Wolkite University

College of Engineering and Technology

Department of Chemical Engineering

Title: Extraction and Characterization of Essential oil from basil leaves

***Prepared by*:** **ID NO**

1. Tamirat Sire…………………………………………… **ENG/771/11**
2. Temesgen Solomon………………..................ENG/785/11
3. Tewodros Tsebelu……………………………….ENG/798/11
4. Tibebu Tilahun……………….........................ENG/800/11
5. Zerubabel Yacob…………………………….......ENG/879/11

Advisor: MR. Abinet Mengesha

Wolkite Ethiopia

Declaration

We hereby declare that the work which is being presented in this thesis entitled with Extraction of Essential Oil from Basil (Ocimum basilicum L.) leaves is our own original work. This project has not been presented for degree in this or other Universities and all resources of materials that used for this thesis work have been fully acknowledged.

	SIGNITURE	DATE
Tamirat Sire	____________________	____________
Temesgen Solomon	____________________	____________
Tewodros Tsebelu	____________________	____________
Tibebu Tilahun	____________________	____________
Zerubabel Yacob	____________________	____________

This project has been submitted for examination with my approval as a University advisor.

Advisor's Name: Mr. Abinet Mengesha

Signature ____________________

Date ____________________

Examiner

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Name	Signature	Date
3________________	____________	________
Name	signature	Date

Acknowledgement

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Abstract

Essential oils are highly concentrated substances extracted from flowers, leaves stems, roots, seeds, barks, resins or fruit rinds. Basil (Ocimum basillicum L.) is an erect herbaceous annual aromatic, spice and medicinal plant that belong to the Lamiaceae family.

Principally, the project aims at extracting essential oil from basil leaves by solvent extraction technology. Experiments were carried out to extract the oil from basil leaves. Samples of 1500g was taken and treated by passing through washing, drying, grinding, extraction, and separation. The effects of particle size at(≤0.5,≤1,≤2)mm volume of solvent (150ml,160ml,200ml)and extracting time (3hr,4hr,5hr) were studied. At particle size ($\leq 1mm, oil\ yield\ was\ 16.667\%$*), at volume of solvent (160ml, oil yield was 13.8%) and extraction time (4hr, oil yield was 16.667%) were the optimum values for these parameters. Besides, the characterization on physical and chemical properties of the essential oil was performed. The moisture content of the fresh basil leaves after 2 full sunny drying days was found as 76.47%. The percentage yield of extracted product at optimum parameters was determined 17 % by weight. Besides, its density and specific gravity was found to be 0.7089 g/ml and 0.7110 respectively.*

The project is financially feasible with Rate of Return (ROR) 38.82% and payback period of 2 years. The project will generate $152,065.00 in terms of tax revenue.

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List of Abbreviations

EDA	Electro-dermal activity
EEG	Electroencephalogram
EO	Essential oil
EY	Extracted yield
O.Basilicum L	Ocimum basilicum Leaves
SG	specific gravity
BPC	British Pharmaceutical Conference

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Basil (Ocimum basillicum L.) is an erect herbaceous annual aromatic, spice and medicinal plant that belong to the Lamiaceae family (Darrah, 1980). The name basil is derived from the Greek word basilus which means "king" (Chang, 2004).

Basil has long been used as an embalming and preserving herb, found in mummies of ancient Egypt. Basil was used also a symbol of mourning in Greece where it was known as basilikon photon, meaning magnificent, royal, or kingly herb. Ancient records from 907 AD indicate sweet basil in the Hunan region of China. Many beliefs and rituals are accompanied with basil. In Italy it is a symbol of love, in France it is named as an herb of royalty. Jewish people used it to get strength during fasting while an African legend claims that basil protects against scorpions. However, a European group has considered it to be a symbol of Satan (Marwat et al., 2011). The plant has been used in many parts of the world to treat a wide variety of disorders. Basil is a popular herb in US and Mediterranean diets (Lee &Scagel, 2009). O.basilicum, sweet basil is used in traditional medicine to treat various ailments: abdominal cramps, gastroenteritis, dysentery, and diarrhea. In northern Oman and Saudi Arabia, juice of leaves or crushed leaves is used in the treatment of wounds, acne, and vitiligo. It is used also as a deodorant, is considered to be an aphrodisiac, worn by men when visiting their women (Ghazanfar, 1994; Schopen, 1983). In the coastal areas of Nigeria, O. gratissimum is used in the treatment of epilepsy, high fever and diarrhoea (Effraim et al., 2003). Pharmacological Activities of Basil oil are the infusion of

O. gratissimum leaves is used as pulmonary antisepticum, antitussivum and antispasmodicum (Ngassoum et al., 2003). Brazilian tropical forest inhabitants use a decoction of O. gratissimum roots as a sedative for children (Cristiana et al., 2006).In India, the whole plant has been used for the treatment of sunstroke, headache, influenza, as a diaphoretic, antipyretic and for its anti-inflammatory activity (Ueda-Nakamura et al.,2006). Juice of the leaves of Tulsi plant, O. sanctum was used as demulcent, stimulant, expectorant. Tulsi was also used in the cure of upper respiratory tract infections, bronchitis, skin infections and earache (Harsa et al., 2003).

Traditionally, extracts of O. kilimandscharicum have been used to mitigate many disorders in East Africa including coughs, colds, measles, abdominal pains, and diarrhea. It has also been used as an insect repellent, particularly against mosquitoes and food storage pests (Bekeleet al., 1995). The essential oils obtained from this plant have been used in northeastern Tanzania for centuries as repellents against nuisance biting insects and malaria vectors (Kweka et al.2008).

O.canum is used for treating various types of diseases, lowering blood glucose, and for treatment of colds, fever, parasitic infestations on the body, and inflammation of joints and headaches (Ngassoum et al. 2003). Traditionally, Generally Ocimum species have been extensively utilized in food and perfumery industries (Telci et al., 2006).

Basil oil is categorized as high essential oil, which means the aroma will evaporate within 24 hours after it is applied to the body (Kardinan etal.2005). Basil oil can be used for aroma therapeutic massage by lightning and refreshing the body. It can also reduce the intensity of digestion problem, headaches, strained muscles and nervous breakdowns (Center for New Crops and Plant Products, Purdue University, US). Essential oils have some distinctive characteristics, which make them a very valuable commodity with many industrial uses and applications. Their aromatic value enables them to be used as flavoring in both the food and beverage industries. These oils are also widely used in both the cosmetic and pharmaceutical industries. With such applications, there is a huge demand for basil essential oils worldwide and hence they have been traded internationally for several centuries. There is hence a need to improve the quality and quantity of the essential oils produced as they have a very competitive and profitable market worldwide. The chemical composition of the essential oils is important in determining their quality and consequently price in the market. It is therefore important to note and understand some of the parameters such as particle size, solvent, temperature, drying conditions, agitation of fluid and time of extraction may affect the quality and yield of essential oil. Several environmental factors and harvest times can affect the chemical content and composition of essential oil. Understanding the development of oil production by basil accessions subjected to cultivated conditions could lead to optimization of oil yields, consistent oil quality, and the production of standardized, dry botanical preparations. Essential oils can be extracted using a variety of methods, although some are not commonly used today. Currently, as technological advances are made more efficient and economical methods are being developed, there are many extraction methods. These include methods such as solvent extraction, supercritical fluid extraction, cold pressing and microwave extraction. The suitability of extraction method varies from plant to plant and there are significant differences in the capital and operational costs associated.

Here are some key points about basil. More detail is in the main article such as; the herb may have anti-inflammatory qualities, basil is a potent antibacterial, containing just 22 calories per 100 grams, basil is nutrient-heavy and calorie-light, basil may contain compounds that fight the effects of aging.

1 .2 Statement of the Problem

The global essential oil market is observing a significant expansion in its size, due to the increasing importance and usage of essential oil in pharmaceutical and aromatherapy aids. The augmenting demand for flavored food and beverages products among consumers is also increasing this market substantially. With the rising development of innovative beauty and personal care products, fueled by the increasing preference for natural products, the usage of essential oil for the creation of new fragrances is surging, leading to an expected upswing in this market over the next few years..

The application of plant in antioxidant, aromatherapy, food, pharmaceutical, cosmetic and other related industries are limited due to lack of adequate research on their chemical and biological potential. Basil is a useful plants which are not well known about its valuable uses and so far its many uses are not discovered. As it is so, currently Ethiopia is importing phenolic compounds from abroad for chemical and pharmaceutical uses. This is a serious challenge which takes millions of dollars annually to meet its sufficient essential oil demand. And basil leaves are not used for any production in our country.

1 .3 Objectives

1 .3.1 General Objective

The general objective of this thesis was extraction of essential oil from basil leaves (Ocimum basillicum L.)

1 .3.2 Specific Objectives

- To determine percentage yield, density, specific gravity and color analysis,
- To determine the effect of different parameters (particle size, time and volume of solvent) in the extraction process.

1 .4 Significance of the Study

Currently, Ethiopia imports essential oils for the pharmaceutical and cosmetics industries. Thus, this project has a significance to provide import substitution by developing small scale process plants to extract essential oil from basil using solvent extraction methods. The technology will be transferred to interested private sectors or any other agencies. Moreover, the government poverty alleviation program will be signified and well supported by proliferation of these small scale process plants through the technology station program.

1 .5 Scope of the Study

The scope of this study is investigating the possibility of essential oil production from Basil. The production process was performed by the method of solvent extraction using Soxhlet apparatus. The extraction process was carried out by varying parameters such as volume of solvent, temperature and extraction time on the response of the parameter which is essential oil yield. Based on the final product yield, the optimum parameters was determined. Moreover, the essential oil extracted from the Basil leaves was analyzed for its percentage yield, density, color, and specific gravity.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Back ground

Essential oils are highly concentrated substances extracted from flowers, leaves stems, roots, seeds, barks, resins or fruit rinds. These oils are often used for their flavor and their therapeutic or odoriferous properties, in a wide selection of products such as foods, medicines, and cosmetics.

Essential oils are concentrated volatile aromatic compounds produced by plants. The easily evaporated essences that give plants their wonderful scents. Each of these complex precious liquids is extracted from a particular species of plant life. Each plant species originates in certain regions of the world, with particular environmental conditions and neighboring fauna and flora.

Essential oils are frequently referred to as the “life force” of plants. Unlike fatty oils, these "essential" oils are volatile, highly concentrated, substances extracted from flowers, leaves, stems, roots, seeds, bark, resin or fruit rinds. The amount of essential oils found in these plants can be anywhere from 0.01 percent to 10 percent of the total. That's why tons of plant material are required for just a few hundred pounds of oil. These oils have potent antimicrobial factors, having wide range of therapeutic constituents. These oils are often used for their flavor and their therapeutic or odoriferous properties, in a wide selection of products such as foods, medicines, and cosmetics. Beware of imitations. Essential oils cannot be substituted with synthetics.

Essential oils have a wide range of uses:

- As an important source of natural flavors and are used extensively in the agro food sector.
- As fragrance and are used in perfume, beauty products, deodorants, soap and detergents.
- As components in pharmaceuticals, antiseptic, and aromatherapy products.

2.2 Major uses of essential oils

2.2.1 Fragrant

Currently fragrant of essential oils are mainly used by the cosmetic industry. Smell has quite an effect on human body and nervous responses. The limbic system in the human body is represented by hippocampus, formic, cingulated gyrus, thalamus, mammillary bodies, amygdale and olfactory bulb. And although this might be sound far too technical to be interesting, it is fascinating how the sense of smell actually happens and the effect it has on us all. Before the term “limbic system” was used, the system was referred to as the rhinencephalonor “smell brain” and is considered as one of the oldest systems in the human body. When a smell enters the nasal cavity, it meets up with over 50,000,000 receptor neurons which are located in the upper part of the nose and nasal septum, and the receptors are specialized in such a way that certain react to certain smells. These receptors then convert the presence of a smell into a message which is sent to the olfactory bulb (which is seen as part of the forebrain and its main sensory input) where the processing of the smell is started and then passed onto other areas of the brain which control emotions, behavior as well as basic thought processes. Some distant memories, for instance from childhood, can only be recalled by smell, and this factunder scores the importance and significance of smell for our mental life and well-being.

Brainwaves: When measuring brainwaves by means of an electroencephalogram (EEG) it has been noted that was an increase of alpha waves when smelling lavender oil, which is assumed to be a relaxant fragrance. These test results did however vary when test subjects were in different states of arousal or relaxation. When using altering odours, such as jasmine, an increase in brain activity was noted. On the other hand, certain odours such as nutmeg, mace extract and valerian oil reduced systolic blood pressure and stress. Interestingly an odor need not be very strong to have an effect on the body. With electro-dermal activity (EDA) testing (where the electrical current between two points of the skin is measured) it was also found that slower currents occurred with relaxing odors such as bergamot and lavender were inhaled.

Hedonics: It must however be kept in mind that hedonics play a large part in interpreting the results of such tests. Hedonics is the personal degree of pleasantness that a person would place on a specific odour or smell. The limbic system is more than just a part of our smelling mechanism: it is an integral part of man in the wider context. Since it has a direct and indirect influence on so many of our body systems, including the regulation of the endocrine and visceral effect or mechanisms and the resultant patterns of behavior and motivation, it therefore implies that our sense of smell is more than simply a coping mechanism, but fulfills its own regulatory work as well.

2.2.2. Medicinal Uses

- Basil oil is a good tonic for the treatment of nervous disorders and stress related headaches, migraines and allergies. It is used to clear the mind and relieve intellectual fatigue, while giving clarity and mental strength.

- It has a beneficial action on the respiratory tract and is often used for asthma, bronchitis and sinus infections. It furthermore is also effective in cases of constipation, nausea, vomiting and cramp, and is also good when used for menstrual problems.
- Due to the emmenagogue properties, it is often used to relieve scanty periods and normalizing menses.
- It helps to minimize uric acid in the blood, thus relieving gout. It is useful in arthritis as well and when used on the skin, it helps to control acne. In general it refreshes the skin and can also be used on insect bites.

In addition to this there are eleven impressive benefits of basil oil. These are the following;

2.3 General characteristics of a Basil Plant

Although popular in Italian and Southeast Asian cookery, basil or sweet basil (Ocimum basilicum) is originally from India. It is an annual herb with aromatic leaves that is closely related to the mints (Lamiaceae). Basil's aromatic leaves, with hints of cloves and pepper, are widely used as a fresh salad ingredient and in soups and stews.

Plant Description: Sweet basil grows as frost-tender annual shrubs up to 20 inches high. The shiny, oval leaves can be 4 inches long, and the stems are tough and square in profile. Basil plants produce spikes of white flowers followed by small, black seeds.

Cultivars: Genovese basil (O. genovese) is a variety of sweet basil traditionally used to make pesto. Thai basil (O.thyriflorum) has large, pointed leaves and purple, branched stems up to 36 inches high. It should not be confused with Thai holy basil (Ocimum tenuiflorum), a separate but closely related basil species. Lemon basil (citriodorum) has fine leaves and a citrus odor. **Propagation:** Basil seed germinates at temperatures above 65 degrees Fahrenheit. Sow seed indoors six to eight weeks before the last frost. Cover seed with 1/4 inch of soil. Seedlings are ready to transplant once they are 6 inches tall and temperatures have risen above 50 degrees F. **Cultivation:** Plant basil seedlings outdoors once all chances of frost have passed. Basil plants thrive in sunny conditions and rich but well-drained soil and need abundant water, especially during the summer. Leave about 2 feet between plants and 3 feet between rows. Fertilize at planting using 3 pounds of low nitrogen (5-10-10) granular fertilizer per 100 square feet. Apply a 3-inch mulch or pine needles or leaf litter around basil plants to keep the soil moist.

