EXTRACTION OF ESSENTIAL OILS FROM JASMINE FLOWER USING SOLVENT EXTRACTION METHOD: A STUDY OF FEED RATIO EFFECTS

THAVASELVAN A/L SUPERAMANIAM

UNIVERSITI MALAYSIA PAHANG

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Tarikh	: 1 Mei 2008

EXTRACTION OF ESSENTIAL OILS FROM JASMINE FLOWER USING SOLVENT EXTRACTION METHOD: A STUDY OF FEED RATIO EFFECTS

THAVASELVAN A/L SUPERAMANIAM

A thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Chemical Engineering

Faculty of Chemical & Natural Resources Engineering
University Malaysia Pahang

MAY 2008

I declare that this thesis entitled "*Extraction of Essential Oils from Jasmine Flower Using Solvent Extraction Method: A Study of Feed Ratio Effects*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Special dedication to my beloved father and mother, K.Superamaniam and K.Saroja, all my family members that always inspire, love and stand besides me, my supervisors, my beloved friends, my fellow colleagues, and all faculty members.

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ABSTRACT

Jasmine essential oils are primarily used in the perfumery industry and have a very high commercial value due to its therapeutic properties. As Jasmine essential oils are composed of heat-sensitive chemical compounds, the use of conventional steam distillation technique would inevitably inflict thermal degradation to the natural fragrance. In this experimental work, solvent extraction method was employed due to its mild extracting condition and lower operating cost. Ethanol was used as the solvent due to its high availability in market. The extract compositions were compared using gas chromatography analysis. Preliminary results showed that volatile oil compounds were successfully isolated from Jasmine flowers using these solvents. It was found that the main constituents of the essential oils were benzyl acetate and benzyldehyde. Further studies also revealed that the composition and yield of essential oils influenced by the ratio of ethanol solvent to the jasmine flower. The most optimum feed ratio of jasmine flower to ethanol solvent is 1: 2 (50mg: 100mL) where it's yield is 14.65% and having process efficiency of 19%. Low yield of the jasmine essential oils can be improved by varying this ratio and carrying out the research in larger scale.

ABSTRAK

Pengekstrakan minyak bunga melur terutamanya digunakan dalam pembuatan minyak wangi dan mempunyai nilai komersil yang tinggi disebabkan oleh ciri-ciri terapinya. Minyak ini adalah terdiri daripada komponen yang sensitif pada haba, oleh itu penggunaan pengekstrakan stim sebagai salah satu cara untuk mengekstrakkan minyak ini secara tidak langsung membawa kepada kesan degradasi haba terhadap bau semulajadi minyak bunga melur. Di dalam kajian ini, pengekstrakan minyak ini dilakukan menggunakan kaedah ekstraksi pelarut kerana ia didapati sesuai untuk tujuan pengekstrakan minyak ini dan kos menggunakan cara ini lebih rendah. Jenis bahan pelarut yang digunakan ialah etanol. Sampel minyak yang didapati daripada kajian ini akan dibandingkan menggunakan analisis gas kromatografi. Keputusan kajian pada peringkat permulaan menunjukan beberapa komponen di dalam minyak ini dapat dikesan menggunakan pelarut-pelarut ini. Komponen utama di dalam minyak bunga melur yang telah dikenalpasti ialah benzil asetat dan benzaldehid. Kajian selanjutnya membuktikan pengesanan komponen dan kuantiti minyak ini adalah dipengaruhi oleh nisbah kuantiti bunga melur kepada pelarut etanol. Hasil paling optimum bagi minyak bunga melur ialah apabila nisbah kuantiti bunga melur kepada pelarut etanol ialah 1: 2(50mg: 100mL) di mana ianya memberikan hasil sebanyak 14.65% dan kecekapan proses sebanyak 19%. Hasil minyak bunga melur yang rendah ini dapat dipertingkatkan dengan mevariasikan nisbah tersebut dan melakukan kajian dengan menggunakan skala yang lebih besar.

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LIST OF ABBREVIATIONS

CO_2	=	Carbon dioxide
FID	=	Flame Ionization Detector
GC	=	Gas Chromatography
GC-MS	=	Gas Chromatography - Mass Spectrometer
RI	=	Refrective Index
SFE	=	Supercritical Fluids Extraction

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Essential oils are the fragrant oils that are present in many plants. Hundreds of plants yield essential oils that are used as perfumes, food flavorings, medicines, and as fragrant and antiseptic additives in many common products.

Essential oils have been used for thousands of years. The ancient civilizations of Mesopotamia, more than 5,000 years ago, had machines for obtaining essential oils from plants. Essential oils were the primary source of perfumes for the ancient civilizations of Egypt, India, Greece, and Rome. Essential oils have been found in 3,000-year-old tombs in the Pyramids, and early Greek physicians, including Hippocrates, mentioned aromatic plant essences and oil massages for their healing and mood-enhancing qualities. The Romans associated essential oils and their fine aromas with wealth and success. Ayurvedic medicine, the world's oldest healing system, has long recommended essential oil massage as a health treatment for many conditions.

Essential oils are produced using several techniques. Distillation uses water and steam to remove the oils from dried or fresh plants, and the expression method uses machines to squeeze the oil out of plants. Other techniques may use alcohol or solvents to remove essential oils from plant materials.

Essential oils are extremely concentrated. It would take roughly thirty cups of herbal tea to equal the concentration of plant essence in one drop of essential oil. Some essential oils made from rose plants require 4,000 pounds of rose petals to make one pound of essential oil, and are thus very expensive. Lavender is one of the easiest essential oils to produce, because it only takes one hundred pounds of plant material to produce one pound of essential oil. Essential oils are generally very complex chemically, containing many different substances and compounds.Scientific research has isolated hundreds of chemicals in essential oils, and has shown many essential oils to have anti-bacterial, anti-fungal, and antiparasitic properties. Some essential oils contain more than 200 identified chemical substances.

Although there are hundreds of essential oils that are used regularly in healing treatments and perfumes, some of the more commonly used essential oils are lavender, chamomile, peppermint, tea tree oil, eucalyptus, geranium, jasmine, rose, lemon, orange, rosemary, frankincense, and sandalwood. Taking into consideration the small scale industries using conventional method which are involved in production of perfumeries literature survey was then taken up. It reveals that extracts of flowers, especially jasmine, rose, *Champak* and leaves of *davana,* have very good market.

Among flowers' most attractive perfume is jasmine flowers. This project was undertaken to explore the possibilities of having an absolute essential oils. The essential oil are so called because they were believed to represent the quintessence of odor and flavor from the flower kingdom – differ in composition properties from fatty or fixed oils, which consist for the most part of glycerides and from mineral or hydrocarbon oils. A scientific definition of the term essential or volatile oils are not possible, although several practical definitions exist. The most common one defines an essential oil as a more or less volatile material isolated from an odorous plant of a single botanical species by a physical process.

1.2 PROBLEM STATEMENT

In modern times, essential oils are used in the manufacture of high quality perfumes, as additives in many common products, and in the healing practice of aromatherapy. Aromatherapy was begun in the 1920s by a French chemist named Réné-Maurice Gattefosse, who became convinced of the healing powers of essential oils when he used lavender oil to effectively heal a severe burn on his body. Gattefosse also discovered that essential oils could be absorbed into the bloodstream when applied to the skin, and had medicinal effects inside the body. Another Frenchman, Dr. Jean Valnet, used essential oils during World War II to treat soldiers, and wrote a major book on the topic in 1964 called *Aromatherapie*. European biochemist, Marguerite Maury, performed thorough studies of how essential oils influence the body and emotions, and popularized essential oil massages as therapy. In the 1990s, aromatherapy was one of the fastest-growing alternative health treatments.

Essential oils are used in several healing systems, including aromatherapy, Ayurvedic medicine, and massage therapy. Essential oils are used for skin and scalp conditions including acne, athlete's foot, burns, cuts, dandruff, eczema, insect bites, parasites, sunburn, warts, and wrinkles. They are recommended for muscle, joint, and circulation problems such as arthritis, high blood pressure, cellulite, aches and pains, and varicose veins. For respiratory problems and infections, various essential oils are prescribed for allergies, asthma, earache, sinus infections, congestion, and colds and flu. Essential oils are also used to improve digestion, promote hormonal balance, and tone the nervous system in conditions including anxiety, depression, sexual dysfunction, and exhaustion.

Essential oils can be used as quick and effective mood enhancers, for increasing energy and alertness or reducing stress and promoting relaxation. Essential oils can be used as perfumes and lotions, and can be used as incense to improve the atmosphere in houses and offices.

In 2002, several reports were made on the benefits of tea tree oil in fighting infections. Although still preliminary, these reports will help pave the way to greater acceptance of essential oils in the mainstream medical community. In the case of tea tree oil, one small study showed its effectiveness in fighting orthopedic (bone, joint, and soft tissue) infections. Another recent study showed promising results for tea tree oil gel in topical treatment of recurrent herpes labialis.

In this project, the Jasmine flower is being used as the substrate. *Jasminum oficinalis,* or also known as Melur in Malay Language, is commonly extracted for it essential oils using hexane as solvent. Conventional steam distillation method is not suitable to process such material since it induces thermal degradation of many compounds contained in the flower. The constituents of the Jasmine solvent-extracted oils contain all the fragrance compounds (among others include benzyl acetate, benzyl benzoate, linalool, phytol, fatty acid methyl ester and paraffin). The latter compounds do not contribute to the scent of jasmine flowers. This extraction product undergoes further processing to separate fragrance compounds from these undesired co-extractives.

Solvent extraction uses very little heat so it is able to produce essential oils from whose fragrance would otherwise be destroyed or altered during steam distillation. Solvent extraction is used on delicate plants to produce higher amounts of essential oils at lower cost. Other than the study on this method it is important to improve the existing products of fragrance and also try to encourage the development of local technologies to take advantage of market opportunities.

Each method of extraction actually has its own advantages and disadvantages. This study is important in discovering solvent extraction method as the most optimal methods for capturing the total spectrum of volatile constituent in this jasmine plant. All in all, the study on this research is important in order to improve the effective extraction time for each solvent to extract the oils and observing the preliminary study on these essential oils of jasmine flower.

1.3 OBJECTIVE

The main objective of this study on extraction of jasmine flowers is actually to carry out the preliminary study of this essential oils and promoting the solvent extraction as a promising method for the most quantitative and qualitative of this essential oils.

1.4 SCOPE OF RESEARCH WORK

This research is based on experimental studies of solvent extraction (using ethanol). In order to achieve the objectives mentioned above, three scopes have been identified:

I. Jasmine flowers were acquired locally to prepare the blended sample to be used in extraction process. A standard procedure would be developed from this research work.

II. To determine optimum feed ratio of jasmine flower and ethanol solvent producing highest quality and substantial yield of essential oil.

III. To analyze the product composition from the extraction process.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Essential oils are the volatile oils distilled from aromatic plant materials. The odor and flavor of the oils is usually dependent upon these oxygenated compounds. Many oils are terpenoids; fews are benzene derivatives. Table 2.1 shows the important constituents of the more common essential oils (Naik S.N., Lentz.H., 1989).

Table 2.1: Essential oils from some natural plant

Name	**Part of plant used**	**Botanical name**	**Important constituent**	**Uses**
Lemongrass and citronella	Leaf	*Cymbopogon spp*	Citral Citronella Terpenes	Perfumery Disinfectant
Eucalyptus	Leaf	*Eucalyptus globules* *Eucalyptus citriodora* *Eucalyptus dives*	Cineale Citronella Terpenes	Not mention
Cinnamon leaf	Leaf	*Cinnamomum zeylanicum*	Eugenol	Used to make artificial vanilla
Clove	Bud	*Eugenia caryophyllus*	Eugenol	Dentistry flavouring
Turpentine	Not mention	*Pinus spp*	Terpenes	Paints
Lavender	Flower	*Lavendula*	Linalol	Perfumery
Sandalwood	Wood	*Santaium*	Sanatols	Perfumery
Nutmeg	Nut	*Myristica*	Myristicin	Not mentioned
Almond	Nut	*Prunis*	Benzaldehyde	Not mentioned

Essential oils can be divided into two broad categories:

I. Large volume oils which are usually distilled from leafy material, (e.g. lemon grass, citronella and cinnamon leaves).

II. Small volume oils which are usually distilled from fruits, seed, buds and, to a lesser extent, flowers, (e.g. cloves, nutmeg and coriander).

Essential oils are the highly concentrated essences of aromatic plants. Aromatherapy is the art of using these oils to promote healing of the body and the mind. The oils are found in different parts of the plant such as the flowers, twigs, leaves and bark, or in the rind of fruit. For example, in roses it is found in the flowers, in basil it is in the leaves, in sandalwood in the wood, and so on. The methods used to extract the oil are time consuming and expensive and require a high degree of expertise. Given that it takes in excess of 220 pounds of rose petals to produce only 4 or 5 teaspoonfuls of oil, it is a process probably best left to professionals.

Due to the large quantity of plant material required, pure essential oils are expensive, but they are also highly effective which is only a few drops at a time are required to achieve the desired effect. Essential oils have an immediate impact on our sense of smell, also known as "olfaction". When essential oils are inhaled, olfactory receptor cells are stimulated and the impulse is transmitted to the emotional center of the brain, or "limbic system". The limbic system is connected to areas of the brain linked to memory, breathing, and blood circulation, as well as the endocrine glands which regulate hormone levels in the body. The properties of the oils, the fragrance and its effects, determine stimulation of these systems.

When used in massage, essential oils are not only inhaled, but absorbed through the skin as well. They penetrate the tissues and find their way into the bloodstream where they are transported to the organs and systems of the body. Essential oils work quickly on both the body and mind. Through our sense of smell to the olfactory nerves and our brain starts to react to the vapor from an essential oil in less than four seconds. The essential ingredients of oil when applied to the body are also absorbed quickly into the skin via the hair follicles, some almost instantly, depending on the essential oil. Quality pure essential oils can be up to 70 times more concentrated than the plant source from which they derive. The advantage of the natural product over a chemically create substitute is that the essential oil is more complex and retains its additional anti-bacterial properties in a concentrated form.

Essential oils may be used singly or in combination to bring about curative and restorative processes in the mind and body, offering a gentle alternative to modern drugs. They can assist in the treatment of physical, emotional and mental changes, skin care and therapeutic massage. Even when used solely for sensual pleasure, they can positively enhance and enrich our daily life.

2.1.1 Harvesting

Correct harvesting is very important. The essential oil content varies considerably during the development of the plant. If the plant is harvested at the wrong time, the oil yield can be severely reduced. The oil is usually contained in oil glands, veins or hairs which are often very fragile. Handling will break these structures and release the oils. This is the reason a strong smell is given off when these plants are handled, so these plants have to be handled very carefully to prevent valuable oils being lost.

2.1.2 Examples of Essential Oils Material

2.1.2.1 Citronella and Lemongrass

The first harvest can take place 6 - 9 months after planting. Then the grass can then be harvested up to four times a year. If harvested too often, the productivity of the plant will be reduced and the plant may even die. If the plant is allowed to grow too large, the oil yield is reduced. For lemongrass it should be 1.2m high with 4 - 5 leaves. The grass should be harvested early in the morning as long as it is not raining. Harvesting can be done with machetes or simple knives.

2.1.2.2 Cinnamon Leaves

Cinnamon leaves are harvested during the wet season since the rains facilitate the peeling of the bark. Harvesting involves the removal of the stems measuring 1.2 - 5 cm in diameter. This takes place early in the morning.

2.1.2.3 Spices

It is essential that the spice is harvested correctly. The main obstacle to correct harvesting is the crop being picked immature. This is usually due to fear of theft or the farmer requiring money urgently. However, every effort should be made to wait until the spice is fully mature.

2.1.3 Grading/Quality

The criteria for essential oil quality are based on its color which is most oils should be clear, colorless and clean. Murky oil is a sign of water being present. Besides that the odor of the essential oils is also one of the criteria for essential oil quality because the odors are specific to the areas in which the plant is grown. This makes it very difficult for new producers to enter the market. Relative density, refractive density, optical rotation, solubility in ethanol and content of specific chemicals are also the other criteria for essential oil quality.

It is important to acquire only the purest essential oils, oils which have not been diluted or adulterated with any other oil or substance. As with most crops, oil quality varies from season to season and from supplier to supplier. Only the top quality first distillation oils should be used to maintain the highest possible standard. Essential oils need never be tested on animals. One of the most accurate methods of testing is liquid gas chromatograph, a proven scientific technique which identifies the active ingredients of each extract. The yield of oil is individual to each plant.

2.2 PROPERTIES AND USES OF THE ESSENTIAL OILS

Each essential oil has its own properties and uses which can classified and identified accordingly to the type of plant it was derived. Table 2.2 shows the properties and uses of the top essential oil. (Lawless, Julia., 1995).

Table 2.2: Properties and Uses of the Top Essential Oils.

