

The molecular weight of NaOH = 40g/mol

And the solution was prepared in 250ml flask

Concentration $= \frac{mole}{volume}$ c = $\frac{n}{v}$

But mole (n)=$\frac{mass(m)}{molecularmass(M)}$

C=$\frac{m}{M*V}$ m=C*M*V

m = 0.1mol/L*40g/mol*0.25L

m =1g of NaOH was used to prepare 0.1M NaOH

3.5.2.6 Determination of acidic value

The same experimental procedure for that of free fatty acid was taken for determination of acidic value. But acidic value is twice that of free fatty acid.

$$Acidic\ value = 2 * FFA$$

3.5.2.7 Determination of saponification value

2g of the oil was placed in a conical flask to which 25ml of ethanoic sodium hydroxide (0.1M) was added and the mixture allowed boiling gently for about 30mins with shaking at regular intervals of 5mins. Few drops of phenolphthalein indicator, as specified by International Standards Organization (ISO 3657, 1988) was added to the warm solution and then titrated with 0.5M HCl. The end point was reached when the pink color of the indicator just disappeared. The same procedure was followed for the blank. The saponification value (sv) is given by:

$$SV = 56.6 * \frac{N\,(VO - VI)}{m}$$

Where: VO = volume of HCl solution used for the blank test, VI = volume of HCl solution for the determination, N = actual molarity of HCl used, and m = mass of sample.

3.5.2.8 Determination of oil density

Density of oil can be calculated based on the data's collected on the experiment in laboratory**.**

$$\boldsymbol{Density\ of\ castor\ oil = \frac{mass\ of\ oil}{volume\ of\ oil}}$$

3.5.3 Characterization of liquid detergent

3.5.3.1 Determination of Alkalinity or PH of detergent

5mL of the detergent solution was added to a beaker or test tube. Using a pH meter the alkalinity of the detergent solution is determined. The electrode of the pH meter is dipped inside the detergent solution.

3.5.3.2 Determination of detergent density

Density of detergent can be calculated based on the data's collected on the experiment in laboratory**.**

$$\boldsymbol{\rho = \frac{m}{V}}$$

Where: ρ: Density of detergent, m=mass of detergent, V= volume of detergent

3.5.3.3 Determination of detergent Solubility

The solubility of detergent in water can be determined in laboratory**.**

3.5.3.4 Determination of effect of concentration

Sodium hydroxide was an alkalinity factor used to convert triglyceride of oil to detergent and glycerol. And also a factor that adjusts the PH value of detergent produced based on the amount of surfactant/oil used in production of detergent. As the amount of caustic soda increases at constant amount of oil, the alkalinity of detergent was increases and also the vice versa is true.

3.5.3.5 Fomability tests on produced detergent

About 20ml of the detergent was added to a 250ml measuring cylinder containing 35ml of distilled water. The mixture was shaken vigorously so as to Production of Detergent from Castor Oil generate foams. After shaken vigorously f for about 2mins, the cylinder was allowed to stand for about 10mins. The height of the foam in the solution was measured by ruler and recorded.

CHAPTER FOUR

4.RESULT AND DISCUSSION

4.1 Result for Characterization of products

4.1.1 Determination of moisture content of castor seed

The moisture content of castor seed was measured using oven machine from 55-80^{0}c. Before inserting castor seed in to oven the castor seed was measured by using digital balance and after inserting oven the mass of castor seed was measured.

Table 7: Moisture content of castor seed

Time (hour)	0	1 hour
Weight (g)	700	687.502

The moisture content of the sample can be calculated by:

$$\boldsymbol{Moisture\ Content = \frac{Initial\ mass\ of\ castor\ seed - Mass\ of\ dried\ sample}{Initial\ mass\ of\ castor\ seed} * 100}$$

Where: mass of castor seed before drying (initial mass)= 700gm

mass of castor seed after drying=687.502gm

Then:

$$\boldsymbol{Moisture\ Content} = \frac{700gm - 687.502gm}{700gm} * 100$$

=<u>1.785%</u>

4.1.2 Characterization of castor oil

4.1.2.1 Determination of the extraction oil Yield

Percentage of extracted oil can be calculated by:

$$\boldsymbol{Percentage\ of\ extracted\ oil = \frac{Weight\ of\ oil}{Weight\ of\ sample} * 100}$$

Table 8: Determination of extraction of oil

Determination	**Value (g)**
Weight of empty beaker (M1)	184.29
Weight of thimble (W1)	50
Weight of sample (M2)	450
Weight of sample + thimble (W2)	500
Weight of empty beaker + oil (M2)	334.29
Weight of oil (M2-M1)	150

$$\boldsymbol{Percentage\ of\ extracted\ oil} = \frac{334.29\ gm - 184.2\ gm}{500gm - 50gm} * 100$$

$$=\underline{\underline{\mathbf{33.33\%}}}$$

4.1.2.2 Determination of specific gravity

Density bottle was used to determining the density of the oil. A clean and dry empty specific gravity bottle was weighed (Mc), castor oil was poured into the specific gravity bottle and was weighed to get (Mo). The oil was then substituted with water of the same volume and reweighed to give Mw.