Culinary Uses: Sweet basil has traditionally been used alongside tomato in Italian recipes, but its peppery flavor also goes with vegetables such as eggplants and zucchini. Fresh basil leaves are used in tomato salads and are a vital ingredient in pesto sauce. Basil is best added to cooked dishes at the last moment, as its flavor dissipates with heat.

Branch Out: Basil grows from square, hairy stems. The stems are usually woody near the ground and thin out near the ends. Basil plants grow several branches which contribute to the bushy appearance. If you look closely, you'll notice the branches grow in pairs opposite of one another. The next pair of branches will also grow opposite one another but perpendicular to the lower branches. This continues up the plant so you have stems growing from all sides to fill out the plant.**:**

Stop and Smell the Basil: As the basil plant matures, it begins to flower. The tiny flowers are typically either white or purple and grow up in a spiky structure from the center of a stem. The flowers are the plant's way reproducing, through seeds. If you allow the flowers to grow, the basil plant draws energy away from leaf growth. The flowers signal to the plant that the growing season is over and you may notice a decline in the plant's production. To continue to be able to harvest leaves, pinch off the flower spikes as they appear.

The potential health benefits of consuming basil and provides a nutritional profile for the herb.

2.4 Impressive Benefits of Basil Essential Oil

Exhibits Antimicrobial Properties: Basil essential oil is a good safeguard against diseasecausing bacteria. It exhibits potential in inhibiting bacterial strains that are immune to antibiotic treatments according to studies. In fact, a group of researchers from the Medical University of Lodz in Poland can attest to its potency. They conducted a test involving sick patients and showed that basil essential oil is highly effective in inhibiting the bacterial activity of E.coli and other strong types of bacteria.

Furthermore, basil essential oil can also inhibit a broad spectrum of viruses and yeasts including Candida, which is among the toughest and most resilient fungi to kill.

Provides a Number of Skincare Benefits: Basil essential oil’s skincare properties make the oil an effective remedy for a number of chronic skin conditions such as acne. Acne can result from overactive sebaceous glands. Accumulation of excess sebum and dirt manifests the growth of bacteria and thereby produce painful red swellings on your face. Applying a face pack using basil oil on a daily basis is beneficial for acne-inflamed skin due to its anti-inflammatory and antibacterial properties. You may also add other ingredients such as lemon juice or rose hip oil to amplify its effects.

Likewise, basil essential oil can help unclog blackheads and whiteheads to give you a clearer and smoother complexion. Moreover, basil essential oil's potent antibacterial properties can remedy ringworm infections. You can also relieve itchy skin with the assistance of basil essential oil.

Eases Leg Cramps and Sore Muscles: Leg cramps or muscle spasms occur when leg muscles are under severe stress brought by strenuous activity or due to a prolonged fixed position. Leg cramps are harmless but it can be very painful and frustrating, especially if it disrupts your good night's sleep. The pain can last anywhere from a few minutes to a quarter of an hour. Fortunately, basil essential oil is a natural analgesic and provides fast relief from pain. You can always keep a bottle of basil essential oil on your bedside table so you can massage your legs with the oil when needed. Likewise, basil essential oil can ease tired and sore muscles. It is also helpful in the treatment of arthritis, sprains, and sports injuries.

Aids in Stress Management and Prevent Adrenal Fatigue: Basil is among the best essential oils for the healing of the mind. In fact, basil has been traditionally used in royal families to strengthen resolve, provide clarity, and to raise the spirit. These traits of basil are especially beneficial to those who have debilitating illnesses or are prone to mental fatigue brought by workplace stress. Work stress can be chronic and takes a toll on your job productivity as well as your general physical and emotional health. A basil steam can help keep your stress in check. Its aromatic vapors can eliminate brain fog and improve your concentration so you can perform any task at hand.

Promotes Proper Digestion: Poor digestion can hamper the proper absorption of vitamins and minerals that our body needs to stay well nourished. Fortunately, basil essential oil promotes proper digestion by restoring the body's pH level. By doing so, this helps the good bacteria within the gut to flourish and improve digestive function.

Before prescription drugs, people use basil oil to treat acid reflux, bloating, stomach cramps, loss of appetite, as well as kills intestinal parasites. Such theories have already been supported by modern studies. It shows that basil essential oil exhibits carminative properties that can provide immediate relief from constipation, indigestion, and flatulence.

Assists in the Treatment of Urinary Tract Infections: Basil essential oil alone has a broad spectrum antimicrobial property that helps speed up the healing process of such infections. Moreover, basil essential oil is a diuretic that increase urine production and helps expel excess salt and water from the body.

Helps Treat Earache and Mouth Ulcers: Basil essential oil can help cure minor ear infections and alleviate pain associated with the infection. All you need is a few drops to ear canal. You can also rub basil essential oil around your ear to reduce inflammation.

Likewise, adding a few drops of basil essential oil can prevent halitosis as it eliminates odor causing bacteria. It also helps protect your mouth from ulcers and sores.

Treats Respiratory Ailments: Breathing in the enticing aroma of the basil essential oil can help you get through cold wintry weathers. As temperatures drop, the air begins to dry and burdens your respiratory system. Fortunately, basil essential oil exhibits favorable respiratory effects due to its antispasmodic properties. It helps decongest clogged sinuses, treats asthma, coughs, and bronchitis. Moreover, basil essential oil also has properties that induce sweat and antipyretic properties that relieve fever.

Basil Essential Oil Fights Allergies: The majority of illnesses are rooted to inflammation. When your body deals with high inflammation, allergens amplify an increased reaction. Basil essential oil can diminish the inflammatory response of allergens and lessen your body's vulnerability to outside sources to prevent the overreaction of your immune system. Likewise, basil essential oil helps detoxify your body and flushes out toxins and harmful microorganisms that act as allergens.

Nourishes Hair: Massaging your scalp with basil essential oil stimulates hair growth. It is also very effective in eliminating excess oil in the scalp, which can lead to dandruff. Likewise, its anti-fungal properties can treat existing dandruff and prevent it from reoccurring. Basil essential oil also adds luster while it strips away grease buildup on your hair.

Natural Insect Repellent and Air Freshener: Basil essential oil is the best substitute to harmful aerosols and expensive air filtration systems. Diffusing basil essential oil is a natural, low-cost, effective, and therapeutic way to purify and scent your home. Its antibacterial and antifungal properties eliminate foul odors caused by bacteria and mold; thus, preventing contamination. Likewise, you can effectively repel mosquitoes using basil essential oil. You can also massage basil essential oil to relieve itch caused by insect bites.

Generally though basil essential oil is notable for its culinary benefits, it also features a variety of uses for both mind and body. Its uses extend far beyond the kitchen and can help treat several ailments. Furthermore, its warm and uplifting aroma can promote a sense of focus and eliminate stress.

Table 2.1 Nutritional value of basil per 100 grams (3.5 ounces)

Energy - 94 kilojoules (22 kilocalorie)	Carbohydrates - 2.65 grams
Dietary fiber - 1.6 grams	Fat - 0.64 grams
Protein - 3.15 grams	Water - 92.06 grams
Vitamin A - 264 micrograms	Thiamine - 0.034 micrograms
Riboflavin - 0.076 milligrams	Niacin - 0.902 milligrams
Vitamin B_6 - 0.155 micrograms	Folate - 68 micrograms
Choline - 11.4 milligrams	Vitamin C - 18.0 milligrams
Vitamin E - 0.80 milligrams	Vitamin K - 414.8 micrograms
Calcium - 177 milligrams	Iron - 3.17 milligrams
Magnesium - 64 milligrams	Manganese - 1.148 milligrams
Phosphorus - 56 milligrams	Potassium - 295 milligrams
Sodium - 4 milligrams	Zinc - 0.81 milligrams

Source: USDA Nutrient Database

As with any foodstuff, basil should be eaten alongside the full range of components that make up a healthy diet.

Basil may have a range of health benefits;

Basil (Ocimum basilicum) is well known for its use in Italian cuisine. It is one of the primary ingredients in pesto sauce. Basil is also commonly included in Indonesian, Thai, and Vietnamese cuisine.

Basil is used in traditional Tamil and Ayurvedic medicine, which is a form of traditional medicine popular on the Indian subcontinent.

There are a number of types of basil, which differ in taste and smell. Sweet basil (the most commercially available basil used in Italian food) has a strong clove scent because of its high concentration of the chemical agent eugenol.

Alternatively, lime and lemon basil have a strong citrus scent due to their high concentration of limonene.

2.5 Other importance of basil

Research indicates that there may be several health benefits associated with basil.

Studies have shown that basil "contains a wide range of essential oils, rich in phenolic compounds, and a wide array of other natural products including polyphenols such as flavonoids and anthocyanins."

According to research conducted at the Swiss Federal Institute of Technology, basil contains (E)beta-caryophyllene (BCP), which may be useful in treating arthritis and inflammatory bowel diseases.

Fighting cancer: A review, published in 2013, investigated the potential for holy basil to prevent cancer. They concluded that, thanks to the phytochemicals it contains, including eugenol, rosmarinic acid, apigenin, myretenal, luteolin, β-sitosterol, and carnosic acid, it may help prevent certain types of skin, liver, oral, and lung cancers.

It appears to do this by increasing antioxidant activity, changing gene expression, triggering cell death, and slowing cell division.

Although more research needs to be done, there is potential for basil extract to be used alongside current cancer treatments.

Reducing the effects of oxidative stress: An adaptogen is a herbal medicine that helps the body adapt to stress; ginseng is perhaps the most well-known. Basil may also fall into this category. In one study, rabbits were exposed to oxidative stress (an increase in damaging free radicals). The rabbits were given 2 grams of fresh basil leaves each day for 30 days, and cardiovascular and respiratory adaptation was monitored.

The researchers measured a significant decrease in blood sugar levels and an increase in antioxidant activity. The basil appeared to help the rabbits deal better with oxidative stress.

Anti-aging properties: According to research presented at the British Pharmaceutical Conference (BPC) in Manchester, basil also have properties that might help prevent some of the harmful effects of aging.

Holy basil extract was effective at killing off harmful molecules and preventing damage caused by some free radicals in the liver, brain, and heart.

Reduce inflammation and swelling: Basil extract may help reduce inflammation.

One study, presented at the Royal Pharmaceutical Society's annual event, found:

"Extracts of O. tenuiflorum (Holy basil) were shown to reduce swelling by up to 73%, 24 hours after treatment."

These effects on swelling were similar in extent to those seen with the drug diclofenac, an antiinflammatory medication that is widely used in the treatment of arthritis.

Rich in antioxidants: Results of a study published in the Journal of Advanced Pharmacy Education & Research showed that ethanol extract – Ocimum basilicum had more antioxidant activity than standard antioxidants.

Antibacterial properties: Basil may have an antibacterial effect.

Lab studies have demonstrated that basil has antibacterial properties; this may be because of the volatile oils it contains, which include estragole, linalool, cineole, eugenol, sabinene, myrcene, and limonene.

Basil restricts the growth of numerous bacteria, including Listeria monocytogenes, Staphylococcus aureus, Escherichia coli O157:H7, Yersinia enterocolitica, and Pseudomonas aeruginosa.

This could mean that adding fresh basil to a salad not only adds flavor, it also helps reduce the number of harmful bacteria on the plate.

Nutrition: Basil is rich in vitamin A, vitamin K, vitamin C, magnesium, iron, potassium, and calcium.

2.6. Chemical Constituents of Essential Oils

Pure essential oils are mixtures of more than 200 components, normally mixtures of terpenes or phenylpropanic derivatives, in which the chemical and structural differences between compounds are minimal. They can be essentially classified in to two groups:

I. Volatile fraction: Essential oil constituting of 90-95% of the oil in weight, containing the monoterpene and sesquiterpene hydrocarbons, as well as their oxygenated derivatives along with

II. Non-volatile residue: that comprises 1-10% of the oil, containing hydrocarbons, fatty acids, sterols, carotenoids, waxes and flavonoids.

2.7 Storage of Essential Oils

After extraction has been completed essential oils should be stored in a safe environment conditions to avoid contaminations that may result in a physic-chemical changes which alters its quality characteristics. Thus, essentials oils;

- Should be stored in shaded areas away from direct sunlight.
- Should always be filled up to brim level.
- Containers (bottles) should be well cleaned or steamed.

2.8 Basil Essential Oils

2.8.1. Physical properties of basil essential oils

There are several physical property standards which must be fulfilled to maintain the quality of Ocimum basilicum essential oils (http://www.fao.org//docrep/nutmeg and derivatives). Some of them are:

I. Appearance, color, fragrance: Basil essential oil is a transparent fluid with pale-yellow color. It has a distinctive flavor and fragrance.

II. Specific gravity: Specific gravity is an important criterion of the quality and purity of an essential oil. At 25^oC, the specific gravity value of basil essential oil varies between the limits of 0.95200- 0.97300. In general, the specific gravity of essential oil is less than 1 .0 (Guenther, 1 960). Thus, essential oil can be collected over (floating on) water.

III. Refractive index: When a ray of light passes from a less dense to a more dense medium, it bents or "refracted" toward the normal. The refractive index of Ocimum basillicum oil is between 1.51- 200-1 .51900 at 20^oC.

IV. Optical gyration (rotation): When essential oils are placed in a beam of polarized light possess the property of rotating through plane of polarization to the right (dextrorotatory) or to the left (laevorotatory). The degree of rotation and the direction are important indicators of purity. The standard optical gyration of a quality Ocimum basillicum essential oil is in the limits between 8.85^oc to 1 1 .85^oc to the left at 25^oC.

V. Solubility: Ocimum basillicum essential oil is insoluble in water and it is well miscible with hydroxcitronellal. However, it can be dissolved in paraffin oil.

2.8.2. Biochemical characteristics of basil essential oils

The content of essential oil in the dried herb is high and varied from 0.75% to 1 .89% of dried leaf. Linalool content varied from 3.9 to 1 9%. The content of 1,8-cineole varied from 0.9 to 1 8.5%. The eugenol content varies from 0.3 to 13.3%. Some cultivars also contained significant levels of one or more of the following compounds: methylchavicol, camphor, citral, limonene, methylcinnamate, caryophyllen, anethol, terpinen 4-ol, myrcene, thymol, ocimene and cinnamaldehyde (Svecova and Neugebauerova, 2010). Chemical analysis of basil has identified linalool, methyl chavicol, and eugenol as the three main constituents of the essential oil content of basil and thus aroma.

2.8.3. Chemical properties of essential oils

In general, essential oils consist of chemical compounds that have hydrogen, carbon, and oxygen as their building blocks. These can be subdivided into two groups: the hydrocarbons, which are made up almost exclusively of terpenes (monoterpenes, sesquiterpenes, and diterpenes); and the oxygenated compound (mainly esters, aldehydes, ketones, alcohols, phenols) and oxides; acids, lactones, sulphur and nitrogen compounds are sometimes also present.

Aldehydes: Citral, citronellal, and neural are important aldehydes found notably in lemons cented oils such as Melissa, lemongrass, lemon verbena, citronella, etc. Aldehydes in general have a sedative effect; citral has antiseptic properties.

Phenols: These tend to have a bactericidal and strongly stimulating effect, but can be skin irritants. Common phenols include eugenol (found in clove and West India bay), thymol (found in thyme), carvacrol (found in oregano and savoury).

Terpenes: Common terpene hydrocarbons include limonene (antiviral, found in 90 of citrus oils) and pinene (antiseptic, found in high proportions in pine and turpentine oils).Sesquiterpenes have outstanding anti- inflammatory and bactericidal properties.

Ketones: Some of the most common toxic constituents are ketones, such as thujone found in mugwort, tansy, sage and wormwood; and pulegone found in pennyroyal and buchu. Non -toxic ketones include jasmine (in Jasmine) and fenchone (in fennel oil).

