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OIL EXTRACTION FROM CASTOR SEED THEN CANDLE PRODUCTION FROM THE CASTOR MEAL

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DECLARATION

We would like to make clear that this thesis is written by us. All sentences and all paragraphs except that we have taken from reference materials, are our own suggestions and descriptions. We have spent full of our effort and time to write this thesis.

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ACRONYMS AND ABBREVIATIONS

N-P-K	Nitrogen phosphorous potassium
Ml	Milliliter
KG	Kilogram
FFA	Free fatty acid
ETB	Ethiopia birr
KG	Kilo gram
G	Gram
BC	Before birth of Christ
VO	Volume of sodium hydroxide
WO	Weight of bottle
W1	Weight of bottle and oil
W2	Weight of bottle and water
M	Molarity
Y	Mass in kilogram (kg)
FI	Feed to equipment
FO	Out stream from equipment.
CP	Specific heat capacity
M	Mass flow rate
Q	Heat flow rate
HV	Heat of vaporization
MIX	Mixture
V	Volume
PD	Design pressure
E	Thickness
F	Design stress

ABSTRACT

Oil can be produced from different raw materials like vegetables, castor seed, soya been & rape seed. Castor oil is one of the most important oil that has diversified uses. After the crude castor oil extracted, usually the residue is used for fertilizer. In our research work, oil is extracted using solvent extraction technique and the remaining residue (meal) is used for candle production for home use. The extracted crude oil mainly characterized physical parameters (density, color & specific gravity) and with chemical characteristic (pH). The physical analysis gives the following results; light yellow and dark yellow for color, 959 kg/m^3 and 0.959 density and specific gravity respectively. Gram of castor oil was 5.92 pH values at 21℃. Then, candle from castor meal with bees wax 50%, produced and physical test was conducted. The candle produced in our experiment result it's mainly characterized by physical parameter such as Color of the flame; length of flame and burning almost same as compared to commercial candle, but durability of burning increase and its drip fastness slightly decrease. As well as we tried differentiated by solvent type used to extract. The Candle produced from meal using ethanol as solvent slightly different from solvent hexane The Color Of the flame almost the same for both solvents. From the laboratory result, duration of candle burning increase using hexane solvent because the meal was having not the same amount of oil to ethanol. Lastly the detail economic analysis and rough social and environmental impacts have been assessed. During a production capacity of oil 500ton/year it is possible to get 10060tons/year of candle. The economical evaluation of our project shows that the plant has payback period (1.06years), breakeven point (21%) rate of return (50.8%). Besides, the process is environmentally friendly and it enables the farmers in arid areas to be involved in castor seed plantation which again contributes or Carbon dioxide sink.

CHAPTER ONE: INTRODUCTION

1.1. Back ground of the study

Castor plant (Ricinus communis) is native to the Ethiopian region of tropical East-Africa; it has become gradually naturalized in tropical and warm temperate regions throughout the world. [1] Weather in India and Brazil is suitable for castor cultivation. It is the spiny seed that the valuable compound of the plant is found which comprises the oil and the meal. The spiny seed pod or capsule is composed of three sections or carpels which split apart at maturity. Each section (carpel) contains a single seed, and as the carpel dries and splits open, the seed is often ejected with considerable force. The compositions of castor beans are oil, fatty acids, white meal and water. Castor beans contain about 30-35% oil, 10-15% water and the rest are the meal in volume base. In some other references the oil content of the seed reaches up to 60 %. The composition of fatty acids can be neglected relative to other components. Although the seeds or beans are extremely poisonous, they are the source of numerous economically important products and are one of earliest commercial products. Among these components that can be expected as the desired product the oil is the most valuable constituent which is targeted on every aspect of the plant breading activity even if nowadays the meal is becoming another targeted constituent of the seed apart from using it as a fertilizer after the oil is extracted it can be serve as raw material for candle preparation since it is full of naturally existing waxes and can be burnt to give light. [2]. Castor oil is natural oil obtained from the seed of the Ricinus Communis. It is unique among naturally occurring oils in that it is the only commercially important oil composed of approximately 90 percent of a hydroxyl, unsaturated C18 fatty acid - ricin oleic acid [3].

Castor oil is extracted from castor beans by either pressing or solvent extraction and it is used in making soap, inks, and plastics; for preserving leather; as an illuminant; in Turkey red oil for dyeing and finishing textiles; and in brake fluids and certain insecticidal oils. The oil content of castor seed is depending up on the seed type and environmental conditions such as temperature, water availability wind soil type. [4]

Castor seed is water resistant and is used for waiting fabrics and their protective coverings. It is used for plastics, ointments and cosmetics. This wide application area of castor oil leads human beings to develop oil extraction methods with different qualities. [5]

The castor seed meal used as candle production. A candle that produced from castor seed meal used as a source of light with one or more combustible wicks that are surrounded by a burning of mass which is solid or semi-solid at room temperature. In the past, candles were made from beeswax obtained from the honeycombs of bees or tallow produced from the suet of beef, pork, lamb etc. Nowadays candle makers generally use candle wax blends based on paraffin wax and stearin to make candles. Beeswax is sometimes used today, but it is scarce and expensive. However, this thesis focused on integrated processes extraction of castor oils using solvent extraction. And candle preparation from the castor meal.

1.2. Statement of Problem

Castor seeds are very poisonous to human and animals as the seed contain resin toxic chemicals, Which, highly grows in most tropical and sub-tropical countries like Ethiopia leads to available at the low price. Our studies to extract the newly Ethiopian castor oil from castor seed. Castor oil has vast applications; here in Ethiopia however, the industrial use of local castor seed is null except for traditional purpose. So, our study was intended to enable the castor seed to be used for oil production that can substitute the imported castor oil and then to produce a candle from the residual castor meal.

1.3. Objectives

1.3.1. General objective

The general objectives of our study were Oil Extraction from Castor Seed then Candle Production from the Castor Meal.

1.3.2 Specific objectives

The specific objectives are the following

- To characterize the raw material and products.
- To study the effect of solvent type and extraction time on quantity of oil (oil yield)
- To develop candle production process from castor meal
- To determine the material and energy balance of the process
- To perform economic analysis

1.4. Significance of Study

The contribution of our work:

- ✓ To replace the total imported of castor oil with appropriate quality and quantity
- ✓ To aware the people how to produce a candle from the residual castor meal
- ✓ To create job opportunity for the people of the country, since it is the new industry for the country
- ✓ To increase the well- beingness and healthy life style of the people
- ✓ The oil extracted from castor seed used for manufacturing high grade lubrication

1.5. Scope of the study

The scope of our project would be extracting oil from the castor seed by using hexane in lab scale and scaling up it in to plant scale that can operate with cold press. And focused on integrated processes extraction of castor oils then candle preparation from the meal by proportionating it with a normal wax to modify some characteristics of candle such as heat stability. The oil extracted has been characterized physically such as color, density, specific gravity.

1.6. Limitation of the study

To achieve our objective there was some sorts during the course of this work.

- ✓ Scarcity of lab equipment's in our laboratory
- ✓ Limitation includes quality and quantity of extracted castor oil.it has low quantity and quality of oil due to lack of functioning equipment's.
- ✓ Inability to characterize the castor oil extracted mainly its chemical properties due to the absence of chemicals
- ✓ Inability to gotten quality and quantity of candle due to Absence all additives and molding materials that used for candle production.

CHAPTER TWO: LITERATURE REVIEW

2.1. Vegetable oils

Most vegetable oils are obtained from beans or seeds, which generally furnish two valuable commodities oil and a protein-rich meal. Seed extraction is achieved by pressing and or by solvent extraction. Some oils, such as virgin olive oil, are used without further treatment but most are refined in some measure before use. The refining processes remove undesirable materials (phospholipids, monoacylglycerols, diacylglycerols, free acids, color and pigments, oxidized materials, flavor components, trace metals and sulfur compounds) but may also remove valuable minor components which are antioxidants and vitamins such as carotenes and tocopherols. [6]

2.2. Castor plant and its seed

The castor plant is a robust annual that may grow 6 to 15 feet (2-5) meters in one season with full sunlight, heat and adequate moisture. In areas with mild, frost-free winters it may live for many years and become quite woody and tree-like. The spiny seed pod or capsule is composed of three sections or carpels which split apart at maturity. Each section (carpel) contains a single seed, and as the carpel dries and splits open, the seed is often ejected with considerable force. [7]

Plant oils are typically composed of triglyceride molecules (technically called esters) composed of a 3-carbon alcohol (glycerol) plus three 18-carbon (or 16-carbon) fatty acids.