$$\boldsymbol{specific\ gravity} = \frac{\boldsymbol{weight\ of\ bottle\ with\ castor\ oil - weight\ of\ empty\ bottle}}{\boldsymbol{weight\ of\ bottle\ with\ water - weight\ of\ empty\ bottle}}$$

$$\boldsymbol{SG} = \frac{\boldsymbol{Mo - Mc}}{\boldsymbol{Mw - Mc}}$$

Table 9: Determination of specific gravity

Determination	**Value (g)**
Weight of bottle with castor oil (Mo)	146.21
Weight of empty bottle (Mc)	106.55
Weight of bottle with water (Mw)	150.69

The specific gravity was determined by calculation using equation : $Specific\ gravity = \frac{Mo-Mc}{Mw-Mc}$

$$specific\ gravity = \frac{146.21-106.55}{150.69-106.55}$$

=39.66/44.14

=**0.898**

4.1.2.3 Determination of PH value

The PH value is directly measured by using PH meter and the PH value of extracted oil was 6.17 based on literature it's between the range.

4.1.2.4 Determination of oil solubility

The obtained castor oil was insoluble in water and this character was determined in laboratory.

4.1.2.5 Determination of free fatty acid Value

$$\boldsymbol{FFA = \frac{(vo-v) * Concentartion\ of\ NaOH * Molar\ mass\ of\ NaOH}{mass\ of\ sample} * 100}$$

$$FFA = \frac{(39-16)ml * 0.1M\ NaOH * 40gm/mol}{10gm} * 100$$

= 0.92

=**92%**

Figure 7; Determination of free fatty acid

4.1.2.6 Determination of acidic value

The acidic value was determine by:

Acidic value = 2 * FFA

= 2 * 0.92

= **1.84**

4.1.2.7 Determination of saponification value

The saponification value is calculated through titration using equation described under. First the blank level changed from pink to colorless at 30mL titration volume. The color at which the saponification test changed from pink color to red color was 17 mL of titration volume.

$$SV = 56.6 * \frac{N\,(VO - VI)}{m}$$

Where: Vo= 30ml volume of HCL solution used for blank test

VI= 17Ml volume of HCL solution for the determination

N=0.5M actual concentration of HCl

m= 2gm mass of oil

Then $SV = 56.6 * \frac{0.5\ (30ml - 17ml)}{2g}$ = $\underline{\underline{\mathbf{183.95}}}$

Figure 8 ;Addition of phenolphthalein Figure 9 ; after titration

4.1.2.8 Determination of oil density

Oil density can be calculated through under described equation:

$$\boldsymbol{Density\ of\ castor\ oil = \frac{mass\ of\ oil}{volume\ of\ oil}}$$

Table 10: Measurements required for determining oil density

Mass of beaker (N)	184.29gm
Mass of beaker and oil(Y)	209.093gm
Mass of oil (Y – N)	24.803gm
Volume of the oil	28.509ml

Then; $\boldsymbol{Density\ of\ castor\ oil = Density\ of\ fluid = \frac{mass\ of\ oil}{volume\ of\ oil}}$

$$\rho f = 24.803gm/28.509cm^3$$

$$= \underline{\underline{\mathbf{0.87gm/cm^3}}}$$

Table 11: Determined property of castor oil

Property	Result	Literature
Extracted oil Yield	33.33%	(30-55)%
Specific gravity	0.898	0.8 – 1.0
PH	6.17	6.0 – 8.1
Oil Solubility	Insoluble in water	Insoluble in water
FFA	92%	-
Acidic Value	1.84	0.14 - 1.97
Saponification Value	183.93	176 - 187
Oil density	0.87gm/cm^3	(0.8 – 0.9)gm/cm^3
Color	Light Yellow	Colorless to very pale-yellow liquid

4.1.3 Characterization of liquid detergent

4.1.3.1 Determination of Alkalinity or PH of detergent

5ml of detergent solution was added to a beaker. Using a PH meter the alkalinity of the detergent solution is determined. The electrode of the PH meter is dipped inside the detergent solution. The PH value of the detergent is recorded. It is 10.69.

Figure 10 ;PH measurement for detergent

4.1.3.2.Determination of detergent density

Density of detergent can be calculated as: $density = \frac{mass}{volume}$

Table 12: Measurements required for determining of detergent density

Mass of beaker	184.29gm
Mass of beaker + detergent	247.29gm
Mass of detergent	63gm
Volume of detergent	70ml

Then; $density\ of\ detergent = \frac{63gm}{70ml}$

$$= \underline{\underline{\mathbf{0.9\ gm/cm^3}}}$$

4.1.3.3.Determination of detergent solubility

The detergent produced is soluble and it was determined in laboratory.