Oxides: By far the most important oxide is cineol (or eucalyptol). It has an expectorant effect, and is well known as the principal constituent of eucalyptus oil. It is also found in a wide range of other oils, especially those of a camphoraceous nature such a srosemary, bay laurel, teatree, and cajuput.

Esters: Probably the most widespread group found in essential oils, which includeslinalylacetate(found in bergamot, clary sage, and lavender) and geranyl acetate (found in sweet marjoram). They are characteristically fungicidal and sedative, often having a fruity aroma.

Alcohols: These compounds have good antiseptic and antiviral properties with an uplifting quality; they are also generally non-toxic. Among the most common terpene alcohols are linalool (in rosewood, linaloe, and lavender), citronellol (in rose, lemon, eucalyptus and geranium) and geraniol (found in palmarosa); also borneol, methol, terpineol, nerol, farnesol, vetiverol, benzyl alcohol, and cedrol (Lawless, 2002)

2.9. Basil Herb

Basil (Ocimumbasilicum L.) is an annual herb, up to 40cm tall which cultivated as a spice 1 0002600m altitude. It is widely cultivated in tropical to temperate regions. The plants are more herbaceous and probably shorter lived, but might despite that be taller and stouter, and have always a strong fragrance (Ryding, 2006).

2.9.1 .Origin and Distribution of Basil

The origin of basil (Ocimum basillicum L.) is uncertain, but it has been cultivated for thousands of years in the Middle East. It was traded through medieval spice routes in Asia, India, Africa, and the Mediterranean. Arriving in England in the 1 500s, in America in the 1 600s, basil now grows all over the world. Consequently, literature is full of folklore reference to this plant there is no enough and exact evidence that reveal origin of this crop, for this reason different authors list different country as an origin (Chang, 2004).Sadeghiet al.,(2009) reported that this species is originated in Egypt east Mediterranean, but it is widely cultivated in Iran, Japan, China and Turkey.

2.9.2 Production Status of Basil in Ethiopia

Ethiopia is a mother of wide agro ecology and suitable for cultivation of many aromatic and medicinal plant which are traditionally used as medicine and food flavoring spice. For these reason, a number of basil accessions are cultivated and widely used throughout the country. Even though research work and information is limited on this crop, farmers of Ethiopia conventionally cultivate and use basil for house consumption and provide for local market. Demand of basil is high for international market due to its multipurpose and some cultivated accession of Ethiopia also exported to different countries to fetchforeign currency. According to MesreshaYimer, (2010), export of Basil is mainly destined to Sudan with 91 .4% share of total export value of basil from Ethiopia, and the rest of export goes to Israel (7.4%), and USA (1 .2%).

2.9.3 Growth of Basil

Basil requires well-drained soils, with a pH ranging from 6.0-7.5 and sown seed is easily germinate with optimum temperature 20°C, but the seeds will germinate well between 15 to 30°C in about 7 days after sowing of seed (Malekiet al.,2013). Basil requires 500 – 800 mm annual precipitation for optimum growth and development. Although, basil is cultivated in different climatic and ecological conditions, the most favorable conditions are found in countries with a warm climate. Light, temperature and moisture are the basic ecological requirements for sweet basil cultivation. Sweet basil develops best under long days in sunny conditions (Caliskanet al, 2009). Planting density/spacing high plant populations are recommended for essential oil and dried basil. Basil grows quickly, and harvests of stems may begin approximately 40-60 days after seedling emergence. Stems may be clipped off, leaving several sets of leaves on the below the cut. Stems are bunched and sold individually at farm markets, or placed in 15 bunch crates and sold wholesale. Some producers of essential oils harvest basil only once and then during the full flowering stage. Other producers harvest the crop just as flowering commences and allows re-growth to have additional harvests during the same season. 4 up to 1 4 cuttings are possible that regular harvesting of stems encourages lateral growth and limits the production of flowers, which are not marketable. Commercial producers use a modified sicklebar mower with an adjustable cutting height for harvesting. For fast re-growth, cuttings can be made at 1 00 to 150 mm above the ground. Harvesting should be done in warm, sunny weather, which will allow for a higher yield of oil. Make sure not to irrigate for a few days before harvest (Agriculture, Forestry and Fisheries, 2012)

2.10 Uses of Basil

Among the aromatic herbs, basil (Ocimum basilicum L.) and its consumption occurs directly and indirectly both in nature and added for industrial processing.

2.10.1 Direct uses of Basil

Basil (Ocimum basilicum L.) is a popular herb grown for the fresh market or for its aromatic leaves, in which its aromatic leaves are used in fresh or dried forms as drug in traditional medicine and as flavoring agent in food and confectionary products as well as beverages (Prakash, 1 990; Marottiet al., 1996). Fresh or dried leaves can be used in soups, stews, and sauces; meat, fish, and egg dishes; salads and vegetables. Dried leaves of basil are used to flavor many products in the food industry, in flavored vinegars and teas.

Mainly in Ethiopia fresh and dried and leaves, fresh and dried seeds are using for centuries. For instance low level families traditionally use basil addition for spices purpose, directly add in common daily food of Ethiopian Shirowot for flavoring purpose by simply putting fresh matured basil inflorescence with stalk without any processing which used for replacement of butter and also they believe it serve them as appetizer in many country of the country.

2.10.2 Indirect uses of Basil

Basil (Ocimum basillicum L.), the oldest spices belonging to the Lamiaceae family, is commercially and extensively cultivated for essential oil production in many continents of the world. Oil and oleoresin of basil are widely utilized for flavor and fragrance in the food, pharmaceutical, cosmetic, and aromatherapy industries. Basil is one of the most popular aromatic plants and it has been used extensively in pharmaceutical, cosmetics, aromatherapy and food industry (Simon et al., 1 999). Medicinally used in the treatment of malaria, colic vomiting, common cold, cough, headaches, diarrhea, inflammation, pain, skin diseases and others (Vanacioet al., 2011).

A number of authors have mentioned the biological activity of basil plant on microbial, fungal and insect repelling properties (Ottaiet al., 201 2). These plants are economically important due to the large quantity of diverse essential oil compounds that are derived from them. For centuries, basil leaves have been a very popular spice and also today, basil essential oils are used hygiene and cleaning products, perfumes, cosmetics and local aesthetics and antiseptics. Most commercial basil cultivars available belong to the common basil (Ocimumbasilicum L.). Because of the constant human demand for new flavors, many Ocimumbasilicum cultivars have been bred during the long cultivation of the herb (Carovic-Stankoet al., 2011).

2.11 Methods of Essential Oil Production

Essential oils can be extracted using a variety of methods, although some are not commonly used today. The specific extraction method employed is dependent upon the plant material to be distilled and the desired end product. The essential oils from aromatic plants are for the most part volatile and thus, lend themselves to several methods of extraction such as steam distillation, solvent extraction, supercritical fluid extraction, etc.

2.11.1 Solvent Extraction

The purpose of distillation is to separate a mixture of several ingredients by taking advantage of their different volatility, or to separate volatile ingredients of a raw material from its non-volatile parts. If the final product is too sensitive to heat or humidity, solvent extraction could be used. Solvent extraction is adapted in producing essential oils generated by some flowers (Rose, Violetta, and Geranium), gums and resins. The raw material is placed in a glass, vessel and soaked with a suitable solvent (petroleum, ether or benzene). After the extraction, the solids are separated from the liquid mixture. The latter is heated so that the more volatile essential oils can be evaporated to be subsequently condensed. Alternatively if the solvent is more volatile, such as ethanol, it could then be vaporized leaving behind the essential oils (Ndou, 1 986). As solvent extraction uses very little heat, it is found to be advantageous in producing essential oils with whole fragrances that would otherwise be destroyed or altered during steam distillation. Therefore, this extraction technique can be used to extract essential oils from very delicate plants to produce higher amounts of essential oils at lower costs (Ndou, 1 986). There are, however, some disadvantages associated with the solvent extraction technique. Solvent residues often contaminate the product causing side effects which make the use of essential oil undesirable for skin applications but could still be fine for fragrances or perfumes (Ndou, 1 986). Therefore, with solvent extraction effective separation of the extracted oil from the solvent is necessary to remove any solvent which may contaminate the essential oils.

2.11.2. Steam Distillation

The vast majority of essential oils are produced by steam distillation. There are, however, different processes that are used. In all of them, water is heated to produce steam, which is used to extract the most volatile aromatic chemicals. The steam is then cooled (in a condenser) and the resulting distillate is collected. The essential oils will normally float on top of the hydrosol (the distilled water component) and may be separated off. Steam distillation is the most commonly used method for extracting essential oils. Many traditional distillers favor this method for distilling most oils as they claim that none of the newer methods produces better quality oils (Boucard et al., 2005). Steam distillation, as described by Boucard et al. (2005), is carried out in a still in which fresh or sometimes dried plant material is placed in a chamber of the still. Pressurized steam, generated in a separate chamber, is then circulated through the plant material. The heat of the steam forces open the tiny intercellular pockets in which the essential oils are contained releasing the oils. During steam distillation, the temperature of the steam must be moderated so that it is high enough to open the oil pouches without destroying the plants, fracturing or burning the essential oils as has been recommended in the literature (Sheridan, 2000). Some or most essential oils have been found to be heat sensitive and hence thermo degradable. As the tiny droplets of essential oils are released, they evaporate and mingle with the steam, travelling through a pipe into a condenser. The steam and oil vapor are then condensed to a liquid mixture. As the oil-water mixture has been found to be nearly immiscible at a temperature lower than about 65 (Sheridan, 2005). The mixture can be separated using various gravity related techniques. Due to the immiscibility of the oil and water at low temperature, the essential oil can be separated from the water by either decanting off the water or skimming of the oil from the top, as the oil is less dense than water at these conditions. The density of some essential oils such as lavender oil has been reported to average 0.89g /L, as opposed to lg/L (Ndou, 1986) for water at room temperature and atmospheric pressure conditions. The water obtained as a byproduct of distillation is referred to as floral water or distillate and retains many of the therapeutic properties of the plant. For this very reason, floral waters are valuable in skin care for making facial mists and toners and are also preferred to essential oils when treating a sensitive individual or child or when a more diluted treatment is required (Sheridan, 2000).

2.11.3 Water/hydro distillation

In this method, the charge (which is usually comminuted) is immersed totally in boiled water. The stills are of the simplest type and are used extensively by smallholder producers of essential oils (Guenther, 1 972). Often they are heated over an open fire. **Disadvantages of the Hydro Distillation**

- The process is slow and the distillation time is much longer thereby consuming more fuel making process uneconomical.
- Variable rate of distillation due to difficult control of heating.
- Extraction of the herb is not always complete.
- As the bottom walls of the still comes in direct contact with the fire from furnace there is a possibility of adjacent plant material getting charred and thus imparting an objectionable odor to the essential oil.
- Prolonged action of hot water can cause hydrolysis of some constituents of the essential oils such as esters, which reacts with the water at high temperatures to form acids and alcohols.
- Not suitable for large capacity / commercial scale distillations and not suitable for high Boiling hardy roots / woody plant materials (Guenther, 1 960). However, it is necessary for the efficient distillation of certain woody materials e.g. sandalwood and cinnamon barks (Noor Azian, 2001).

2.11.4 Steam and Water distillation

To overcome the drawbacks of the water/ hydro distillation, the technique was modified and wet steam distillation was developed. The plant material is supported on a cage / perforated grid below which water is boiled. Direct contact of plant material with hot furnace bottom is thus avoided. The water below the grid is heated by open fire which produces saturated and wet steam which rises through the plant material vaporizing the contained essential oil.

Disadvantages:

- Unsafe, time consuming due to low pressure steam, poor quality oil.
- Improper condensation, oil separation incomplete, less recovery.
- Poor material of construction and excessive pollution (Guenther, 1 960).

2.11.5. Hydro-diffusion

Although introduced more recently than carbon dioxide extraction, hydro-diffusion is similar to steam distillation except that the steam is produced above the plant material and percolates down through it (Chrissie, 1 996). The advantage of hydro-diffusion over distillation is that the process is quicker, especially for fibrous material such as woods and barks. The resultant oils are reported to have a superior aroma and a richer cooler obtained by ordinary distillation.

Nevertheless, oils captured by hydro-diffusion process are not widely available.

2.11.6. Mechanical Expression

Prior to the discovery of distillation most essential oils were expressed mechanically or cold pressed (Sellar, 2001). It is the simple process of heating the plant material to low temperatures and then physically pressing the essential oil out. Today mechanical expression is used mainly for citrus peels and is unpopular due to the low extraction yield.

2.11.7. Microwave Assisted Techniques

Microwave energy is a superior alternative to several thermal applications owing to its efficient volumetric heat production. The volumetric heating or heating of the bulk as opposed to transferring heat from the surface, inwards, is more efficient, uniform and less prone to overkill or supererogation. Controllability is by far the greatest advantage of microwaves over conventional thermal technologies. In processing applications, the ability to instantaneously shut the heat source makes enormous difference to the product quality and hence the production economics. The raw material is heated directly by microwaves and this brings about quality consistency and minimizes the impact on the environment as opposed to using fossil fuels or less efficient, indirect electrical heating systems. Specifically in the essential oil extraction, microwave mediated processes are highly desirable due to their small equipment size (portability) and controllability through mild increments of heating. However, so far the microwave technology has found application in very few industrial bio-processing installations due to the lack of available data on microwave interaction with heterogeneous natural raw materials. The sensing and close control of microwave process is a challenging science and there seems to be insufficient literature in this regard.

2.11.8. Turbo-Extractor

This method is used for solvent or water-extraction of numerous solid raw materials, mainly vegetal, used in the perfume, flavor, cosmetic, pharmaceutical, and spirit and food industries. It is energy and time saving production of natural extracts. The equipment is equipped with a high blade turbine. It is used for crushing materials within the solvent and fluidizing the comminuted pieces. Extraction is accelerated by the intimate and turbulent contacts between the solid and the liquid phase. Nevertheless, this type of equipment is very expensive and not economical.

2.11.9 Factors Affecting Solvent Extraction of Basil Essential Oil

The selection of the equipment for an extraction process is influenced by the factors which are responsible for limiting the extraction rate. Thus, if the diffusion of the solute through the porous structure of the residual solids is the controlling factor, the material should be of small size so that the distance the solute has to travel is small. On the other hand, if diffusion of the solute from the surface of the particles to the bulk of the solution is the controlling factor, a high degree of agitation of the fluid is required (Coulson et al.,2002).

There are some important factors to be considered.

2.11.9.1 Particle Size

Particle size influences the extraction rate in a number of ways. The smaller the size, the greater is the interfacial area between the solid and liquid, and therefore the higher is the rate of transfer of material and the smaller is the distance the solute must diffuse within the solid as already indicated. On the other hand, the surface may not be so effectively used with a very fine material if circulation of the liquid is impeded, and separation of the particles from the liquid and drainage of the solid residue are made more difficult. It is generally desirable that the range of particle size should be small so that each particle requires approximately the same time for extraction and, in particular, the production of a large amount of fine material should be avoided as this may wedge in the interstices of the larger particles and impede the flow of the solvent.

2.11.9.2. Solvent

The liquid chosen should be a good selective solvent and its viscosity should be sufficiently low for it to circulate freely. Generally, a relatively pure solvent will be used initially, although as the extraction proceeds the concentration of solute will increase and the rate of extraction will progressively decrease, first because the concentration gradient will be reduced, and secondly because the solution will generally become more viscous.

2.11.9.3 Extraction time

Oil yield obtained (expressed in percent) is extraction time dependent. In general, the oil yield increased with increase in extraction time.

2.11.9.4 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, thereby increasing the total operational cost.