Essential oil	**Biological Name**	**Properties**	**Uses**
Clory Sage	*Salvia Sclarea*	Warming, soothing, antiseptic, anticonvulsive, astringent, antiphlogistic, digestive, deodorant, tonic, uterine, bactericidal, antidepressant.	Menstrual problems, anxiety, depression, high blood pressure, acne boils, oily skin and hair, cramp, migraine, the genitor-urinary system disorders such as amenorrhoea, wrinkles, ulcers.
Eucalyptus	*Eucalyptus Globulus*	Antiseptic, analgesic, antineuralgic, antirheumatic, antispasmodic, diuretic, expectorant, antiviral, hypoglycaemic, febrifuge, vulnerary, depurative, stimulant.	Muscular aches and pains, poor circulation, rheumatoid arthritis, asthma, bronchitis, flu, cold, epidermics, chicken pox, headaches, neuralgia, throat infections, skin disorders such as burns, cuts, herpes, wounds, insect bites.
Geranium	*Pelargonium Graveolens*	Soothing, refreshing, relaxing, antidepressant, astringent, antiseptic, antihaemarrhagic, deodorant, diuretic, fungicidal, anti-inflammatory	Anxiety, adrenocortical glands and menopausal problems, sore throat, tonsillitis, cellulites, engorgement of breast, broken capillaries, eczema, hemorrhoids, oily complexion, mature skin, ulcers, wounds.
Jasmine	*Jasminum Officinale*	Analgesic (mild), antidepressant, anti-inflammatory, antiseptic, antispasmodic, aphrodisiac, carminative, cicatrisant, expectorant, galactagogue, sedative, tonic (uterine)	Depression, nervous exhaustion and stress related conditions, jasmine is said to produce the feeling of optimism, confidence, euphoria, and it is especially good in cases of apathy, indifference, or listlessness. Jasmine is also used for catarrh, coughs, laryngitis, dysmenorrhoea, labor pains,

			uterine disorders, skin problem such as dry, greasy, irritated, sensitive skin, and for muscular spasms and sprains.
Lavender	*Lavendula Vera Officinalis*	Analgesic, anticonclusive, antidepressant, antimicrobial, antirheumatic, antiseptic, antispasmodic, antitoxic, deodorant, sedative, diuretic, choleretic, hypotensive, stimulant, tonic, vulnery, cytophylatic, insecticide	Excellent first aid oil. It soothes cuts, bruises and insect bites. One of the most versatile therapeutic essences. For nervous system disorders such as depression, headache, hypertension, insomnia, migraine, sciatica, shock. Useful in treating skin conditions such as acne, allergies, athlete's foot, boils, dandruff, dermatitis, sunburn, eczema. Treatment of disorders such as rheumatism, throat infections, flu, bronchitis, and asthma.
Lemon	*Citrus Limonum*	Refreshing, antiseptic, stimulating, anti-anaemic, antirheumatic, antisclerotic, antitoxic, hypertensive, antiscorbutic, bactericidal, insecticidal, astringent, tonic,	Warts, depression, acne and indigestion, arthritis, cellulites, high blood pressure, nosebleeds, obesity, poor circulation, rheumatism, asthma, throat infections, bronchitis, cold, fever, flu. Treatment of anemia, brittle nails, corns, mouth ulcers, greasy skin, cuts, spots, and varicose veins.
Peppermint	*Menthe Piperita*	Digestive, cooling, refreshing, mentally stimulating, analgesic, anti-inflammatory, antimicrobial, antiseptic, antiviral, astringent, expectorant, stomachic, hepatic, cordial, antispasmodic.	Muscle fatigue, bad breath, toothache, bronchitis, indigestion, and travel sickness, neuralgia, muscular pains, asthma, sinusitis, spasmodic cough, cramp, dyspepsia, skin problem such as acne, dermatitis, ringworm, scabies, and nausea.

Ylang Ylang	*Cananga Odorata ver genuina*	Antidepressant, anti-infections, euphoric, relaxant, antiseptic, hypotensive, aphrodisiac, nervine, regulator, sedative (nervous), stimulant (circulatory), tonic	Depression, nervous tension, high blood pressure, hyperpnoea, (abnormally fast breathing), tachycardia, digestive upsets. For skin care such as hair growth, acne, hair rinse, oily skin, irritated and insect bites. For nervous system disorders such as frigidity, impotence, insomnia.

From Table 2.2, it can be concluded that the significant use of the essential oil is mainly in pharmaceuticals industry where most of it have the anti-depressant properties. There are also some other ways to enjoy the magnificent scent of these natural ingredients. A few drops of essential oil in radiator fragrance or light bulb ring will fill the room with a wonderful fragrance and ambience. You can choose the oils depending on the mood. You can also add one drop of Geranium oil or Myrrh oil into your facial moisturizer to bring out a radiant glow in your skin. One interesting use of this oil is to freshen the shoes by only dropping a few drops of Geranium oil directly into your shoes or place a cotton ball dabbed with a few drops of lemon oil and leave it in the shoes overnight. For student, they are recommended to use rosemary oil while reading, studying or during exams. This is because this oil is believed to promote alertness and stimulate memory. There are many other ways to apply these oils. But in this study, we do not focus on the use of it but we focus on the production of the oil.

2.3 HAZARDOUS ESSENTIAL OILS

One should bear in mind that not all essential oil are safe to be used in aromatherapy even with or without the express administration by a qualified aromatherapy practitioner. This is due to the high toxicity levels that the essential oils might have. Some of the oil can be hazardous as they can cause severe dermal irritation and even damage the mucous membranes and delicate stomach lining in undiluted form. Hence dermal application should be avoided as a general practice; it is advisable to use essential oils only for external remedies. Oils that fall under this category are bitter almond, calamus, camphor (brown & yellow), cassia, cinnamon (bark), fennel (bitter), pine (dwarf), rue, sage (common), thyme (red), wintergreen, garlic, onion, mustard and wormwood.

2.3.1 Toxicity

Essential oil such as Ajowan, Basil (exotic), Camphor (white), Cassia, Cedarwood (Virginian), Cinnamon (leaf), clove (bud), coriander, Eucalyptus, fennel (sweet), hyssop, juniper, nutmeg, pepper (black), sage (Spanish), tagetes, thyme (white), turmeric, should be used only on dilution (at least 1:3) and for a maximum of two weeks due to toxicity levels.

2.3.2 Photo toxicity

Some oils can cause skin pigmentation if the applied area is exposed to direct sunlight. Essential oils such as bergamot, cumin, ginger, lemon, lime, orange; should not be used either neat or on dilution on the skin, if the area will be exposed to direct sunlight.

2.3.3 Pregnancy

Essential oils should be used in half the usual stated amount during pregnancy, because of the sensitivity of the growing child. Oils of adjoin, angelica, anise star, aniseed, basil, Cedarwood (all types), celery seed, cinnamon leaf, citronella, clary sage, clove, cumin, fennel (sweet), hyssop, juniper, nutmeg, Spanish sage, and thyme (white); should be totally avoided during pregnancy.

2.3.4 High blood pressure

Oils of hyssop, rosemary, sage (Spanish and common) and Thyme are to be avoided in case of high hypertension.

2.3.5 Dermal/skin irritation

Oils of basil (sweet), black pepper, borneol, cajeput, caraway, Cedarwood (Virginian), cinnamon (leaf), clove (bud), eucalyptus, garlic, ginger, lemon, peppermint, pine needle (scotch and longleaf), thyme (white) and turmeric; especially if used in high concentration may cause irritation to the skin.

2.4 EXAMPLES OF IMPORTANT ESSENTIAL OILS

Table 2.3 below shows few examples of an important essential oils which indicates their method of production, part of plant being used and also the chief constituents inside the essential oils of each plant (Naik S.N., Lentz.H., 1989).

Table 2.3: Examples of important essential oils

Name of oil	**Method of production**	**Part of Plant used**	**Chief constituents**
Almond, bitter	Steam	Kernels	Benzaldehyde 96%-98%
Bergamot	Expression	Peel	Linalyl acetate 40%, linalool 6%
Cinnamon	Steam	Bark	Cinnamic Aldehyde, eugenol
Clove	Steam	Buds	Eugenol 85%-95%

Eucalyptus	Steam	Leaves	Cineole 70%-80%
Jasmine	Cold pomade	Flowers	Benzyl acetate, linalool and esters
Lemon	Expression	Peel	d-Limonone 90%
Rose	Steam, solvent, enfleurage	Flowers	Geraniol and citronellol 75%
Sandalwood	Steam	Wood	Santalol 90%, esters 3%
Wintergreen	Steam	Leaves	Methyl salicylate 99%

2.5 EXTRACTION OF ESSENTIAL OILS

2.5.1 Introduction

Essential oils can be extracted using a variety of methods, although some are not commonly used today. Currently, the most popular method for extraction is steam distillation, but as technological advances are more efficient then the economical methods has being developed which is solvent extraction method.

There are several extraction methods for making resins and extracts from plants, and each will be discussed briefly below. Some plants contain alkaloids as part of their chemical composition, and these different alkaloids will extract into different solvents. For example, *Blue Lotus* contains alkaloids that will only extract into alcohol, whereas *Amanita muscaria* contains an alkaloid that will extract into water, but will be destroyed in alcohol. When doing resin extractions from plants, it is important to know what chemical compounds will extract into what solvents.

2.5.2 Methods Available for Extraction

Various extraction methods can be used in the manufacturing of essential oils. The methods employed are normally dependant on type of botanical material being used. But there are exceptions which is for instance the CO_2 extraction is a great way to extract most oils, but the huge cost involved in following this method at the moment, would place it out of the financial reach of most people. Although the extraction of essential oils may sound only to be of technical interest, it is one of the key points which determine the quality of the oil that is used, since a wrong or wrongly executed extraction, can damage the oil, and alter the chemical signature of the essential oil.

Volatile oils can be recovered from plants by a variety of methods which are steam distillation, enfleurage, supercritical fluid extraction using CO_2 and solvent extraction.

2.5.2.1 Steam Distillation

Steam distillation is usually carried out at atmospheric pressure. If the constituents of oil are subjected to hydrolysis, the process is carried out in a vacuum. Much distillation for essential oil is done at the harvest side in extremely crude stills. These stills are converted oil drums or copper pots equipped with pipe condensers running through the water tubs. The efficiency is low, and the oil is contaminated with pyrolysis products.

It was the most common method of extracting essential oils. Steam distillation is done in a still. Fresh, or sometimes dried, botanical material is placed in a closed container of the still, and pressurized steam is generated which enters the container and circulates through the plant material. The heat of the steam forces the pockets that hold the essential oils to open and release them. Tiny droplets of essential oil evaporate and attach to the steam, which then travels up a long tube surrounded by a cold water bath. The cold forces the steam to cool and condense back into water. Essential oils do not mix well with water so it forms a film on the water’s surface. To separate the essential oil from the water, the film is then decanted or skimmed off the top into a collection vial and the water into a large vat (Essentialoils., 2002).

2.5.2.2 Enfleurage

The enfleurage process is a cold fat extraction process used on a few types of delicate flowers (Jasmine, Tuberose, Violet etc), which yield no direct oil on distillation. Enfluerage process is mainly applied to flowers that do not yield appreciable amounts of oils by steam distillation method or which are too delicate to withstand the temperature of boiling water.

In this method, chassis (glass plates in a frame) are covered with highly purified and odorless vegetable or animal fat and the petals of the botanical matter that are being extracted are spread across it and pressed in. The flowers are normally freshly picked before it encased in their fatty bed. The petals remain in this greasy compound for a few days to allow the essence to disperse into the compound, where the then depleted petals are removed and replaced with a fresh harvest of petals.

This process is repeated until the greasy mixture is saturated with the essence. When the mixture has reached saturation point the flowers are removed and the enfleurage pomade. The fat and fragrant oil are then washed with alcohol to separate the extract from the remaining fat, which is then used to make soap.

The mixture is then subjected to heating treatment to boil off alcohol and the remains of essential oil are collected. This method is very labor-intensive and subsequently very costly. This method is sometimes used to extract essential oil from tuberoses and jasmine (Essentialoils, 2002).

2.5.2.3 Supercritical Fluid Extraction Using CO_2

This process is another method of extraction using carbon dioxide gas which is kept under high pressure at a constant temperature. Plants are placed in a stainless steel tank and, as carbon dioxide is injected into the tank, pressure inside the tank builds up. Under high pressure, the carbon dioxide turns into a liquid and acts as a solvent to extract the essential oils from the plants. When the pressure is decreased, the carbon dioxide returns to a gaseous state, leaving no residues behind. The equipment for this process is very expensive and so are the resulting oils. Carbon dioxide extractions have fresher, cleaner, and crisper aromas than steam-distilled essential oils, and they smell more similar to the living plants because high heat is not used. This extraction method produces higher yields and makes some materials easier to handle. Many essential oils that cannot be extracted by steam distillation can be obtainable with supercritical carbon dioxide extraction.

There are many positive aspects of the supercritical CO_2 extraction process and the resultant supercritical CO_2 essential oils. The CO_2 supercritical extraction process eliminates the need for potentially harmful solvents like hexane, avoiding unnecessary environmental pollution and potential human bodily harm. Another very important consideration is that the supercritical CO_2 extraction process avoids heat degradation to the plant matter, producing an essential oil that is a more authentic version of the original plant matter (Scalia.S., Giuffreda.L., Pallado.P., 1999).

Another positive aspect to the CO_2 distillation process is the aroma of the essential oil. The CO_2 supercritical extract offers a more genuine aroma of the actual herb, spice or plant. The aroma of the CO_2 extracts of ginger, cardamom and other spices are more active, spirited and warm in nature than the rather flat and lifeless aroma of the same plants that have been steam distilled.

Finally, many people are concerned with the higher unit for unit price of the CO_2 extracted essential oil. Although the supercritical extracts often cost more initially, they are typically more concentrated and thus less of these oils is needed in the production of formulas. Because can generally use less of the CO_2 essential oil than the hydro or steam distilled oil, the higher price is sometimes offset (Aroma, 2004).

2.5.2.4 Solvent Extraction

A hydrocarbon solvent is added to the plant material to help dissolve the essential oil. When the solution is filtered and concentrated by distillation, a substance containing resin (resinoid), or a combination of wax and essential oil (known as concrete) remains. The most important factor in a success of this practice is the selection of the solvent. The solvent must be selective, which is quickly and completely dissolve the odoriferous components, but have only a minimum of inert matter, have a low boiling point, be chemically inert to the oil, evaporate completely without leaving any odorous residue, low priced and, if possible, non-flammable.

Solvent extraction uses very little heat so it's able to produce essential oils whose fragrance would otherwise be destroyed or altered during steam distillation. Solvent extraction is used on delicate plants to produce higher amounts of essential oils at a lower cost. In this process, a chemical solvent such as hexane is used to saturate the plant material and pull out the essential oils. The plant is removed and this renders a solvent. The solvent is then boiled off under a vacuum or in a centrifugal force machine to help separate it from the essential oil. Because the solvent has a lower boiling point than the essential oil, it evaporates and the oil is left.

The solvent is cooled back into liquid and reclaimed. Along with the essential oil, the fats, waxes, and heavier oils can be extracted. This produces a substance called a concrete. The process is continued by dissolving oils into warm alcohol. The alcohol is removed under a vacuum and pure essential oil is left. Although more cost-efficient than enfleurage, solvent extraction is more expensive than steam distillation and least costly compare to CO_2 supercritical extraction, so it is reserved for costly oils which cannot be distilled. A solvent extracted essential oil is called an absolute (Aroma, 2004).

2.6 INTRODUCTION OF JASMINE FLOWER

Jasmine is one member of a genus of about 200 species of shrubs and climbing vines that are native to tropical areas of Southeast Asia, Africa and Australia. The popularity of their fragrance has resulted in many species of jasmine now being grown all over the world. True jasmine grows as a climbing vine with oval, shiny leaves and tubular, waxy white flowers. Two types of jasmine are used for the extraction of oil. Some botanist describes them as two distinct species: *J.grandiflorum* and *J.oficinale,* while others consider *J.grandiflorum* to be a variety of o*ficinale* (Lotus, 2003). The oil of the flowers is virtually identical; for aromatherapy purposes they are used interchangeably. Jasmine has always presented special problems to those who attempt to extract its alluring perfume. Although the plant blooms reliably and consistently, it only produces a few delicate flowers per plant over a period of days to weeks. These flowers last only one day, but continually produce essential oil before they wither and die. The scientific name of the flower used for this experimental purpose was *Jasminum oficinale.*

Botanical Name	: *Jasminum oficinale*
Family Name	: Oleaceae
AKA	: *Jasminum grandiflorum, Jasminaceae*
Local Name	: Melur

Figure 2.1: The picture of bloomed jasmine flower

2.7 JASMINE PLANTS

2.7.1 Description

Jasmine is an evergreen fragile climbing shrub that can grow up to 10 meters (33 feet) high. It has dark green leaves and small white star-shaped flowers, which are picked at night when the aroma is most intense. An experienced picker can pick 10,000-15,000 blossoms per day (Ashbury's, 2003).

2.7.2 Distribution

The plant is native to China, but China produces very little essential oil. Most of the essential oil produced is from India, France, Morocco, Algeria, Egypt, Italy and Turkey. Called the "King of Flower Oils", this oil has been famous since the earliest days as an aphrodisiac. It was used widely in Indian and Chinese medicine. It arrived in Europe through Spain when the Moors conquered the area (Ashbury's, 2003).

2.8 JASMINE ESSENTIAL OILS

The essential oil is very costly, of which the French oil is the most expensive, because of the enormous quantity of flowers needed to produce a relatively small amount of oil. The labor costs are also pushed up because the flowers are gathered at night. Remember that "bargains" in Jasmine oil should be questioned by knowledgeable therapists.

Jasmine works primarily on the emotional level. It has been found to have a significant effect on psychological and psychosomatic problems. Its use is especially good when these are linked to an emotional problem. It is useful when someone lacks confidence or self esteem. It is described as uplifting.

Jasmine is therefore, an excellent anti-depressant and very useful when treating impotence or frigidity resulting from anxiety and tension. Table 2.4 below show the general information of jasmine flower essential oils (Ashbury's, 2003):

Table 2.4: General Information of Jasmine Flower Essential Oils

General Information of Jasmine Flower Essential Oils	
Odor	Rich, warm and floral
Color	Dark-orange brown
Conventional Method of Production	A concrete is produced by solvent extraction. The absolute is produced from alcohol separation of the concrete. The absolute then can be steam distilled.
Source of Oil	Blossoms
Representative Constituents	Alcohol: benzyl acetate benxyl alcohol - Ester: benzyl benzoate - Ketone: cis-jasmone - Phenol: eugenol - Ester: indole, methyl anthranilate, methyl jasmonate
Extraction	1,000 lbs of flowers yield approximately one pound of liquid concrete, which yields 0.2% aromatic molecules.
Precautions	Jasmine oil is non-toxic, non-irritant and generally non-sensitizing, although some people do have an allergic reaction to the oil. As jasmine oil is used to ease labor as well as an emmenagogue, it should not be used during pregnancy. It can impede concentration, so should be used with care.
Uses	It is a valuable remedy in cases of severe depression. It soothes the nerves and produces a feeling of confidence, optimism and euphoria. It revitalizes and restores energy. Jasmine oil facilitates delivery in childbirth: it hastens the birth by strengthening the contractions.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter focuses on the achievement of the conceptual study, laboratory work, analyzing and completion of the project. The detailed experimental procedure will be discussed throughout this chapter. There are three main stages in achieving jasmine essential oils through this experiment.

i. Sample preparation
ii. Jasmine essential oil extraction
iii. Product analysis

3.2 OVERALL METHODOLOGY

Experimental work was divided into two parts. The first part is to determine the optimum feed ratio of jasmine flower to ethanol solvent where it had been conducted with three different ratio which is shown in Table 3.1 below;

Table 3.1: Flower to ethanol solvent ratio

Ratio	**Flower (gram)**	**Ethanol (mL)**
1 : 2	50	100
1 : 5	20	100
1 : 10	20	200

The second part, where experimental results were analyzed using appropriate method and apparatus. It consists of analyses of the optimum feed ratio, as well as the identifications of the extracts constituents. Figure 3.1 shows the outline of the methodology employed in this work.

