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Comparative Extraction and Chemical Characterization of Essential Oils from *Rosa Damascena* and *Rosa abyssinica*

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Abstract

The study had the objective of extracting essential oils from two rose species, *Rosa damascena* and *Rosa abyssinica*, using hydrodistillation, and to compare their yields, chemical compositions, and quality characteristics. Fresh rose petals and pollen samples (300 g each) of *R. damascena* (collected from Debrebirhan Rose Farm) and *R. abyssinica* (collected from Gullele Botanical Center) were subjected to hydrodistillation at 90 ℃ for 3-3.5 hours. Essential oil yields were measured gravimetrically and volumetrically. Gas chromatography-mass spectrometry GC-MS) having a DB-1701 column was used to analyze chemical Components found in the essential oils. (Components were identified by comparison with mass spectral libraries. For *R. damascena*, the maximum oil yield (0.0964%, w/w) was obtained from pure petals, while for *R. abyssinica*, pure pollen gave the highest yield (0.114%, w/w). GC-MS analysis revealed 9-19 components across samples. *R. damascena* oil was characterized by high levels of citronellol (39.9%), nonadecane (23.1%), and (+)-3-carene (17.3%) in petal samples, and phenylethyl alcohol (32.3-34.8%) and nonadecane (32.3-34.6%) in mixed and pollen samples. *R. abyssinica* oil was dominated by 1-pentacosene (39.5-55.4%), caryophyllene (13.6-17.1%), and hexacosane (15.2%). Quality parameters indicated *R. damascena* oil contained higher levels of 2-phenylethyl alcohol (3.16%) and heptadecane (4.36%) compared to previous reports. Both *R. damascena* and *R. abyssinica* are viable sources of essential oils with distinct chemical profiles. *R. damascena* oil exhibits superior fragrance qualities suitable for cosmetic and perfume industries, while *R. abyssinica* oil contains bioactive compounds such as caryophyllene with potential therapeutic applications. Prior to this work there is no conducted studies about essential oil extraction from *R. abyssinica*.

Keywords

Rosa Damascena, *Rosa abyssinica*, Essential Oil, Hydrodistillation, GC-MS, Citronellol, Caryophyllene

1. Introduction

Plants are defined as living organisms of the kind exemplified by trees, shrubs, herbs, grasses, ferns, and mosses, typically growing in a permanent site, absorbing water and inorganic substances through their roots, and synthesizing nutrients in their leaves by photosynthesis using the green pigment chlorophyll.

Among plants, some are classified under medicinal plants which are sources of modern and traditional medicine. The FDA (Food and Drug Administration) has approved that more than one third (39.1%) of drugs are of natural origin, and 48.6%

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of all cancer drugs registered from the 1940s until today are either natural products or derivatives [1].

From early time of human civilization to now most of medicines has been extracted from plants. the radical development of science in the field of allopathy allows plants to be the main resource for both cultural and modern medicines. [2].

The traditional practice of plant-based medicines and treatments, which has been applied for long time, led to the development of modern medicines [3]. A complex defense system naturally developed by plants contains a sophisticated range of components. The presence of antimicrobial compounds in plants may serve as botanical pesticides, or as bactericidal and fungicidal agents active against pathogens of human disease [4]. In today's world, about 35,000-70,000 plant species are identified as relied sources of medicine making. Plants with ethnopharmacological uses have been the primary sources of medicine for early drug discovery relating to their original ethnopharmacological purposes [5].

In order to survive in the environment, plants develop antioxidants, and these oxidants have a role in the reduction of health risks that contribute to conditions such as diabetes and hypertension [38]. Further, cost-effectiveness of plant-based medicines and their effectiveness make them prior sources of modern medicines [6].

The global population size increment and spread of various communicable and non-communicable diseases trigged the research works on medicines and plants become the first choice of pharmaceutical industries. [7].