2.11.9.5 Agitation of the Fluid

Agitation of the solvent is important because this increases the eddy diffusion and therefore the transfer of material from the surface of the particles to the bulk of the solution. Further, agitation of suspensions of fine particles prevents sedimentation and more effective use is made of the interfacial surface. In most cases, the solubility of the material which is being extracted will increase with rial which is being extracted will increase with

2.11.9.6 Solvent Extraction Apparatus (Soxhlet Apparatus)

Soxhlet extractor is a piece of laboratory apparatus invented in 1 879 by Franz von Soxhlet. It was originally designed for the extraction of lipid from a solid material. Typically, soxhlet extraction is used when the desired compound has limited solubility in a solvent, and the impurity is in soluble in that solvent. It allows for unmonitored and unmanaged operation while efficiently recycling a small amount of solvent to dissolve a large amount of material. A Soxhlet Extractor has three main sections: A percolator (boiler and reflux) which circulates the solvent, a thimble (usually made of thick filter paper) which retains the solid to be laved, and a siphon mechanism, which periodically empties the thimble.

Assembly;

1 .The source material containing the compound to be extracted is placed inside the thimble

2. The thimble is loaded into the main chamber of the Soxhlet extractor.

3. The extraction solvent to be used is placed in a distillation flask.

4. The flask is placed on the heating element.

5. The Soxhlet extractor is placed atop the flask.

6. A reflux condenser is placed atop the extractor.

Operation: The solvent is heated to reflux. The solvent vapour travels up a distillation arm and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapour cools, and drips back down into the chamber housing the solid material. The chamber containing the solid material slowly fills with warm solvent. Some of the desired compound dissolves in the warm solvent. When the Soxhlet chamber is almost full, the chamber is emptied by the siphon. The solvent is returned to the distillation flask. The thimble ensures that the rapid motion of the solvent does not transport any solid material to the still pot. This cycle may be allowed to repeat many times, over hours or days. During each cycle, a portion of the non- volatile compound dissolves in the solvent. After many cycles the desired compound is concentrated in the distillation flask. The advantage of this system is that instead of many portions of warm solvent being passed through the sample, just one batch of solvent is recycled. After extraction the solvent is removed, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains in the thimble, and is usually discarded.

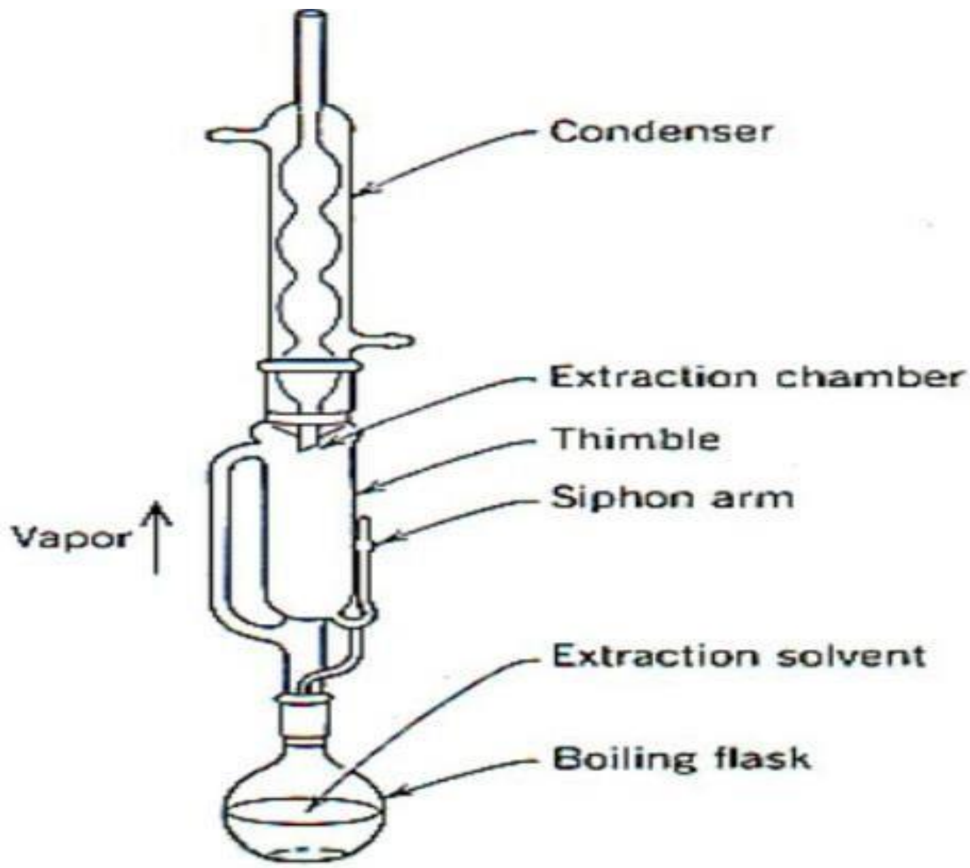


Figure 1. Soxhlet apparatus (Source: http:// www.olroresins melbia.com.

2.Extraction process flow sheet of basil oil

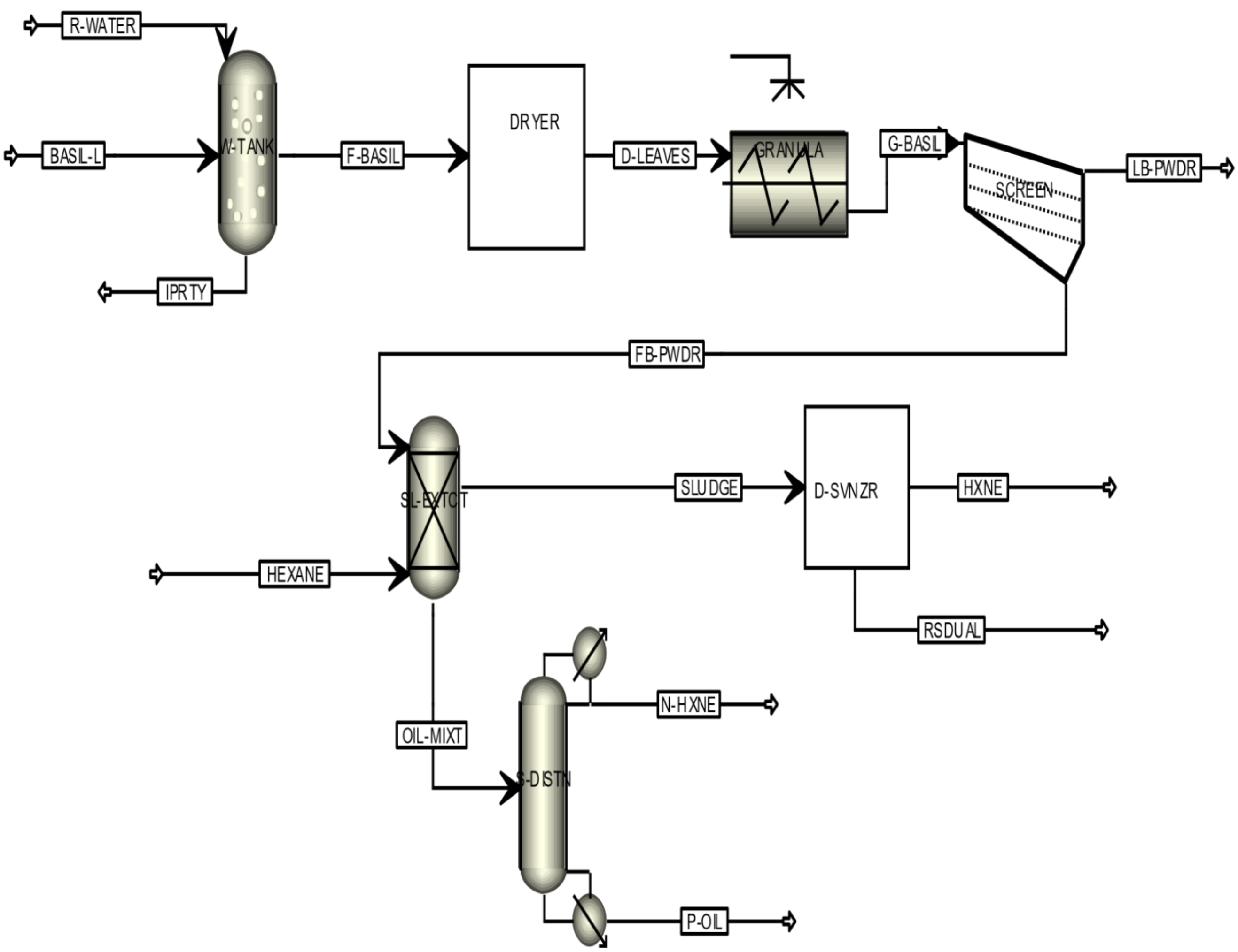


Figure 2. Process flow diagram of solvent extraction of basil essential oil

CHAPTER THREE

3. MATERIALS AND METHADS

3.1. Equipment's

Electronic weight balance
Sieve
Measuring cylinder
Soxhlet apparatus
Beaker
Washing tank
Mortar and pestle
Volumetric flask
Thimble
Litmus paper
Plastic container
Rotary evaporator
Water

3.1.1. Chemicals

- Hexane
- KOH

Raw material: Basil leaves

3.2. Methods

The method that used for the extraction of essential oil from basil leaves is solvent extraction and it includes the following procedures.

I. Sample collection (Collection of plant material)

A sample of basil leaves was collected from wolkite city

The sample plant material was taken to the laboratory of School of Chemical Engineering in wolkite University.

Figure 3.1 a) Fresh b)

Figure 3. fresh (b) dry basil leaves

II. Washing

The collected sample leaves was then washed to remove dusts and other un-necessary materials.

III. Treatment of the basil leaves

The washed basil leaves was then weighed and dried for 2 full sunny days drying period. After completion of drying, the leaves were reweighed to determine any potential mass loss as a result of the evaporation of both moisture and volatile oil components due to the drying effect.

Four samples of the basil leaves were taken, weighted and dried in sun light and the weight was measured after two days of full sunlight. The percentage moisture content of the basil leaves was determined using the following formula (General Health Welfare, &Delhi, 2005).

Moisture content = $\frac{W1 - W2}{W1} * 100\ \%$....................(3.1)

IV. Size Reduction

Once the moisture of the leaves is removed by sun drying the basil leaves was crushed using mortar and pestle which grinds the material into smaller size in order to increase the contact area of the leaves for maximum extraction of the oils.

Figure 4. Grinded basil powder and b) sieved basil powder

V. Raw Material Storing

The milled (grinded) leaves was stored in a sealed bag and cool place for about four days until extraction to avoid any further loss of volatile components at room temperature.

3.2.2. Experimental set up

Generally, in solvent extraction of the plant material was packed into the extraction chamber so that extraction could commence. For each load, plant materials were placed into the extraction chamber. The first load was conducted to set-up and establishes the procedure and determines processing parameters. The experiments of this study were conducted in the laboratory of chemical engineering department in Wolkite University.

The experimental setup of the apparatus that was used for the extraction of the essential oil from the given plant materials by means of solvent extraction method for this specific study is shown in figure below. The experiment was conducted in a Soxhlet apparatus. Soxhlet apparatus consist of one round bottom flask of 500ml which is connected with extracting chamber which holds raw materials. The top flask is connected with condenser through the connecter.

Figure 5. Experimental set up of Soxhlet apparatus

3.2.3. Experimental Procedures

From the prepared sample, about 30g was weighed and placed in a carefully folded filter paper. The filter paper containing the sample then inserted into the Soxhlet apparatus. The weight of the filter paper and sample was recorded. A 150ml of solvent (n-hexane) was measured using a measuring cylinder and then poured into reboiler (bottom flask) of the Soxhlet apparatus and heated at a temperature of about 69℃. When the solvent is boiling, the vapor was raised through the vertical tube into the condenser at the top. Then the liquid condensate was drips into the filter paper thimble in the center, which contains the oil to be extracted. The extract seeps through the pores of the thimble and was filled the siphon tube, where it flows back down into the round bottom flask. It was then removed from the tube. The experiment was repeated by varying parameters (extraction time at 3hr, 4hr, 5hr, and temperature of 69℃, particle size of 1mm, 0.5mm and 2mm and volume of solvent 150ml, 160ml and 200ml). At the end of the extraction, the resulting mixture containing the oil was passing through a rotary evaporator to recover solvent from the oil. The oil extracted was then stored in a plastic container and characterization was performed.

3.3. Characterization of Extracted Basil Essential Oil

The yield of essential oil, density, specific gravity at 25^oC and color was analyzed using standard procedures and compared with literatures.

3.3.1. Percentage yield of extracted basil essential oil

The crude oil was weighed and the percentage yield of basil essential oil was calculated on dry matter basis using the following formula(General Health Welfare, &Delhi, 2005);

Percentage of extraction Yield $= \frac{\text{mass of oil}}{\text{mass of the sample on dry basis}} * 100\%$ ………(3.2)

3.3.2. Density and Specific gravity of essential oil

The 10ml amount of sample of oil and water was filled into separate clean and dry measuring cylinders. The sample of oil and water was then weighed and the density and specific gravity (SG) of the oil was calculated using the following expressions (General Health welfare and Delhi, 2005).

Density of oil sample $= \frac{\text{weight of oil sample}}{\text{volume of oil sample}}$

SG of oil sample $= \frac{\text{mass of sample}}{\text{mass of an equal volume of water}}$

3.3.3. pH Determination

pH value of the extracted essential oil was measured directly using litmus paper.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1 Results

4.1.1 Determination of moisture content of basil leaves

Four samples of basil leaves were collected at different times for moisture content analysis. Then, the moisture content was calculated using equation (3.1).

Table 1. Moisture content of fresh basil leaves

	Initial mass (g)	Drying time (hr)	Final mass (g)	Moisture content (%)
Sample 1	293	22	66.92	77.16
Sample 2	378	22	89.47	76.33
Sample 3	402	22	94.48	76.49
Sample 4	412	22	99.25	75.91
Average	371.25	22	87.53	76.47

From the above table the average moisture content of basil leaves is calculated as follow:

Average moisture content = $\frac{W1 - W2}{W1} * 100\%$

$$= \frac{371.25 - 87.53}{371.25} = 76.47\%$$

the result shows that it is not fully dreid and the water in the leaves have a little effect on the experiment by blocking the pore of substrate.

4.1.2 Percentage yield oil

4.1.2.1 Effect of volume of solvent in oil yield

The yield of oil extracts of basil leaves calculated using equation (3.2) are shown in the table below.

Table 2. Yield of basil essential oil by solvent extraction.