4.1.3.4.Determination of effect of concentration

The amount of caustic soda can have a direct relation with the alkalinity of detergent. As it increases in oil the alkalinity of detergent can rise. Depending up on different concentration of caustic soda the result can be discussed below:

I. Detergent produced at concentration of 30g NaOH in experiment

When concentration of caustic soda lowers than the normal lye solution, the detergent which can be produced would be greasy detergent.

II. Detergent produced at concentration of 40g NaOH

When it is at normal lye concentration it will give a good detergent.

III. Detergent produced at concentration of 50g

When the concentration higher than the normal lye solution is would be very viscous almost change to soap.

4.1.3.5.Foamability tests on produced detergent

One of the characteristics of detergents and soap is creating foam. So, the fomability of the detergent was checked in the laboratory.

About 20ml of the detergent was added to a 250ml measuring cylinder containing 35ml of distilled water. The mixture was shaken vigorously so as to Production of Detergent from Castor Oil generate foams. After shaken vigorously for about 2mins, the cylinder was allowed to stand for about 10mins. The height of the foam in the solution was measured by ruler and recorded. The results obtained are as recorded in the result section of this work and good foam ability is 2.57cm.

Table 13 : Determined Properties of detergent

Property	**Result**	**Literature**
Density (gm/cm^3)	0.87gm/cm^3	0.932g/cm^3
PH	10.69	8 - 12
Solubility	Soluble in both hard and distilled water	Soluble
Fomability	2.57cm	2.6cm for 2 minute

4.2. Discussion

The result obtained from the percentage oil content 33.33% fall within the range of the percentage oil content (30 – 55%) of castor been found in literature depending on the variety. Though something close to 100% yield (basing on 55% oil content of castor been) would have been expected, the mode of extraction is a very important parameter affecting the yield. The good yield could be attributed to the nature of the seeds, particle size and using of hexane as solvent.

The oil quality desirable as demonstrated from the saponification value of 183.93 mg ethanoic sodium hydroxide/g of oil this is found in agreement with the standards in literature (176 -187 mg ethanoic sodium hydroxide/g of oil). The specific gravity values of oil is 0.898 which also full fill the reported value in literature (0.8 – 1.0). The acidic value of oil 1.84 also which fall in the range of literature (0.14 – 1.97). In case of detergent the value of density 0.87 gm/cm^3 shows a little difference according to values in literature, however this little difference can be considered being within an acceptable experimental error that can be attributed to the presence of some impurities and other components during experiment.

Sodium hydroxide was an alkalinity factor used to convert triglyceride of oil to detergent and glycerol. And also a factor that adjusts the PH value of detergent produced based on the amount of surfactant/oil used in the production of detergent, as amount of caustic soda increases at constant amount of oil, the alkalinity of the detergent was increases and vice versa.

Moreover, the neutralization and sulphonation reactions gave a detergent of high enough efficiently as seen from the result of fomability tests. Usually, the efficiency of a washing liquid detergent is assessed through the amount of foam it is capable of producing. The foam height of 2.57cm persisted for about 10minutes. The detergent formed was the result of esterification's of castor oil.

Ricin oleic acid (castor oil) is primarily treated with concentrated Sodium hydroxide as a neutralization and then treated with a concentrated Sulphuric acid. The reaction proceeded at a temperature of 35 ^{0}C and detergent was formed. Sodium silicate added to eases removal of dirt and in detergent industry provides emulsification of organic of organic oils. Sodium chloride added to increase the brightness of the product and change the product to semi solid. Fragrance (perfumes) was added to improve the aromatic properties of the detergent. The bleaching agent (H2O2) added helped to bleach the color of the castor oil so that milk colored detergent was produced. PH tests showed that the detergent exhibited basic property. The detergent can thus be described as amphoteric. This classification is characteristic of the intrinsic property of castor oil. This pH range is preferable to that of acidic as it is non - corrosive to the skin and cloths. Finally, got liquid detergent.

CHAPTER FIVE

5. MASS AND ENERGY BALANCE

5.1 Mass Balance

From general material balance

Input + Generation – Output – Consumption = Accumulation

Assumptions

- For steady state systems accumulation is zero
- For non-reactive species generation consumption is zero

Basis

- Batch process
- Plant uses 6000 kg/day
- Working day is 300 days per year.
- Assume a forward material balance

5.1.1 Mass Balance on soxhlet extractor

Based on laboratory work

Input =450g which is =0.45Kg of grinded castor seed

Output = 150ml = 0.15 L

Assume 8 batches for extractor and 3 hrs for each batch.

Then calculate for the plant based on it is capacity, the plant uses 6000 kg/day of castor seeds. From the laboratory work 150 ml of oil was extracted from 450 g of castor seed then,

Input=output

$$\dot{v} = \frac{6000Kg/day \times 0.15L}{0.45kg} = 2000\frac{L}{day}$$

$$\dot{m} = \rho \dot{v} = 2000\frac{L}{day} \times 961\frac{kg}{m^3} \times \frac{1m^3}{1000L} = 1922\frac{kg}{day}$$

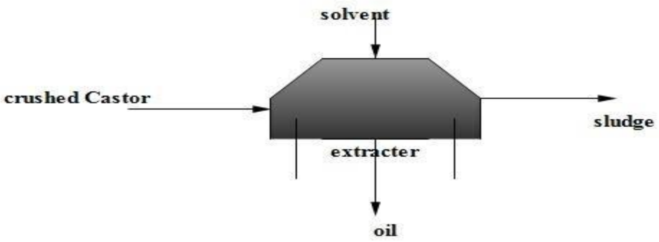
This means 2000 L/day can be extracted from the 6000 kg/day of castor seed.