Plants which possess odoriferous oil in either of their organs or sometimes even in the whole plant are said to be aromatic plants. The odoriferous oil found in these plants makes them desirable in cosmetics, beverage and pharmaceutical industries. Many aromatic plants are also used for medicinal purposes and are said to be medicinal and aromatic plants (MAP) and categorized under medicinal plants because these plants are sources of medicines which help for health preservation.

As of the World Health Organization, 30% of the drugs sold worldwide contain compounds derived from plant materials which include more than 21,000 taxa [9, 18]. And the plants are categorized under economically valuable groups.

Aromatic plants are found globally, and in most countries, people collect them in the wild. In India, half of the country's native plants, which is more than 7,500 species, are used in ethnomedicines, and China accounts next with 6,000 species having medicinal usage. Over 5,000 plant species are commonly used for medicinal treatments in Africa. In Europe, about 2,000 species are being used.

Classification of aromatic plants depends on their cultivation in climatic zones of the world like tropical, equatorial, temperate, and cold. The difference in climatic zone also determines the chemical properties of the species [2, 5].

Along 3 and 15 °north latitude, and 33 and 48 °east longitude Ethiopia is found in the horn of Africa with varied agro ecological zones. Due to Ethiopia characterized by a wide range of ecological, edaphic, and climatic conditions, there is Ethiopia is a huge flora composition [9] Various forms of medicinal plants including trees, shrubs, climbers, and herbs; of those, herbal medicinal plants are dominantly used for different human and animal treatments in Ethiopia. These plants are collected mainly from riverbanks, cultivated areas, bushlands, forests, woodlands, and grasslands, among others. They are used for treatments of stomachaches, dysentery, diarrhea, asthma, cancer, evil eyes, earaches, sores of throat and gum, cough, and so on. For such treatments, these medicinal plants have specific parts used for treatment; most of them are leaves and roots [9, 10]. It is estimated that about 6,500-7,000 flora species including medicinal plants are found in Ethiopia, and 12-19% of those are endemic [10, 11]. The community trust and belief in healing values of plant-based medicines and inadequate modern health centers are leading factors for the demand of aromatic plants in Ethiopia.

Traditionally, about 800 species of medicinal plants grown locally have been used to treat approximately 300 medical conditions by conventional healers [3, 7, 16].

Herbs, essential oils and spices are the most widely raised names with aromatic plants. Two kinds of oils, namely fixed and essential (volatile oils), are extracted from plants. Fixed oils consist of esters of glycerol and fatty acids (triglycerides or triacylglycerols), while essential oils (EOs) are complex mixtures of volatile and semi-volatile organic compounds originating from a single botanical source that determine the specific aroma of plants and the flavor and fragrance of the plants (Sirousmehr et al., 2014; Tisserand and Young, 2013).

Liquid products extracted from plant and plant materials (leaves, flowers, roots.) via different extraction methods are said to be essential oil. The oil contains tens or hundreds of volatile and non-volatile compounds, and the fragrance or flavor of the plant. Essential oils are present in plants in specialized cells/glands (subcuticular spaces of glandular cells, organelles); these glands may be anywhere on the plant body depending upon the morphology and physiology of the plant. They may be on leaves, flowers, stems, roots, bark, or wood [2, 3].

Due to their valuable properties while using in production, these oils are mostly wanted in cosmetics and drug manufacturing industries [36].

The essential oils are complex mixtures of secondary metabolites consisting of low-boiling-point phenylpropenes and terpenes [8]. Essential oils and other botanicals have been used in wellness practices as early as at least 5,000 years ago. Ancient Egyptians' use of aromatic botanicals is in mummification; in preparing the bodies of the deceased for burial, embalmers used various botanicals such as cinnamon, resins such as frankincense and myrrh, and an early form of cedar or juniper essential oil [28, 43]. *Asteraceae* or *Compositae*, *Lamiaceae* or *Labiateae*, and *Apiaceae* or *Umbelliferae*. are usually known families of essential oils.:

Detailed compositional analysis of volatile compounds of the oils can be obtained by gas chromatography and mass

spectrometry. It was found that there are valuable mixtures of mainly terpenoids like linalool, geraniol, borneol, menthol, thujanol, citronellol, α-terpineol and a variety of low molecular weight aliphatic hydrocarbons like phenols (thymol, carvacrol, eugenol, gaiacol) and aromatic aldehydes (cinnamaldehyde, cuminal, and phellandral) [21].