Run	Initial mass of sample (g)	Initial volume of solvent (ml)	final mass of residual	% yield
1	30	150	26	13.34
2	30	160	25.85	13.8

3	30	200	25.8	14.0

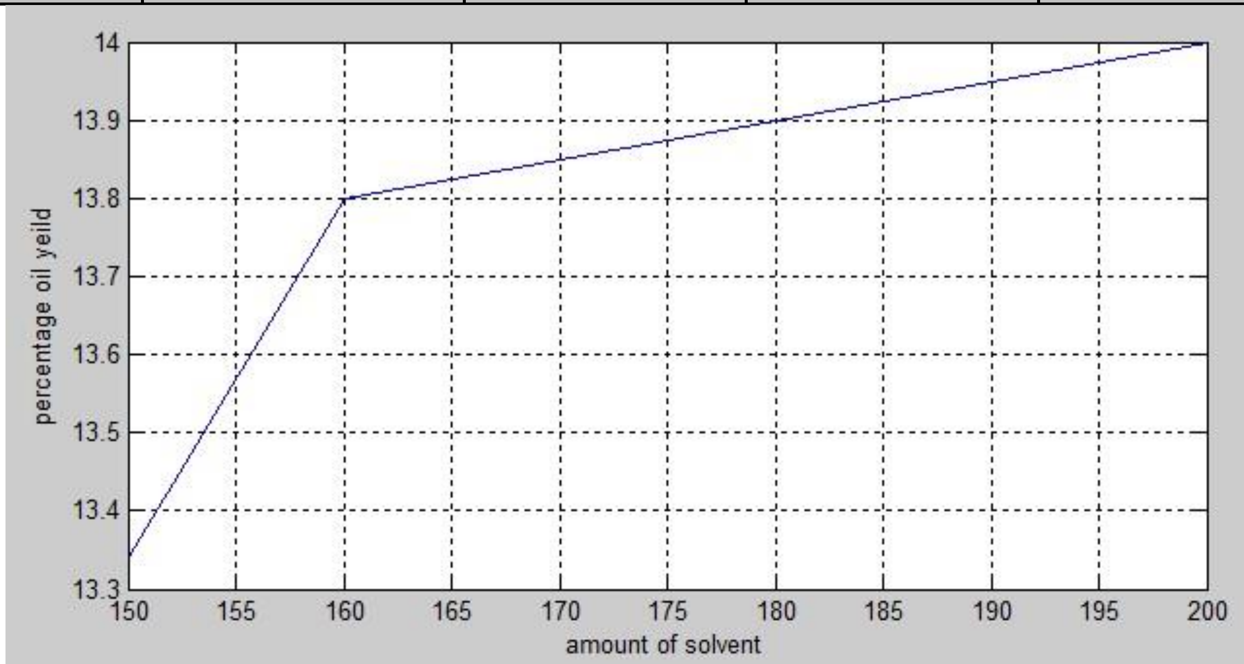


Figure 6. Effect of solvent on oil yield

As the volume of solvent increases the oil yield also increases. However the rate of change of yield becomes decreasing after 160ml. So, adding extra amount of solvent increase cost of oil extraction. So adding more solvent increase cost of production and may have effect on profitability of the company. Therefore the optimum volume of solvent for this experiment is 160ml. Because, there is a small difference between the oil yields by using 160ml and 200ml which is 13.8% and 14.8% respectively.

4.1.2.2 Effect of particle size on extracted Essential Oil Yield

Table 3. weight of oil with respect to time extracted by hexane

Weight(gm)	Time(hr.)	Particle size(mm)	Tempera ture (^{0}C)	Mass of residual (gm)	% yield of oil
30	3	≤ 0.5	69	28.2	6
30	4	≤ 1	69	25	16.667
30	5	≤ 2	69	26.5	11.667

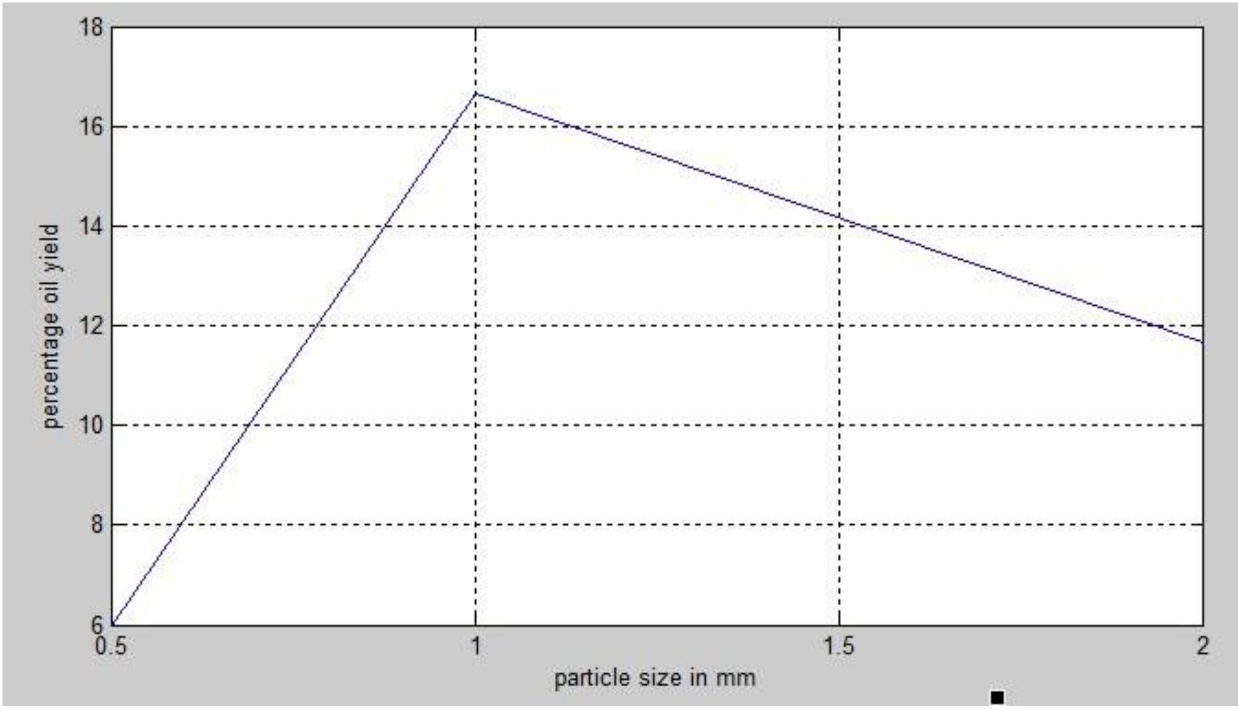


Figure 7. Effect of particle size on oilyield

The highest yield we obtained from the second experiment (16.667%) with the particle size of ≤ 1mm. This shows that at the particle size(≤1mm) have good surface contact area with solvent.so increasing particle size reduce surface contact area and affect oil yield .Therefore the optimum particle size for this experiment is particle size which is ≤1mm.

4.1.2.3 Effect of Extraction Time on Essential Oil Yield

Table 4. weight of oil with respect to time extracted by hexane

Weight(gm)	Time(hr.)	Particle size	Mass of residual(gm)	Oil yield in %
30	3	≤1mm	28.5	6
30	4	≤1mm	25	16.667
30	5	≤1mm	24.9	17

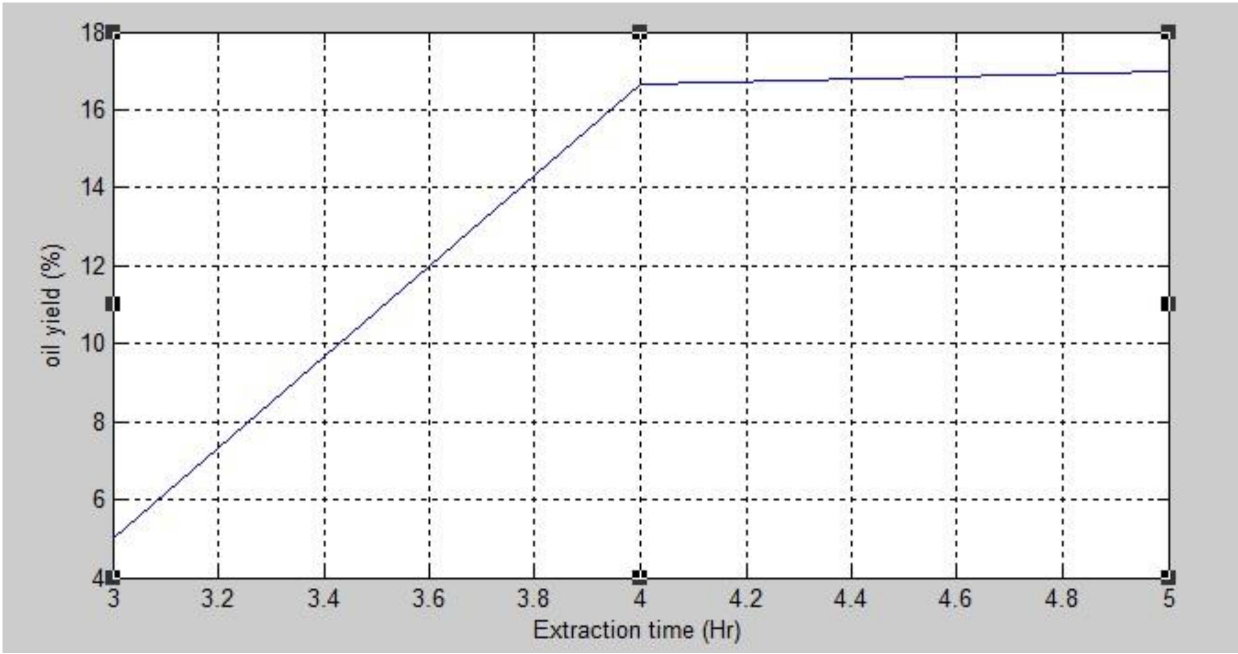


Figure 8. Effect of Extraction time on oil yield

Initially as the extraction time increase the oil yield increase however after 4hr increasing time was showed a little effect on oil yield .This shows that increasing extraction more and more after optimum oil yeild has not effect.

The highest yield we obtained from the third experiment (17%) at the time duration of 5hr. However, extraction Time at 4 hrs. is preferable because there is a little difference between second experiment and third experiment oil yield.

4.1.3. Density and Specific gravity of oil

An empty washed and dried beaker was weighed on the top load weighing balance. The weight of the beaker was recorded. Exactly 10ml of each of the oil sample were measured and pour into the beaker and weighed. The average weights of the 10 ml of the samples were recorded. The procedure was repeated with water and the weight of 10 ml of water was obtained to be 10g. The density and the specific gravity were specified on the following table.

Table 5. Average density and specific gravity of essential oil

Run	Volume of oil (ml)	Mass of oil (g)	Volume of water (ml)	Mass of water (g)	Density of oil (g/ml)	Density of water (g/ml)	Specific gravity of oil
1	10	6.659	10	9.970	0.6659	0.9970	0.6679
2	10	6.941	10	9.970	0.6941	0.9970	0.6962
3	10	7.21 3	10	9.970	0.721 3	0.9970	0.7235
4	10	7.544	10	9.970	0.7544	0.9970	0.7567
Average	10	7.089	10	9.970	0.7089	0.9970	0.71 1 0

Using data's of the above table, the average density and specific gravity of the essential oil sample was determined as follow.

$$\text{Density of oil sample} = \frac{\text{weight of oil sample}}{\text{volume of oil sample}}$$

$$= \frac{7.089}{10} = 0.7089\text{g/ml}$$

$$\text{SG of oil sample} = \frac{\text{density of sample}}{\text{density of an equal volume of water}}$$

$$= \frac{0.7089\text{g/ml}}{0.9970\text{g/ml}} = 0.7110.$$

4.1.4. Color

Color of the extracted essential oil was analyzed and compared to the standard color in literatures.

Color of the extracted basil essential oil was found a greenish black. This is slightly different from the standard color which is greenish yellow color.

4.1.5 pH

pH value of essential is 5.7-7.4(Becker, O ,2005).

By using litmus paper pH value was determined pH value 6.4 was obtained

This shows that it has a little acidic characteristics howevever it has a very weak acid pH values that has a little effect on product.

4.1.6 Determination of Acid Value or Acid Number

To determine the Acid value, Standard alcoholic KOH solution (0.1M) was prepared by dissolving 2 gram KOH with 0.4 liter of distilled water.

Adding of 10 drops of phenolphthalein and 3g of sample essential oil in to a 250 ml of flask and mix the solution with magnetism heating mixer (not more than one minute).

The solution was titrated with 0.1M of KOH solution in presence of 3 drops of phenolphthalein as indicator until the end point (colorless to dark pink) is recognized and the pink color must be stay for the minimum of 60second;

Acid value = $\frac{56*M*V}{m}$

Where m= mass of sample oil = 3 gram

M=molarities (concentration) of KOH solution and = 0.1M

V= volume of KOH solution used during titration = ΔV = 2ml Therefore the acid value of our experiment was:

$$= \frac{56*0.1M*2ml}{3g}$$

$$= 3.7 mgKOH/g$$

This shows 3.7mg KOH is required to neutralize 1g of oil sample

4.1.7 Determination of saponification value

After the 0.5M KOH and 2g of oil was titrated the result for the solvent hexane and the pink color was disappeared when the titrate volume reaches at 14 ml from 25 ml and saponification value of oil

$$Sv = \frac{(S - B) \times M \times 56.1}{\text{Sample weight}}$$

Where;

S-volume before titration

B-volume at which color disappeared

M-Molarity

$$S.V = \frac{(25-14) \times 0.5 \times 56.1}{2}$$

$$= 154 \text{ml KOH/g}$$

This shows that 154ml of KOH is required to saponify 1g oil sample.

4.2 Discussion

From the experimental result the moisture content of the basil leaves is different from that of literature. The percent of moisture content of the basil leaves on literature is 82-83%. The mean average moisture content of the three basil leaves sample was found 76.47%. The variation is because of so many factors such as different drying time, weather condition, geographical locations, production techniques and plant collection time.

Percentage yield of the product from the experimental result is found different from the standard one. The variation is resulted from incomplete evaporation of the solvent (n-hexane) during evaporation. Besides, the evaporation of the amount of moisture content of the raffinate during extraction decreases the final mass of the residue, which then increases the percentage of yield. Moreover, during the extraction process, a small particle of the sample leaving the thimble with the solution leads to increase the percentage of yield.

From the result the density and specific gravity of basil essential oil is different from the standard value. As it has been found the density of basil essential oil is 708.90kg/m^3 which is far from the standard density which is 928kg/m^3. The variation is due to the presence of some solvents (incomplete removal of solvents) during evaporation.

Moreover, some fine particles of the solute leaving the thimble with solution during extraction process have their own contribution in decreasing the density of the oil. The variation of density of the oil in turn decreases the specific gravity due to their linear relationship. Here, the calculated specific gravity was 0.7110, somewhat less than 0.9520 in literature.

Color of the extracted basil essential oil was greenish black. This is slightly different from the standard color which is greenish yellow color. This is due to different factors. The use of very young basil leaves and immature part of leaves, moisture content of powder and operating temperature may be the reason for variation of oil color. Besides, the proportion of solute and solvent is a critical factor for oil color. Thus, as it has been observed from the result at low solute and solvent proportion the color becomes more greenish black.

Unlikely, increasing the proportion of solute and solvent tends the color of the oil to the standard one.

To some extent in addition to the original odor of the basil powder, the extracted oil has odor of the solvent (n-hexane). This was incomplete separation of the oil and solvent which resulted from low efficiency of the separator.

Table 6. comparison of the standard values and experimental result

Variables	Literature value	Experimental result
Moisture content	80- 82%	76.4 %
Extraction time	3 to 8 Hr	4Hr
Particle size	-	≤ 1
Amount of solvent	-	160ml
Color	Greenish yellow	Greenish black
pH	5.7 to7.4	6.4
Specific gravity	< 0.9520	0.7110
Density	0.928g/ml	0.7089g/ml

Reference for literature value(Becker, OR 2005.)

CHAPTER FIVE

5. MATERIAL AND ENERGY BALANCE

5.1. Material Balance

As materials pass through different processing operations, their quantity can be described by material balances. Such balances are made by statements of conservation of mass. Thus, from general material balance:

Input + Generation – Output – Consumption = Accumulation

Industrial scale up from laboratory work

Laboratory level

M =1500g Moisture content =76.47%

Percentage yield= 17%

Scaling up is possible by material balance for equipment's and finding corresponding value of the proposed capacity

Basis; 1125L/day Assumptions:

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

Basic data:

- Density of basil essential oil = 0.928kg/L (at temperature of 25^oC)
- Density of n-hexane = 0.659kg/L.