Now, do the material balance to calculate the rest one.
Amount of hexane required is calculated based on the laboratory work
The ratio of castor seed to hexane is 1:3 so

The amount of hexane required per day calculate as;

$$6000\frac{kg}{day} \times 3 = 18000\frac{kg}{day}$$

$$\dot{v} = \frac{\dot{m}}{\rho} = \frac{18000kg/day}{645.8\frac{kg}{m^3}} = 27.8724L/day$$



Based on general mass balance

Mass in = Mass out

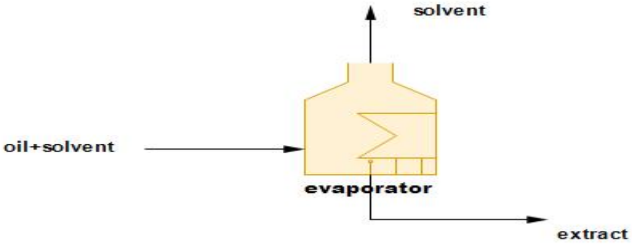
Mass of seed + mass of solvent = mass of oil + mass of solvent

The solvent used for extraction is recovered and it has no effect on the material balance. So, we can neglect it min=mout

$$6000\frac{kg}{day}+18000\frac{kg}{day}=4046.315\frac{kg}{day}+\dot{m}\,sludge+18000kg/day$$

$$\dot{m}\,sludge=6000\frac{kg}{day}-4046.315\frac{kg}{day}=1953.685\frac{kg}{day}$$

5.1.2 Mass Balance on heater Evaporator



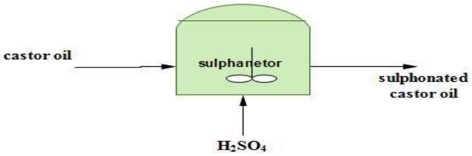
mass flow rate of oil + mass flow rate of solvent = mass of flow rate of oil + mass flow rate of solvent

28,046.3112kg/day=4046.315kg/day + mass flow rate of hexane

$$\dot{m}_{hexane}=24{,}000.596\frac{kg}{day}$$

5.1.3 Mass Balance on Sulphation process

Assume 5 batches per day and 4.5hrs for each batch.



The ratio of castor oil to the sulfuric acid is 2:1 based on the laboratory work.

Amount the castor oil produced per day is 2000L/day.

$$\dot{V}\ H2SO4=2000\frac{L}{day}\times\frac{1}{2}=1000\frac{L}{day}$$

$$min=mout$$

$$castor\ oil + H2SO4 = treated\ castor\ oil$$

$$2000\frac{L}{day} + 1000\frac{L}{day} = treated\ castor\ oil$$

$$treated\ castor\ oil = 3000\frac{L}{day}$$

Since the reaction is exothermic it needs cooling system and it requires water that used for cooling system. Based on laboratory work the ratio of treated castor oil to the water used for cooling was 1:3 then,

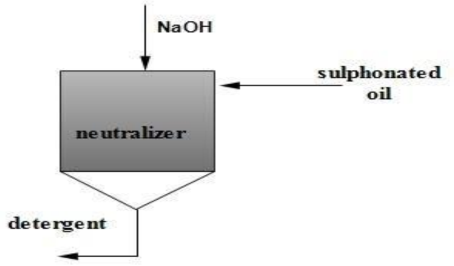
$$3000\frac{L}{day} \times 3 = 9000\frac{L}{day}$$

5.1.4 Mass Balance on Neutralization

As the laboratory work implies 40 g of NaOH which is diluted in the 100ml of distilled water is required to neutralize the oil. So,

$$Amount\ of NaOH\ required = \frac{0.04kg \times 6069.52kg}{0.0288kg} = 8429.9\frac{kg}{day}$$

$$\dot{V} = \frac{\dot{m}}{\rho} = \frac{8429.9\frac{kg}{day}}{2130\frac{kg}{m^3}} = 3.957699\frac{m^3}{day} = \ 3957.699\frac{L}{day}$$



$$\min = mout$$

$$treated\ castor\ oil + NaOH = detergent$$

$$3000\frac{L}{day} + 3957.699\frac{L}{day} = 6957.699\frac{L}{day}$$

5.2 Energy Balance on Selected Equipment

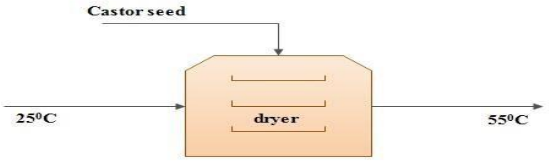
From general Energy Balance

Energy in – Energy out + Generation – Consumption = Accumulation

When we derived the mass balance , we did by saying the law of conservation of mass, which states that the total generation of mass is 0.