Figure 1castor beans

2.3. Factors affecting chemical composition of seeds

We have seen that seed chemical composition varies among different species and cultivars. Additionally, chemical composition within seeds from the same genotype can vary significantly depending on the maternal plant environment and/or the position of the seed within the plant or inflorescence.

i. Position in the mother plan

The variation in seed chemical composition in seeds from the same plant is caused by competition for nutrients among seeds. In general, seeds that grow closer to the source of nutrients are favored in this competition.

ii. Season effects

Seed chemical composition can also be affected by the season that the seed experiences during maturation. For example, late season soybean seeds have higher protein concentration. In sunflower, seed oil quality tends to improve gradually over the season, with seeds produced in late summer having the best quality**.**

iii. Temperature

There are several reports that link higher temperatures during seed growth with production of smaller seeds. Although this temperature effect has been studied by measuring seed mass, it can be concluded that smaller seeds have a lower accumulation of storage reserves, especially carbohydrates. In most cases, the temperature effect on seed size is the consequence of changes in seed growth rate and seed filling period.

iv. Nutrients

Evidence about the effects of nutrient supply on seed size and composition comes from several fertilization experiments. These experiments showed that the mineral nutrient supply to the mother plant is one of the most important external factors affecting seed chemical composition. In general, addition of a particular mineral nutrient to the mother plant causes increases in the concentration of that nutrient to the seed. This effect has been reported in several species for both macro- and micro-nutrients.

v. Water stress

Water stress causes an increase in seed protein concentration in winter wheat, perennial ryegrass, maize, spring wheat, soybean, and common bean. In maize, plants subjected to water stress during seed filling produced seeds with 33% higher protein concentration and 18% lower oil concentration.in general the magnitude of Water stress effects depends on the timing that it occurring during seed development.[8]

2.4. Castor oil

The trade in castor oil as an item of commerce goes back to antiquity. The castor oil is obtained from the extracting method or pressing the castor seed which known with botanical name Ricinus Communis. This oil is inexpensive, environmentally friendly and also a naturally-occurring resource. The oil that comes from castor is a viscous, pale-yellow color, non-volatile, and also non-drying oil with a bland taste and sometimes used as a purgative. Furthermore, the oil has a slight characteristic odor while the crude oil tastes slightly acrid with a nauseating after-taste. The oil is one of the relative in the vegetable oil family which has a good shelf life and it does not turn rancid unless the oil subjected to excessive heat.

The largest exporter of castor oil is India and the other major producers of castor oil are China and Brazil. The total world production of the extracted castor oil is about 500000 tons and the productions of seeds are estimated at one million. [9]

2.4.1 The Castor Oil Properties

Relative to other vegetable oils, castor oil has different physical and chemical properties which vary with the method of extraction the oil. The castor oil that obtains from the cold pressing has low acid value with low iodine value and has slightly higher saponification value compared to the solvent-extracted oil, and the oil is lighter in color. The chemistry of castor oil is focused on its high content of ricin oleic acid and also the other three points of function that exist in the castor molecule.

1. One of the molecule functions is the carboxyl group that can give a huge and wide range of the esterification
2. Second one is the single points of unsaturation which can be altered using the hydrogenation process or the epoxidation process or the vulcanization process

3. The last one is the hydroxyl group in the castor oil can be acetylated or alkylated maybe can be remove from the oil molecule by using the dehydration process to increase the unsaturation of the oil compound to provide the semi-drying castor oil.

By high-temperature pyrolysis and by caustic fusion, the hydroxyl position of oil which is so reactive the molecule can be split at that point to yield useful product with shorter chain length. Actually, the presence of the hydroxyl group on the castor oil is adding the extra stability to the castor oil and also preventing the formation of hydro peroxides. [9] Typical Properties of Castor Oil can be summarized in the following table.

Table: 2.1 typical properties of castor oil

Property	Value
Density@20^{o}c	(0.956-0.963)g/ml
Refractive index	1.477-1.479
Saponification value	177-187
Iodine value	82-88
Saponification matter	(0.3-0.5)%
Hydroxyl number	160mm
viscosity@20^{o}c	(9.5-10.0)dpa.s

Table: 2.2 Average compositions of castor seed oil /fatty acid chains

Acid name	Average percentage range
Ricin oleic acid	85-95
Linoleic acid	2-6
Linoleic acid	1-5

Unique to castor oil is that regardless of where the beans are grown, the chemical composition remains constant. It is this consistency that has allowed castor oil to be used as the absolute standard for viscosity by the Bureau of Standards.

Castor oil's chemical formula is: CH_3-$(CH_2)_5$-CH (OH)-CH_2-CH=CH-$(CH_2)_7$-COOH. It is a fatty acid with 18 carbon atoms, a double bond between the ninth and tenth carbons, and is known as Dodecahydroxyoleic Acid. No other vegetable oil contains such a diverse and high proportion of fatty hydroxyacids. The ever-expanding end uses of castor oil and its derivatives make it imperative for businesses and companies to have an updated and comprehensive knowledge of the various applications of each castor oil derivative. This section provides extensive details on the current, emerging and future possible end use applications of castor oil and its derivatives. Special emphasis is given to providing real life and exclusive data for niche applications such as the use of castor oil to produce polyurethane, nylon 6 and nylon 11.

2.4.2 Oil extraction technologies

2.4.2.1 Mechanical pressing

Operating principle

The process begins by putting the oilseeds inside the feed hopper. The screw press has a horizontal main shaft that carries the screw composition which is formed integrally with the shaft. The rotation of the screw occurs inside the cage or barrel that is a structure formed by steel bars. Spacers are placed between the lining bars allowing the drainage of oil as the pressure over the grains is increased. A movable cone or choke control is installed at the discharged end. This device has the function of operating pressure by changing the width of the annular space through which cake must pass. It is possible to adjust the choke by a hand-wheel on the opposite end of the screw. [10]

2.4.2.2Solvent extraction

Extraction with solvents is the most effective method for the recovery of oil (almost 98%), especially with materials with low oil content, like soybeans. This method is not indicated to oilseeds with high oil content, like peanut and sunflower, requiring a prior step of pressing of the seeds and then the cake produced is extracted with a solvent. 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.

One of the disadvantages of the extraction is that the solvent extracts some non-triglycerides, which does not occur in the expelling. [11]

Another serious problem is the presence of volatile organic impurities in the final product, which can compromise the quality and go against the new profile of consumers who are seeking for natural products aiming to have a healthier diet. [10]

The choice of solvent takes into account a number of factors, notably, solvent extraction capacity, effects of solvent on oil properties, process safety, solvent volatility and stability, and economic considerations.[12]

2.5. Comparison of processes

The two processes discussed in this chapter, solvent extraction, and mechanical extraction (screw press and batch hydraulic pressing) can be compared and evaluated under three main parameters: environmental, economic and oil yield.

Today, the process most commonly used commercially is solvent extraction. This process has the advantage of high oil yield (over 98%) and the total domination of the technological process. After oil extraction, the remaining solvent should have a proper disposal to prevent environmental damage and avoid additional costs to the process, as well having higher investment cost (i.e. costly equipment).

Mechanical methods are the oldest methods of oil extraction. The great advantage of these methods is not using any kind of chemical products, producing a crude oil with high quality and ready for consumption, in some cases. Despite the environmental advantages, the economics are unfavorable, since although the facilities have lower costs than those in the chemical process, the low oil yield, and high oil content in the cake, can make the process unprofitable. [14]

2.6. Use of castor oil

Castor Oil & Castor Oil Derivatives Uses

- By Industry
- Agriculture
- Food
- Textile Chemicals
- Paper

- Cosmetics & Perfumeries

Other End Products Where Castor Oil & Derivatives are used

- Medicinal Uses of Castor Oil
- Anti-cancer Drugs
- Antifungal Drugs
- Heart & Blood Pressure Drugs
- Human Immunodeficiency Virus (HIV) Protease inhibitors

2.7. Castor meal

The castor meal or the castor cake waste is the excellent bio-fertilizer as it contains optimal composition of nutrients especially N-P-K. The toxic called ricin in the castor meal makes it unsuitable for animal feed. This situation makes the price for castor meal is lower compared to the prices of soymeal and rapeseed meal as both type of the meal can be used as animal feed.it Recently the meal can be served as in the production of candle for lightening.

2.7.1 Raw Materials and combustion products of candle

2.7.1.1 Raw Materials

Candles are made up of one or more wicks surrounded by a solid material, the wax, which can be burnt. The term ‘wax’ covers a variety of different products of mineral, animal or vegetable origin which have a number of common physical properties.

A. Paraffin Waxes

Paraffin wax is a complex composition of hydrocarbons which are solid at room temperature and which have a wax-like consistency. As well as being derived from mineral oil paraffin waxes can also be produced by Fischer-Tropsch-synthesis. Paraffin waxes used in candle production today are mainly derived from the fossil fuel crude oil.

B. Beeswax

Beeswax, the oldest known raw material for candles, is a metabolic product of the honeybee. The wax is exuded from glands on the abdomen of the worker bees and used to make the honeycomb. The wax acquires its cooler and pleasant smell over a period of time through contact

with honey and pollen. The availability of this raw material is naturally limited. Natural beeswax contains a number of impurities which are removed by various purification methods.

C. Stearin

Stearin (Greek steer – tallum) is, in normal conditions, a solid, crystalline blend of various fatty acids mainly made up of palmitic acid and stearic acid. Although it has wax like properties it is not normally categorized as a wax. The base products for the production of stearin are animal resp.Animal raw materials are mainly beef and pork tallow.

Candle producers usually use vegetable based stearic acids now a days. A special characteristic of stearin is that the softening and melting points are almost identical whereas in paraffin waxes these points are approximately 15 °C apart.

D. Hardened Fats

Natural fats and oils are made up of blends of triglycerides with different fatty acids. According to the length of the chain and the degree of saturation (saturated, mono or polyunsaturated) these fatty acids are solid, semi-solid or oily substances. Tallow was used in very early times for the production of candles.