5.1.1. Mass- balance on dryer

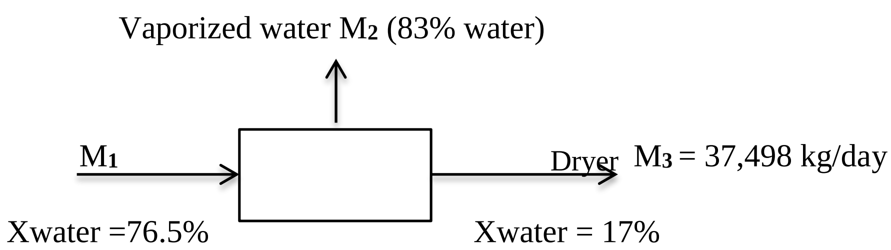
from experimental result;from 30g of dry basil 5g of oil was obtained in 4hr.

in 24 hr, $\text{mass of oil} = \frac{24 \times 5}{4} = 30\text{g}$

to produce 6250kg/day,mass of dry basil required;

=

Mass of dry basil



General mass balance

$$M_1 = M_2 + M_3$$

$$M_1 = M_2 + 37{,}498 \text{ kg/day} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Component mass balance:

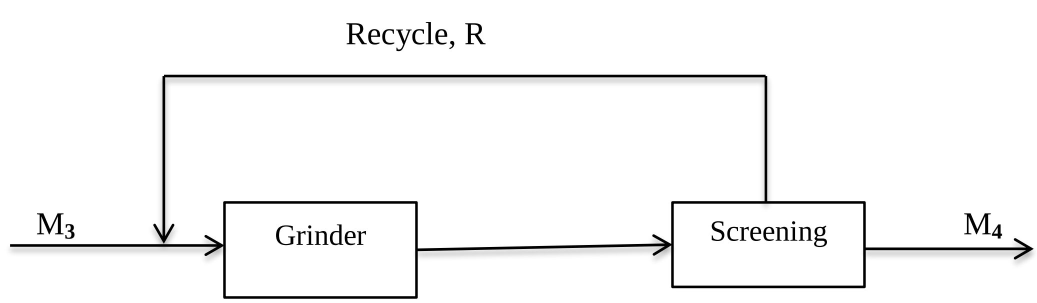
Water mass balance: $Xw_1\, M_1 = Xw_2 M_2 + Xw_3\, M_3$

$$0.765 \times M_1 = 0.83 x M_2 + 0.17 \times 37{,}498 \text{kg/day} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Adding equations (i) and (ii) simultaneously gives; M1 =380744kg/day and M2=343246kg/day.

5.1.2. Mass balance on Grinder:

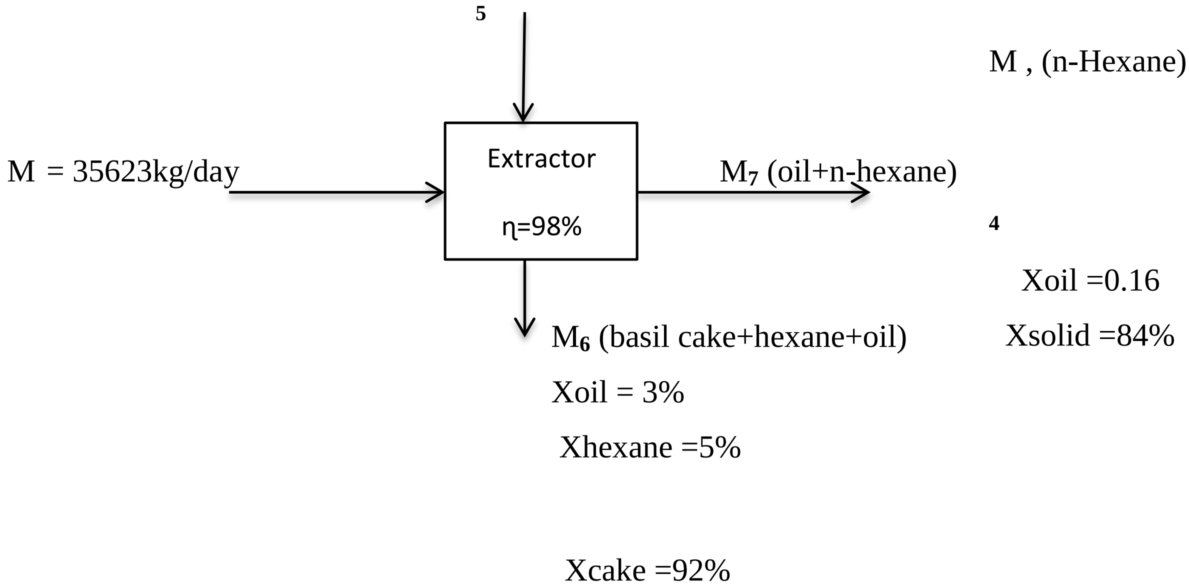
Assume efficiency of the grinder is 95%.



$M_3 = M_4 + R$

37,498kg/day = M_4 +R   assume (R=2% of M_3) M_4=37,498kg/day- 0.02(37,498kg/day) M_4= 35,623kg/day.

5.1.4. Mass balance on extracting chamber:



From experiment the solvent to solute ratio is 6:1 (v/w), therefore he amount of solvent is;

Volume of hexane = 213738L/day

Density of hexane =0.659kg/L

Thus, the amount of hexane needed (M_5) = density × volume =

0.659kg/day×213738L/day

= 140853 kg/day

Total mass balance:

$$M_4 + M_5 = M_6 + M_7$$

35623+140853 = M_6 + M_7 Component

mass balance on Solid: $0.84 \times M_4 = 0.92 \times M_6$

$$0.84 \times 35623 = 0.92 \times M_6$$

M_6= 32525 kg/day

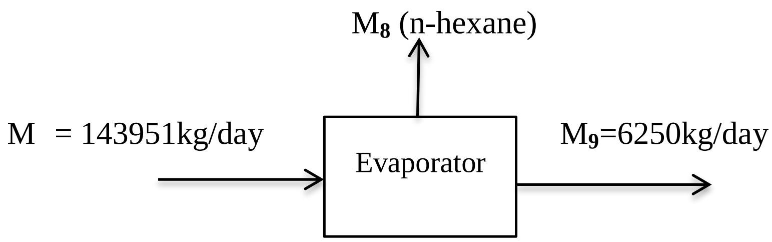
Substituting M6 in to the above equation of total mass balance gives;

35623+140853= 32525+ M_7 M_7

= 143951kg/day

5.1.3. Mass balance on Evaporator

7



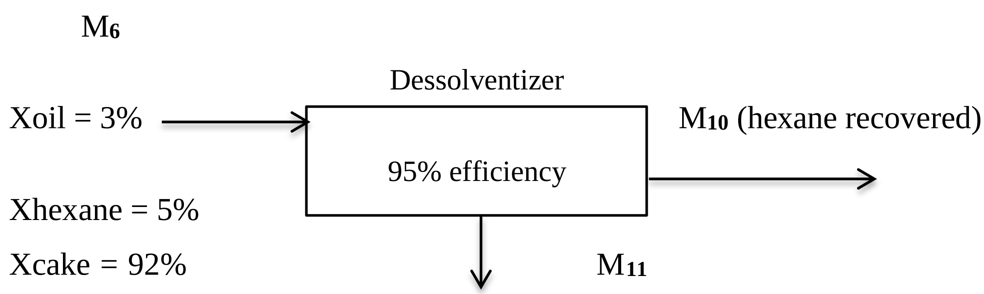
Total mass balance:

$M_7 = M_8 + M_9$

143951kg/day= M_8 + 6250kg/day M_8

=137701 kg/day

5.1.4. Mass balance on Desolventizer



Total mass balance:

$M_6 = M_{10} + M_{11}$

M_6 =32525kg/day= $M_{10} + M_{11}$

For 95% efficiency, M_{10}=0.95(5%M6)

M_{10}=0.95(0.05×32525 kg/day)

M_{10}=1545kg/day.

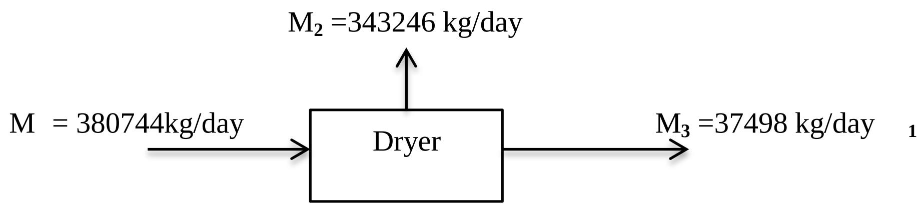
Thus, $M_{11} = M_6 - M_{10}$

= 32525 – 1546

=30980 kg/day.

5.2. Energy Balance

5.2.1. Energy balance on dryer



Assumption: input Ti =25°c

Steady state operation

Mass of water vapor =343246 kg/day

Mass of dried basil = 37498kg/day

Total mass = 380744 kg/day

$$\text{Xvapor} = \frac{\text{mass of vapor}}{\text{total mass}}$$

$$= \frac{343246 \text{ kg/day}}{380744 \text{ kg/day}} = 0.9$$

$$\text{Xdried basil} = \frac{\text{mass of dried basil}}{\text{total mass}} = 1 - \text{Xvapor}$$

= 1 - 0.9 = 0.1

$$\text{Cpmixture} = \text{Cp vapor}_{\text{X}}\text{vapor} + \text{Cp dried}_{\text{basil}}\text{X dried basil}$$

= 1 .883×0.9 + 2.148×0.1

= 1.91 KJ/kg

Thus, the amount of heat supplied to the drier is:

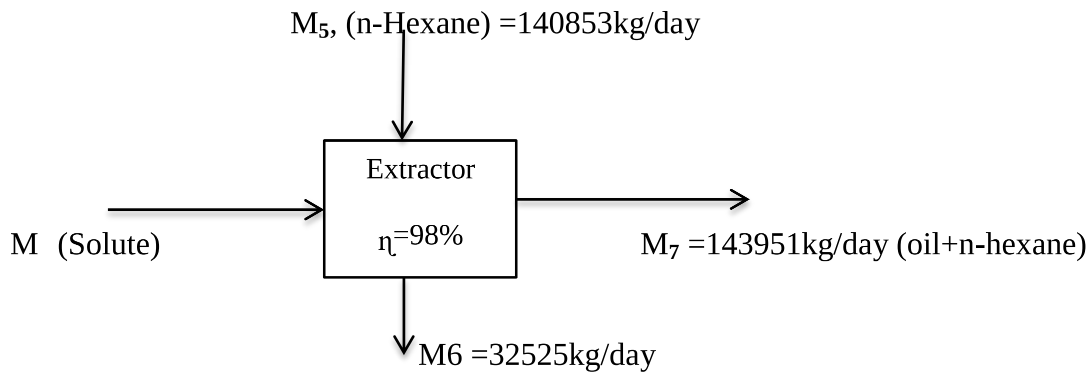
$$Q = \text{M mixture} \times \text{Cp mixture } \Delta T$$

380744 kg/day x1.91 kJ/kg× (38-25) =

9453873 kJ/day

5.2.2. Energy balance on extractor

4



Mass of hexane = 140853kg/day

=35623kg/day

Mass of basil powder =35623kg/day

Total mass = mass of hexane + mass of basil powder

=176476 kg/day

$$X_{hexane} = \frac{\text{mass of hexane}}{\text{total mass}} = \frac{140853\text{kg/day}}{176476\text{ kg/day}} = 0.8$$

$$X_{basil\ powder} = \frac{\text{mass of basil powder}}{\text{total mass}} == 1 - X_{hexane}$$

$=1- 0.8 = 0.2$

$$Cp_{,mixture} = Cp_{hexane} X_{hexane} + Cp_{basilpowder} X_{powder}$$

$=2.338\times0.8 + 2.14\times0.2$

$=2.2984$ kJ/kg k

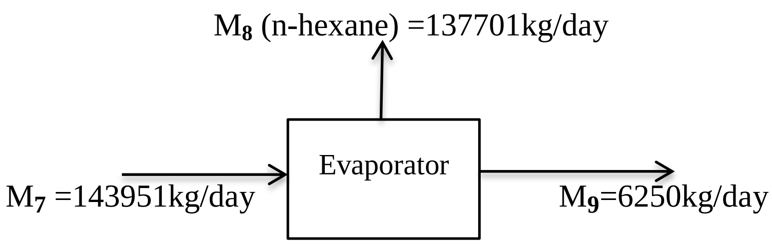
Thus, the amount of heat supplied to the extractor is:

$$Q = M_{mixture}\times Cp_{mixture}\times \Delta T$$

$= 176146\times2.2984\times (69-25)$

$=17813574$ kJ/day.

5.2.3. Energy balance on Evaporator



Mass of mixture = 143951kg/day

Mass of hexane = 137701kg/day

Mass of oil = 6250 kg/day

$$X_{hexane} = \frac{\text{mass of hexane}}{\text{total miture}}$$

$$= \frac{137701}{143951} = 0.956$$

$$X_{oil} = \frac{\text{mass of oil}}{\text{mass of mixture}} = 1 - X_{hexane} = 1 - 0.956 = 0.044$$

$$Cp_{mixture} = Cp_{hexane} X_{hexane} + Cp_{oil} X_{oil}$$

$$= 2.338 \text{ kJ/kg K} \times 0.956 + 2.23 \text{ kJ/kg K} \times 0.044$$

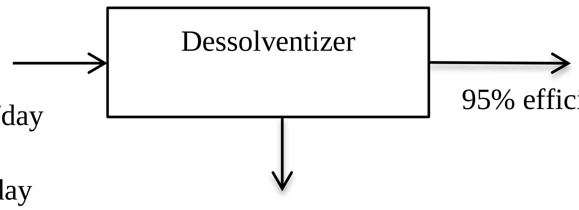
$$= 2.33 \text{ kJ/kg k}$$

Heat supplied to evaporator (Q) = $M_{mixture} \times Cp_{mixture} \times \Delta T$

$$= 143951 \times 2.33 \times (69-25) =$$

14,757,856kJ/day

5.2.4. Energy balance on Desolventizer



95% efficiency

M_6= 32525kg/day M_{10}(hexane recovered) =1545kg/day

M_{11} =30980kg/day

Mass of mixture = 32525kg/day

Mass of hexane = 1545 kg/day

Mass of cake = 30980 kg/day

$$X_{hexane} = \frac{\text{mass of hexane}}{\text{mass of miture}} = \frac{1545\text{kg/day}}{32525\text{kg/day}} = 0.047$$

$$X_{cake} = \frac{\text{Mass of cake}}{\text{mass of miture}} = 1 - X_{hexane}$$

$$= 1 - 0.047 = 0.95$$

$$Cp_{mixture} = Cp_{hexane} \times X_{hexane} + Cp_{cake} \times C_{akey}$$

But, $Cp_{cake} = Cp_{basil\ residual} X_{basil\ residual} + Cp_{oil} X_{oil} =$

$$2.14 \times 0.95 + 2.23 \times 0.03$$

$$= 2.1\text{kJ/kg k}$$

$$Cp_{mixture} = 2.338 \times 0.05 + 2.142 \times 0.95$$

$$= 2.1518 \text{ kJ/kg k}$$

Therefore, the amount of heat supplied to the desolventizer is:

$$Q = M_{mixture} \times Cp_{mixture} \times \Delta T =$$

$$32525\text{kg/day} \times 2.1518 \text{ kJ/kg K} \times (69-25) =$$

$$3079440\text{kJ/day.}$$

CHAPTER SIX

6. EQUIPMENT SIZING, DESIGNING AND ECONOMIC ANALYSIS

6.1. Equipment Sizing

6.1.1 Sizing of Drier

$$\text{Mass of fresh basil leaves (M1)} = 380744\ \text{kg/day} = 15864\text{kg/hr}$$

$$\text{Heat supplied to drier, Q} = 9453873\text{kJ/day} = 393911\ \text{kJ/hr}$$

$$\text{Working air velocity of Drier} = 0.5 - 1.5\text{m/s.}$$

$$Q = MCP\ \Delta T$$

$$\text{Mair} = \frac{Q}{\text{Cp, air}\ \Delta T}$$

$$\frac{393911\ \text{kJ/hr}}{(2.61\ \text{kJ/kg K} * 13\text{K})} = 11609\text{kg/hr}$$

$$A = \frac{\text{Mair}}{\text{Vair}}$$

$$= \frac{11609\ \text{kg/hr}}{(1.2*3600*1.12)} = 2.4\text{m}^2$$, (density of air =1.12Kg/m^3, Vair = 1.2m/s)

$$2.4\ \text{m}^2\left(\frac{1\ \text{ft}^2}{(0.3048\ \text{m})^2}\right) = 25.8\ \text{ft}^2$$