Energy input = Energy output

5.2.1 Energy Balance on oven



$Q = mCp\Delta T$ where, Q is energy required, Kj ΔT is temperature change, K

Cp is specific heat capacity kJ/kg.k M is mass kg

$$M_{seed}\ 6000\frac{kg}{day}$$

$$Cp_{seed} = 2.61\frac{kj}{kg.k}$$

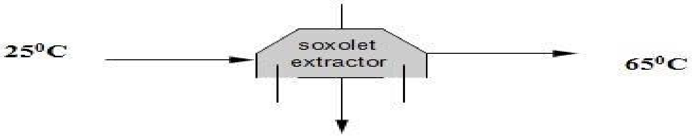
$$T_{in} = 25℃$$

$$T_{out} = 55℃$$

$$Q = 6000\frac{kg}{day} \times 2.61\frac{kj}{kg.k} \times (55-25)k$$

$$Q = 469,800\frac{KJ}{Kg}$$

5.2.2 Energy Balance on Soxhlet Extractor



$$\dot{m}\,seed = \frac{6000kg}{day}$$

Tin = 25^0 c

Tout = 65^0 c

Cpseed=2.61KJ/Kg.K

Cp $_{\text{hexane}}$ =2.26KJ/Kg.K

$Q = mCp\ \Delta T$

$$\dot{m} = 18000\frac{kg}{day} Cp = X_{seed} \times Cp_{seed} \times X_{hexane} \times Cp_{hexane}$$

$$Cp_{hexane} = 2.244\frac{Kj}{kg.k} \times X_{hexane} = \frac{\dot{m}hexane}{totalmass} = \frac{18000\,kg}{320000\,kg} = 0.5625$$

$$Cp_{seed} = 2.61\frac{kj}{kg.k} \times X_{seed} = 1 - X_{hexane} = 1 - 0.5625 = 0.4375$$

$$Cp = (0.4375 \times 2.61) + (0.5625 \times 2.244) = 2.4041\frac{Kj}{kg.k}$$

$$Q = 32000\frac{kg}{day}\times 2.4041\frac{kj}{kg.k}\times\left(65-25\right)k = 3,077,280\frac{kj}{day}$$

5.2.3 Energy Balance on heater evaporator

$m_{oil} = 4046.35\text{kg}$ $\qquad Cp_{hexane} = 2.24\frac{kj}{kg.k}$

$Cp_{oil} = 1.8\frac{kj}{kg.k}$ $\qquad m_{hexane} = 18000\frac{kg}{day}$

$$Cp = (m_{oil}\times X_{oil}) + (m_{hexane}\times X_{oil})$$

$$X_{oil} = \frac{4046.315kg}{28046.315kg} = 0.14427$$

$$X_{hexane} = 1 - 0.14427 = 0.85573$$

$$Cp = (0.14427\times 1.8) + (0.85573\times 2.24) = 2.1765\frac{kj}{kg.k}$$

$$Q = 28046.3\frac{kg}{day}\times 2.1765\frac{kj}{kg.k}\times(70-30)k$$

$$Q = 2441684.76\frac{kj}{day}$$

5.2.4 Energy Balance on Sulphator

moil= 4046.35 kg/day

mH2SO4= 2023.15 kg/day

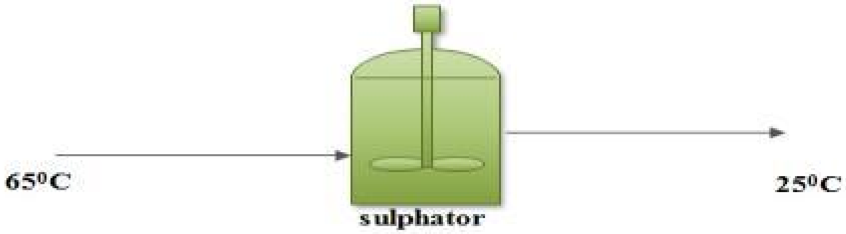
Cpoil = 1.8kj/kg.k

CpH2SO4 = 2.12 kj/kg.k

Tin = 65

Tout = 25

The reaction is exothermic and energy release



$$X_{oil} = \frac{4046.35}{4046.35 + 2023.15} = 0.666$$

$$X_{H2SO4} = 1 - 0.666 = 0.334$$

$$Cp = (0.666 \times 1.888) + (0.333 \times 2.12) = 1.965 \frac{kj}{kg.k}$$

$$Q = 6069.5 \frac{kg}{day} \times 1.965 \frac{kj}{kg.k} \times (25 - 65)k$$

$$Q =- 477062.7 \frac{kj}{day}$$

Water is required for this operation for cooling purpose and the amount of water required was calculated on material balance calculation section.