E. Additives

As well as the above mentioned main raw materials, a number of additives are used to compound candle materials. These are mainly synthetic waxes from the polymer-chemistry branch e.g. polyethylene waxes and copolymers as well as high melt Fischer-Tropsch paraffin waxes. To achieve special effects other natural waxes e.g. carnauba wax, montane wax etc. are employed as additives. Colors, lacquers and fragrances complete the range of materials used in candle production

2.7.1.2 Candle Combustion Products

When burning candles, as in every case when burning hydrocarbons, water and carbon dioxide are produced. In addition, other combustion products can be formed in traces such as carbon monoxide, nitric oxide, organic hydrocarbons and soot. As well as the correct relation of the wick to the candle, the purity of the raw materials and additives used plays a decisive role.

2.8. Reason for selection of castor seed

Several feed stocks from vegetable source such as soybean, rape seed, and canola, palm, corn, and Jatropha and castor seeds have been studied as an alternative to oil candidate. Among these sources, castor seeds are a potentially promising feedstock since among vegetable oils, castor oil is distinguished by its high content (over 85%) of ricin oleic acid. There is no other vegetable oil contains so high a proportion of fatty hydroxyl acids and castor oil is the most stable viscosity of any vegetable oil.

The castor-oil plant is easy to grow and is resistant to drought, which makes it an ideal crop for the extensive semi-arid regions globally. Even if the seed can be cultivated in such away the seed has no value directly. In most parts of Ethiopia now a day it is assumed to be useless plant. This opportunity gives us to obtain the seed cheaply.

2.9 Process description

2.9.1 Oil production process description

The process of extracting castor oil from castor beans is a very simple separation process by means of a mechanical oil-seed expeller. Mainly the oil production process from oil seeds such as castor seed passes through three stages namely seed preparation, oil extraction and refining.

i. Seed preparation

Upon receipt at the processing plant, oleaginous materials require varying degrees of seed preparation prior to the oil extraction process. Seed cleaning, seed drying, size reduction, hull removal, heating/drying, flaking, and extruding are all potential unit processes involved in seed preparation.

ii. Oil extraction

Mechanical pressing: The main step in the process, pressing is done in continuous screw presses. Consisting of a barrel containing a stainless helical screw, the expeller has a pitch of a screw that presses the beans to extract the oil. The pitch of the screw flights gradually decreases towards the discharge end, to increase the pressure on the pulp as it is carried through the barrel. It is difficult to reduce the oil content of the pressed cake to below (8 – 10) %.

Solvent extraction: The solvent used in the majority of oilseed solvent extraction plants around the world is commercial hexane, a mixture of hydrocarbons generally boiling in the temperature range of (65– 69) °C. Most commercial hexane available contains approximately 65% normal hexane, with the remaining 35% of the composition consisting of cyclopentane and hexane isomers. As hexane vapor is three times heavier than air and slight amounts of hexane mixed in air can create an explosive mixture, special care must be taken in constructing and operating solvent extraction plants.

Settling or desolventizing of miscilia: The expelled oil contains residues, around 0.05 – 0.1%. To remove these particles, the expelled oil must pass through a settling tank to separate the solid particles from the oil.

iii. Refining

Water degumming: A pretreatment process applied to seed oils to remove impurities and partly remove phospholipids.

Neutralization: The purpose of neutralization is to reduce the concentration of free fatty acids (FFA) to a maximum 0.10% through the use of a diluted alkali solution, typically sodium hydroxide. [6]

Bleaching: The main purpose is to remove residual soap, pigments and oxidized components. This process is applied under vacuum with the addition of bleaching earth.

2.9.2 Candle production

Candle is an illuminating device made of a fiber wick enclosed in a cylinder of wax or fatty material. Beeswax candles were used by the Romans, and tallow (animal fat) candles have been made in Europe since the Middle Ages. In the 18th century, spermaceti, a wax obtained from the heads of whales, was introduced for candles. Since the mid-19th century, ordinary candles have been made from mixtures of paraffin wax, stearic acid (a solid fatty acid), and beeswax. Hydrogenated vegetable oils and other waxes are also used. It is highly desirable in rural areas where there is no electric light.

Candles are also used in traditional and religious ceremonies and also in hotels and restaurants. The use and techniques of production of candle passes different stages of change through age.

Candles have accompanied mankind for more than 2000 years. Besides their liturgical relevance, candles were predominantly used as a source of light and in the early history of their development were the better alternative to pinewood spill (the chip from revivified pinewood) Closely connected to the more than 2000 years development history of the candle are the efforts to improve its quality. Beeswax candles had been developed by the Romans to such an extent that by approximately the middle of the second century A.D. they could be burnt in a closed room without soothing annoyingly or excessively. [13]

Beeswax candles showed significant advantages when compared to tallow candles. The latter had a rancid odor and smoked and scooted whilst burning. It was only as late as the mid nineteenth century that stearin and paraffin wax offered further high-quality raw materials available for the manufacture of candles alongside bee's wax. During the same period decisive improvements were made to wicks, in particular the braiding techniques and chemical treatments so further prerequisites for candles that enable them to burn well were fulfilled. Candle has its own raw materials and the preparation follows its own unique procedures such as melting the wax adding the additives needed and finally molding followed by rapid cooling.

CHAPTER THREE: MATERIALS AND METHODS

3.1. Materials and chemicals

Table 1material was used

Materials	Use	Materials	Use
Oven	For drying the seed	Simple distillation	For separation
Plate	Washing and sorting	Beaker	Measurement and handling of chemical sample
Electronics balance	Weighting sample	Measuring cylinder	Volume measurement
Glass & aluminum foil	For molding	Heater or stove	To supply heat
Mortar	Further size reduction	PH meter	To measure PH
Soxhlet apparatus	To extract oil	Thermo meter	Measure temperature
Thimble	Sample handling	Flask	To handle product and solvent
Spatula	Take up the sample for weight and removal cake	Casserole	For melting cake sample
Kurt polymer	Handling sample	Wick	For burning

Table 3.2 major chemicals were used

Chemicals	Use	Chemicals	Use
Castor seed	As a raw material	Water	For condensation
Hexane	As solvent	Buffer solution	PH meter adjustment
Ethanol	As solvent	Distilled Water	PH meter adjustment

3.3. Methods of processing

3.4. Pre-treatment of castor seeds

The pre-treatment involves the preliminary preparations of the seeds in the following:

A. Shelling: This involves the removal of the shells to obtain the seeds. It was done manually.

B. Clearing: This involves the removal of foreign matter introduced during the sun drying Oil and any unshelled seeds

C. Drying: the moisture content of the seed was reduced using the electric oven. The oven was operated at 80^{o}C for about 24 hours.

D. De hulling: Separation of the shell from the nibs (cotyledon) was carried out using tray to blow away the cover in order to achieve very high yield. The oil in the shell is not significant that much and it is much important to remove it to attain maximum possibility of oil extraction with solvent extraction.

E. Crushing: Mortar was used to reduce the sizes of the dry seeds so as to increase the interfacial area between the solvent and the solute.



Figure 2 Pretreatment stages: a) clearing, b) De hulling and c) Size reduction

3.4.1. Characterization of castor seed

1. Castor seed moisture content determination
2. 200g of the cleaned sample were weighed and dried in an oven at 80°C for 8hrs and the weight was taken after every 2hrs. The procedure was repeated until a constant weight was obtained.

   The moisture content determined by using the following formula.

$$\text{MC } (\%) = \frac{W1 - W2}{W1} * 100$$

3.5. Extraction of castor oil

The solvents were selected 25g weighed of the dried castor seed samples moisture determination with were transferred into four thimbles the kept in chamber extraction unit of Soxhlet apparatus. A volume of 100ml of Hexane and ethanol were added respectively for two different times: 2 hour and 4-hour apparatus assembled. Heated at a constant temperature of 80^{o} C to

reflux. The heat caused the solvent to vaporize through the thimble containing the sample as the solvent boiled in the flask; the vapor was trapped and cooled by the condenser above the thimble. The cooling turned the vapor into warm liquid which hydrolyzed the sample in the thimble. When the thimble was filled with the drops of the warm solvent from the condenser, the solvent (which contained traces of the oil) was poured out into the flat bottom flask beneath the thimble contain the solvent. At the end of each extraction process, the milled sample was removed from the

Thimble and the extraction process repeated, but this time for solvent recovery from the oil. By simple distillation.



Figure 3 (a) Soxhlet extraction b) simple distillation

3.5.1 Castor oil characterization

A. Determination of Density and Specific gravity

An empty washed and dried beaker was weighed (Wb) and then filled 10 ml of oil in to the beaker and reweighed to give (W1). The oil was substituted with water after washing and drying the beaker and weighed to give (W2)

$$\text{Density of oil sample} = \frac{W1-Wb}{volume\ oil\ sample}$$

B. Specific gravity (Sp.gr)$= \frac{W1-Wb}{W2-Wb}$

C.Determination of pH value of the oil

- 2g of the sample were poured into a clean dry beaker

- The pH electrode was standardized with buffer solution and distilled water the electrode immersed into the sample and the pH value were read and recorded.

D.Color characterization: The colors of the oil extracted through solvent extraction were inspected with necked eye.



Figure 4 (a) oil produced by hexane b) oil produced by ethanol

3.6. The effect of time and solvent type on oil extraction

The efficiency of solvent extraction of oil from oil seeds of castor seed oil were influced by different factors such as solvent type used and extraction time etc.