6.1.2. Sizing of Grinder

$$\text{Mass of dried leave} = 37{,}498\ \text{kg/day} = 1562\text{kg/hr}$$

$$\text{Density of the leave} = 142\ \text{kg/m}^3\ (0.35\text{g/metric cup, 1 metric cup} = 0.25 * 10^{-3}\text{m}^3)$$

$$\text{Working velocity} = 1.2\ \text{m/s}\quad (0.5 - 1.5\ \text{m/s})$$

Assume 10% allowance

$$\text{Maximum volumetric gas flow rate} = 8.98\ \text{m}^3/\text{s}$$

$$\text{Volume} = \text{mass/density} = (1562\ \text{kg/hr})/142\ \text{kg/m}^3$$

$$= 11\ \text{m}^3/\text{hr}$$

$$\text{Volume} = (11\ \text{m}^3/\text{hr}) + 0.1 \times 11\ \text{m}^3/\text{hr}$$

$$= 12\ \text{m}^3/\text{hr}$$

$$= 2954\text{gal/hr}$$

$$\text{The area of grinding} = \text{the maximum volumetric flow rate of gas/working velocity}$$

$$= \frac{(8.98\ \text{m}^3/\text{s})}{1.2\text{m/s}}$$

$$= 7.48\ \text{m}^2$$

$$= 7.48\ \text{m2} \times \left[\frac{1\ \text{ft}^2}{(0.3048\text{m})^2}\right]$$

$$= 80\text{ft}^2$$

6.1.3 Sizing of Extractor

$$\text{Mass of solvent (hexane)} = 140853\text{kg/day} = 35213\text{kg/batch}$$

$$\text{Mass basil to extractor} = 35623 \text{ kg/day} = 8905\text{kg/batch}$$

$$\text{Density of mixture} = \text{density of hexane} \times \text{fraction of hexane} + \text{density of raw leaves} \times \text{fraction of leaves.}$$

$$= 659 \text{ kg/m}^3 \times 0.798 + 101.44 \text{ kg/m}^3 \times 0.2$$

$$= 546.4 \text{ kg/m}^3$$

$$\text{Density of basil powder} = 101\ .44 \text{ kg/m}^3 \text{ (http://www. aqua} - \text{calc. com)}$$

$$\text{Total mass of mixture} = \text{mass of solvent} + \text{mass basil powder}$$

$$= 35213\text{kg/batch} + 8905\text{kg/batch}$$

$$= 44118\text{kg/batch}$$

$$\text{Volume of mixture, V} = \frac{\text{mass}}{\text{density}}$$

$$\frac{44118 \text{ kg}}{546.4\text{m}^3}$$

$$= 80.7 \text{ m}^3$$

Assume 10% safety factor

$$\text{Vtotal} = \text{V} + 0.1 \text{ V}$$

$$= 80.7 + 0.1 \times 80.7$$

$$= 89 \text{ m}^3$$

$$= 89\text{m}^3 \left(\frac{246.17\text{gal}}{\text{m}^3}\right)$$

$$= 21864.7\text{gal}$$

6.1.4. Sizing of evaporator

$$\text{Mass of mixture} = 143951 \text{ kg/day} = 5998 \text{ kg/hr}$$

$$\text{Mass of hexane} = 137701\text{kg/day} = 5737.5 \text{ kg/hr}$$

$$\text{Mass of oil} = 6250\text{kg/day} = 260 \text{ kg/hr}$$

$$\text{Xhexane} = \frac{\text{mass of hexane}}{\text{mass of mixture}}$$

$$= \frac{5737.5 \text{ kg/hr}}{5998 \text{ kg/hr}}$$

$$= 0.956$$

$$Xoil = \frac{\text{mass of oil}}{\text{mass of mixture}} = 1 - Xhexane$$

$$= 0.044$$

$$\text{Density of mixture} = \text{density of hexane} \times \text{fraction of hexane} + \text{density of oil} \times \text{fraction of oil}$$

$$= 659 \times 0.956 + 928 \times 0.044$$

$$= 670.8 \frac{kg}{m^3}$$

$$= \text{Volume of mixture, V} = \frac{\text{mass of mixture}}{\text{density of mixture}}$$

$$= \frac{5998 kg/hr}{670.8\ kg/m^3}$$

$$= 8.9 \frac{m^3}{hr}$$

Assume 10% safety factor

$$Vtotal = V + 0.1\ V$$

$$= 8.9 \frac{m3}{hr} + 0.1 * 8.9 \frac{m^3}{hr}$$

$$= 9.8 \frac{m^3}{hr}$$

$$= \frac{4257 gal}{hr}$$

6.1.5 Sizing of Condenser

$\text{Mass of solvent and oil mixture} = 143951 kg/day$

Horizontal condenser is designed to condense 143951kg/day (10,400.5 kg/hr) of mixture of oil and solvent. The Coolant used is water which is supplied in the tube side at an inlet temperature of 20 °c and leaves at an outlet temperature of 35°c.

$$\text{Latent heat of vaporization of hexane} = 333.1\ 46 \frac{kJ}{kg}.$$

The amount of heat removed from the vapor: $Q = m \times \lambda$

$$= 1\ 0{,}400.5 \frac{kg}{hr} \times \left(1 \frac{hr}{3600 sec}\right) \times 333.1\ 46 \frac{kJ}{kg}$$

$$= 962.46 \frac{kJ}{sec}$$

The amount of water circulated

$$Mw \times CpH2o \times \Delta T = Mv\lambda$$

$$Mw \times 4.1\ 87 \frac{kJ}{kg}.K(35 - 20) = 962.46 \frac{kJ}{sec}$$

$$Mw = 962.46 \text{ kJ/sec} / (4.1\,87 \text{ kJ/kg.K} \times 1\,5 \text{ K})$$

Logarithmic mean temperature difference;

$$Mw = 1\,5.26$$

$$\text{LMTD } (\Delta Tlm) = \frac{(\Delta T1 - \Delta T2)}{\ln\left(\frac{\Delta T1}{\Delta T2}\right)}$$

$$= \frac{((69-35)-(50-20))}{\ln((69-35)-(50-20))}$$

$$= \frac{4}{\ln\frac{34}{30}}$$

$$= 32°C\ (305K)$$

The material construction of condenser is stainless steel and it's over all heat transfer coefficient is 600 w/m²K (Coulson J.M. and Richardson J.F. (2002).

$$\text{Total heat transfer area } = \frac{Q}{(U \times \Delta Tlm)}$$

$$= \frac{962.46 \text{ kJ/sec}}{(600 w/m^2\, K \times 305\, K)}$$

$$= 5.25\ m^2$$

$$= 5.25 m^2 \times \left[\frac{1\ ft^2}{(0.3048 m)^2}\right]$$

$$= 56.5 ft^2$$

6.1.6 Sizing of Desolventizer

Assume the temperature of the steam interring into the desolventizer at 130°C and leaving the desolventizer at 80°C. The temperature of the raffinate rise from 40°C to 70°Cand also the heat transfer takes place counter current.

$$Q = UA\Delta Tmean$$

$$\text{Area of evaporator, } A = \frac{Q}{U\Delta T \text{ mean}}$$

$$\Delta Tmean = \frac{\Delta T1 - \Delta T2}{\ln(\frac{\Delta T1}{\Delta T2})}$$

$$= \frac{(1\,30-70)-(80-40)}{\ln(\frac{60}{40})}$$

$$= 49.3°C$$

$$\text{From energy balance } Q = 3079440 kJ/day = 128310 \text{ kJ/hr}$$

$$A = \frac{128310 \text{ kJ/hr}}{600 * 49.3}$$

$$A = 5.33 \text{ m}^2$$

$$= 5.33\text{m}^2(1 \text{ ft}^2/ (0.3048\text{m})2)$$

$$= 57.5\text{ft}^2$$

6.1.7 Sizing of Hexane storage tank

$$\text{Mass of hexane} = 63{,}012 + 1390 \times X \text{ kg/day}$$

$$\text{Where, } X = \text{ number of days}$$

$$\text{Thus, for 1 day: Mass of hexane} = 63{,}012 + 1390 \times 1$$

$$= \frac{64{,}402\text{kg}}{\text{day}} = \frac{2683.4\text{kg}}{\text{hr}}$$

$$\text{Volume of hexane, V} = \frac{\text{mass of hexane}}{\text{density of hexane}}$$

$$= \frac{2683.4\text{kg/hr}}{659\text{kg/m}^3}$$

$$= 4.07\text{m}^3$$

Assume safety factor 1 0%

$$\text{Vtotal} = V + 0.1 V$$

$$= 4.07 + 0.1 * 4.07$$

$$= 4.477 \text{ m}^3$$

$$= 4.477\text{m3}\left(246.1\frac{7\text{gal}}{\text{m}^3}\right)$$

$$= 1102\text{gal}$$

6.1.8 Sizing of Oil storage tank

For one period of storage, the size of the storage tank will be will be determined as follow:

$$\text{Mass flow of the oil product} = 6250\frac{\text{kg}}{\text{day}}$$

$$\text{Density of basil essential oil} = \frac{928\text{kg}}{\text{m}^3}$$

$$\text{Volume of oil} = \frac{\text{mass of oil}}{\text{density of oil}}$$

$$= \frac{6250\text{kg/m}^3}{928\frac{\text{kg}}{\text{m}^3}}$$

$$= 0.673\text{m}^3$$

Using 15% safety factor the volume of the storage tank will be:

6.2 Design of Major Process Equipment's

6.2.1. Extractor design

$$\text{Volume of storage tank} = \text{Volume of oil}$$
$$= 0.673 + 0.15 * 0$$
$$= 0.774m^3$$
$$= 153\text{gallon}$$

Basic data: The data is on 1 hour base

Amount of feed basil powder 1593.6kg =

❖ Percent

The amount oil extracted .90kg = 25

weight of

Amount of oil in drained solution before evaporation 10,400kg =

Weight of discharge solid before desolventization = .10kg 1695

Weight solvent oil − free solid 1630.67kg =

– weight of Weight of drained solution (Wm) = weight of discharged solid solution with

entrained

solvent oil free solid

solution;

= 1695.10– 1630 .67

$$= \frac{64.43}{1695.10}$$

= 64.43kg

= 3.8%

- ❖ Weight of oil obtained after evaporation of extract liquid;

Moil = 20.83kg

- ❖ Percent weight of oil in Mesilla;

$$\%\text{oil} = \frac{20.83}{10,400}$$
$$= 0.20\%$$

- ❖ Coulson and Richardson for chemical engineering sixth edition volume 2, gives the equation for calculating theoretical stages as;

$$a^m = \left(\frac{so}{sm}\right)\left[1 - \frac{s1}{w1}\right]$$

Where; m - Number
of stages S_o -
Extracted Oil
S_1 - Oil in extract solution S_m- Residual oil in
solid feed a - A characteristic factor for
equilibrium stages.

Moisture content = 17%

Extractable oil = 1.4%

Percent oil in solution = 0.20%

Percent weight of entrained solution = 3.8%

From the data obtained;

$$\text{On solute; } SF + So = S1 + Sm$$

$$\text{On solution; } WF + Wo = W1 + Wm$$

Where;

W_o- Extracted solution

W_1 - Weight of miscella

W_m - Weight of entrained solution

W_F - Weight of out flowing solution

S_F - Weight of out flowing solute

$$So = 25.90kg$$

$$S1 = 20.83kg$$

$$W1 = 1\,0{,}400kg$$

For 1593.6kg basil powder on oil-free basis, and 3.8% solution in the solid, entrained solution weight, Wm becomes;

$$Wm = \frac{1\,593.6}{0.962} \times 3.8\%$$

$$= 62.925kg.$$

$$\text{But, a is given by, a } = \frac{Wf}{Wm}$$

$$WF + Wo = W1 + Wm$$

$$So = 25.90kg$$

$$WF + 25.90 = 10{,}400 + 62.925$$

$$WF = 1 0,437.05kg$$

$$So = 1593 \times 1\frac{.4}{0.93} = 2398.06kg$$

$$Sm = 5.07$$

$$S1 = So - Sm$$

$$= 2398.06 - 5.07 = 2393kg$$

For 0.20% oil concentration in the solution weight becomes:

$$W1 = \frac{S1}{0.20\%} = \frac{2393}{0.20} = 11,965kg$$

For 1593.6kg basil powder oil-free basis and 3.8% solutions in the solid entrained solution weight Wm becomes;

$$Wm = 0.038 \times \frac{1593.6}{0.962} = 62.95kg$$

$$Wo = So = 2398.06kg$$

$$WF = Wm + W1 - Wo$$

$$= 9629.89kg$$

$$a = \frac{Wf}{Wm} = \frac{9629.89kg}{62.95kg}$$

$$= 1 52.97$$

$$a^m = \left(\frac{so}{sm}\right)\left[1 - \frac{s1}{w1}\right]$$

$$152.97^m = \left(\frac{2398.06}{5.07}\right)\left[1 - \frac{2393}{11965}\right] = 378.39$$

$$m\log1 52.97 = \log378.39$$

$$m = 1.1 8\text{stages or approximately 2 stages}$$

Estimation of Efficiency and Actual Number of Stages for Extraction:

$$Eo = \frac{1}{1 + \frac{3.7(1 0)4KM}{LT\rho}}$$

Where K - Vapour – Liquid equilibrium ratio, y/x; y – Gas
phase concentration at equilibrium, (mole fraction); x - Liquid phase concentration at equilibrium, (mole fraction); M - Molecular mass of the substance, Kg/Kmole; h – Effective liquid depth, mm; ρ - Liquid density, Kg/m3 ;T - Absolute temperature, K N-hexane is assumed to be the vapour since it is the more volatile component

The amount of hexane used in the extraction = 10,502kg

The molecular mass of hexane is 81 .17Kg/K mole

The number of moles of hexane will therefore be equal to = 1 29.38Kmoles

Molecular mass of basil oil = 21 6kg/kmol

Mass of oil = 25.90kg

$$\text{Number of mole of oil } = \frac{25.90}{21\ 6} = 0.1\ 2\text{kmole}$$

$$\text{Mole fraction of hexane } = \frac{1\ 29.38}{1\ 29.38 + 0.12} = 0.99$$

$$\text{Mole fraction of oil } = 0.01$$

$$K = \frac{y}{x} = 99$$

From the extractor cross-sectional area calculations;

From equipment sizing volume of extractor = 1 7m^3

$$V = \frac{\pi D^2 h}{4}$$

$$\text{Assume} \frac{h}{D} = 2.0$$

$$h = 2D$$

$$= \frac{2\pi D^3}{4}$$

$$D = \sqrt[3]{\frac{16}{2\pi}}$$

$$= 1.36\text{m}$$

With 5% allowance D = 1.5m, h = 3.0m, r = 0.75m

If it is assumed that the space above the material on the screw conveyer is 1 0% of cross sectional area, then the space that will be created above the conveyer will be.