5.3 Engineering economic analysis

5.3.1 Cost Analysis

5.3.1.1 Equipment cost Estimation

Table 14 ;Purchased equipment cost

Epuipement name	Material of construction	Amount	Size of equipment	Equipment type	Total cost
reactor	Stainless steel	1	32.59m^3	Jackted and agitated	3034561
pump	Cast-iron fitting	4	4inch diamter	Centerfugial pump	2951453
Settiling tank	Carbon steel	1	12.78m^3	cylindrical	378221
Sulphination tank	Stainless steel	1	12.78m^3	cylindrical	1706431
conveyer	Carbon sttel	1	10 inch W/D	chain	386424
Water tank	plastic	4	5.18m^3	cylindrical	109219
Caster seed storage tank	Carbon steel	2	3.96m^3	cylindrical	220818
Oil storage tank	Carbon steel	4	20.35m^3	cylindrical	348845
mixer	Stainless steel	1	2.2m^3		12023
Soxhlet extractor		1	1.34m^3		2503175
Total					11651170

Estimating total Capital investment cost

- Purchased equipment cost (PEC)=11651170birr

PEC = 15-40%FCI

Take 30% then FCI= 11651170/0.3

=38837233.33 birr

- Instrumentation and control = 2-8%FCI

$$take\ 4\%\ \ then\qquad 0.04\times 38837233.33 = 1553489.333\ birr$$

Purchased equipment installation including insulation and painting= 6-14%FCI.

$$take\ 11\%\ then\qquad 0.11\times 38837233.33\ = 427095.666\ birr$$

Piping (installed) = 3-20% FCI

$$take\ 10\%\ then\qquad 0.1\times 38837233.33 = 3883723.333\ birr$$

Electrical (installed) =2-10%FCI

$$take\ 7\%\ then\qquad 0.07\times 38837233.33 = 2718606.333 birr$$

Building including service= 5-20%FCI

$$take\ 9\%\ then\qquad 0.09\times 38837233.33 = 3495351\ birr$$

Yard improvements = 3-7%

$$take\ 5\%\ then\qquad 0.05\times 38837233.33 = 1941861.667\ birr$$

Service facilities (installed) = 6-18%FCI

$$take\ 13\%\ then\qquad 0.13\times 38837233.33 = 5048840.333\ birr$$

Land =1-3% FCI

$$take\ 2\%\ then\qquad 0.02\ \times 38837233.33 = 776744.6666\ birr$$

Table 15 ; Total direct cost

Direct cost	Percent	Cost(birr)
Land	0.02	776744.6666
Service facilities	0.13	5048840.333
Yard improvements	0.05	1941861.667
Building including service	0.09	3495351
Electrical (installed)	0.07	2718606.333
Purchased equipment installation	0.11	4272095.666
Piping	0.1	38837223.333
Instrumentation and control	0.04	1553489.333
Total		23690712.33

Table 16 ;Total indirect cost

Indirect cost	Percentage	Cost (birr)
Engineering and supervision	0.1	3883723.333
Contingency	0.05	1941861.667
Construction expense	0.2	7767446.666
Contractor’s fee	0.03	1165117

Total indirect cost		14758148.67

Fixed capital investment cost =60-80%TCI

Take 68% then

$$TCI = \frac{38837233.33}{0.68} = 57113578.43 \text{ birr}$$

TCI = FCI +WC

WC = TCI – FCI

= 57113578.43 – 38837233.33 = 18276345.1 birr

Estimation of Total Product Cost

Total product cost = Manufacturing cost + General expenses

Manufacturing cost = Direct production costs + fixed charges+ plant overhead costs

A= Direct production costs

Table 17 : Raw materials cost

materials	Amount/year	Cost/unit(birr)	Cost/amount(birr)
Castor seed	250,000kg	5	1250000
Sulfuric acid	1785m^3	5500	9817500
Sodium hydroxide	1838kg	20	36760
water	4234m^3	15	63510
Sodium chloride	3654kg	40	146160
Hydrogen peroxide	980L	45	44100
colorant	243L	24	5832
Total			11363862

Raw material cost =20-50%total product cost

Take 35%

$$total\,product\,cost = \frac{raw\,material\,cost}{0.35} = 32468177.14\,birr$$

Operating labor =12-25% TPC Take 18%

$$0.18 \times 32468177.14 \ = 5844271.886\,birr$$

Direct supervisory = 15-25% operating labor Take 21%

$$0.21 \times 5844271.886 = 1227297.096\,birr$$

Utilities = 5-20% TPC Take 13%

$$0.13 \ \times 32468177.14 = 4220863.028 birr$$

Maintenance and repairs = 4-10% FCI Take 7%

$$0.07 \ \times 38837233.33 \ = 2718606.333\,birr$$

Operation supply 7-20 % maintenance and repairs cost Take 14 %

$$0.14 \times \ 2718606.333 = 380604.8866\,birr$$

Laboratory chargers = 10-20% operating labor Take 16%

$$0.16 \ \times 5844271.886 \ = 935083.5018\,birr$$

Patents loyalties =1-5%TPC Take 3%

$$0.03 \times 32468177.14 = 974045.3142 birr$$

Total direct product cost (TDPC) = 16300772.05 birr

Total Fixed Cost (TFC)