3.6.1. The effect of time extraction on the oil yield

In general, a prolonged extraction time results in an increased yield of the oil until equilibrium is reached. Thereafter, the concentration of compound was not increase further but there were have greater liability for degradation. Prolonged extraction time was also not desirable from an economic standpoint of labor and energy requirements. Therefore, it was essential to find an optimum extraction time. So, in this study we set 2 different times such as 2 and 4 hour.

3.6.2. The effect of solvent type on the oil yield

The liquid chosen were good selective solvent and their viscosities were sufficiently low for it to circulate freely.

Generally, a relatively pure solvent was used initially, although as the extraction proceeds the concentration of solute were increase and the rate of extraction were progressively decrease, first because the concentration gradient were reduced, and secondly because the solution were generally become more viscous.

The most commonly used solvents for food processing were water, aqueous solutions of acids and nontoxic salts, commercial hexane, and in some cases other alkanes, ethanol and to a lesser extent the other lower alcohols, methylene chloride, methyl ethyl ketone, and acetone.

It is desirable to select solvents to be cheap, noncorrosive, nonflammable, non-explosive, nontoxic, easily removable, and easily recoverable in our study we were be select hexane and ethanol.

3.7. Candle processing method

1. Measure the wax

Measure 27 g meal from the two solvents and also Measure 27g the bee's wax

2. Melt the wax

We were added the meal in our ceasrol and heat for 10min add bees wax and melting the wax by casserole at the temperature of 140^{o}c for 30 minutes, stirring frequently

3. Attach the wick

We were attached the wick at the bottom of our container before we were pouring in the wax.

4. Pour the mix melted wax to the molding unit

We were poured the wax into our containers; let it cool fower a few minutes. When the temperatures on the thermometer were reads 40 degrees, it's time to pour. Then, we slowly pour the wax into our container. Hold the wick in place

5. Cut the wick

We were to cut our candle wick after drying the wax.

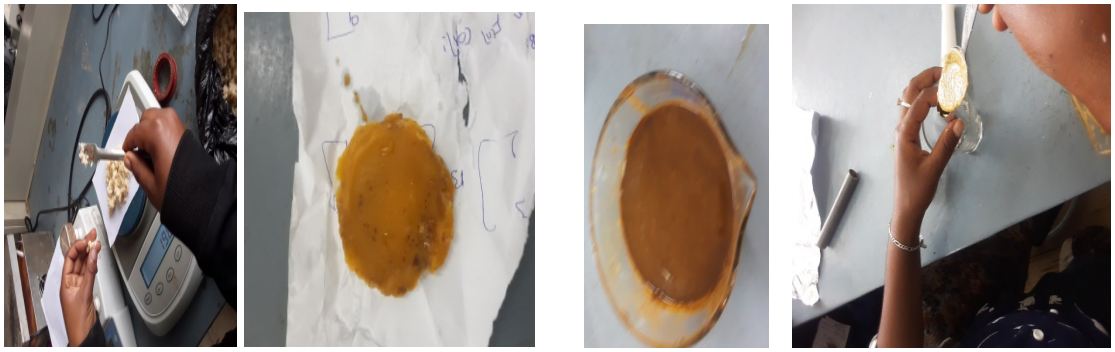


Figure 5 a) Measure the wax b) Melt the wax and c) Pour the mix melted wax

3.7.1. Candle characterization

The candle produced can be characterized with physical inspection. The characteristics inspected are:

A. To determine Durations of candle of burning

We were Measure 14g melted wax and we were poured in to the molding unit then we were cooled a few minute and dried at room temperature for 3days.then after 3 days we were burned the two sample candles. We were set burning time for 15 minutes. Then we were visualizing our necked eye. And we were recorded duration of time

B. To determine Flame of candle of burning

The flame was the fires visible portion. So, we were seen the flame during candle burning by visual inspection.

C. To determine Dripping fastness candles

We were determining this and visualize in time of candle burning. which candle sample was quickly drip fall dawn in the liquid form during candle burning



Figure 6 a) candle burning by ethanol b) hexane

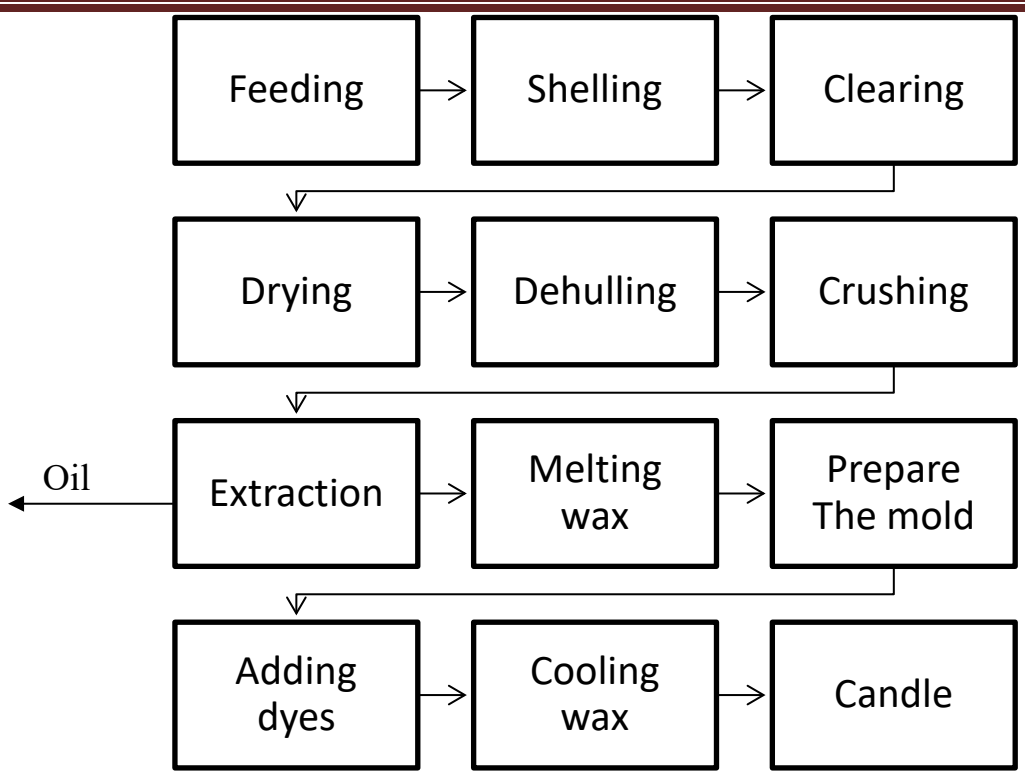


Figure 7 flow chart of candle production from castor seed

CHAPTER FOUR: RESULT AND DESCUSSION

4.1 Analysis of laboratory result

4.2 Moisture content determination

As it has been discussed in the methodology part it was tried to determine the moisture content of the seed. The result obtained can be given as follows with mass corresponds to time.

Table 2 tables to show moisture content of castor seed

Time(hr.)	0	2	4	6	8
Weight(g)	200	192	185.5	180.5	180

The moisture content then was calculated as

$$W= \frac{(\text{initial masssof sample}-\text{dried mass of sample})*100}{\text{initial mass sample}}$$

$$\text{Moisture content}= \frac{(200-180)*100\%}{200}=10\%$$

From this result the moisture content were obtained to 10%

4.3. Percentage yield of oil, time and solvent type effect

The laboratory experimental outputs in some variable with different level were recorded.

Table 3 percentage yield of oil, time and solvent type effect

Time(hr.)	Solvent type(ml)	Extracted oil in(g)	% Yield
2	Ethanol	7.2	29
2	Hexane	10.57	42
4	Ethanol	7.5	30
4	Hexane	11.2	44

$$\%\text{oil yield}= \frac{\text{weight of oil}}{\text{weight sample on the dry basis}}$$

% yield oil extracted by hexane= $\frac{42+44}{2} = \frac{86}{2}$=43%

% yield oil extracted by ethanol= $\frac{29+30}{2}$=30%

Average % yield = $\frac{43+30}{2}$=36.5%

The percentage yield of oil extracted by using hexane and ethanol as solvent from castor seed ranges from (29-44) %. The percentage yield of oil was maximum 44% from castor seed (cake) using hexane as a solvent and residence time for 4hour. While the minimum percentage yield of oil was 29% from castor seed cake using ethanol as a solvent and residence time for 2hour. In general oil extracted from castor seed cake may vary depending on solvent type and extraction time. Hexane generally the highest extraction agent. So, hexane was more preferable than ethanol.