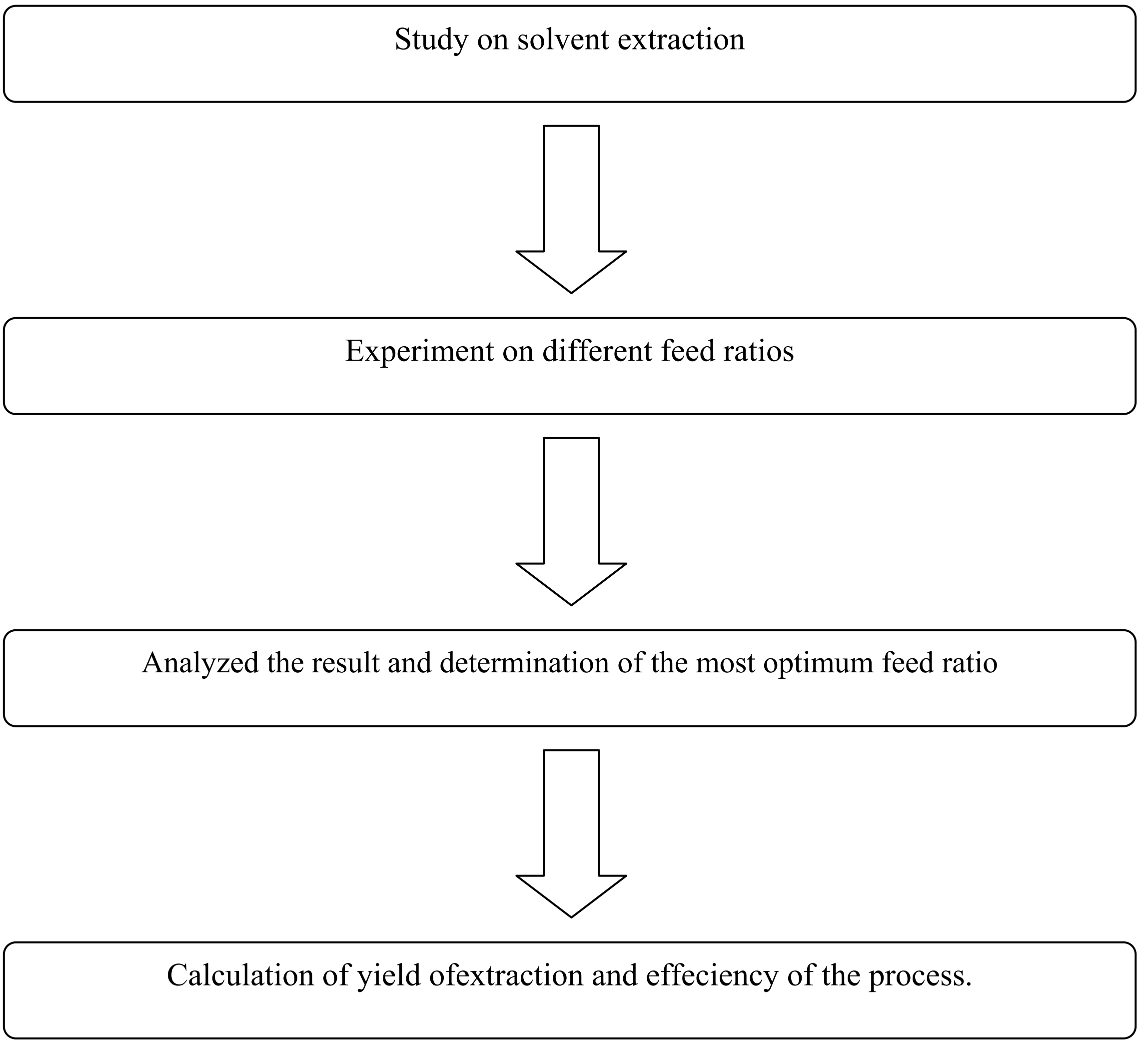


Figure 3.1 Outline of the overall methodology

3.3 EXTRACTION EXPERIMENTAL WORK

3.3.1 Sample Preparation

Jasmine flowers which were about to bloom were used as sample. Selected jasmine's petals is prepared in three different ratios of flower to ethanol solvent as described in Table 3.1. Jasmine flower was blended. Extraction of essential oils from jasmine flower is a mass transfer controlled extraction (very much depends on the matrix-solvent interface; thus the geometry of sample) due to its minute amount. Since the essential oils are normally located inside the 'pocket' of flower, a suitable method had been worked out to expose these 'pockets' for an efficient extraction. Then, each of the samples would be soaked for two days respectively in solvent ethanol

3.3.2 Apparatus and Procedures

3.3.2.1 Apparatus: Rotary Evaporator

The schematic diagram of the experimental apparatus used for both experimental studies is shown in Figure 3.2. It consists of evaporator flask (2L), receiving flask (solvent recovery), adjustable hot bath temperature (range 30^{o}C to 100^{o}C), rotation speed controller, one condenser for standard and reflux distillation (cooling water), vacuum pump and silicon surrounding the bath for the protection. It also has an individual switches for rotation speed and bath temperature. The temperature of each sample was controlled by its water bath temperature. The solvent will be evaporated and left inside the receiving flask while the essential oils remained inside the evaporator flask. Below is the procedure for each experimental work that had been done in this study.

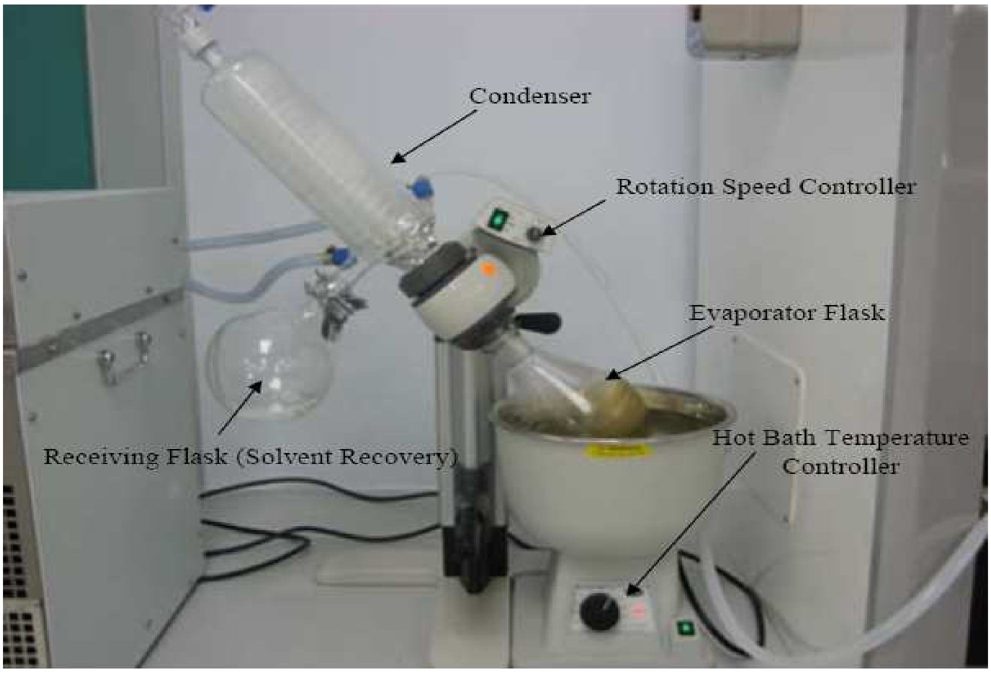


Figure 3.2: Rotary Evaporator

3.3.2.2 Procedure: Experimental Work

3.3.2.2.1 Extraction using ethanol

Table 3.2: Experiment conditions

Reagent	Ethanol
Solvent boiling point	Ethanol (78°C)
Pressure	Vacuum Pressure
Rotation Speed	5 rpm

3.3.2.2.2 Overall experimental works:

In both experimental processes, solvent is used to saturate the jasmine flowers and extract the essential oils from the flower. After two days of soaking the flowers had been filtered to separate it from the essential oils and the oils that had been collected were being evaporated to separate it from the solvent. Because the solvent has a lower boiling point than the temperature that had been set for the water bath, so it will evaporate and only the oils left. The solvent is condensed into liquid and reclaimed. Along with the essentials oils were fats, waxes, and heavier oils. The overall methodology flow chart of solvent extraction for both experiments was shown in Figure 3.3 below.

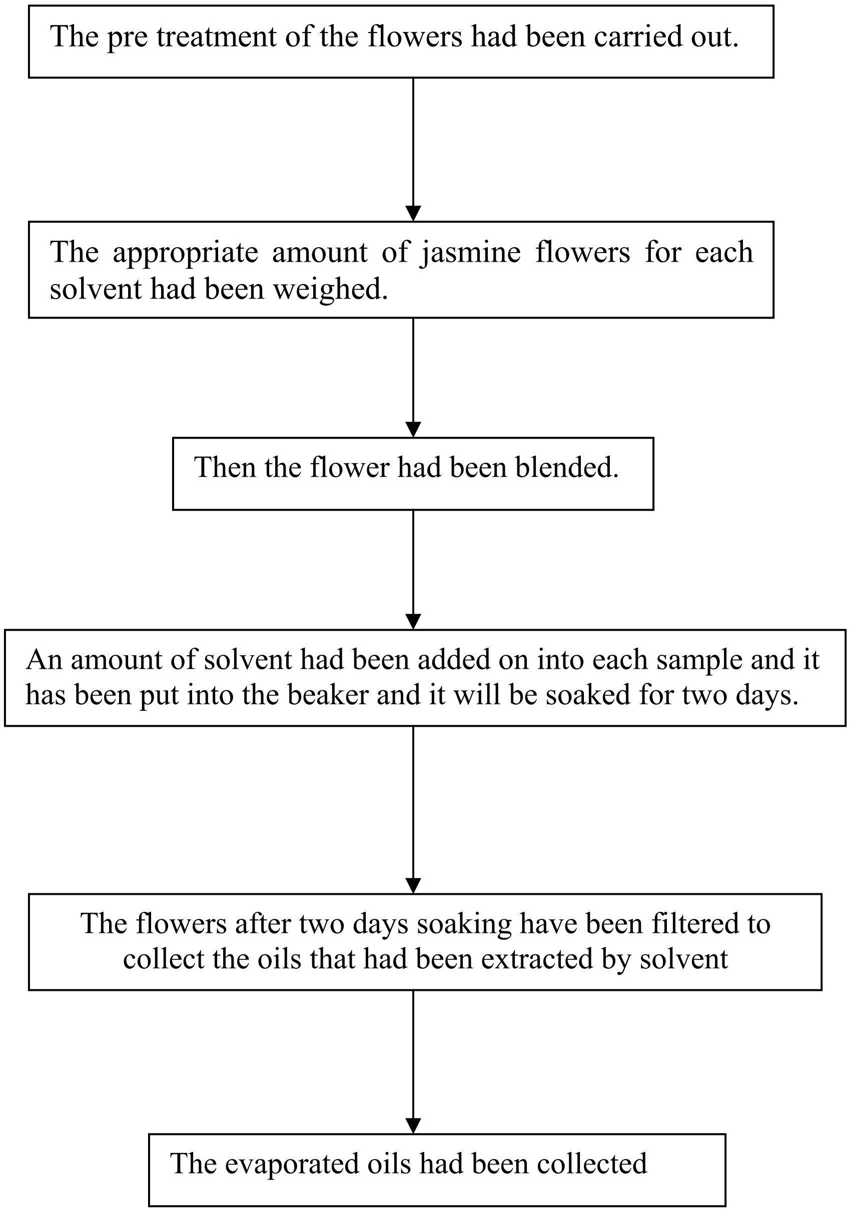


Figure 3.3: Overall methodology of solvent extraction

3.2.3 Analysis

3.2.3.1 Analysis of Essential Oils Using Gas Chromatography

Gas chromatography analyses of the essential oil samples were carried out using a gas chromatography (Agilent Technologies 6890N USA) equipped with flame ionization detector (FID), and capillary column 25.0 m x 450 μm x 1.20 μm nominal. Helium was used as the carrier gas at 30 cm/sec flow rate and 2.92 psi inlet pressure. Temperature was programmed from 40°C to 260°C with a final hold time of 3 min. Injector and detectors were maintained at 250°C and 300°C, respectively. 1 μL of oil samples were injected using a syringe.

3.2.3.2 Identification of essential oil constituents

Essential oil constituents were identified by comparing retention times of the chromatogram peaks with those of reference compound run under identical conditions. Analytical results were obtained using the reference compounds based on the area ratio between target components and the reference compounds. Figure 3.4 shows computerized GC System.

Figure 3.4: Computerized GC System

3.3.3.3 Calculation of yield of the extracts.

The amount of percentage yield of the extracts obtained from these experiments was calculated using Eqn 3.1 as shown below.

Yield of the essential oil (%)

$$= \frac{\text{amount of essential oil (g) obtained}}{\text{amount of jasmine flower (g) used}} \times 100\% \qquad \text{(Equation 3.1)}$$

3.3.3.4 Calculation of effeciency of the process.

Efficiency of the extraction process (%)

$$= \frac{\text{Amount of oil (g) recovered from solvent}}{\text{Amount of oil (g) dissolved in solvent}} \text{ X } 100\% \qquad \text{(Equation 3.2)}$$

CHAPTER 4

RESULTS AND DISCUSSION

4.1 QUALITATIVE ANALYSIS

This chapter discusses based on the data from the experiment that had been carried out. The results describe on the analysis of the component of jasmine essential oils based on the literature and comparing the purity of this oil by varying the ratio of solvent and jasmine flower. The samples of jasmine essential oils were compared with the standard component of jasmine essential oils which is benzyl benzoate as the first component and benzaldehyde as a second identification component in this oil. The qualitative analysis has been done using gas chromatography with a suitable method.

4.1.1 GC Analysis of Standard Benzyl Benzoate (1%, 2%, 3%5% and 10% concentration)

In this result, it is important to determine the retention time of Benzyl benzoate using the method that have been set in the gas chromatography in order to clarify the existing of this component in the sample of jasmine essential oils from the experiment. As a result for the benzyl benzoate analysis in Figure 4.1, Figure 4.2, Figure 4.3, Figure 4.4, Figure 4.5, Figure 4.6, it is found that this compound has retention time of 0 min (1%), 0 min (2%), 17.837 min (3%), 17.827 min (5%) and 18.408 min (10%). This result was also confirmed by the data from the literature (refer Appendix A) that showed almost for the GC analysis the retention time of benzyl benzoate is between 17 to 18 min depending on the method used. For this reason, this compound is assumed as reference compound to monitor the sample of jasmine essential oils from the experiment.

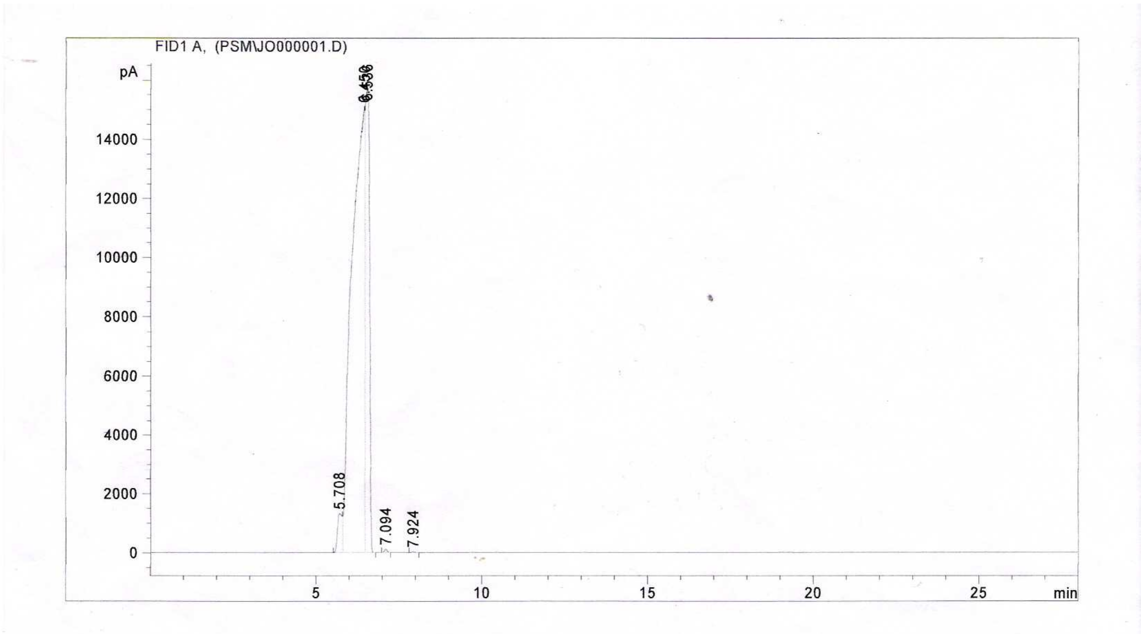


Figure 4.1: GC Analysis of Standard Benzyl Benzoate (1%)

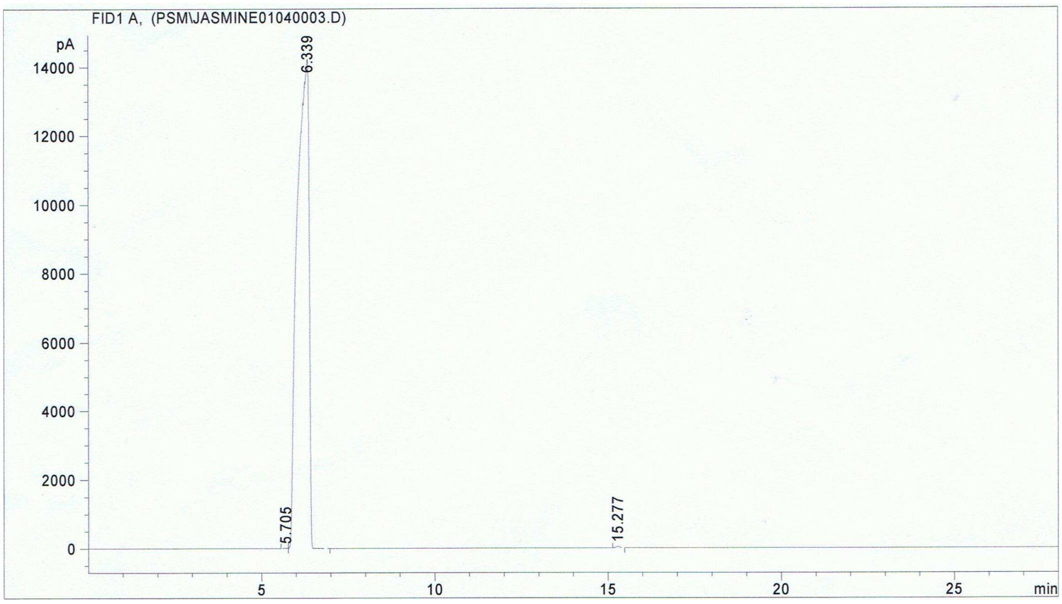


Figure 4.2: GC Analysis of Standard Benzyl Benzoate (2%)