Depreciation cost = 5-15% FCI Take 10%

$$0.1 \times 38837233.33 = 3883723.333\ birr$$

Local taxes 1-5% FCI Take 2%

$$0.02 \times 38837233.33 = 776744.6666\ birr$$

Insurance 0-1% FCI Take 0.6%

$$0.006 \times 38837233.33 = 233023.4 birr$$

Rent (land + building) =5-15% Take 9%

Building =10-25% local taxes Take 18%

$$0.18 \times 776744.6666 = 139814.04\ birr$$

Rent

$$0.09 \times (776744.6666 + 139814.04) = 82490.283\ bir$$

TFC = **4975981.4** birr

Plant overhead cost

=50% (operation labor +cost of supervision +cost of maintenance

$$POC = 0.5 \times (5844271.886 + 1227297.096 + 2718606.333) = 489508.7656\ birr$$

Manufacturing cost = TDPC + TFC + POC

$$= (16300772.05 + 4975981.4 + 489508.7656) birr = 21766262.22\ birr$$

General Expense

General expense = Administrative costs + distribution and selling costs +research and development costs + financing cost

Administrative costs = 12% operating labor

$$0.12 \times 5844271.886 = 701312.6263\ birr$$

Distribution and selling costs = 10% TPC

$$0.1 \times 32468177.14 \ = 3246817.714\ birr$$

Research and development costs = 7% TPC

$$0.07 \times 32468177.14 \ = 2272772.4\ birr$$

Financing (interest) = 3% TCI

$$0.03 \times 57113578.43 \ = 1713407.353\ birr$$

$$GE = (701312.6263 + 3246817.714 \ + 2272772.4 + 1713407.353) birr$$

$$GE = 7934310.093\ birr$$

5.3.1.2 Profitability Analysis

- $the\ amount\ detergent\ produced\ is\ 4435 \frac{L}{day}$
- $operating\ day\ in\ year\ is\ 300\ day$

amount of detergent produced in year is

$$300\ \frac{day}{year} \times 4435 \frac{L}{day} = 1330500 \frac{L}{year}$$

Cost of detergent per liter 65 birr

Total production cost =manufacturing cost + general expense cost

= 21766262.22 birr + 7934310.093 birr

= 29700572.31 birr

Total income

$$1330500 \frac{L}{year} \times 65 \frac{birr}{L} = 86482500 \frac{birr}{year}$$

Gross earning = total income -total production cost

$$86482500 - 29700572.31 \ = \ 56781927.69 birr$$

Income tax (35) %Gross earning

$$0.35 \times\ 56781927.69\ = 19873674.69\ birr$$

Net annual profit = gross earning – income tax

$$56781927.69 - 19873674.69\ \ = 36908253\ birr$$

Rate of return before income tax

$$ROR = \frac{Net\ earning}{Total\ capital\ investment} \times 100$$

$$ROR = \ \frac{36908253\ birr}{57113578.43birr}\ \times 100 = 64.6\ \%$$

Pay back period

The plant life period is 12 year.

Depreciation 3%FCI

$$PBP = \frac{FCI}{net\ profit + deprecatation}$$

$$\frac{38837233.33}{36908253 + 1165117} = \frac{38837233.33}{38073370} = 1.02 \approx 1\ year$$

5.4 Plant layout

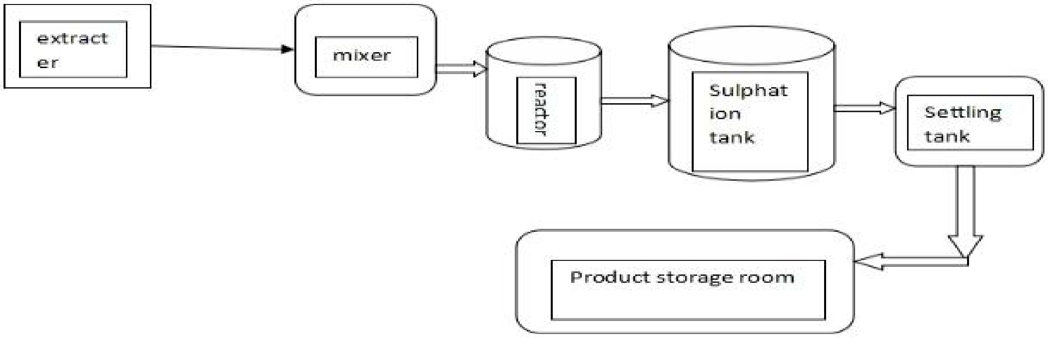


Figure 11 ; plant layout of detergent production

5.5 Site location

It is clear that detergent is a very popular good and service in Ethiopia. There isn't a soap manufacturing facility in the Oromia region near Ambo town, despite the fact that demand is great and castor trees are easily grown there. Because of this, we want to build a detergent manufacturing facility close to Ambo.