Therefore height of material in the launder,

T = 342k now from the calculation of $\begin{aligned} h &= 1.5 - 0.15 \\ &= 1.35\text{m} \end{aligned}$ diffusion;

$$\frac{\rho}{M}\text{ave} = \left(\frac{628}{216}\right)\text{ave} = 2.903 \text{ or } = \frac{0.34\text{m}^3}{\text{kmol}}$$

$$\text{Then; efficiency (Eo)} = \frac{1}{1 + 3.7(10)4\frac{99*0.28}{1\ .35\times 342\times 928}} = 98\%$$

Actual number of stages;

$$\text{Actual number is given by } = \frac{\text{theoretical number of stages}}{\text{Efficiency}}$$

$$= \frac{2}{0.98}$$

$$= 2.04\text{stage, then we have 3 stages}$$

6.2.2 Hopper Design Calculations

The hopper is a holding vat for the solid charge. Solids are charged from it mechanically propelled into the extractor. The basis for hopper design calculation is presented here under.

- 4Shift operations per day, and 3 runs per shift.
- Radius of hopper cylindrical part = 1.2m
- Height of hopper cone base = 0.09m
- Height of hopper down comer = 0.6m
- Radius of down comer = 0.12m
- Radius of down comer part = 0.5m

$$\text{Quantity of solids required per shift } = \frac{9{,}562\text{kg}}{\text{shift}}$$

$$\text{For three runs per shift } = 31\ 87.3\text{kg}$$

$$\text{For hexane } = 63{,}01\frac{2\text{kg}}{\text{shift}}$$

$$\text{For three runs per shift } = 63{,}01\frac{2}{3} = 21\ {,}004\text{kg}$$

Volume of powder

$$\text{Volume of basil powder } = \frac{3187.3\text{kg}}{101\frac{.4\text{kg}}{\text{m3}}} = 31\ .5\text{m}^3$$

$$\text{Volume of basil powder in the cone part } = \frac{\pi r^2 h}{3}$$

$$= \frac{\pi(0.75)^2 1.5}{3} = 0.88\text{m}^3$$

The volume of the cylindrical part will be;

$$= 31.5 - 0.88$$
$$= 30.62\text{m}^3$$

And for allowance of 5% in the design,

$$= 30.62 + (0.05 \times \quad 30 \quad .62\ )$$

$$= 32.1\ 5m^3 \text{ this value is total volume} \quad \text{of} \quad \text{hopper cylinder}$$

$$\text{But; } 32.15 = r \quad {}^2h$$

$$\text{Therefore, } h = \quad .1m \qquad 7$$

$$\text{Total height of hopper } = 7.1 \quad + \quad 1\ .5 \quad 6m \quad = 8.$$

$$\text{Total volume of hopper (cylinder and} \quad \text{cone} \quad) = \quad 15 \qquad 32.0.88m+$$

$$= 33.03m^3$$

$$\text{Volume of cylindrical down} \quad \text{comer} \quad = \quad h \qquad r^2$$

$$= 3.135 \times 0.8^2 \quad 1 \quad .5 \qquad \times$$

$$= 3.01\ m^3$$

$$\text{The total volume of hopper } = \quad .01 \quad m\ ^3 + \quad .03 \quad 3 \quad 33 \qquad ^3$$

$$= 36.04m^3$$

$$\text{Surface area of cylindrical} \quad \text{part} \quad = \qquad 2\pi h$$

$$= 2 \times \pi \times 1.2 \times 7. = 53.53m^2$$

6.3 Economi Canalysis Plant parameters

- ✓ Capacity= 150 tons per year
- ✓ Working days per year = 300

6.3.1 Total capital investment

Total Capital Investment = Fixed Capital Investment + Working Capital Investment

For this case, capital investment items are calculated based on the purchased equipment cost of the plant.

Fixed capital cost = *f* (purchased equipment cost)

6.3.2. Cost indexes

A cost index is merely an index value for a given point in time showing the cost that time relative to certain base time. So, present cost is estimated from cost index as follows.

Present Cost = $\text{Original Cost} \times \dfrac{\text{Index Value at Present Time}}{\text{Index value at Time Original Cost was Obtained}}$

Table 7. Chemical engineering equipment cost index

Year	Chemical Engineering price cost index
2011	550.8
2012	585.7
2013	584.6
2014	567.3
2015	576.1
2016	556.8
2019	?

Source: www. Matches/equipment cost. Com

6.3.3 Purchase equipment cost estimation

Then by using extrapolation we get cost index of present 2019 as follows:

Cost index for 201 5=576.1

Cost index for 201 6=556.8

$$\frac{2016-2015}{556.8-576.3}=\frac{2019-2016}{Y-576.3}$$

Then by solving * Y= 498.9 i,e cost index for 2019

.Table 8. Total purchased equipment cost

Equipment name	Quantity	Equipment specification	Capacity(size)	Total price($)
Dryer	1		25.8ft^2	8,673.00
Grinder	1		80ft^2	9,100.00
Extractor	1		21864gal	17,463.00
Evaporator	1		4257gal	37,780.00
Condenser	1		56.5 ft^2	36,580.00
Desolvenizer	1		57.5 ft^2	34,898.00
Oil storage tank	1	Horizontal,Cylindrical	153 gal	3,000.00
Hexane storage tank	2	Horizontal,Cylindrical	1102 gal	2,280.00
TOTAL				1 49,774.00

Source: www. Matches/equipment cost. Com

Total purchased equipment cost (PEC)=$149774

Estimating total Capital investment cost (TCI)

Purchased equipment installation = Take 39%

0.39 × 149,774 = $58, 411.86

Instrumentation and control = Take 5%

0.05 × 149,774 = $1 9,470.62

Piping (installed) = Take 31 %

0.31 × 1 49,774 = $46,429.94

Electrical (installed) = Take 10%

0.1× 1 49,774 = $1 4,977.40

Building = Take 29%

0.29 × 1 49,774 = $43,434.46

Yard improvement = Take 10%

0.1× 1 49,774 = $1 4,977.40

Service facilities = Take 55%

0.55 × 1 49,774 = $82,375.70

Land = Take 6%

0.06 × 1 49,774 = $8,986.44

Table 9. Summary of fixed capital investment for solid liquid processing plant

	Components	Cost ($)
1 .Direct cost	Purchased equipment cost (PEC)	149,774.00
	Purchasedequipment installation, 39%PEC	58,411 .86
	Instrumentation and control, 13%PEC	19,470.62
	Piping (installed), 31 %PEC	46,429.94
	Electrical(installed), 10%PEC	14,977.40
	Building, 29%PEC	43,434.46

	yard improvement, 1 0%PEC	14,977.40
	Service facilities, 55%PEC	82,375.70
	Land, 6%PEC	8,986.44
	A. Total direct cost	438,837.82
2.Indirect cost	Engineering and Supervision, 32%PEC	47,927.68
	Construction expenses, 34%PEC	50,923.1 6
	B.Total direct and indirect cost	537,688.66
	C. Contractors fee’s, 5%B or 18%PEC	26,884.43
	D.Contingency, 10%B or 36%PEC	53,768.87
Fixed-capital investment =B+C+D		618,341.96

Fixed-capital investment = $618,341.96

$$TCI = FCI + WC$$

The working capital cost = (10-20)% of total capital investment

$$TCI = FCI + 0.15TCI$$

$$TCI = FCI/0.85 = 618,341.96 \quad /0.85$$

$$TCI = \$727 \quad ,461.13$$

6.3.4 Estimation of Total Production Cost

Cost of raw materials

The cost of each raw material per year is estimated by multiplying the raw material required per day by 300 working days per year and 24 working hours per day, and then multiplying by raw material unit price.

Table 10. Cost of raw materials

Raw Material	Quantity per annual (Kg/year)	Unit price (birr/kg)	Total cost(birr)
Basil leaves	172907	0.37	6404.00
n-Hexane	480012	1.5	720018.00
Total			28002

Annual utility cost estimation

Annual utility cost estimation can be determined from energy balance by calculating the total amount water and electricity cost.

Current price of electricity = 0.48Birr/ kWh

Total power used annually = 220,167kWh /yr .

Cost of current = 105,680Birr/yr = ($3914 / yr)

Total amount of water required per year = 1 6,480 m^3/yr

Water: current price = 5birr per 1m3

Total Cost of water =82,404birr/yr= $3052.00/yr.

Total utility cost = 1 88,084birr/yr =$6966.00/yr

Table 11. Operating labor cost estimation

Work specification	No required	Monthly salary(birr)	Yearly salary(birr)
Manager	1	9,000.00	108,000.00
Production head	1	4,000.00	48,000.00
Quality head	1	5,200.00	62,400.00
Purchasing and sales head	1	4,600.00	55,200.00
Accountant	1	3,000.00	36,000.00
Secretary	1	2,200.00	26,400.00
Laboratory technician	1	3,000.00	36,000.00
Mechanics	1	2,300.00	27,600.00
Production line worker	4	1 ,400.00	67,200.00
Raw material storage worker	1	1 ,200.00	14,400.00

area workers			
Final product storage area worker	1	1 ,200.00	14,400.00
Driver	3	2,500.00	90,000.00
Security guard	4	1 000.00	48,000.00
Cleaners	4	800.00	38,400.00
Electrician	1	1 ,400.00	16,800.00
Total	26	$2093	$25111

Table 12. Estimation of Total Product Cost

	Components	Cost(birr)
1Manufacturingcost	A. Direct production cost	
	1.Raw material cost,10%TPC	784,058.00
	2.Operating Labor (OL)	25,111 .00
	3.Direct supervision and clerical labor(DS), 1 7.5%OL	4,394.40
	4. Utilities, 30%TPC	6,966.00
	5.Maintenanceand repair(CMN), 6%FCI	37,100.51
	6.Operatingsupplies,30%CMN	11,130.15
	7.Laboratorycharges(LC), 30%OL	7,533.00
	8.Patents and royalties, 3%TPC	0.03TPC
	Direct production cost	876,293.06+0.03TPC
	B. Fixed charges	
	1.Depreciation, 1 0%FCI	61,834.20
	2.Local taxes,2.5%FCI	15,458.55

	3.Insurance, 0.7%FCI	4,328.39
	4. Rent, 1 0%FCI	61,834.20
	Fixed charges =	1 43,455.34
	C. plant overhead , 60%(OL +CMN+DS)	39,963.54
	manufacturing cost = A + B + C=1 ,059,711 .94+0.03TPC	
2.General expenses	1.Administrative costs, 15%(OL+ DS +CMN)	9,990.88
	2.Distribution and selling costs, 11 %TPC	0.11 TPC
	3.Research and development costs, 5%TPC	0.05TPC
	4.Financing interest, 5%TCI	36,373.05

Total product cost (TPC) = Manufacturing cost + General expenses

Manufacturing cost = direct production cost (variable) + fixed operating cost + plant

= 1, 059, 71 1 .94+0.03TPC

General expenses = 46,363.93+0.1 6TPC

Total production cost (TPC) = Manufacturing cost + General expenses TPC=

1,106,075.87+0.19TPC

$$TPC = \frac{110,6075.87}{0.82}$$

= $1,365,526.00

6.3.5. Profit Analysis

Net income, Payback time and return on investment

Gross Profit

Current price of basil oil = $12/kg

Annual revenue=$12/kg*150,000 kg= $1,800,000.00

Total production cost= $1,365,526.00

Gross annual profit =$1,800,000.00- $1,365,526.00= $434,474.00

Income Tax on gross profit (35%) = $152,065.00

Net Income= $434,474.00- $152,065.00=$ 282,408.10

Percent profit

$$\%\text{Pofit} = \frac{\text{Net profit}}{\text{TPC}} \times 100$$

$$= \frac{\$282{,}408.10}{\$1365526} \times 100$$

$$= 20.86\%$$

Percent rate of return, $\%\text{ROR} = \frac{\text{net income}}{\text{TCI}} \times 100$

$$282408.86/727461.13 = 38.82\%$$

Payback period PBP $= \frac{\text{FCI}}{\text{Netprofit+depreciation}}$

= $61 8,341 .96/($282,408.10+$61,834.196)

=1.80yr ≈ 2yrs

So, the payback period of the project is estimated to be two years.

Table 13. Cash flow table

Year	Cash flow
-3	-421,215
-2	-627,329
-1	-736,448
0	-575,843
1	-349,529
2	-23,837
3	301,855
4	627,547
5	931,597
6	1,214,005
7	1,496,413
8	1,778,821
9	2,061,229
10	2,179,335

Present value (PV) $= \sum_{t=1}^{n} \frac{CFt}{(1+r)^2}$

Hence, present value $= \sum_{t=1}^{n} \frac{CFt}{(1+r)^n} = \frac{CF1}{(1+r)^1} + \frac{CF2}{(1+r)^2} + \cdots \frac{CF10}{(1+r)^{10}}$

By substituting cumulative cash flow value from the table above and interest rate (r =10%)

PV= $ 3,161,572

Net present value (NPV) $\sum_{t=0}^{n} \frac{CFt}{(1+r)^n} = CFto + PV$

Hence, net present value, $= \sum_{t=1}^{n} \frac{CFt}{(1+r)^n} = CFo + \frac{CF1}{(1+r)^1} + \frac{CF2}{(1+r)^2} + \cdots \frac{CF10}{(1+r)^{10}}$

NPV= -736,448 + 3,161,572

= $ 2,425,124

Present index (PI) = $\frac{\sum_{t=1}^{n} \frac{CFt}{(1+r)^n}}{CFto}$

$= \frac{\$3161572}{\$716448} = 4.293$ It indactes the feasiblitiy of the project.

6.3.6 Plant location

The location of the plant can have a crucial effect on the profitability of a project and the scope for future expansion. Many factors must be considered when selecting suitable site. The principal factors to consider are:

- ✓ Location, with respect to the marketing area;
- ✓ Raw material supply;
- ✓ Transport facilities;
- ✓ Availability of labor;
- ✓ Availability of utilities: water, fuel, power;
- ✓ Availability of suitable land;
- ✓ Environmental impact, including effluent disposal;
- ✓ Local community considerations;
- ✓ Climate;

CHAPTER SEVEN

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusion

The work was intended to study on the possibility of oil extraction from the selected herb, the influence of the extraction parameters such as particle size, extracting time, proportion of solute to solvent, operating temperature etc. Variability of these operating conditions was the predominant factors for the oil yield and quality characteristics. There are different methods of oil extraction from basil leaves. In this work solvent extraction method using Soxhlet apparatus was used. In solvent extraction n-hexane was used as a solvent. In this study, based on the analysis of experimental results, it has been realized that the individual factors and their interaction effects are significant model terms on yield and quality of oil. The maximum yield and quality of oil was achieved under the optimum conditions at moisture content of 76.47%, volume of solvent 160ml, and the extracting time of 4 hour.

The observed quantitative and qualitative variation of the oil from the standard value was due to the operating parameters like extraction time, amount of solvent and sample size. Thus, determination of the appropriate optimum parameters for the recommended particle size needs to have a consideration to get the maximum amount of the required product.

Finally, this study envisages the establishment of a plant with a capacity of 150 tons per year. Thus, with a rough economic analysis have been made the project is financially feasible with 20.68% of profit, 38.82% of Rate of Return (ROR) and payback period of two years.

7.2. RECOMMENDATIONS

Production technology is an essential element to improve the overall yield and quality of essential oil. Therefore, using more efficient methods of extraction is recommended to extract more yields with good quality.

Once the required activities of the extraction process have been accomplished, further treatments are recommended to be taken on the extracts before using the essential oil for the treatment of various diseases.

Comparing to exporting the raw plant materials, extracting essential oils can save more the country's foreign currency and hence the production of essential oils could still be a good source of foreign exchange revenue for our country. Many plant species have been lost and some are in danger of extinction. It has also caused biodiversity conservation problems. It is therefore vital that systematic cultivation of these plants be introduced in order to conserve the biodiversity and protect endangered species.

Furthermore, the requirement of essential oils for use in aromatherapy is increasing and creating a demand for organically produced exotic oils. The development of the essential oils industry is therefore important to our country which has rich resources of raw materials (medicinal plants) or the climatic conditions for the initiation of crop wise cultivation programs.

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