The oils are usually extracted by steam distillation, while currently the use of supercritical carbon dioxide extraction has become increasingly popular. Depending on type and concentration, essential oils exhibit cytotoxic effects on living cells, although non-genotoxic. The cytotoxic activity of essential oils is mostly due to the presence of phenols, aldehydes, and alcohols [14, 21, 22]. It has been known for centuries that aromatic plants mainly their essential oils or components can act against a large variety of organisms including bacteria, viruses, fungi, protozoa, parasites, and insects [21, 23, 24]. Moreover, the essential oils can exhibit hypolipidemic [21], antioxidant [24], digestive stimulant [25], and antitoxigenic [23] activities and can also contribute to odor and ammonia control [21].

As of now over 3,000 plants has been applicable for extraction of essential oils and up to 300 of them are mostly desirable for fragrances and flavors [26]. Essential oils are used in food industries commonly in beverage and confectionary products and the pharmaceutical sector uses in cosmetics manufacturing and aromatherapy functional properties [27, 28].

The trend of using essential oils in health sector, demand for flavors and fragrances along with growing economic standards and increasing reliability over natural and organic ingredients in cosmetic formulations are the factors driving the essential oils market.

The global essential oil market as per the report published by Fior Markets is expected to grow from USD 7.9 Billion in 2017 to USD 16.2 Billion by 2025 at a CAGR of 9.4% during the forecast period 2018-2025.

Traditionally, essential oils are used by Ethiopians as human as well as animal medicines [16, 17, 20]. The 2006 WHO report shows that in Ethiopia, the majority of humans and household pets more than 80% and 70% respectively have relied on medicines extracted from plants.

The processing of herbs in Ethiopia has been limited to essential oil extraction and production of herbal tea. Estimates reveal that the country produces around 3 MT of essential oil mainly from eucalyptus, lemongrass, and rosemary. The processing of herbal tea is made by Ethio-AgriCeft using chamomile.

Nowadays, due to the increase in establishments of food, beverage, and pharmaceutical industries which use essential oils as an input and the habit of people using essential oils individually at home, the demand for essential oils in Ethiopia has increased.

1.1. Essential Rose Oil

Comprising some 2,500 species in more than 90 genera, Rosaceae the rose family of flowering plants (order Rosales) is primarily found in the North Temperate Zone and occurs in a wide variety of habitats [13]. Several species are economically important as food crops, including apples, almonds, cherries, pears, raspberries, and strawberries, while others, such as the rose, are grown as ornamentals [30, 31].

One of the most important *Rosa* species is *R. damascena* Mill., of which some cultivars are used for oil production and others are cultivated throughout the world as garden roses (Guenther, 1952). It is called the Damask rose because, in the beginning, this species was introduced from Damascus to Europe (Gault and Synge, 1987). *Rosa damascena* primarily grows in its natural habitat and still this plant is wild in some countries like Caucasus, Syria, Morocco, and Andalusia (Chevallier, 2001). The origin of Damask rose is Iran and the Middle East region (Zargari, 1992; Krussman, 1981). This type of rose is known as the national flower of Iran [29, 32, 46].

Essential rose oil is a pale yellow semisolid volatile compound which is extracted by distillation from fresh petals of the rose plant. The portion which is solid at ordinary temperatures forms about 15-20% and consists of odorless stearoptene containing principally saturated aliphatic hydrocarbons (C14-C23 normal paraffins) [33]. The oil is very expensive and very liable to adulteration. Bulgaria, Turkey, and Morocco are major producers of rose oil. The oil is prepared in copper alembic stills by peasants or in large factories under careful scientific control. Some 3,000 parts of flowers yield only one part of oil [33, 34].