Effect of solvent type on oil yield

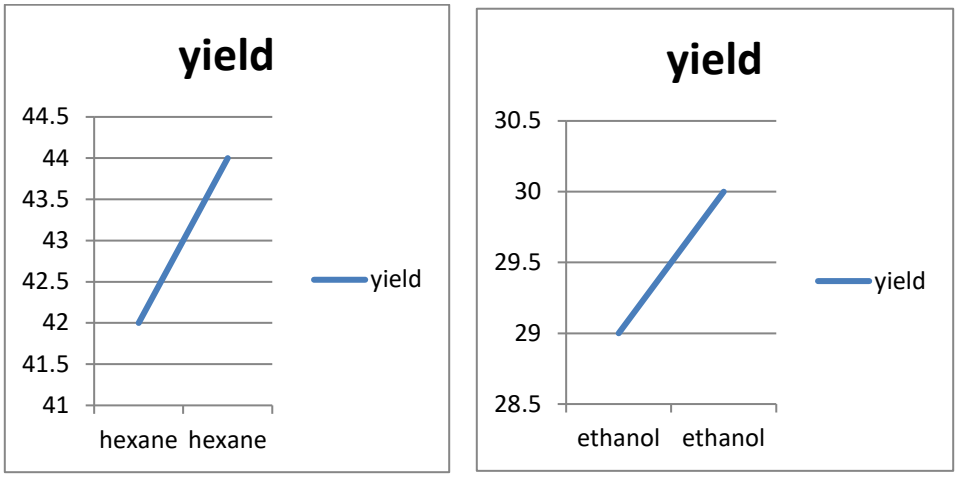


Figure 8 Effect of solvent type on oil yield

The Effect of solvent type on oil yield were shown in the fig 4.1.the response using hexane as a solvent the yield of oil increase. Based on the result obtained using ethanol as a solvent is not recommended because, the yield is very low relative to hexane. Since the main aim is yield. It is impossible to use solvents that can extract oil in such a manner as ethanol.

Effect of extraction time on oil yield

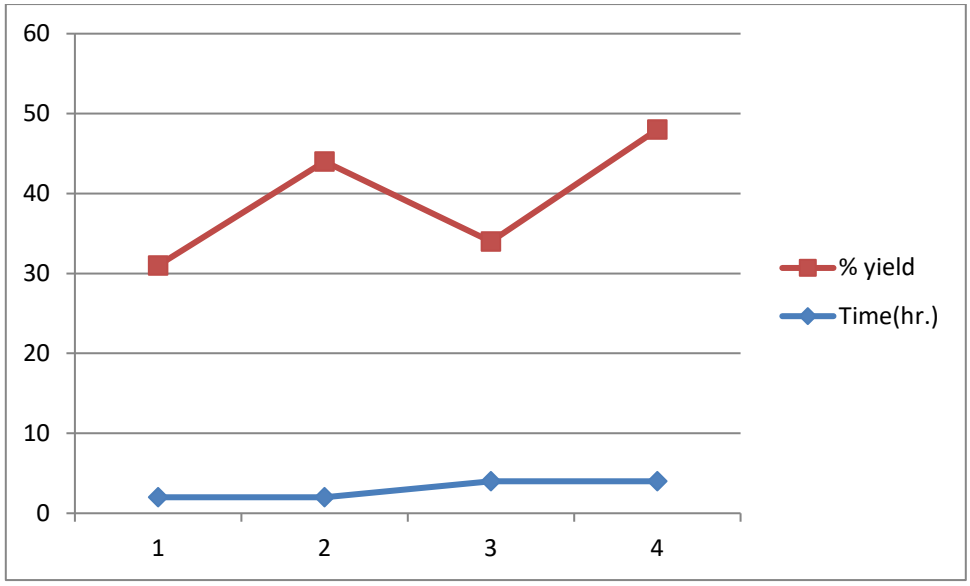


Figure 9 Effect of extraction time on oil yield

The results to see the effect of residence time on oil extraction has been seen in the above fig 4.2.As it has been presented in the above figure, % yield of oil obtained increases as time of extraction increases.

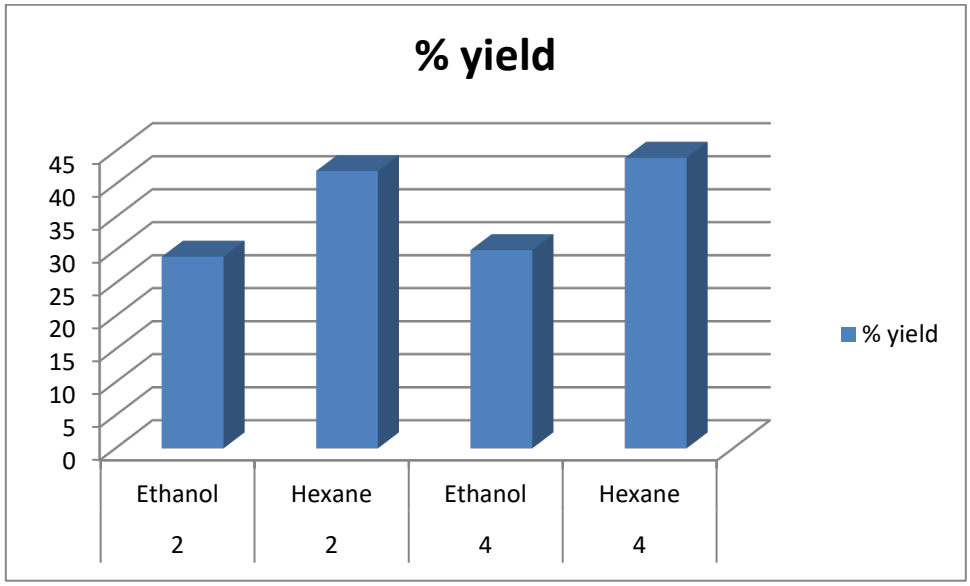


Figure 10 effect of time and solvent type on percentage yield of oil

We have seen the fig 10 both extraction time and solvent type affects percentage yield of oil.

4.2 Characterization of extracted oil

a) Determination of density of oil

The density of oil extracted has been measured from oil samples extracted for different time and with different solvent. The density of oil has been determined to be 959kg/m^3.

b) PH determination

The PH of the oil is measured and obtained with a value of 5.92at 20.1^{0}c by measuring with PH meter.

c) Specific gravity of oil

The specific gravity of oil is taken from its density analysis. The value is 0.959

d) Determination of color

The Color of castor seed oil extracted by hexane and ethanol solvent were slightly different. The oil extracted by hexane was light yellow while oil extracted by ethanol is orange color.

4.3. Candle characterization

A. To determine Durations of candle burning

We were seen our experiment the results Durations of candle burning slightly increase the candle produced from hexane compared to ethanol.

B. to determine length Flame and of candle of burning

Based on our experiment result we were seen length of the Flame, color of flame almost the same ethanol solvent compared to hexane. And also, no effect on the color of flame and Length of Flame the addition of castor seed meal in to bees wax.

C. To determine Dripping fastness of candles

Based on our experiment result we were visualizing dripping fastness of candle was decreased hexane solvent compered to Ethanol. The dripping fastness of candles that produced from castor meal was decreased as compared to commercial candle. All the above criteria are examined

from physical observation. The stability of the candle molded is related to its physical strength applied to external force.

4.3. Discussion of the laboratory result

Various test results different values of parameter for the same material characterization but one thing should be noted here that value should not be far apart to each other more unless the experiment failures is specified. This was what happens during our work. Although further analysis of characteristics of castor oil such as iodine value, saponification value. Acid value viscosity were not were not tested it was tried that most of its physical characteristics such as density, color and also chemical property such as PH, the result obtained was not that much different from literature sayings. For example, the color of the castor oil is yellowish in literatures such that it was light yellow from hexane and dark yellow from ethanol. in our laboratory output; the PH value was 5.92at 21 ^{0}c which has an accepted value of 5.8 – 6.5 in literature references. The oil content of the seed ranges from 42-45% by mass.

But based on our laboratory analysis it was possible to extract 36.5% by mass considering the efficiency of equipment used. It is also possible to say the seed contains 42-45 % oil. Even it may contain greater than this value depending on the conditions where the seed grows and seed types.

The color of the result varies depends on the two solvent which was extracted by hexane is light yellow. While the color which was extracted by ethanol is dark yellow. This might be the difference polar nature of the two solvents.

Hexane is non-polar organic solvent while ethanol is polar organic solvent the polar solvent (ethanol) was extracting polar components of the cake and hexane were extract non polar components of the cake. In the cake different types of ions are found. This polar ion example potassium could extract by ethanol. And hexane also dissolves non polar components of the cake such as fatty acid. The meal remaining after extraction of oil from castor seed can serve as fertilizer or candle production as substitution raw material. As it has been tried for the later application, proportionate it with other candle raw materials such as bee wax, durability of the candle increase. As well as we tried differentiated by solvent type used to extract. From the laboratory result duration of candle burning increase using hexane solvent because the meal

were have not the same amount of oil to ethanol. The oil inside the meal was increases combustion. When combustion increase drip fastness increase. The Appearance of the flame and length almost the same.

Lastly the economic performance and many other factors have to be considered when evaluating projects such that the most common factors with economic feasibility are environmental and political. Castor oil plant has no effect on environment since it has no effluent and by products is applicable for other major product candle in addition to fertilizer. In the other side with political consideration, it has no any political case. The site and plant location of the plant was selected in such a way that not to contradict the environmental and political rules and regulations in addition to considerations of raw material availability, facilities exist, market proximity.by considering all these factors the plant location shall to be placed in south Ethiopia.

CHAPTER FIVE: MATERIA AND ENERGY BALANCE OF CANDLE AND OIL

Material and energy balances are very important in an industry. Material balances are fundamental to the control of processing, particularly in the control of yields of the products. The increasing cost of energy has caused the industries to examine means of reducing energy consumption in processing. The basic principle for both material and energy balance is simply based on the following equation:

5.1 Material balance for oil

Basis: a plant production capacity is 500 tone/year, annual working time is 300 days/year, there for, the daily production capacity is 69.44kg/hr.to achieve this objective we have expected to due energy and material balance on main stage of the process. From our experiment we get

9.1goil from 25g of castor seed cake.