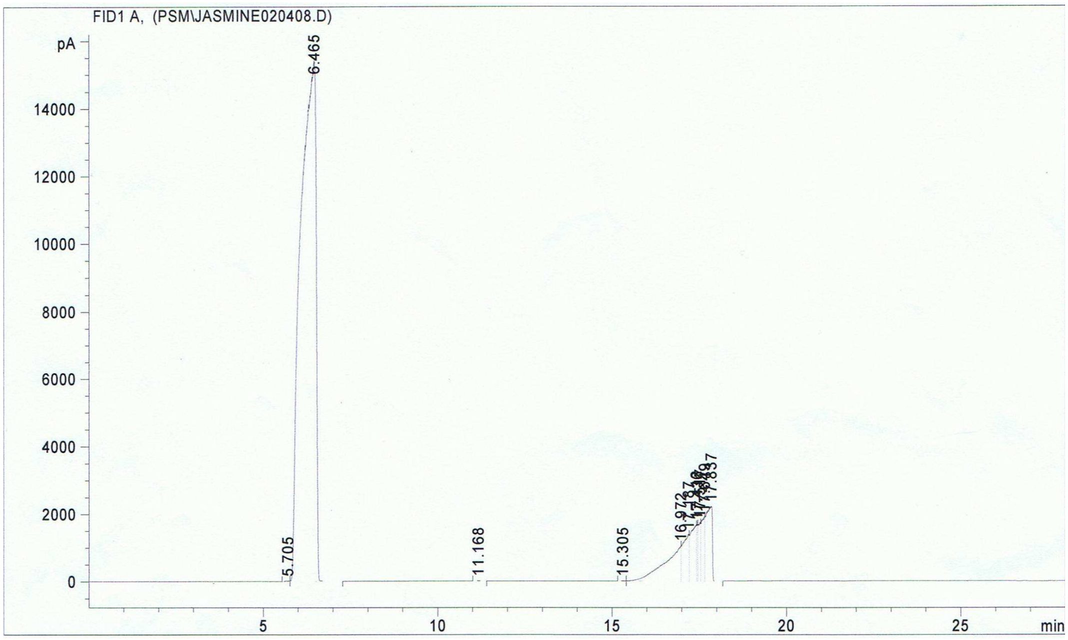


Figure 4.3: GC Analysis of Standard Benzyl Benzoate (3%)

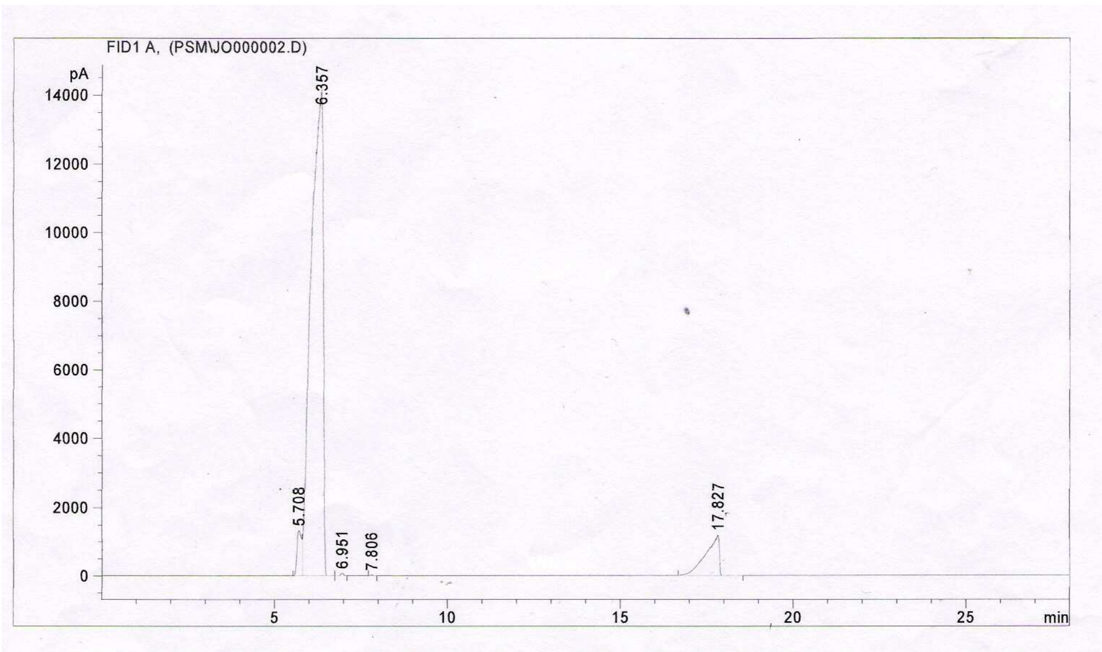


Figure 4.4: GC Analysis of Standard Benzyl Benzoate (5%)

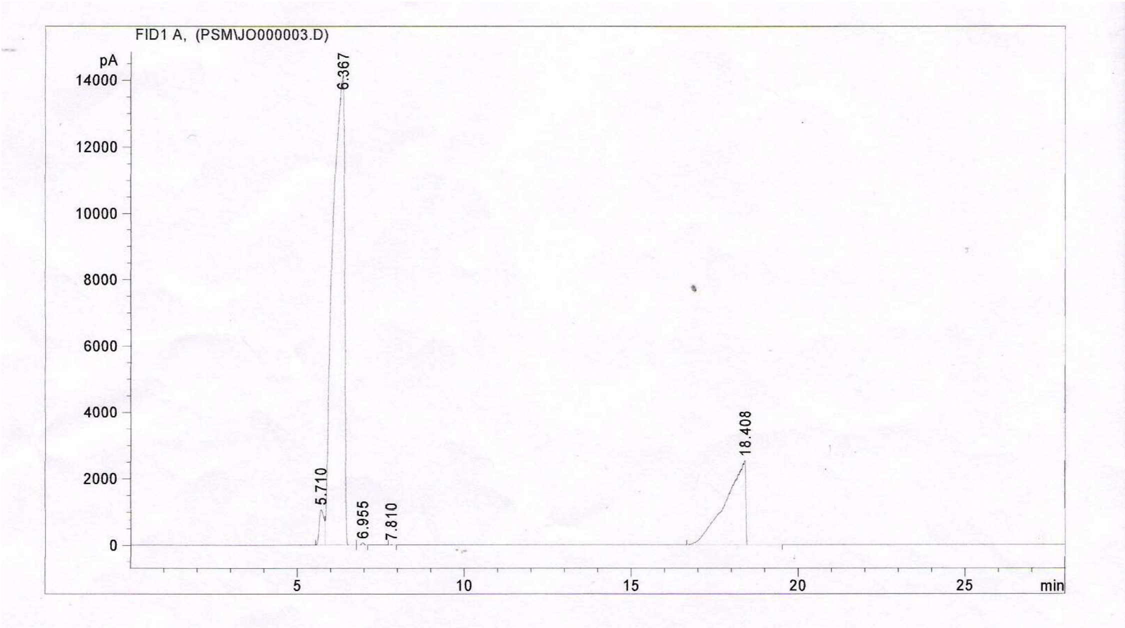


Figure 4.5: GC Analysis of Standard Benzyl Benzoate (10%)

4.1.2 GC Analysis of Standard Benzaldehyde (1%, 2%, 3% 5% and 10% concentration)

Ethanol is being found at the retention time of 6.415 min in the chromatograph result in Figure 4.6, Figure 4.7, Figure 4.8, Figure 4.9, Figure 4.10. The retention time of ethanol is 6.415 min and this had been used as a reference to determine the solvent in the sample of jasmine essential oils. Based on the chromatograph that have been shown in Figure 4.1, Figure 4.2 and Figure 4.3 when the standard benzaldehyde had been analyzed, the retention time are 15.416 min (1%), 15.479 min (2%), 15.554 min (3%), 15.751 min (5%) and 15.972 min (10%) can be considered as the peak for this compound while the other peaks are negligible and considered as the impurities inside the oil. Retention time for the benzaldehyde is range from 10 to 20 min depending on the method used in the GC analysis. Due to this reason, the benzaldehyde component had been assumed to be from 15 min to 16 min. It has been a reference to analyze the sample of jasmine essential oil that has been collected.

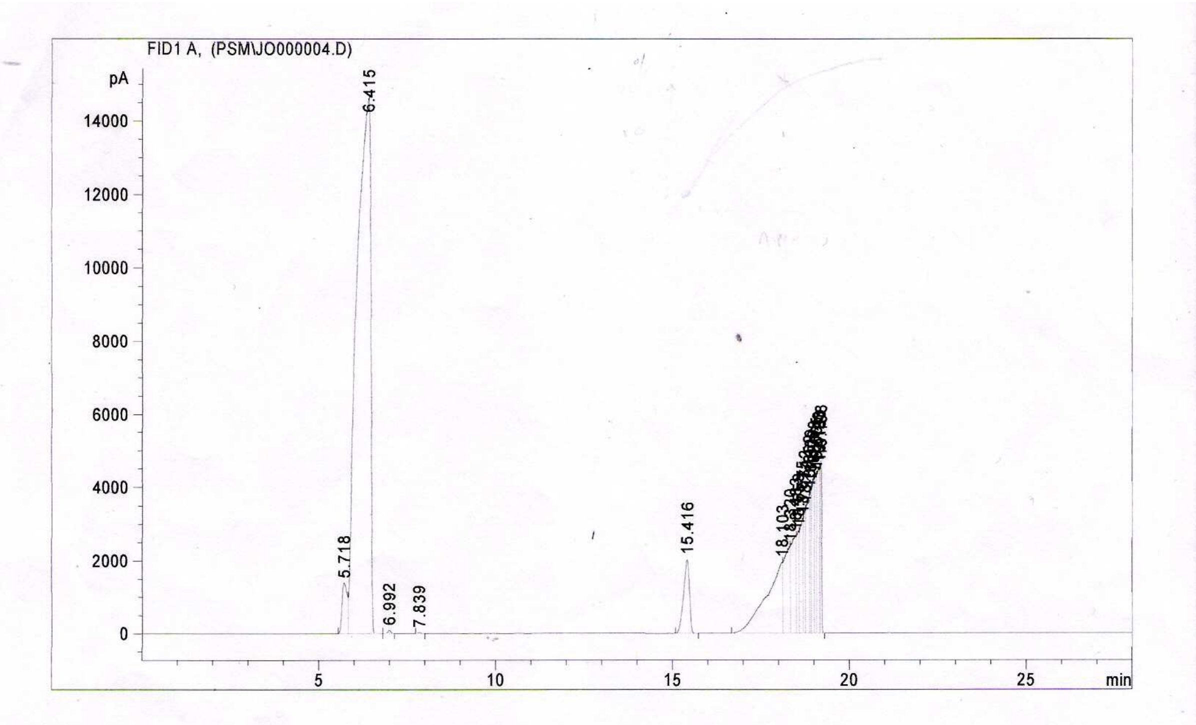


Figure 4.6: GC Analysis of Standard Benzaldehyde (1%)

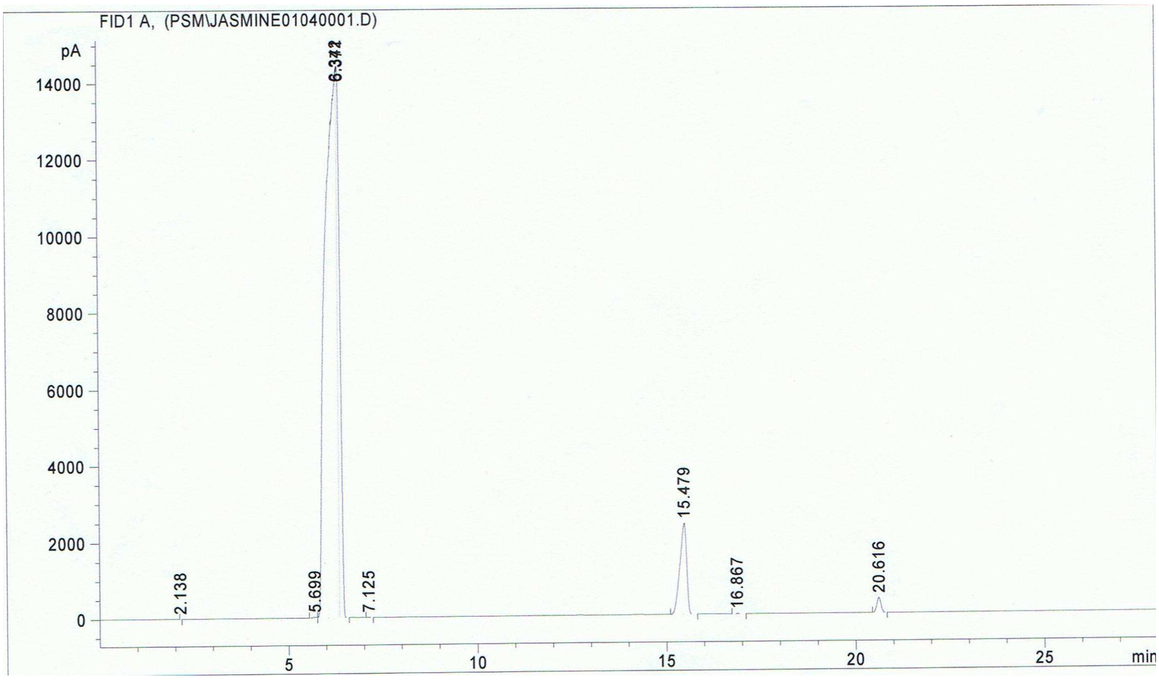


Figure 4.7: GC Analysis of Standard Benzaldehyde (2%)

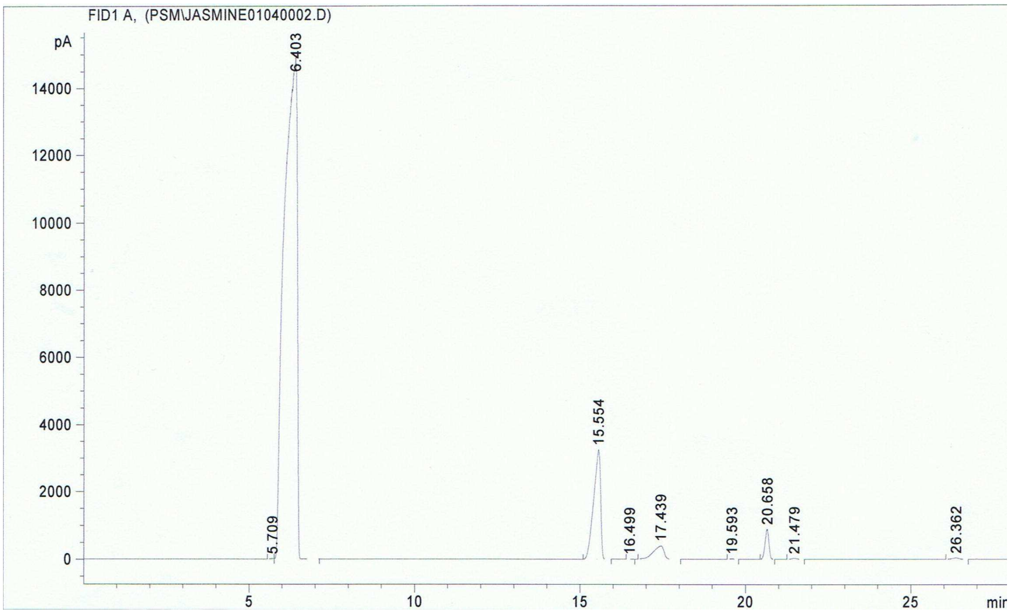


Figure 4.8: GC Analysis of Standard Benzaldehyde (3%)

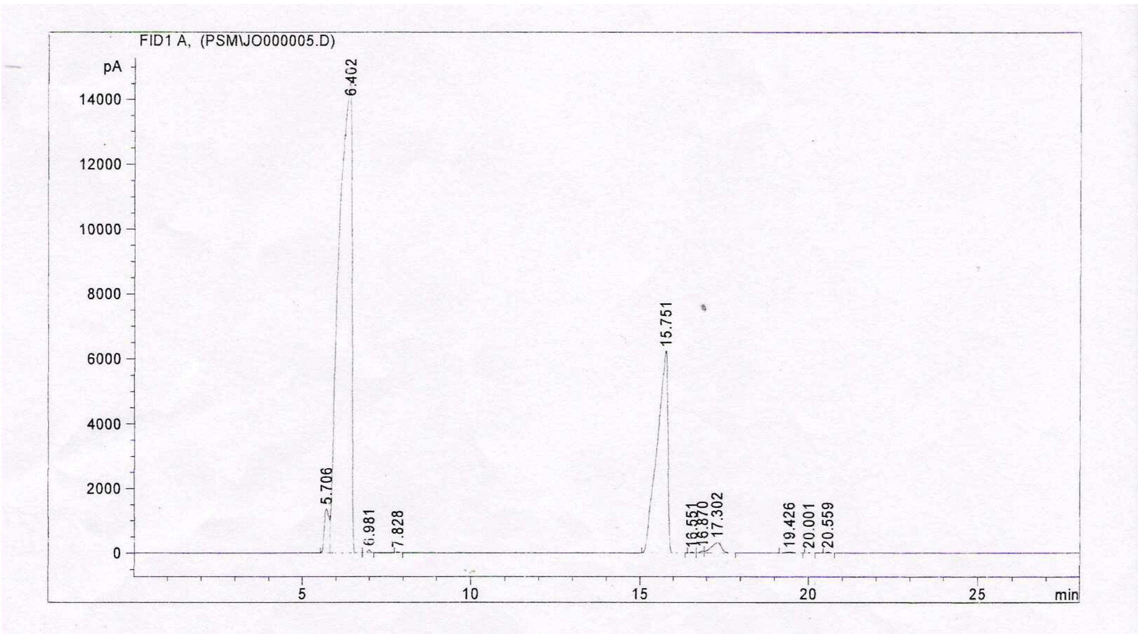


Figure 4.9: GC Analysis of Standard Benzaldehyde (5%)