The main components found in essential rose oil are limonene (0.4%-12.8%), 2-phenylethyl alcohol (1.0%-1.3%), citronellol (16.2%-57.8%), geraniol (0.9%-14.1%), and eicosane (0.3%-2.1%) [32].

Rose essential oil is among the ten most expensive essential oils in the world, which accounts for up to 15,000 USD/kg, and is used in pharmaceutical [37], cosmetics, food, and drinking industries.

Rosa abyssinica is the only indigenous rose species in Africa and is popular in Ethiopian highland areas including Bale [12]. The plant is characterized by evergreen rosacea with white and creamy fragrant flowers and orange climbing hips. It is mostly found in upland dry evergreen forests and margins or clearings of forests as well as in bushland and dry grasslands. It is also found near houses and on riverbanks in dry, moist, and wet Weyna Dega and Dega agroclimatic zones of Gondar Tigray Gojam, Shewa, Harerge, Arsi, and Bale, 1,700-3,300 m. The plant is used for firewood, food (fruit), medicine (flowers, roots, fruit), and live fence [39].

The ultimate objective of these work was to extract essential oil from two commonly known rose plants, namely *R. damascena* and *R. abyssinica*, by hydrodistillation, and finally to compare the results depending on yield amount, component composition, and characteristics.

1.2. Statement of the Problem

Naturally, Ethiopia is blessed with biodiversity, having

plenty of plant varieties used mostly for medicinal purposes. As a part of life, Ethiopians have used these plants for human and animal treatments for centuries [19]. The majority of the population has relied on traditional medicine throughout their lives (Kassaye, Amberbir, Getachew, & Mussema, 2006).

As of now in the country there are about 887 plant species identified as having medicinal relevance's for human and animal treatment.

Herbs, shrubs and trees are the leading medicinal plants [15] and twenty four (2.7%) of the medicinal plant species are endemic to Ethiopia, and most are found in the wild.

Rosa damascena and *R. abyssinica* are cultivated in most areas of the country, and it is an easy process to extract oil, but essential oils are not yet used as a source of income in Ethiopia as in other countries like Bulgaria or Turkey. Nowadays, due to the increase in establishments of food, beverage, and pharmaceutical industries which use essential oils as an input and the habit of people using essential oils individually at home, the demand for essential oils in Ethiopia has increased. Ethiopia's imports of essential oils, perfumes, cosmetics, and toiletries were US$72.29 Million during 2020, according to the United Nations COMTRADE database on international trade.

It is believed that Ethiopia can earn a significant amount of foreign currency from the export of essential rose oil, and this research aimed to extract essential rose oil from *R. damascena* and *R. abyssinica* by hydrodistillation and finally compare the extracted oil in terms of yield quantity, components, and characteristics.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study was to extract essential rose oil from two varieties, namely *R. abyssinica* and *R. damascena*, by hydrodistillation, and finally to compare the results depending on yield amount, component composition, and characteristics.

1.3.2. Specific Objectives

The study had the following specific goals:

1) Maximizing the production of rose oil from rose petals.
2) Testing the physical and chemical characteristics of rose oil.
3) Comparing and contrasting the essential oils extracted from the two varieties.

2. Literature Review

Rose plant is categorized under the *Rosaceae* family and is defined by a woody perennial flowering structure [40]. All over the world, up to three hundred species and tens of thousands of cultivars. The stems of roses are armed with sharp prickles, and the size and shape of flowers vary but usually have colors ranging from white through yellows and red [41].

In Asia, most native species are found, and Europe, North America, and northwestern Africa also have smaller numbers of species. Rose petals are preferred for the purpose of beauty and fragrance.

The plant size varies in different places; sometimes it seizes seven meters long, and the good thing is the plant can hybridize easily, which makes it suitable for developing garden roses. The leaves mostly grows from the plant stem usually grows up to quarter of meters in size, pinnate, with (3-) 5-9 (-13) leaflets and basal stipules; the leaflets usually have a serrated margin, and often a few small prickles on the underside of the stem. Above half of are deciduous but a few (particularly from Southeast Asia) are evergreen or nearly so [42].