We used 1000g of castor seed for drying

And from this 1000g, 100g of castor seed cake was obtained

For 1000g castor seed=100g castor cake

? Fo For 25g castor cake

$=\frac{1000g*25}{100}$=250g of castor seed was needed before drying

And 25g castor seed cake=9.1g oil yields this means 0.025kg castor seed cake= 0.0091kg oil

For 0.0091kg oil=0.025kgcastor seed cake=0.25kg castor seed

0.0091kgoil=0.25kgcastor seed

69.44kgoil ? Fo

Fo $=\frac{69.44kg\ oil*0.25kg\ castor\ seed}{0.0091kgoil}$=1907.7kg castor seed before drying for the given plant capacity

5.1.1 Material balance on dryer

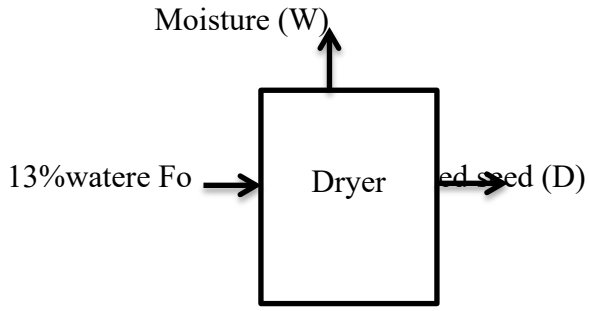


Figure 11 Material balance on dryer

Over all material bacterial balance

Fo= W+D…….1

Component balance

0.13*Fo=0.9W+0.1D…….2

Calculating these variables simultaneously

1907.7=W+D

0.13*1907.7=0.9w+0.1D

Substituting equation 1 to equation 2

0.13*1907.7=0.9W+0.1(Fo-W), 248kg=0.9W+0.1*1907.7-0.1w

248kg=190.77kg-0.8w, 248kg-190.77kg=0.8W, W= 57.23kg*0.8=71.54kg

D=Fo-W, D=1907.7kg-71.54kg=1836.16kg dried seed.

5.1.2 Material balance on Dehulling

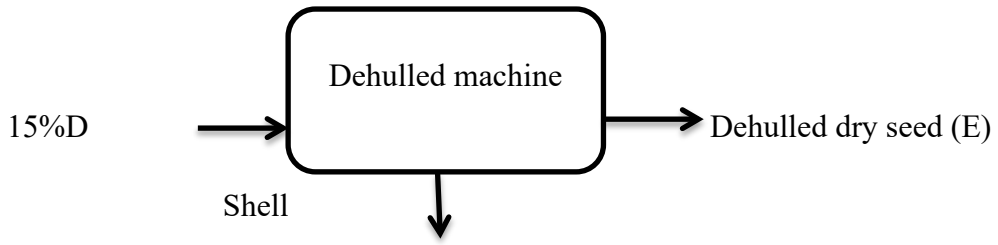


Figure 12 Material balance on Dehulling

Over all material balance

D=S+E……..1

Component material balance on shell

0.15D=S+0……2

S= 0.15*1907.7kg=286.115kg, S=286.2kg

E= D-S=1907.7kg-286.2kg=1621.5kg Dehulled castor seed

Assume material balance on size reduction negligible no loss.

5.1.3 Material balance on extractor

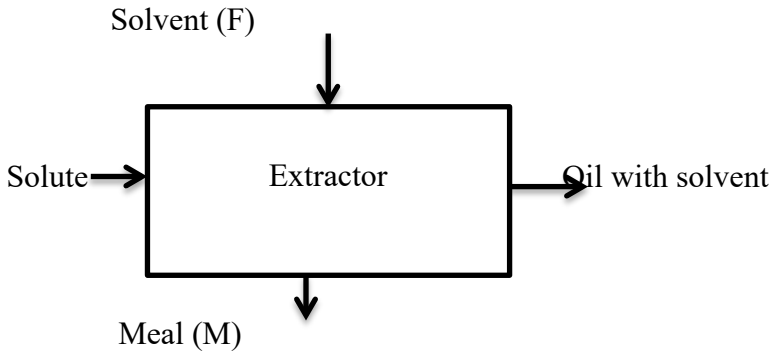


Figure 13 Material balance on extractor

Assumption

Steady state operation

Then Input=output

Castor cake (kg/hr) + solvent=extracted oil with solvent + meal

From the experimental work the ratio of oil to solvent=0.116

Amount of solvent=castor seed cake/0.116, 1621.5kg/0.116=13978.4kg

F=13978.4kg/hr of solvent input for extraction. From our objective, production capacity the extracted castor seed oil=69.44kgoil/hr there for.

Castor seed meal = castor seed cake +solvent- Oil with solvent

13978.4kg/hr+1621.5kg/hr- (69.44kg/hr+13978.4kg/kg)=

15599.9kg/hr-14047.44kg/hr= 1552.5kg/hr obtained

M=1552.5kg/hr obtained

5.1.4 Material balance for separator

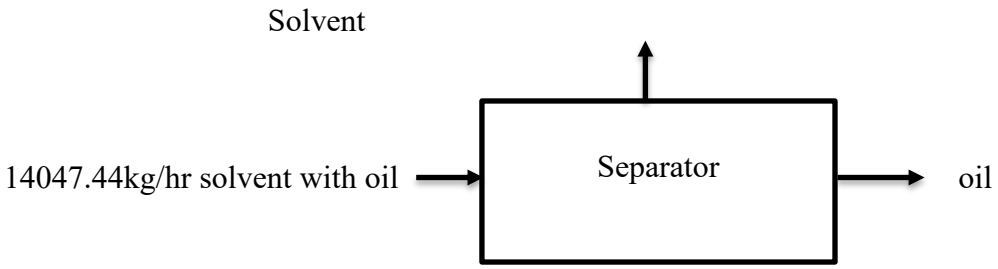


Figure 14 Material balance for separator

Castor seed with solvent=extracted oil with solvent-loss of solvent-amount solvent

Extracted oil with solvent =14047.44kg/hr, 10%loss

Loss of solvent=0.1*14047.44kg/hr=1404.7kg/hr

Extracted oil =14047.44kg/hr-13978.4kg=69.04kg/hr

5.2. Material balance for candle

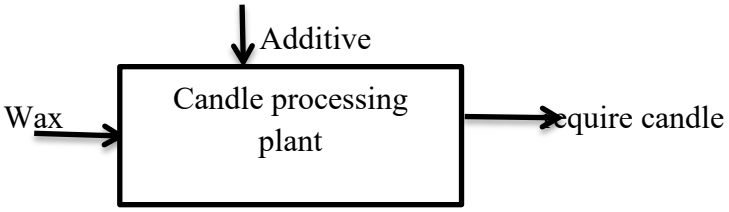


Figure 15 Material balance for candle

Assumption

- Additives mass is negligible relative to the mass of wax
- Mass is conserved
- Assuming 10% of impurities such as un-melted material is inserted. .
- Oil content (or un extracted) of the meal is neglected.
- No reaction is held inside the system. Only phase change, such as solid to the liquid (viscous fluid) and from the liquid to solid is held.

Standing on the assumptions:

The material (overall) balance is given as

Wax required (W) +Additives (A) =Impurities (I) + Candle obtained(C)

W+A=I+C

W+A=I+C, C=W-I

I=10%W=0.1*1552.5kg/hr.=155.25kg/hr.

1552.5kg-155.25kg/hr.

C= 1397.25kg candle/hr.

5.3. Energy balance

The most energy intensive equipment in the integrated castor oil and candle production plant was.

- Extractor
- Wax heating
- Energy for seed drying

In these devices we were try to calculate the heat duties each equipment should handle to accompany the given task.

5.3.1 Energy balance on extractor

Energy added by the heater +Energy added in the thimble after condensation=Energy taken up by the condenser

Assumption

The Soxhlet extractor is fully insulated

But from conservation of energy

Energy added to the thimble after condensation=energy taken up by the condenser

M (solvent oil)*Cp mixture (T2-T2)

C p of hexane at 25ºC =2.26KJ/kg. K

C p of ethanol 2.46kj/kgk

C p of oil at 25ºC = 1.8kJ/Kg º K

T2 =353k

CP_{averge}=2.26kj/kgk+2.46kj/kgk+1.8kj/kgk= 2.17kj/kgk

Q = $M_{(solvent+ Oil)}$ *$CPav_{erage}$*(T2-T1)= 0.1164kg* 2.17kj/kgk *(353-298)k=

13.89kj

Energy added in the thimble = M mix Cp (T2-T1) = 0 assume the castor seed and condensed solvent is at the same temperature inside the thimble.

5.3.2 Energy required in the wax melted

As it has been tried to see in the material balance the annual consumption of wax is calculated to be1552.5kg/hr. The melting point of castor meal reaches up to 138 ^{0}c. Let us take the melting temperature to be 140℃.

Q=mcpΔT, Cp= $\frac{(3.85)kj}{kgk}$

Q=1552.5kg/hr*3.85kj/kgk*(140-25)k=687369.375kj/hr, Assuming $300\frac{days}{year}$,

95.46kj/year.