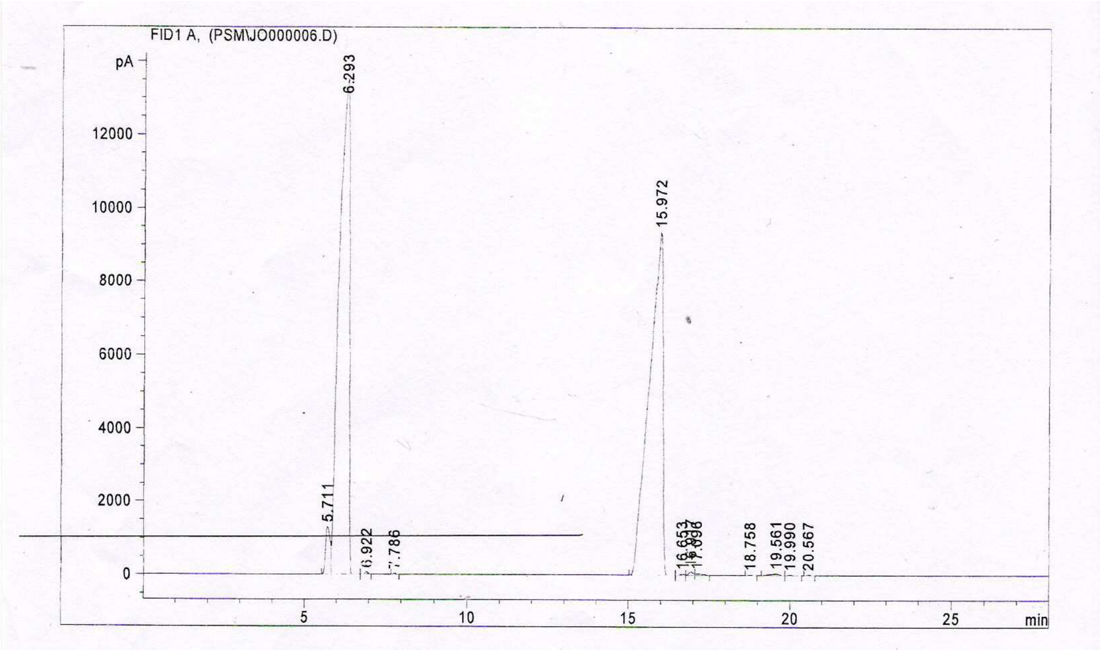


Figure 4.10: GC Analysis of Standard Benzaldehyde (10%)

4.1.3 GC Analysis of Jasmine Essential Oil for 1: 2 (Flower: Solvent) Feed Ratios

From the GC analysis in Figure 4.11 for the sample extracted by ethanol using 1: 2 (flower: solvent) feed ratio, ethanol has been found at the retention time of 6.396 min. While for the compounds of benzyl benzoate and benzaldehyde, both have been identified in this sample too. For benzyl benzoate, it exists at the retention time of 15.406 min while for the benzaldehyde, it has been found at 16.795 min. The existences of these two major components prove that the sample is jasmine oil. The concentration of the two components also is higher than the oil that extracted using 1: 5 and 1: 10 feed ratios (flowers: solvent). This is parallel with the literature that higher amount of jasmine flower will produce high amount of essential oils.

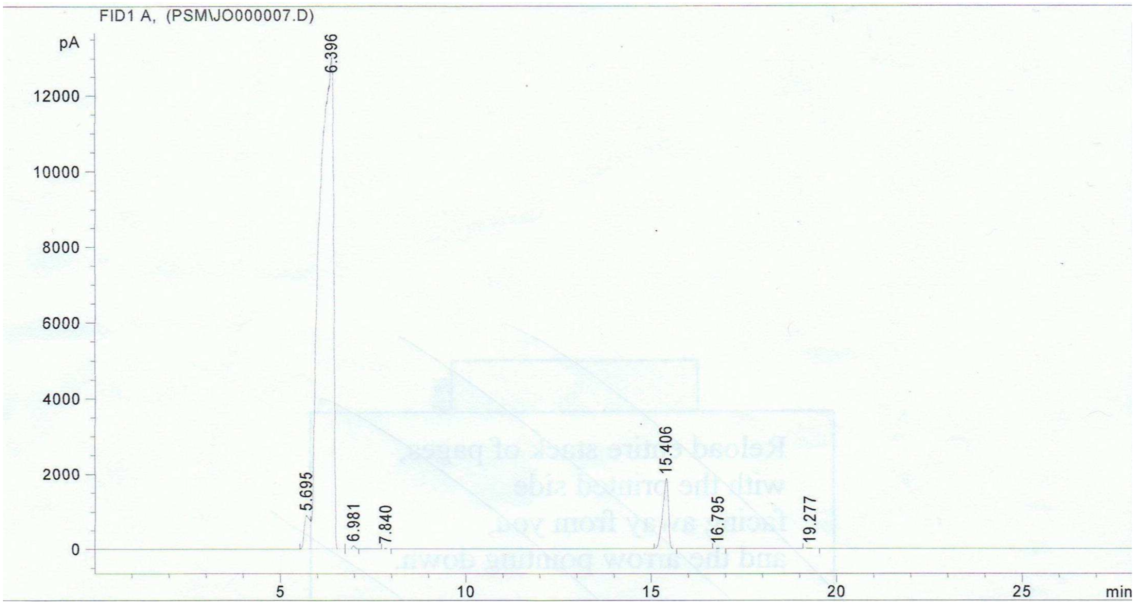


Figure 4.11: GC Analysis of 1: 2 Ratio Sample

4.1.4 GC Analysis of Jasmine Essential Oil for 1: 5 (Flower: Solvent) Feed Ratio

From the GC analysis in Figure 4.12 for the sample extracted by ethanol using 1: 5 (flower: solvent) feed ratio, solvent ethanol has been found at the retention time of 6.459min. For compound benzaldehyde, it exist at the retention time of 15.234 while for benzyl benzoate none of peak is been trace compared to the first sample which is the peak is exist. This is meant that, it was proved that some chemical constituent of these oils cannot be obtained by taking normal petal condition in this extraction process.

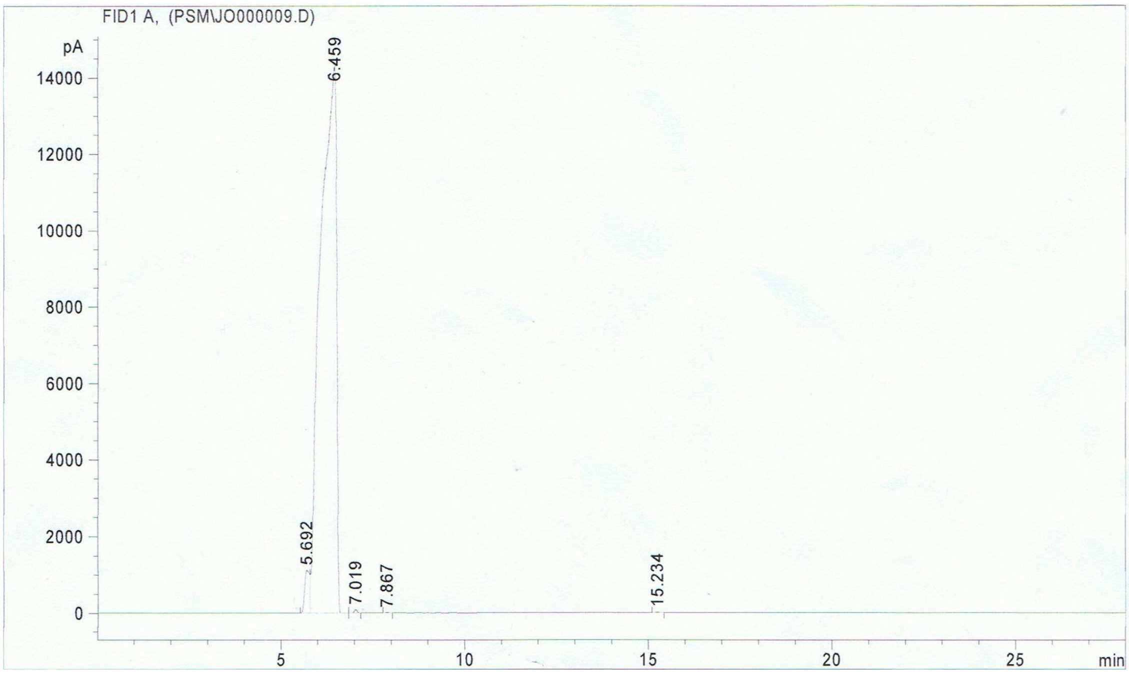


Figure 4.12: GC Analysis of 1: 5 Ratio Sample

4.1.5 GC Analysis of Jasmine Essential Oil for 1: 10 (Flower: Solvent) Feed Ratio

From the GC analysis in Figure 4.13 for the sample extracted by ethanol using 1: 10 (flower: solvent) feed ratio, ethanol has been found at the retention time of 6.191min. While for both component benzyldehyde and benzyl benzoate, only benzyldehyde is found at retention time of 15.116. This result is almost same case like second sample (1: 5 ratio). Based on this result it shows that the qualitative analysis of this sample is not the optimum result since there is still an amount of major component does not found.

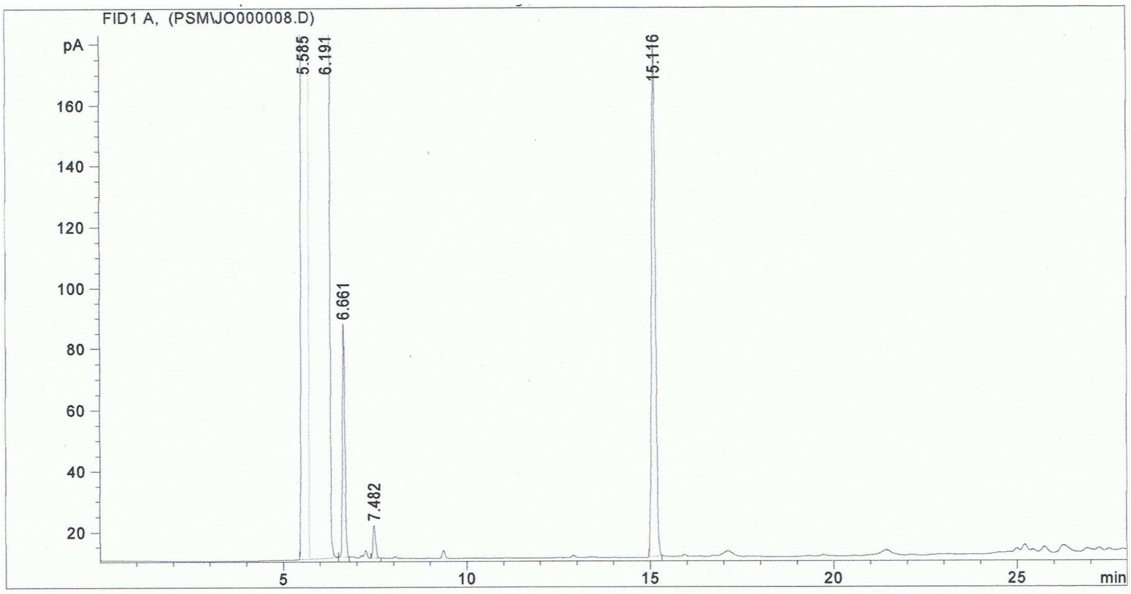


Figure 4.13: GC Analysis of 1: 10 Ratio Sample

4.1.6 Concentration of Benzaldehyde and Benzyl Benzoate in Jasmine Essential Oil Extract using different feed ratios

From the table 4.1 below we can see the data that show concentration of 2 components in Jasmine oil. The concentration was determined by using graph concentration versus peak area that plot using data from GC analysis. We can see that sample with 1: 2 (flower: solvent) ratio have higher concentration of benzyl benzoate and benzaldehyde.

Table 4.1: Concentration Data of Two Component in Jasmine Oil

Ratio (Flower : Solvent)	**Area (%)**	**Benzyl Benzoate Concentration(%)**	**Benzaldehyde Concentration(%)**
1 : 2 (50g : 100mL)	5.3843	2.6368	1.1617
1 : 5 (20g : 100mL)	0.0211	0.0103	0.0046
1 : 10 (20g : 200mL)	0.3338	0.1635	0.0720

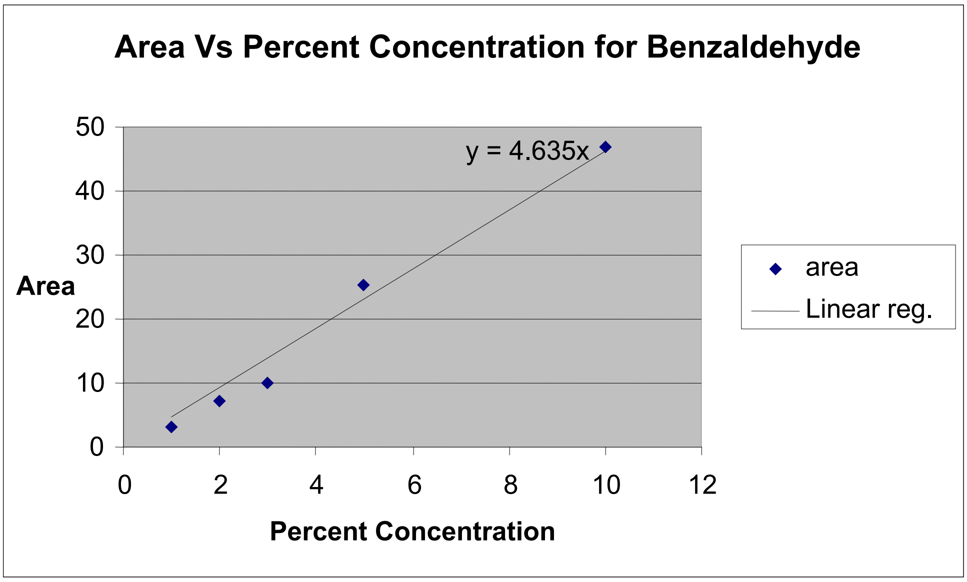


Figure 4.14: Area versus Percent Concentration for Benzaldehyde

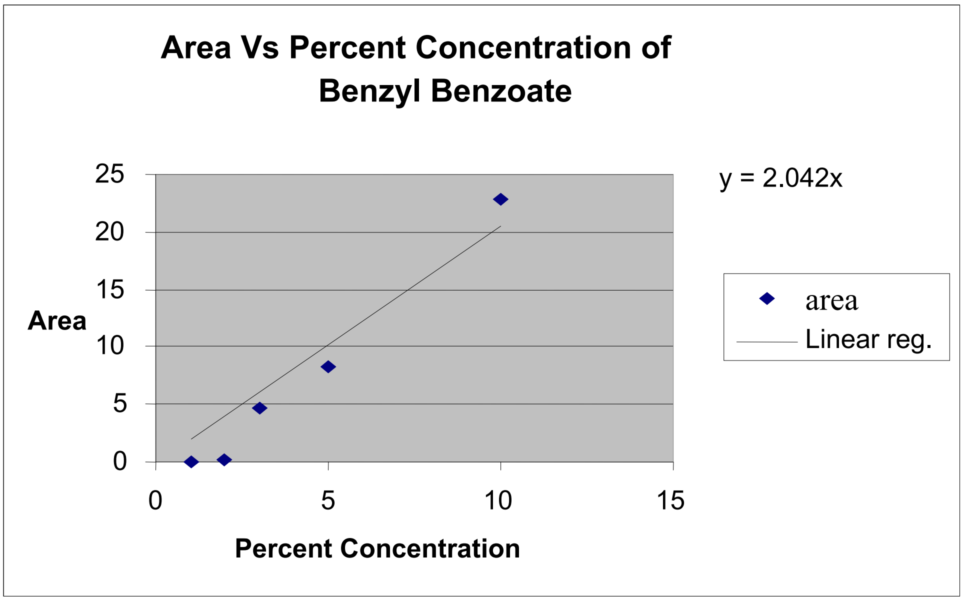


Figure 4.15: Area versus Percent Concentration for Benzyl Benzoate

4.2 QUANTITATIVE ANALYSIS

4.2.1 Efficiency of Extraction Process

Based on Table 4.2 that shows sample's feed ratio, oil dissolved in solvent,essential oil recovered and efficiency of extraction process, the efficiency of for different time of extraction ranged from 3.41% to 19%. Efficiency of extraction process also depends on the best effect ratio of jasmine flowers to ethanol solvent and equipment used. Besides that the ethanol in this sample is too much so it is quite difficult to recover higher amount of oil. As shown in the sample of 1: 2 feed ratio, extraction process is higher (19%) and it also recovered more amount of oil (25 ml) compared to the other samples but the oil recovery may remain lots of impuruties such as water and solvent during the putrities process using rotary evaporator.

Table 4.2: Sample's feed ratio , Oil dissolved in solvent, Oil recovery, Efficiency

Sample(Ratio) (Flower: Solvent)	Oil dissolved in solvent (mL)	Oil Recovery (mL)	Efficiency (%)
1 : 2 (50g : 100mL)	132	25	19
1 : 5 (20g : 100mL)	109	6.4	5.87
1 : 10 (20g : 200mL)	211	7.2	3.41

4.2.2 Yield of Jasmine Essential Oils

Based on the above experimental result in Table 4.3, 1: 2 feed ratio achieve the highest yield of oil which is 14.65% compared to other samples. Although there is yield of essential oil in this research but the recoveries of this oil are still low due to some factors.

From the experiment that had been done, the lower recoveries of essential oils were caused by two major reasons which are incomplete recovery of essential oil from the jasmine flower by ethanol and also loss of dissolved essential oil in condensate during evaporation process.

As a conclusion, the yield of jasmine essential will be much better and higher if there is no losses of the oil during the recoveries time and the research had been done in larger scale. Besides that the operating condition of equipment should be handled correctly to give the effective extraction process.