The flowers of most species have five petals, with the exception of *Rosa sericea*, which usually has only four. Each petal is divided into two distinct lobes and is usually white or pink, though in a few species yellow or red. Beneath the petals are five sepals (or in the case of some *Rosa sericea*, four). These may be long enough to be visible when viewed from above and appear as green points alternating with the rounded petals [41, 42]. Roses are insect-pollinated in nature.

Essential oils and other botanicals have been used in wellness practices as early as at least 5,000 years ago. Ancient Egyptians used aromatic botanicals for mummification; in preparing the bodies of the deceased for burial, embalmers used various botanicals such as cinnamon, resins such as frankincense and myrrh, and an early form of cedar or juniper essential oil [35, 44].

In Ethiopia, rose flowers are used for beauty and fragrance traditionally, but the extraction of rose essential oil is not well developed. In 2006, farmer Fekade Lakew started cultivating and extracting rose essential oil from *R. damascena* in Amhara Regional State, Debre Birhan town. The project is supported by a German company, and nowadays it has about twelve thousand hectares of rose cultivation land.

Rosa abyssinica, called "Kega" in Amharic, is mainly found in highland areas of Ethiopia. The plant branch is used for firewood, and the fruit is eaten usually by children. Due to its good fragrance, the flower has traditionally been used in some parts of the country. But no researches were found about cultivation and extraction of essential rose oil from *R. abyssinica*.

Both *R. abyssinica* and *R. damascena* have good potential for cultivation in Ethiopia. But still now, the country has not earned a significant amount of income from this sector. Essential rose oil is among the top ten most expensive oils in the world because of its characteristics and its intended use in cosmetics and perfume industries.

Ethiopia is found in the equatorial region, which is suitable for rose flower cultivation [45] because rose plants in this region produce flowers with blooms that weigh up to 3 grams, much more weight than in other areas. The yield amount during extraction also increases with flower bloom

size.

Essential oils are commonly used the production of pharmaceutical and different food products, soft drinks, distilled alcoholic beverages (hard drinks), detergents, soaps, toilet products, cosmetics, pharmaceuticals, and insecticides. Moreover, in today's world market, the demand for essential oils is rapidly growing, especially in the cosmetics and perfume industries.

The method of extracting or production technology for essential oil is crucial because it determines the overall yield and quality of the product. Distillation is widely used extraction method of this precious oil from plants and due to small occurrence of oils in plants hundred kilograms of plants are required to get single ounce of essential oils.

Generally, essential oils are extracted by classical and conventional methods.

In this extraction method, the bottom part of the vessel is filled with water, and the plant materials are placed at some distance above the water level. As the generated steam begins boiling the water, the water vaporizes. The vapor, which contains a mixture of water and distilled oil, is then passed through a condenser, which allows the separation of the oil from the water. Then the condensed oil is subsequently separated by decantation in a Florentine flask. The oil floats at the top and is easily separated. The distilled water still contains some soluble parts of the oil and therefore is sent back to the evaporator [6].

Advantages of steam distillation:

1) It is a cheaper process.
2) It is faster as compared to other methods.
3) Properties of essential oil extracted by steam distillation are not altered.

3. Materials and Methods

3.1. Materials

Fresh rose petals and pollen samples of *Rosa damascena* were collected from Debrebirhan Rose Farm (Amhara Regional State, North Shewa Zone) in the early morning before sunrise. The samples were transported to the laboratory in ice boxes and stay at 20 ℃ until extraction.

Fresh samples of *Rosa abyssinica* were collected from Gullele Botanical Center (Addis Ababa) following the same protocol and stored at -10 ℃ until extraction.

3.2. Sampling

Three types of samples (300 g each) were collected for each species:

1) Pure Petals
2) Pure Pollen
3) Mixed (50% Petals + 50% Pollen)

All samples were cleaned to remove dust, insects, and other debris, washed gently with water, and dried softly before extraction.