Therefore, the rating for wax melted is 95.46kj/year.

5.3.3. Energy for seed drying

Be extraction the seeds are allowed to dry and go through deshelling for more the moisture inside the seed and shell respectively. So as to do the seed should be inserted in to dryer which is operates up to 80 °c. The energy required is sensible energy to raise only the temperature.

$Q=mc_p\Delta T$ =1907.7kg/hr*cpseed kj/kgk*(80-25) k

Taking C_{Pseed} is to be the average specific heat capacity of oil and the wax ,C_{Poil}=2.08kj per kgk and scaling up the specific heat of the oil with 80 % since it is more heat absorptive to calculate the specific heat capacity of wax it becomes,$C_{Pwax}= 3.85kj/kgk$

Take the average to be 2.96 $\frac{kj}{kgK}$

$Q=mc_p\Delta T$ = 1907.7kg/hr*2.96kj/kgk*55k =310573.56kj/hr=43.135kj/year

CHAPTER SIX: ECONOMIC ANALYSISE

6.1Capital cost estimation

Before attempts the design of a process and plant it is the responsibility of chemical engineer to make economic evaluation. It is essential that the chemical engineer be aware of the many different types of costs involved in the manufacturing process. Even if insufficient technical information is available to design a plant completely, we must still make and economic evaluation to determine if is economically and financially feasible.

Total capital investment of any plant capacity be including in its side both fixed capital investment and working capital investment. Total capital investment is the sum of fixed capital investment and working capital investment. Fixed capital investment represents the capital necessary for the installed process equipment with auxiliaries that are needed for complete process operation.

Total fixed capital investment =direct capital investment+ indirect capital investment. To estimate fixed capital investment of the plant, first find the cost of each purchased equipment cost.

6.1.1 Estimating Purchased Equipment cost [PEC]

The installation of equipment involves costs for labor, foundations, supports, platforms, construction expenses, and other factors directly related to reelection of purchased equipment. There is general range of installation cost as a percentage of the purchased-equipment cost for various types of equipment. Installation labor cost as a function of equipment size shows wide variations when scaled from previous installation estimates.

Table 4 Purchased equipment cost

Number	Equipment's name	Size of equipment	Material of construction	Quantity	Cost of equipment 1000 ETB	
					Unit cost	Total cost
1	Working storage tank	$1.6m^3$	Carbon steel	1	86.1	86.1

2	Pressing machine(expeller)	85kg/hr	Stainless steel	1	630	630
3	Water heater	0.45m^3/day	Carbon steel	1	81.6	81.6
4	Separator vessel	0.42m^3	Stainless steel	1	415.8	415.8
5	Vacuum drier or evaporator	46.089kg/hr	Stainless steel	1	1333	1333

6	Neutralizer	1.08m3	Stainless steel	1	555	555
7	Plate type HE	0.6373m3	Stainless steel	2	79	158
8	Final product storage tank	4.5m3	Stainless steel	1	916	916
9	Degumming tank	1.08m3	Stainless steel	1	555	555
10	Molding tank	1 set	Carbon steel	1	150	150
11	Washer tank	923m3/day	Carbon steel	1	6.3	6.3
12	Deodorizer	923m3/day	Stainless steel	1	1333	1333
13	Pump	0.9948m3/day	Carbon steel	10	67.2	67.2
14	Melter	465kg/batch	Carbon steel	1	57	57
15	Boiler	210kg/hr.	Stainless steel	1 set	600	600
Total purchased equipment cost 7554						

6.1.2. Fixed capital investment estimation

Capital investment is the total amount of money needed to supply the necessary plant and manufacturing facilities plus the amount of money required a working capital for operation of the facilities. This project considers the proportional costs of each major component of fixed capital.

i. Direct cost **(**DC**)**

Direct cost is the type of fixed capital investment costs that directly applicable for plant erect.

Before we are going to estimate the direct cost first of all find the fixed capital investment FCI.

Table 5 direct investment cost

Number	Item	Typical estimation factors	Cost in ETB
1	Purchased equipment cost	7554000	
2	Purchased equipment installation	25%PEC	1888500
3	Instrumentation and control	25% PEC	1888500
4	Piping installed	45% PEC	3399100
5	Building including service	20% PEC	1510800
6	Electrical installed	25% PEC	1888500
7	Yard improvement	5% PEC	377700
8	Service facility	10% PEC	755400
9	Land	1% PEC	75540
Total direct cost (TDC)			11784040

ii. Indirect cost: indirect costs are expenses which are not directly involved with material And labor or actual installation of complete facility.

Table 6 indirect cost table

Number			Cost in ETB
1	Engineering and supervision	25% PEC	1,888,500
2	Construction expense	10% PEC	755,400
3	Contractor's fee	20% PEC	1510800
4	Contingency	20% PEC	1510800
Total indirect cost (TIDC)			5665500

Therefore, fixed capital investment were be

FCI = TIDC + TDC = 5665500ETB+11784040ETB=17449540ETB

6.1.3 Total capital investment

The total capital investment = fixed investment + working capital investment

In most plants working capital investment takes (10-20) % of total capital investment. Assume to be 15 %.

TCI = FCI +working capital = FCI + 0.15TCI

$$TCI=FCI/(1-0.15)=\frac{17449540}{0.85}=20528870.59ETB$$

6.1.4 Estimation of working capital

And working capital will be the difference of total capital investment and fixed capital investment

WCI = TCI – FCI= 20528870.59ETB -17449540ETB=3079330.59 ETB

6.2 Total product cost estimation

Determination of the necessary capital investment is only one part of a complete cost estimate. Another equally important part is the estimation of costs for operating the plant and selling the Products. These costs can be grouped under the general heading of total product cost. The latter, in turn, is generally divided into the categories of manufacturing costs and general expenses. Manufacturing costs are also known as operating or production costs. Further subdivision of the

manufacturing costs is somewhat dependent upon the interpretation of direct and indirect costs. Fixed charge is 10-20%TPC

TPC=Manufacturing cost+ General expense

6.2.1Manufacturing Cost

Manufacturing Cost=Fixed charges +Direct production costs +Plant overhead costs.

A. Fixed charge

Expenses are always present in industrial plant whether or not the manufacturing process in operation.

1. Depreciation

The annual depreciation rate for machinery and equipment ordinarily is about 10% of the total-capital investment.

$$D_{pre} = 10\%\ \text{TCI} = 0.1 * 20528870.59\ \text{ETB} = 20528870.59ETB$$

2. Sake For the of promoting local investors in Ethiopia provides land free from tax and rent.
3. Insurance (I) = 1% of FCI

Insurance =0.01*17449540ETB= 174495.4ETB

Fixed charges = D p + I

Fixed charge =20528870.59ETB+174495.4ETB=2227382.459ETB

Since fixed charge is (10-20) % of total production cost taking 15 % to be the optimum

TPC= $fixed\frac{charge}{0.15} = \frac{2227382.459}{0.15} ETB = 14849216.39ETB$

B. Direct production cost

Table 7 general expenses

Number	Item	Assume	Cost (ETB)
1	Raw material cost	10%TCI	2052887.059
2	Operating labor cost	10%PEC	755400
3	Direct supervision and clerical labor cost	10%PEC	755400
4	Maintenance and repairs cost	5%PEC	377700
5	Operating supply	10%maintenance and repairs	37770
6	Laboratory charges	10% operating labor	75540
7	Patent and loyalist cost	2%PEC	151080
8	Utility cost	10%PEC	755400
Direct production cost (DPC)			4961177.059

C. Plant-overhead costs (5- 10) % of PEC, take 5%

Plant overhead = 377,700 ETB

Manufacturing cost = A + B + C = 222738.459ETB + 4961177.059ETB + 377,700 ETB =4963782141ETB

6.2.2General expenses

General expenses=administrative cost+ distribution and selling costs +research and development costs.

Table 8 General expense

Number	Item	Assume	Cost in ETB
1	administrative cost	10%operating labor	75540
2	distribution and selling costs	2%PEC	151080
3	Research and development costs.	5%PEC	377700
4	Financing (interest cost)	2%PEC	151080
general expense			755400

6.3. Total income and expense

Total annual product = 500 $\frac{tonne}{year}$ 10060.2tone/ year

But the unit price is= $1.5ETB/16.26gram for$ candle and $30ETB/kg$

Sell income =10060 $\frac{tonne}{year}$*1000, $\frac{kg}{tone} * \frac{1.5ETB}{0.16Kkg} + \frac{500000kg}{year} * \frac{30ETB}{kg} = 943044280.4$ETB

C. Measure of profitability

1. Gross profit: Gross profit= total income –total expenses = total sales revenue (TSI) Sale tax = 45% TSI =424369926.2 ETB

Gross profit =943044280.4ETB - 496378214ETB - 424369926.2 ETB =44451077ETB

Net profit

Net profit=gross profit (1-income tax)

Currently income tax in Ethiopia 45% for annual income greater than 60,000 $\frac{ETB}{year}$.

$$\text{NP}= grossprofit * (1 - 45) = 24248092283ETB/yea$$

Break Even Point:

$$BEP = \frac{FCI}{TSP - TPC} * 100\%$$

$$\text{BEP} = \frac{17449540}{94304428.4-14849216.39} 100\% = 21\%$$

iv. Payback period:

Now taking the minimum acceptable rate (Mar) = 15% and calculating the reference payback period.

$$\text{Reference payback period}= \frac{BEP}{mar+\frac{BEP}{n}} = \frac{0.21}{0.15+\frac{0.21}{12}} = 1.25year$$

$$\text{Payback period}=\frac{FCI}{NP+D} = \frac{17449540ETB}{2424809283\text{ETB}+20528870.59\text{ETB}} 0.06year$$ after it starts production.