CHAPTER SIX

Conclusion and recommendation

6.1 Conclusion

This project have been undertaken to extract castor oil from it's seed, refine this and to produce a detergent. The extraction was done using n-hexane as a solvent. For further purify oil, the majority of gums were removed. The result obtained for the extraction showed percent oil extracted was 33.33%. The castor oil produced in this project was analyzed for specific gravity (0.898), saponification value (183.93), oil density (0.87 gm/cm^3), PH (6.17), free fatty acid value (92%). These values were very relative to literature. Liquid detergent was produced using sodium hydroxide, sulphuric acid and ingredients (i.e. sodium silicate, sodium chloride, perfume, bleaching agent) at constant mixing time 1 hour up to 2 hours, mixing rate of 300 rpm. The reaction proceed at temperatures between 35^{0}C – 40^{0}C. Neutralization and Sulphating of oil gives a detergent. The bleaching agent (H_2O_2) added helped to bleach the color of the castor oil so that semi milk color detergent was produced. PH tests analyzed as 10.69 and showed that the detergent exhibited basic property. The foam height of 2.57cm persisted for about 2 minutes and this is good relative to the literature 2.6cm with the standard value. However, density (0.87gm/cm^3) shows a little difference according to values in literature it can be considered being with in an acceptable experimental errors and impurities during experiment. The production of liquid detergent from castor oil was successively done. The many desirable intrinsic qualities of castor oil makes it very useful in the detergent industry, thus castor oil can serve as a good substitute to petroleum and coal, the conventional detergent bases and also could serve as a good cleaning agent.

6.2 Recommendation

Due to linear structure castor oil, such sludge or meal based on it should be digestible to soil micro-organism. If we reuse the blending of castor meal (sludge) and castor husk through further extraction and optimization method, they used as organic fertilizer for farmers. It's an alternative way due to their less cost.

The solvent extraction method was used to extract the oil, but it was challenging to do so because a small-scale castor oil extraction industry requires expensive equipment with well-designed control systems, instrumentation to recover the solvent, and a lot of electrical power to separate the solvent from the oil. High mechanical pressing efficiency must therefore be beneficial for oil extraction.

Despite the fact that there are numerous plants reducing detergent, demand is steadily rising. We strongly advice the government to invest in this project because the establishment of such a factory will save the nation foreign exchange by replacing current imports and because it uses agricultural output as an industrial input and is in line with the five-year development goal of our nation.

Our further proposal is that foreign imports be made for raw components such as LABSA, perfume, NaOH and colorants. Because imported raw materials are so expensive and have a negative impact on plant profitability, it’s preferable for investors to invest in the production of those raw materials.

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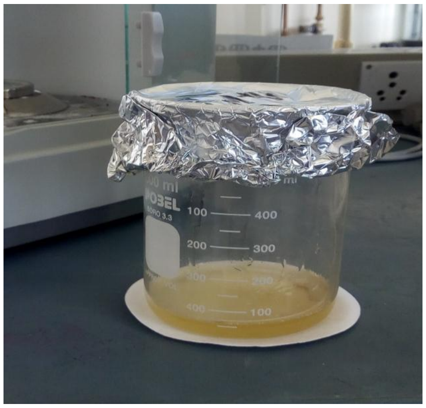
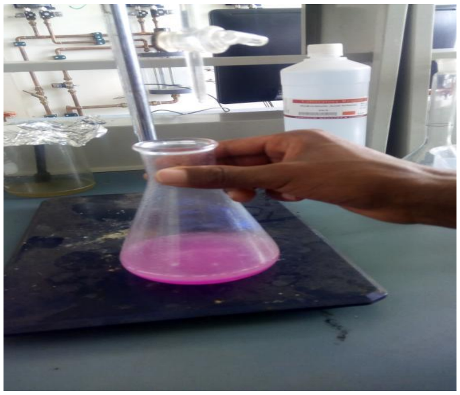
Appendix

Grinding of castor seed

soxhlet extractor

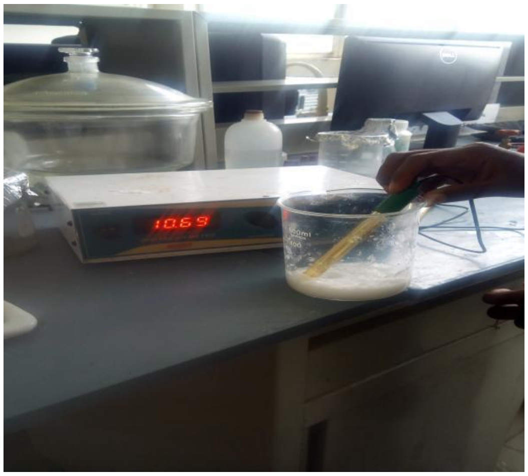


Extracted castor oil



determination of free fatty acid

Produced liquid detergent



PH measurement