Table 4.3: : Sample's feed ratio, Amount of Flower Used, Oil recovery, Yield

Sample(Ratio) (Flower: Solvent)	**Amount of Jasmine Flower used(g)**	**Amount Of Oil Recovered(g)**	**Yield (%)**
1 : 2 (50g : 100mL)	50	7.3241	14.65
1 : 5 (20g : 100mL)	20	2.1154	10.58
1 : 10 (20g : 200mL)	20	2.7681	13.84

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Based on the results discussed in Chapter 4, extraction of essential oils from jasmine flower using solvent extraction method by varying the feed ratio of jasmine flower to ethanol solvent produced high quality and quantity of extracts when the ratio is 1: 2 (flower: solvent). At this ratio, the sample is the best in extraction of fragrance compounds since its yield high concentration of two major major component in jasmine oil which is benzaldehyd and benzyl benzoate compared to other sample.

At the beginning, the research did not progress as expected. However, after the research had been done, a lot of challenge had to be faced in order to achieve the objective of this study. Some of the problems are to extract it which needs high capital costs of investment on gaining the raw material (jasmine flower) to be used in the experiment and also the equipment that had been used which is still under training and commissioning. Finally, the research was being done successfully and the problems occur had be managed intelligently and easily handled.

GC traces of the active constituent of the jasmine extracts shows that there were no harmful chemical permeated with the product. Beside, from the qualitative result, it has subsequently proved that these jasmine essential oils can be used in pharmaceutical, cosmetic as well as food and drink industries.

Overall, in this research, a method has been described for recovering the dissolved essential oil effectively is by using feed ratio of 1: 2 (flower: ethanol solvent) to trap the essential oils of jasmine flower. Extraction of jasmine flower using this feed ratio found some of the major component inside the essential oil which is benzyl benzoate and benzaldehyde. While for the yield, although lower recoveries and the oil recovery may remain lots of impuruties such as water and solvent during the putrities process using rotary evaporator but it still preserved the natural fragrance and hopefully the yield will be improve in future study.

Through this condition, the optimum qualitative and quantitative of its essential oils has been recovered.

5.2 RECOMMENDATIONS

Result obtained from this research shows that feed ratio of 1: 2(flower: solvent) is the most optimum ratio to extract jasmine essential oils compared to other ratios. Since current research is mainly about solvent extraction, the future research also can be extended to a CO_2 supercritical fluid extraction method to extract jasmine essential oils.

Opportunities are external events or conditions that researchers could potentially exploit on the research advantage. The opportunities that extraction of essential oils from jasmine flowers using CO_2 supercritical fluid extraction is it will achieve the existence of growth in niche markets, where quality is more important than price. Although it cause a lot of investment but the product can be sold with a high price due to the purity of the essential oils extract from jasmine flowers and people will buy even though it is too expensive.

It is potential to extend the range of available products including new product development through other method of extraction which is CO_2 supercritical fluids extraction in extraction of jasmine flower compared to the conventional methods which is solvent extraction. CO_2 supercritical fluids extraction both at the analytical-and preparative scale offers considerable advantages over the conventional method of solvent extraction for extracting the essential oils from jasmine flower. Using supercritical CO_2, extraction can be performed in a shorter time and it will not alter the chemical signature of perfumes. It will be the most optimum method to get a pure 48 essential oil without leaning residue of any solvent inside it. Besides that, the yield of essential oils is should be much higher when using this method. CO_2 supercritical fluid extraction will produce cleaner extracts than the solvent extraction.

All in all, the SFE technique will be an attractive alternative to currently used methods since it can still preserve the purity of the essential oils. Other than that, the future research on solvent extraction can be carrying out for larger scale in improving the yield of the essential oil. Different analysis equipment and method also can be carrying out to gives the accurate qualitative result such as using gas chromatography - mass spectrometry (GC-MS).

REFERENCES

1. Gracia.G.L., Laque de Castro M.D. (2000). Continuous Subcritical Water Extraction of Medicinal Plant Essential Oils: Comparison with Conventional Techniques. *Talanta*.Volume (51):1179-1185.

2. Lawless, Julia (1995). *The Illustrated Encyclopedia of Essential Oils Rockport*. MA: Element Books.

3. Naik S.N., Lentz.H. (1989). Extraction of perfumes and flavours from plant materials with liquid CO_2 under liquid-vapor equilibrium conditions. *Fluid Phase Equilibria.* Volume (49): 115-126.

4. Raghuram Rao G.V. (2004). Modeling Solute-co-Solvent Interactions for Supercritical Fluid Extraction of Fragrances. *The Journal of Supercritical Fluid*. Volume (5): 19-23.

5. Reverchon.E., Porta.G.D. (1995). Supercritical CO_2 Fractionation of Jasmine Concrete. *The Journal of Supercritical Fluid*. Volume (8):60-65.

6. Scalia.S., Giuffreda.L., Pallado.P. (1999). Analytical and Preparative Supercritical Fluid Extraction of Chamomile Flowers and its comparison with Conventional Methods. *Journal of Pharmaceutical and Biomedical Analysis*. Volume (21): 549-558.

7. Seader J.D., Ernest J.H. (1998). *Separation Process Principles*. New York. Wiley-VCH. Ullmann's (2004). *Processes and Process Engineering*. 3rd edition. Wiley-VCH.

8. S.B. Hawthorne, Y. Yang, D.J. Miller, *Anal. Chem*. 66 (1994) 2912.

9. Y. Yang, S. BÖwadt, S.B. Hawthorne, D.J. Miller, *Anal. Chem*. 67 (1995) 4571.

10. K. Hartonen, K. Inkala, M. Kangas, M.L. Riekkola, J. *Chromatogr.* A785 (1997) 219.

11. M.M. Jimeènez-Carmona, J.J. Mancluès, A. Montoya, M.D. Luque de Castro, *J. Chromatog*r. 785 (1997) 329.

12. C.W. Huie. A review of modern sample preparation techniques for the extraction and analysis of medicinal plants. *Anal. Bioanal. Chem*. **373:** 23-30 (2002).

13. M. letellier, H. Budzinski, L. Charrier, S. Capes and A.M. Dorthe. Optimization by factorial design of focused microwave assisted extraction of polycyclic aromatic hydrocarbons from marine sediment. *J. Anal. Chem*. **364:** 228-37 (1999).

14. O. Zuloaga, N. Etxebarria, L.A. Fernandez and J.M. Madariaga. Optimization and comparison of microwave assisted extraction and Soxhlet extraction for the determination of polychlorinated biphenyls in soil samples using an experimental design approach. *Talanta*. **50:** 345-57 (1999).

15. L. Wang and C.L. Weller. Recent advances in extraction of nutraceuticals from plants. *Trends Food Sci. Technol*. **17:** 300-12 (2006).

16. C. Latha. Microwave assisted extraction of embelin from *Embelia ribes*. *Biotechnol.Lett*. **9243:** 10529 (2006).

17. M.Kratchanova, E. Pavlova and I. Panchev. The effect of microwave heating of fresh orange peels on the fruit tissue and quality of extracted pectin. *Carbohydr. Polym*. **56:**181-86 (2004).

18. M.D. Luque de Castro, M.M. Jimenez-Carmona and V. Fernandez. Towards more rational techniques for the isolation of valuable essential oils from plants. *Trends Anal. Chem*. **18(11):** 708-16 (1999).

19. J.M.Bowman, M.S.Braxton, M.A. Churchill, J.D. Hellie, S.J. Starrett, G.Y. Causby, D.J. Ellis, S.D. Ensley, S.J. Maness, C.D.Meyer, J.R. Sellers, Y. Hua, R.S.Woosley, D.J. Butcher, Microchem. J. 56 (1997) 10.

20. M.Taverna, A.E. Baillet, D. Baylocq, J. Assoc.Off.Anal. Chem. 73 (1990) 206.

21. R.K. Verma, G.C. Uniyal, M.M. Gupta, Indian J. Pharm. Sci. 52 (1990) 276.

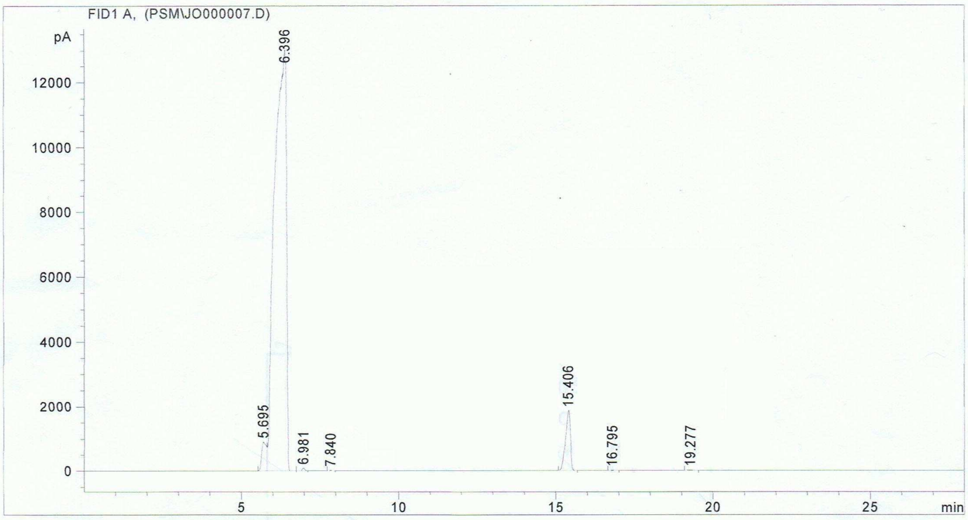
22. G. Vernin, E. Vernin, C. Vernin, J. Metzger, Flavour Fragr. J. 6 (1991) 143.

23. C.M. Bignell, P.J. Dunlop, J.J. Brophy, J.F. Jackson, Flavour Fragr. J. 12 (1997)

APPENDIX A

APPENDIX A-1: Gas Chromatograph analysis result for jasmine oils extracted for sample I (1: 2) ratio

```
Acq. Instrument : Instrument 1                    Location : Vial 7
Injection Date  : 19/02/2008 15:37:29                  Inj :    1
                                               Inj Volume : 1 µl
Method          : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 19/02/2008 10:36:28  by NORA
Method Info     : jasmine oil (PSM)
```




```
=====================================================================
                        Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: FID1 A,
```

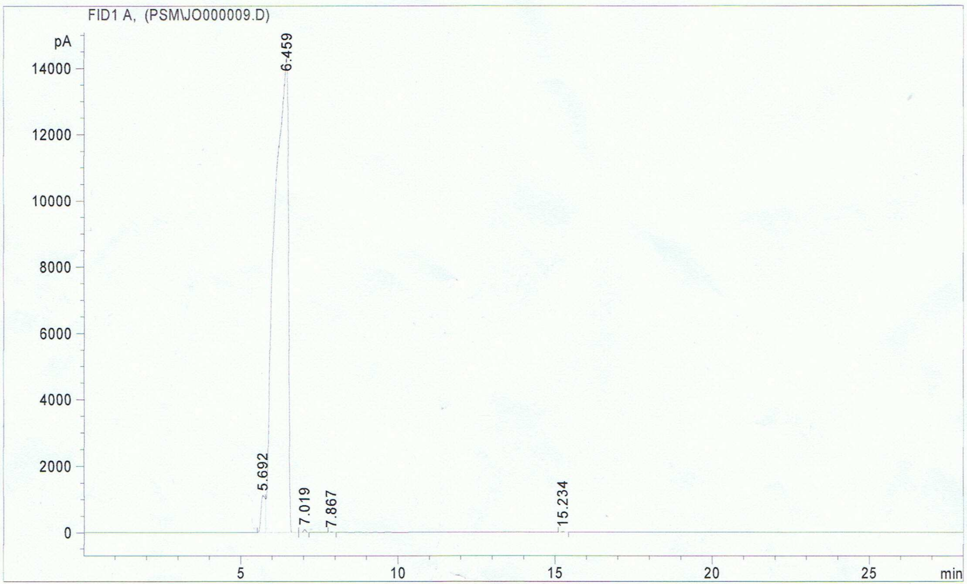
Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.695	BV	0.1419	9357.48730	895.61768	2.49367
2	6.396	VV	0.3285	3.45034e5	1.30055e4	91.94792
3	6.981	VB	0.0796	425.88181	81.95998	0.11349
4	7.840	BB	0.0833	71.05962	13.31686	0.01894
5	15.406	BB	0.1490	2.02046e4	1856.08386	5.38432
6	16.795	BB	0.1035	47.27529	6.68619	0.01260
7	19.277	BB	0.1371	109.04115	9.48845	0.02906
Totals :				3.75250e5	1.58686e4	

```
=====================================================================
                         *** End of Report ***

Instrument 1 19/02/2008 16:18:22  NORA                        Page   1 of 1
```

APPENDIX A-2: Gas Chromatograph analysis result for jasmine oils extracted for sample II (1: 5) ratio

Sample Name: CN

```
=====================================================================
Acq. Operator   : NORA                              Seq. Line :   1
Acq. Instrument : Instrument 1                       Location : Vial 9
Injection Date  : 20/02/2008 09:07:13                     Inj :   1
                                                   Inj Volume : 1 µl
Acq. Method     : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 19/02/2008 10:36:28  by NORA
Analysis Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 20/02/2008 09:41:15  by NORA
                  (modified after loading)
Method Info     : jasmine oil (PSM)
```



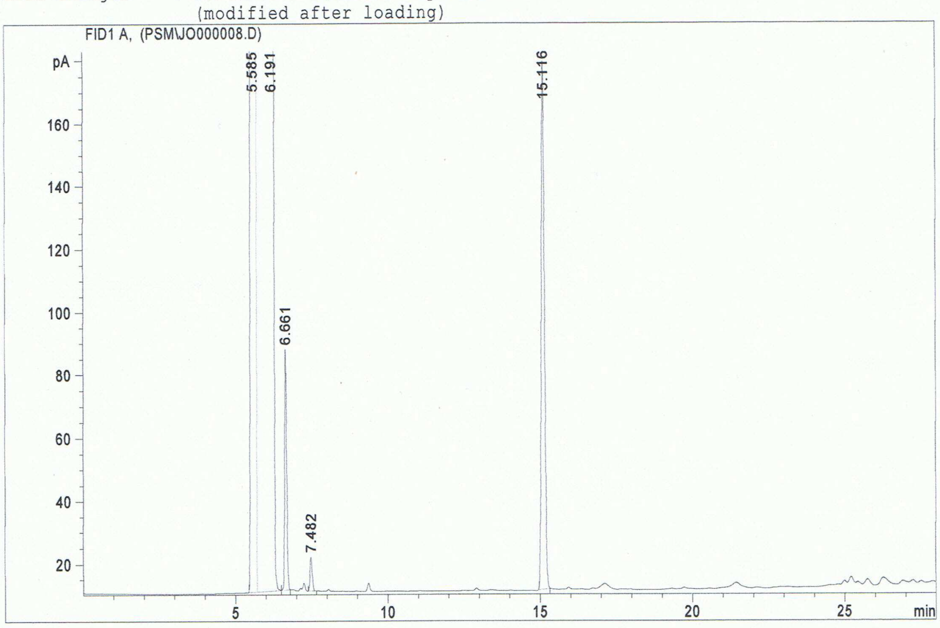

```
=====================================================================
                        Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: FID1 A,
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.692	BV	0.1330	1.07863e4	1123.93335	2.45417
2	6.459	VV	0.3517	4.28092e5	1.43216e4	97.40214
3	7.019	VB	0.0800	468.25705	89.53756	0.10654
4	7.867	BB	0.0825	70.56237	12.96341	0.01605
5	15.234	BB	0.0946	92.73039	12.93954	0.02110
Totals :				4.39510e5	1.55609e4	

```
=====================================================================
                        *** End of Report ***
```

APPENDIX A-3: Gas Chromatograph analysis result for jasmine oils extracted for sample III (1: 10) ratio

```
Data File C:\CHEM32\1\DATA\PSM\JO000008.D
Sample Name: BN

=====================================================================
Acq. Operator   : NORA                          Seq. Line :   8
Acq. Instrument : Instrument 1                   Location : Vial 8
Injection Date  : 19/02/2008 16:09:18                 Inj :   1
                                               Inj Volume : 1 µl
Acq. Method     : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 19/02/2008 10:36:28  by NORA
Analysis Method : C:\Chem32\1\METHODS\DEF_GC.M
Last changed    : 25/03/2008 10:54:39  by nora
                  (modified after loading)
```




```
=====================================================================
                         Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: FID1 A,
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.585	BV	0.1116	1.68995e4	2276.19043	4.66102
2	6.191	VV	0.2683	3.44055e5	1.59751e4	94.89314
3	6.661	VB	0.0709	352.45322	76.34064	0.09721
4	7.482	BB	0.0775	53.79073	10.72797	0.01484
5	15.116	BB	0.1032	1210.26147	167.60185	0.33380
Totals :				3.62571e5	1.85060e4	

```
=====================================================================
                          *** End of Report ***
```

APPENDIX A-4: Gas Chromatograph analysis result for standard Benzyl Benzoate at Concentration 1%

a File C:\CHEM32\1\DATA\PSM\JO000001.D
mple Name: BB1%

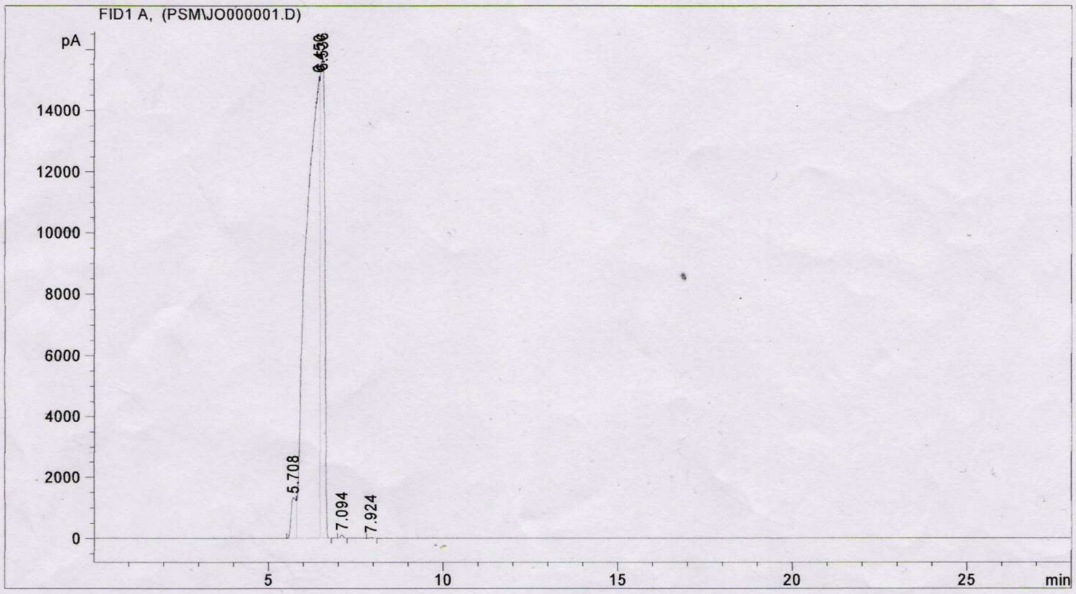
===

Acq. Operator : NORA
Acq. Instrument : Instrument 1
Injection Date : 19/02/2008 11:50:15