Assuming the construction and plantation age of 1 year the payback period becomes

0.06year+1 years =1.06year

Since Payback $_{\text{period}}$< Payback $_{\text{reference}}$, the project feasible.

$$\text{ROI (ROR)} = \frac{NP}{TCI} * 100\% , \frac{2424809}{20528870.5.9} * 100\% = 50.8\%$$

CHAPTER SEVEN: ENVIRONMENTAL ANALYSIS AND PLANT LOCATION

7.1. Environmental analysis

Castor oil has side advantage as a green economy in addition to its safest mode to use by product for other purposes (candle production).

7.2. Plant location

The geographical location of any industrial plant has strong influence on the success of the project. Considerable care must be exercised in selecting the plant site, and many different factors must be considered. Primarily, the plant should be located where the minimum cost of production and distribution can be obtained, but other factors, such as room for expansion and safe conditions for plant system as well as the surrounding community, are also important.

7.2.1 Plant location selection factors

1. Raw materials availability
2. Energy availability
3. Transportation facilities
4. Waste disposal
5. market
6. climatic conditions
7. water supply
8. labor supply

Three factors are usually considered the most important. These are the location of the markets and raw materials and the type of transportation to be used.

Transportation

The transport of materials and products to and from the plant will be an overriding consideration in site selection. If practicable, a site should be selected that is close to at least two major forms of transport: road, rail, waterway (canal or river), or a sea port. The least expensive method of shipping is usually by water; the most expensive is by truck.

Raw materials

The availability and price of suitable raw materials will often determine the site location. Propylene is the major raw material for the manufacture of acrylic acid; hence the plant can be located near any plant producing propylene. It will reduce transportation and storage costs.

Location of markets:

Consumer products often are delivered in small shipment to a large number of customers. Since acrylic acid acts as a raw material for the production of consumer goods like paints, plastics, pharmaceutical binders etc. It is always advantages for the plant to be situated in an industrial area. Other additional factors include

Water

Water is needed by every processing plant for a number of different purposes. Potable water is needed for drinking and food preparation. The plant site must have an adequate amount of each type of water at all times of the process.

Climatic Conditions

Adverse climatic conditions at a site will increase costs. Stronger structures will be needed at locations subject to high winds or earthquake.

Pollution and Ecological Factors

All industrial processes produce waste products, and full consideration must be given to the difficulties and cost of their disposal. The disposal of toxic and harmful effluents will be covered by local regulations, and the appropriate authorities must be consulted during the initial site survey to determine the standards must be met.

Site Conditions

An ideal chemical plant site is above the flood plain, flat, has good drainage, a high soil- bearing capability, and consists of sufficient land for the proposed plant and for future expansion. Considering the above factors, our plant location has been selected to be in south Ethiopia region around 10km away from mizanteferi town.

7.3. Plant layout

After the process flow diagrams are completed and before detailed piping, structural, and electrical design can begin, the layout of process units in a plant and the equipment within these process units must be planned. This layout can play an important part in determining construction and manufacturing costs, and thus must be planned carefully with attention being given to future problems that may arise. Since each plant differs in many ways and no two plant

sites are exactly alike, there is no one ideal plant layout. However, proper layout in each case will include arrangement of processing areas, storage areas, and handling areas in efficient coordination and with regard to such factors as:

1. New site development or addition to previously developed site
2. Type and quantity of products to be produced

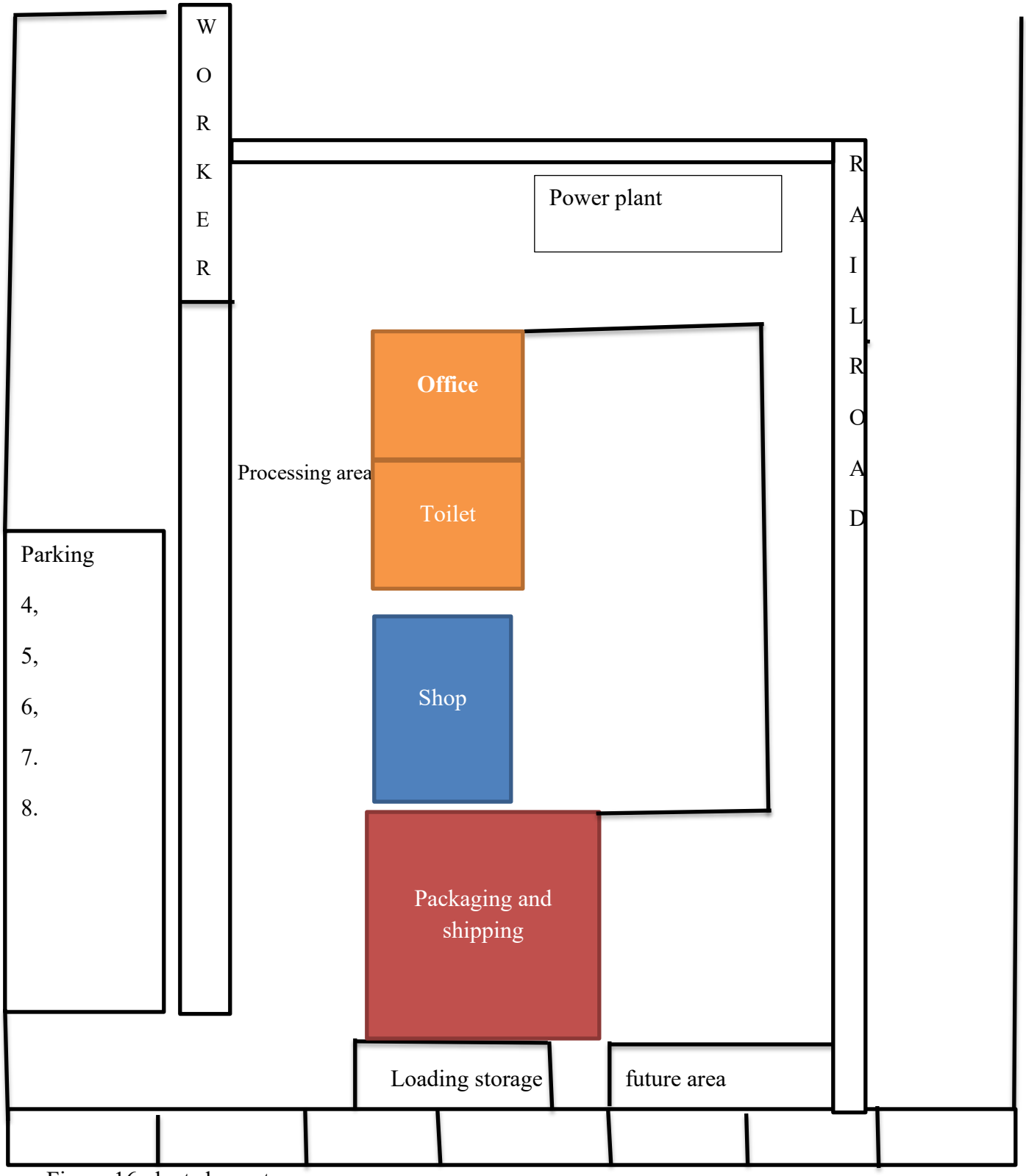


Figure 16 plants lay out

CHAPTER EIGHT: CONCLUSSION AND RECOMONDATION

8.1 CONCLUSION

Depending on the laboratory output, the oil content of the castor seed is 36.5% by mass and the moisture content can reach to (10-23%by mass and among which it is possible to remove 10% by drying. Drying the seed as much as possible enables the extraction process to be efficient. Different solvents have different penetration abilities to extract the oil from the castor seed. Further increasing of extraction time has no significant for economic benefits. The cake after it leaves its oil with any mechanism of extraction can have additional application other than the current application as a fertilizer as a proportionating raw material for candle production. Integrating the candle production and oil extraction plant together is more economically and environmentally feasible rather than each individual can provide. Castor has twin applications on the processing step other than the green field development namely for castor oil and castor meal for candle production. Investing on castor seed oil with capacity 500ton/year can have a side plant of candle production with capacity 10060.9 tone/year. The integrated plant can create job opportunity for some people starting from the seed farming up to seed processing for the final product. Mainly the integrated plant can provide 424370169.1birr for the government in the form of tax with a payback period of 1.06 years.

8.2. RECOMONDATION

1. Doing this thesis we face several challenges, those challenges are absence of some chemicals and equipment, utilities such as water, light and enough internet access and also there is no enough skilled laboratory assistant. Therefore, we recommend that the department may try to solve those problem raised above and the laboratory must be started on the on the scheduled time.

2. Ethiopia should install castor oil plant to export the castor seed by adding value and to minimize the cost to import the castor oil for local consumption since it is the 4^{th} largest castor seed producing country in the world per annum and the second largest castor seed producing country per hectare in the world.

3. Further deep study should be held on the use of the meal as proportioning raw material to the normal wax for candle production.

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