Seq. Line : 1
Location : Vial 1
Inj : 1
Inj Volume : 1 µl

Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed : 19/02/2008 10:36:28 by NORA
Method Info : jasmine oil (PSM)

Sample Info : STANDARD BB



===
Area Percent Report
===

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: FID1 A,

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.708	BV	0.1246	1.33711e4	1315.57507	2.40208
2	6.450	VV	0.3135	4.02599e5	1.50804e4	72.32619
3	6.536	VB	0.1068	1.39902e5	1.57296e4	25.13311
4	7.094	BB	0.0826	592.23535	110.37060	0.10639
5	7.924	BB	0.0963	179.38496	28.53469	0.03223

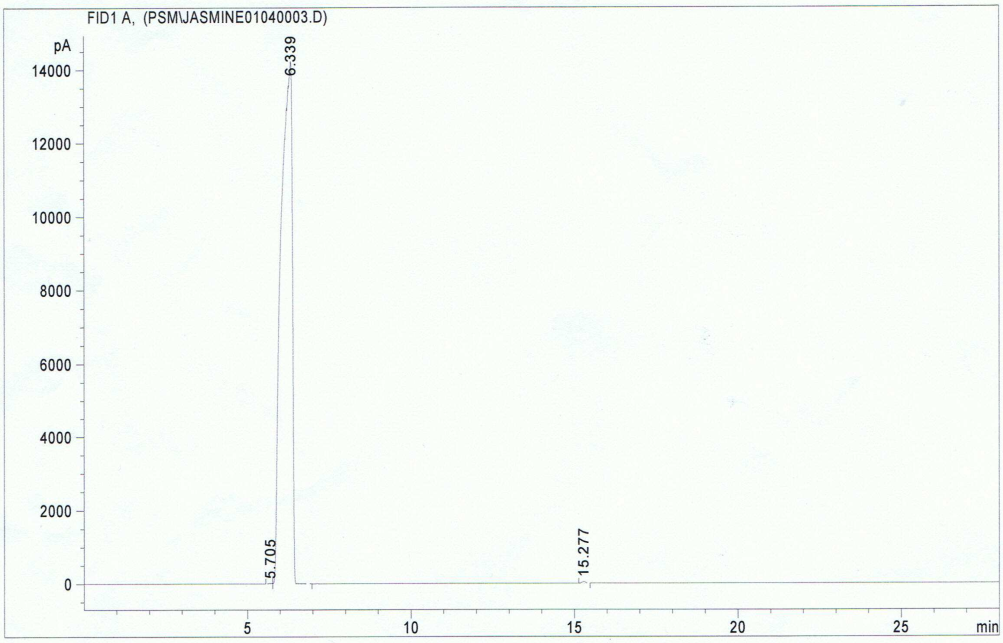
Totals : 5.56644e5 3.22645e4

===
*** End of Report ***

trument 1 19/02/2008 16:10:34 NORA   Page 1 of 1

APPENDIX A-5: Gas Chromatograph analysis result for standard Benzyl Benzoate at Concentration 2%

```
Data File C:\CHEM32\1\DATA\PSM\JASMINE01040003.D
Sample Name: BB2%

=====================================================================
Acq. Operator   : nora                          Seq. Line :   3
Acq. Instrument : Instrument 1                   Location : Vial 3
Injection Date  : 01/04/2008 16:40:31                 Inj :   1
                                               Inj Volume : 1 µl
Acq. Method     : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 01/04/2008 15:18:44  by fiza010408
Analysis Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 01/04/2008 17:09:23  by nora
                  (modified after loading)
Method Info     : jasmine oil (PSM)
```




```
=====================================================================
                         Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: FID1 A,

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [pA*s]      [pA]        %
----|-------|----|-------|----------|----------|--------|
   1   5.705 BV    0.1136   81.21432   11.07474  0.02400
   2   6.339 VB    0.2812 3.37933e5  1.42246e4  99.87799
   3  15.277 BB    0.1056  331.58990   44.67208  0.09800

Totals :                  3.38345e5  1.42804e4

=====================================================================
                          *** End of Report ***
```

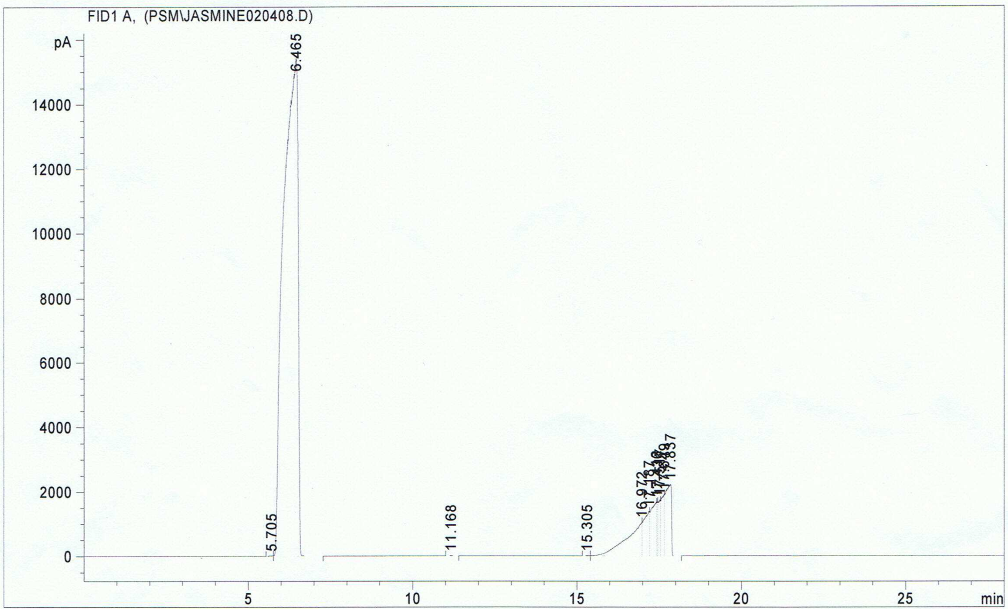
APPENDIX A-6: Gas Chromatograph analysis result for standard Benzyl Benzoate at Concentration 3%

Data File C:\CHEM32\1\DATA\PSM\JASMINE020408.D
Sample Name: BB 3%

===

Acq. Operator : nora
Acq. Instrument : Instrument 1 Location : Vial 4
Injection Date : 02/04/2008 09:51:56 Inj : 1
Inj Volume : 1 µl
Acq. Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed : 01/04/2008 15:18:44 by fiza010408
Analysis Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed : 01/04/2008 17:09:23 by nora
(modified after loading)
Method Info : jasmine oil (PSM)

Sample Info : JASMINE OIL



===

Area Percent Report

===

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Sample Amount : 1.00000 [ng/ul] (not used in calc.)
Use Multiplier & Dilution Factor with ISTDs

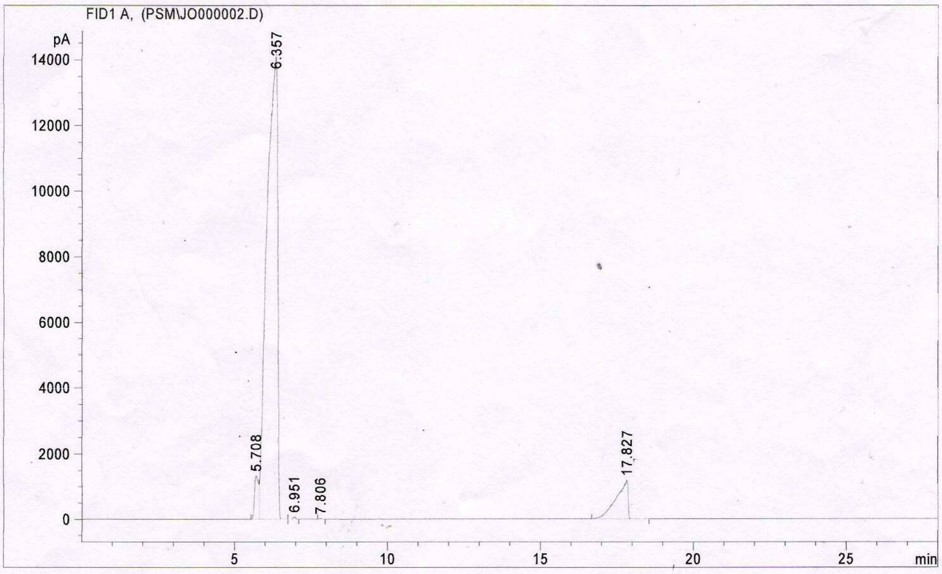
Signal 1: FID1 A,

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.705	BV	0.0944	118.87733	15.51069	0.02009
2	6.465	VB	0.3581	4.69255e5	1.54185e4	79.30853
3	11.168	BB	0.1219	68.57938	6.78654	0.01159
4	15.305	BV	0.1022	75.00085	8.99824	0.01268
5	16.972	VV	0.3864	3.41296e4	1038.57703	5.76822
6	17.187	VV	0.1460	1.66836e4	1380.90723	2.81969
7	17.412	VV	0.1382	1.93406e4	1681.65491	3.26874
8	17.436	VV	0.0254	3060.33130	1668.49646	0.51723
9	17.517	VV	0.0603	8654.61914	1732.71948	1.46271

APPENDIX A-7: Gas Chromatograph analysis result for standard Benzyl Benzoate at concentration 5%

Data File C:\CHEM32\1\DATA\PSM\JO000002.D
Sample Name: BB5%

```
=====================================================================
Acq. Operator   : NORA                              Seq. Line :   2
Acq. Instrument : Instrument 1                       Location : Vial 2
Injection Date  : 19/02/2008 12:28:00                     Inj :   1
                                                   Inj Volume : 1 µl
Method          : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 19/02/2008 10:36:28  by NORA
Method Info     : jasmine oil (PSM)

Sample Info     : STANDARD BB
```



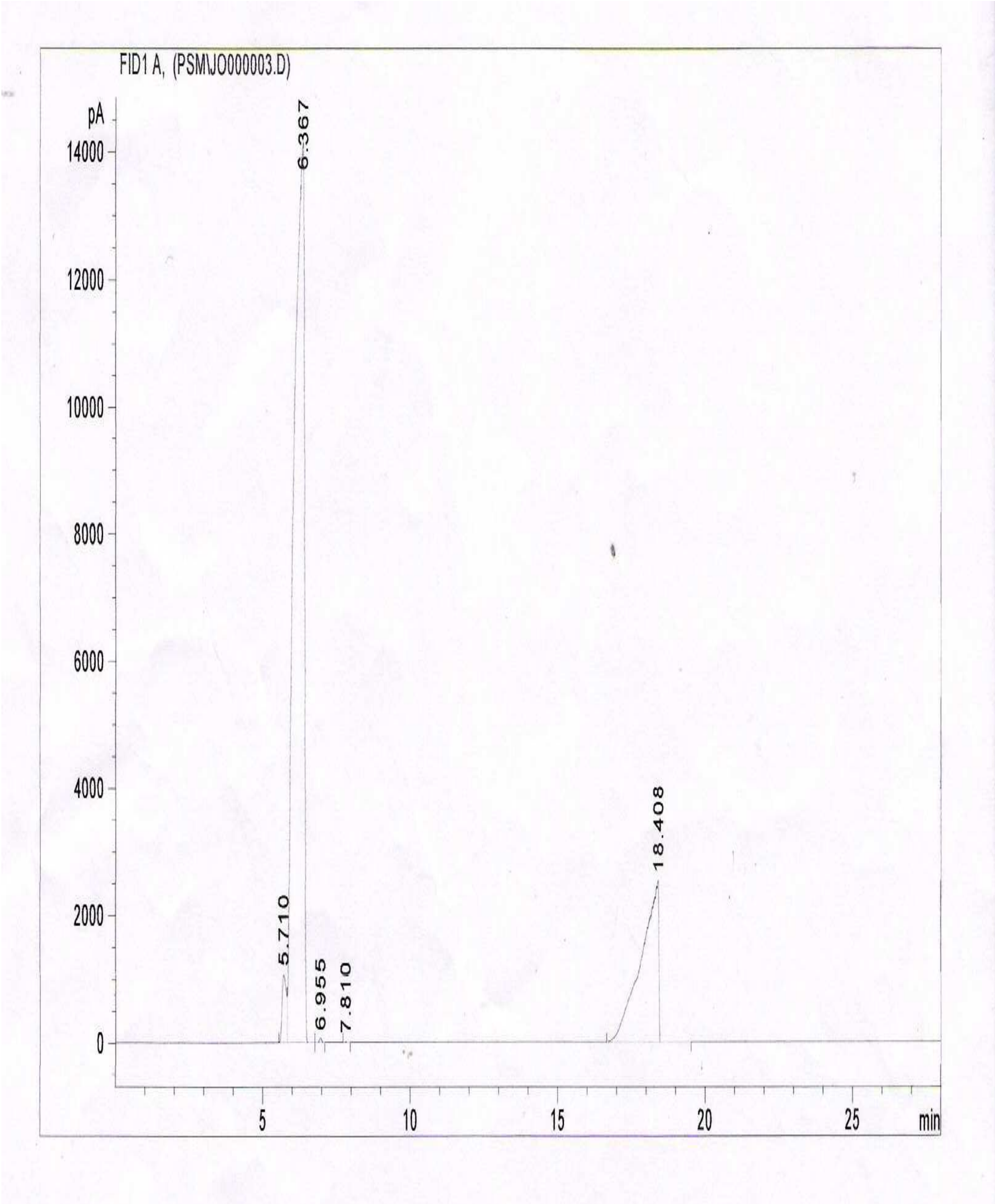

```
=====================================================================
                        Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: FID1 A,
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.708	BV	0.1283	1.22409e4	1330.66052	3.14676
2	6.357	VV	0.2869	3.44139e5	1.41432e4	88.46731
3	6.951	VB	0.0818	364.82336	70.05183	0.09378
4	7.806	BB	0.0811	104.93826	20.35608	0.02698
5	17.827	BB	0.3320	3.21516e4	1186.89893	8.26518
Totals :				3.89001e5	1.67512e4	

```
=====================================================================
                        *** End of Report ***
```

Instrument 1 19/02/2008 16:11:22   NORA   Page   1 of 1

APPENDIX A-8: Gas Chromatograph analysis result for standard Benzyl Benzoate at concentration 10%



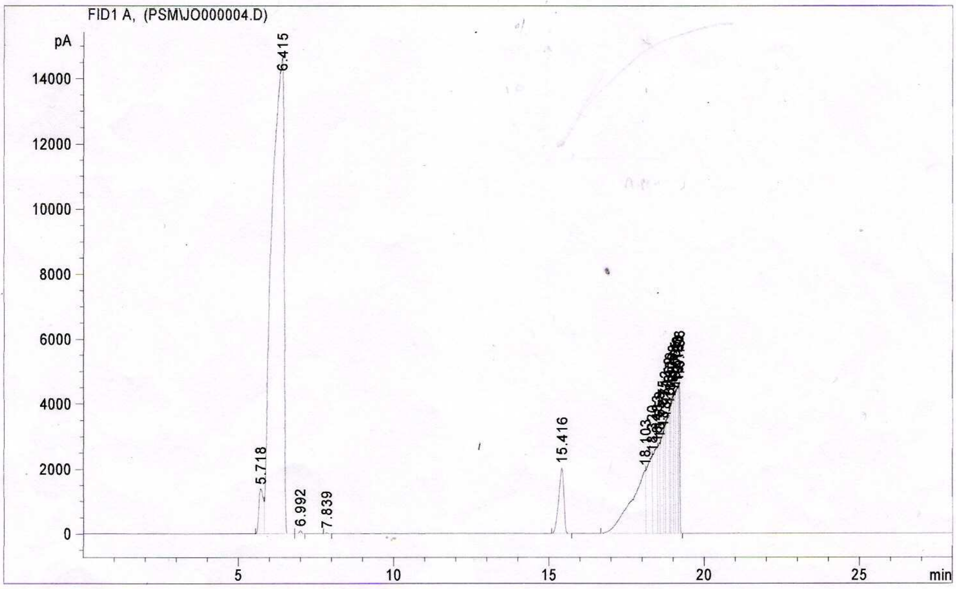
APPENDIX A-9: Gas Chromatograph analysis result for standard Benzaldehyde at concentration 1%

Data File C:\CHEM32\1\DATA\PSM\JO000004.D
Sample Name: BD1%

===

Acq. Operator : NORA Seq. Line : 4
Acq. Instrument : Instrument 1 Location : Vial 4
Injection Date : 19/02/2008 13:43:38 Inj : 1
Inj Volume : 1 µl
Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed : 19/02/2008 10:36:28 by NORA
Method Info : jasmine oil (PSM)

Sample Info : STANDARD BD



===
Area Percent Report
===

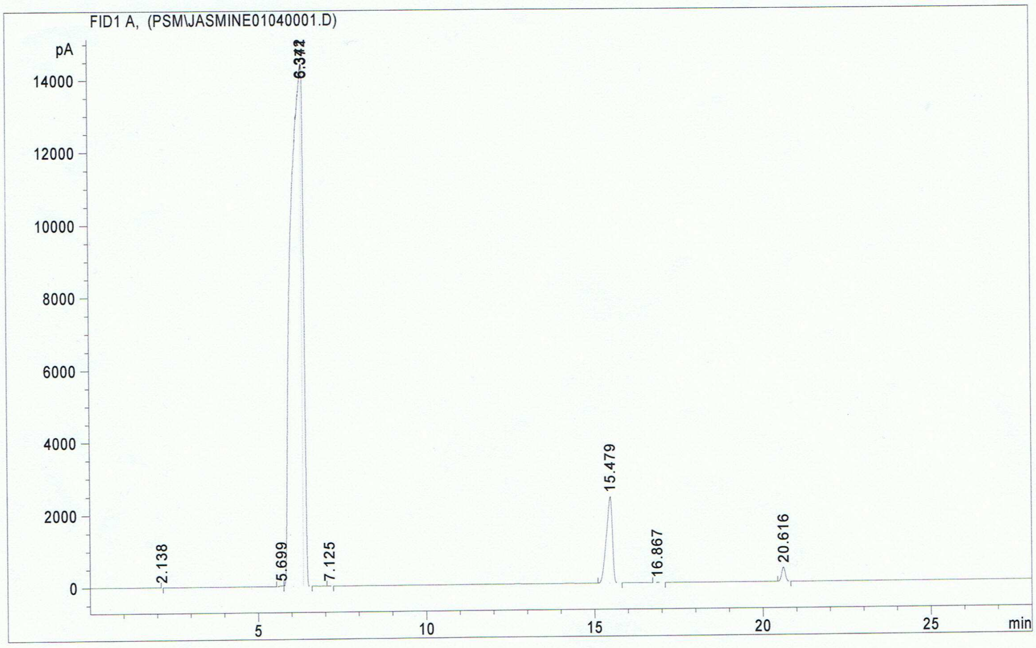
Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: FID1 A,

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.718	BV	0.1382	1.40826e4	1390.27332	1.97622
2	6.415	VV	0.3188	3.96563e5	1.46516e4	55.64993
3	6.992	VB	0.0789	445.39926	86.77724	0.06250
4	7.839	BB	0.0838	137.96255	25.63565	0.01936
5	15.416	BB	0.1486	2.33273e4	2021.79138	3.27353
6	18.103	BV	0.3775	6.24556e4	1945.75781	8.76443
7	18.320	VV	0.1392	2.78103e4	2382.78442	3.90263
8	18.483	VV	0.1173	2.60899e4	2685.58228	3.66122
9	18.559	VV	0.0619	1.33871e4	2792.58057	1.87862
10	18.675	VV	0.0787	1.95503e4	3136.58862	2.74351
11	18.742	VV	0.0457	1.25513e4	3426.12378	1.76133
12	18.869	VV	0.0882	2.73412e4	3835.91382	3.83681
13	18.909	VV	0.0334	9385.97266	3995.47388	1.31714

APPENDIX A-10: Gas Chromatograph analysis result for standard Benzaldehyde at concentration 2%

```
Data File C:\CHEM32\1\DATA\PSM\JASMINE01040001.D
Sample Name: BD2%

=====================================================================
Acq. Operator   : nora                            Seq. Line :   1
Acq. Instrument : Instrument 1                     Location : Vial 1
Injection Date  : 01/04/2008 15:22:29                   Inj :   1
                                                 Inj Volume : 1 µl
Acq. Method     : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 01/04/2008 15:18:44  by fiza010408
Analysis Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 01/04/2008 16:22:20  by nora
                  (modified after loading)
Method Info     : jasmine oil (PSM)
```




```
=====================================================================
                       Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: FID1 A,
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	2.138	BB	0.0180	1.34477	1.21039	0.00033
2	5.699	BV	0.1058	149.45743	20.09896	0.03681
3	6.342	VV	0.2507	3.01082e5	1.43528e4	74.14494
4	6.371	VB	0.0615	7.22551e4	1.44019e4	17.79366
5	7.125	BB	0.0642	13.03708	3.15385	0.00321
6	15.479	BB	0.1521	2.94704e4	2370.08740	7.25742
7	16.867	BB	0.1216	73.75029	7.70937	0.01816
8	20.616	BB	0.0980	3027.14697	396.71933	0.74547
Totals :				4.06072e5	3.15536e4	

```
=====================================================================
```

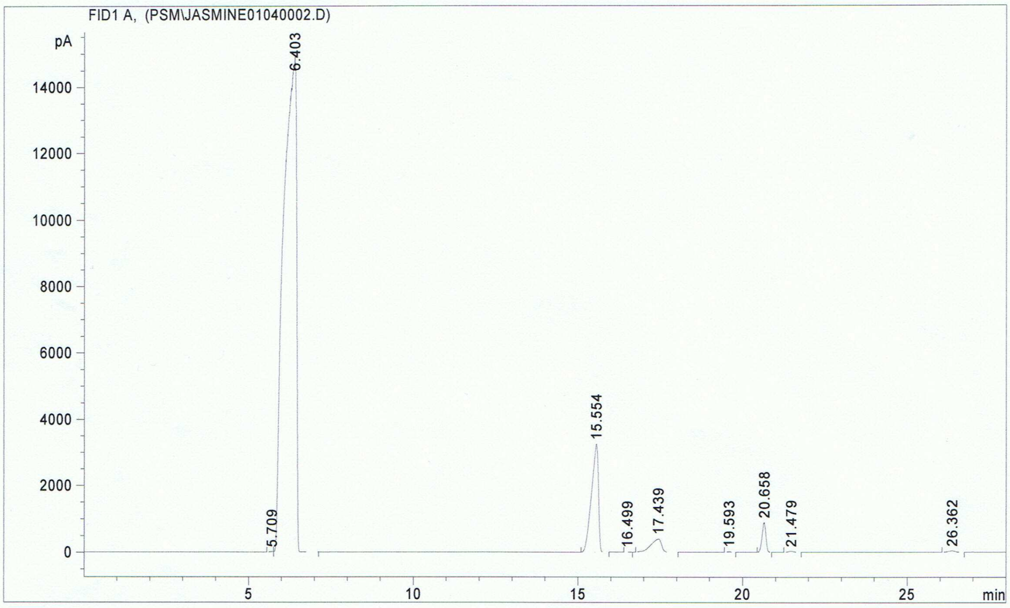
APPENDIX A-11: Gas Chromatograph analysis result for standard Benzaldehyde at concentration 3%

Sample Name: BD3%

===

Acq. Operator : nora
Seq. Line : 2
Acq. Instrument : Instrument 1
Location : Vial 2
Injection Date : 01/04/2008 16:01:27
Inj : 1
Inj Volume : 1 µl

Sequence File : C:\CHEM32\1\SEQUENCE\JASMINE OIL 2008.S
Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed : 01/04/2008 15:18:44 by fiza010408
Method Info : jasmine oil (PSM)



===

Area Percent Report

===

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: FID1 A,

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.709	BV	0.1050	93.65268	13.15626	0.02005
2	6.403	VB	0.3189	4.03147e5	1.48865e4	86.29548
3	15.554	BB	0.1782	4.68649e4	3230.99194	10.03166
4	16.499	BB	0.0945	31.56413	4.57313	0.00676
5	17.439	BB	0.2642	8859.37500	394.14737	1.89639
6	19.593	BB	0.0987	129.29179	17.38819	0.02768
7	20.658	BB	0.1037	7102.53516	884.43127	1.52033
8	21.479	BB	0.1377	365.15329	31.63329	0.07816
9	26.362	BB	0.1722	576.96704	40.25525	0.12350

Totals : 4.67170e5 1.95031e4

1 Warnings or Errors :

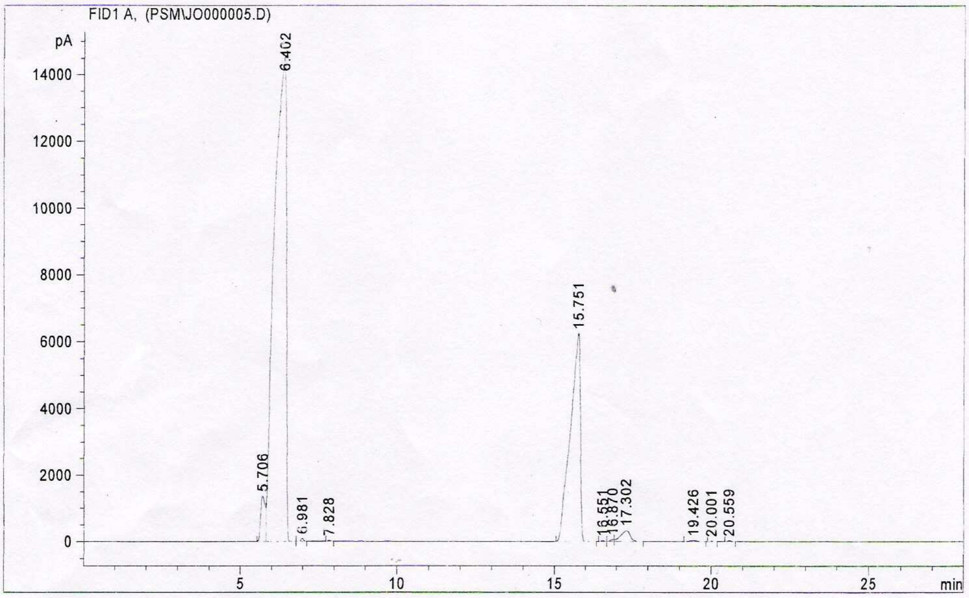
APPENDIX A-12: Gas Chromatograph analysis result for standard Benzaldehyde at concentration 5%

Data File C:\CHEM32\1\DATA\PSM\JO000005.D
Sample Name: BD5%

===

Acq. Operator : NORA　　Seq. Line : 5
Acq. Instrument : Instrument 1　　Location : Vial 5
Injection Date : 19/02/2008 14:21:36　　Inj : 1
Inj Volume : 1 µl
Method : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed : 19/02/2008 10:36:28 by NORA
Method Info : jasmine oil (PSM)

Sample Info : STANDARD BD



===

Area Percent Report

===

Sorted By : Signal
Multiplier : 1.0000
Dilution : 1.0000
Use Multiplier & Dilution Factor with ISTDs

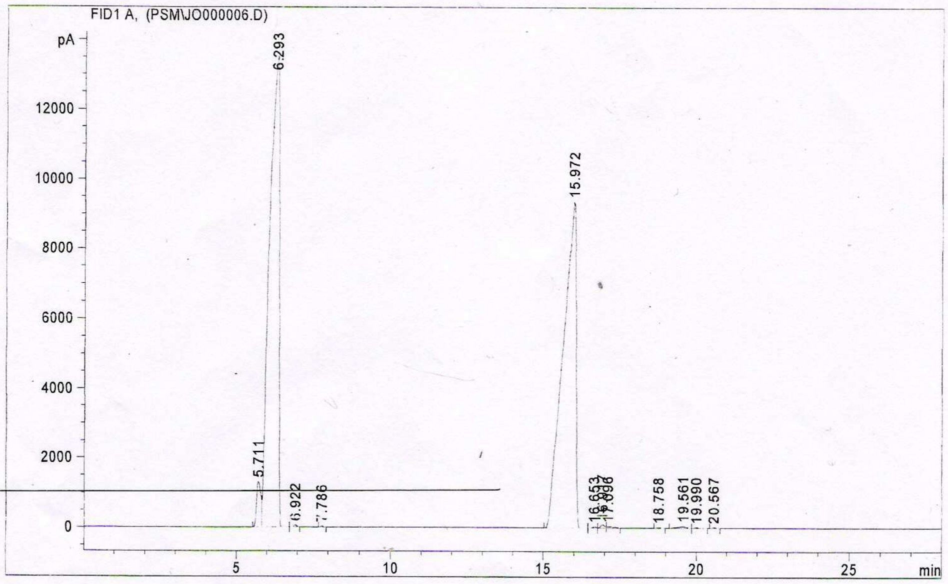
Signal 1: FID1 A,

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.706	BV	0.1363	1.34253e4	1357.89404	2.44157
2	6.402	VV	0.3152	3.89056e5	1.45395e4	70.75548
3	6.981	VB	0.0809	459.87103	89.60703	0.08363
4	7.828	BB	0.0797	143.56517	28.07049	0.02611
5	15.751	BB	0.2664	1.39025e5	6206.04150	25.28362
6	16.551	BV	0.1006	91.46976	13.07761	0.01664
7	16.870	VV	0.0954	367.50171	49.61597	0.06684
8	17.302	VB	0.2437	6675.20215	323.59579	1.21398
9	19.426	BB	0.1870	392.34128	24.74596	0.07135
10	20.001	BB	0.1017	46.08505	5.68024	0.00838
11	20.559	BB	0.0926	178.16098	24.26957	0.03240

Totals : 5.49861e5 2.26621e4

APPENDIX A-13: Gas Chromatograph analysis result for standard Benzaldehyde at concentration 10%

```
Sample Name: BD10%

=====================================================================
Acq. Operator   : NORA                              Seq. Line :   6
Acq. Instrument : Instrument 1                       Location : Vial 6
Injection Date  : 19/02/2008 14:59:29                     Inj :   1
                                                   Inj Volume : 1 µl
Method          : C:\CHEM32\1\METHODS\JASMINE OIL PSM 2008.M
Last changed    : 19/02/2008 10:36:28  by NORA
Method Info     : jasmine oil (PSM)

Sample Info     : STANDARD BD
```




```
=====================================================================
                         Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: FID1 A,
```

Peak #	RetTime [min]	Type	Width [min]	Area [pA*s]	Height [pA]	Area %
1	5.711	BV	0.1325	1.23163e4	1288.95374	2.11310
2	6.293	VV	0.2558	2.92739e5	1.35091e4	50.22532
3	6.922	VB	0.0831	313.27530	57.93161	0.05375
4	7.786	BB	0.0790	90.73894	17.34604	0.01557
5	15.972	BV	0.3459	2.74750e5	9347.68066	47.13887
6	16.653	VV	0.0992	196.84383	26.63241	0.03377
7	16.917	VV	0.1186	806.67249	90.82629	0.13840
8	17.096	VB	0.1757	579.71027	39.16139	0.09946
9	18.758	BB	0.1077	98.58403	11.08841	0.01691
10	19.561	BV	0.2198	820.80408	43.95807	0.14083
11	19.990	VB	0.1139	61.10205	6.60385	0.01048
12	20.567	BB	0.0925	78.88962	11.02890	0.01354

APPENDIX B

APPENDIX B-1: Identification of the Compounds in Jasmine Concrete

Reverchon et al. *The Journal of Supercritical Fluids, Vol. 8, No. 1, 1995*

TABLE I

Identification of the Compounds Contained in the Jasmine Concrete and in its Fractions Produced by Supercritical CO_2 Extraction. Product A: Extraction Performed at 80 bar, 40 °C; Product B: Extraction Performed at 85 bar, 40 °C; Product C: Extraction Performed at 200 bar, 40 °C.

Compound	*Rt* (min)	A%	B%	C%	Waxes %	Concrete %
Benzaldehyde	12.5	tr.	—	0.67	—	tr.
Benzene methanol	23.1	0.31	0.08	—	—	0.09
C_7H_8O (m.w. 108)	26.4	—	0.08	—	—	0.77
Linalool	28.3	12.26	0.25	—	—	2.20
Benzyl acetate	33.2	62.35	0.90	—	—	13.02
Methyl salicylate	35.3	tr.	—	—	—	tr.
Phenylethyl acetate	40.0	tr.	—	—	—	tr.
Indole	42.1	0.40	0.53	—	—	0.36
Eugenol	46.5	0.59	0.14	—	—	0.37
cis-Jasmone	49.4	2.00	0.55	—	—	0.70
Methyl caprate	53.6	—	—	—	—	tr.
Tetradecane	55.4	tr.	0.31	0.23	—	0.22
α-Farnesene	56.5	1.62	0.67	—	—	0.61
Hexenyl benzoate	60.3	0.64	0.54	—	—	0.37
Benzoic acid methylester	61.6	tr	0.15	—	—	tr.
Methyl jasmonate	65.1	0.30	0.26	—	—	0.20
Benzyl benzoate	71.3	12.61	28.31	1.30	—	8.05
Hexadecene	75.5	0.20	—	3.11	—	2.74
Methyl myristate	76.0	0.31	0.96	0.06	—	0.58
Methyl hexadecadienoate	77.0	—	—	0.54	—	tr.
Methyl palmitoleate	77.6	—	—	1.10	—	0.97
Methyl palmitate	80.2	0.33	1.25	0.19	—	0.45
Phytol	81.2	3.74	28.55	7.14	—	5.79
Methyl linolenate	85.2	0.80	6.90	3.37	—	1.90
FAME (m.w. 290)	87.4	—	—	—	—	0.25
Methyl linoleate	88.4	0.40	4.23	1.59	—	1.26
Methyl oleate	89.2	0.28	11.81	31.08	—	3.74
Methyl eicosenoate	94.1	0.82	11.97	7.24	—	2.82
Eicosane	96.8	—	—	—	0.03	tr.
Methyl arachidate	97.5	0.04	0.63	1.18	—	0.93
Heneicosane	100.9	—	—	—	0.05	tr.
Tricosane	102.0	—	—	—	—	0.31
Methyl heneicosane	105.0	—	—	—	0.27	tr.
Methyl erucate	106.0	—	0.25	0.21	0.11	2.13
Cyclic compound (m.w. 386)	107.2	—	—	—	—	0.53
Methyl behenate	108.6	—	—	0.33	—	0.19
Pentacosane	110.0	—	—	—	0.11	1.00
Heptacosane	114.2	—	—	—	8.76	7.48
Methyl pentacosane	117.1	—	—	0.72	0.08	tr.
Octacosane	118.1	—	—	—	1.61	0.75
Paraffin (m.w. 394)	119.4	—	—	—	—	1.75
FAME (m.w. 410)	120.3	—	—	0.80	—	tr.
FAME (m.w. 410)	121.1	—	0.91	35.38	—	2.24
Methyl heptacosane	123.4	—	—	—	0.08	0.20
Nonacosane	126.1	—	—	—	59.70	21.88
Squalene	129.2	—	—	3.77	—	tr.
Methyl octacosane	132.0	—	—	—	1.37	1.60
Triacontane	134.2	—	—	—	1.58	1.31
Methyl nonacosane	139.8	—	—	—	0.20	tr.
Hentriacontane	144.6	—	—	—	23.70	9.27
Methyl triacontane	154.3	—	—	—	2.31	0.74
Tritriacontane	158.3	—	—	—	0.06	0.24

Rt = retention time, min; % computed by peak area without any correction factor; FAME = fatty acid methyl ester; m. w. = molecular weight; tr. = traces, (area < 0.05%); — = non detectable;