3.3. Extraction Procedure

Hydrodistillation was performed using a 2 L round-bottom flask with 700 mL distilled water. The extraction conditions were:

Table 1. *Extraction condition of both roses.*

Parameter	R. damascena	R. abyssinica
Freezing time	4 days	2.5 days
Freezing temperature	-20 ℃	-10 ℃
Distillation time	3.5 h	3 h
Distillation temperature	90 ℃	90 ℃
Water volume	700 mL	700 mL

The essential oil was separated from the hydrosol using a separating funnel, and the volume and weight of the extracted oil were recorded. The extraction yield was calculated as:

$$\text{Extraction yield (\%)} = (\text{mass of oil} / \text{mass of sample}) \times 100$$

3.4. GC-MS Analysis

Component analysis was performed using a gas chromatograph-mass spectrophotometer (GC-MS) at Addis Ababa University, College of Natural Science, Chemistry Department.

Instrument parameters for *R. damascena*:

1) Model: GC 5977E MSD
2) Ion source temperature: 230 ℃
3) Detector temperature: 150 ℃
4) Column: DB-1701 (30 m × 0.25 mm × 0.25 μm)
5) Carrier gas: He at 1 mL/min
6) Split mode: 1/20
7) Injection volume: 1 μL
8) Temperature program: 60°C (2 min) → 200°C (14 min) → 240°C (13.33 min); total run time 29.33. Min

Instrument parameters for R. abyssinica:

1) Model: 7820A GC equipped with 5977E MSD
2) Column: DB17-01 (30 m × 0.25 mm × 0.25 μm)
3) Temperature program: 60-240 ℃ (gradient)

Components were identified by comparison of mass spectra with NIST library data.

4. Results and Discussion

4.1. Extraction Yield

4.1.1. Rosa Damascena

Table 2. Extraction summary result for rose damascene.

Sample	Sample size	Oil volume (mL)	Oil mass (g)	Yield (%)
Pure petal	300 g	0.3	0.2892	0.0964
Pure pollen	300 g	0.2	0.1928	0.064
Mixed	300 g	0.2	0.1928	0.064

The highest yield (0.0964%) was obtained from pure petals of *R. damascena*. This is consistent with previous reports where petals are the primary source of essential oil in Damask rose [32, 47]. The yield is comparable to values reported for Iranian *R. damascena* (0.016-0.19%) and Turkish rose oil production [34].

4.1.2. *Rosa abyssinica*

Table 3. Extraction summary result for rose Abyssinica.

Sample	Sample size	Oil volume (mL)	Oil mass (g)	Yield (%)
Pure petal	300 g	0.2	0.1928	0.064
Pure pollen	300 g	0.355	0.34	0.114
Mixed	300 g	0.2	0.1928	0.064

Interestingly, for *R. abyssinica*, the highest yield (0.114%) was obtained from pure pollen, not petals. This is a novel finding as this is the first reported extraction of essential oil from *R. abyssinica*. The result suggests that the oil glands in this species may be more concentrated in pollen structures compared to petals.

4.2. Component Analysis

4.2.1. Rosa Damascena - Pure Petal Sample

Table 4. Summay of identified components from rosa Damascena sample one.

RT (min)	Area (%)	Component	Quality
8.8042	1.9976	Tricyclo [2.2.1.0 (2,6)] heptane, 1,3,3-trimethyl-	87
10.0325	3.1648	Phenylethyl Alcohol	95
10.8914	39.9464	Citronellol	98
11.3035	17.2649	(+)-3-Carene	91
11.7754	1.3469	Citral	96
15.2743	4.3626	Heptadecane	98

RT (min)	Area (%)	Component	Quality
17.3920	4.0302	Z-5-Nonadecene	99
17.5624	23.0540	Nonadecane	95
20.4332	4.8327	Heneicosane	99

Nine components were identified. Citronellol (39.9%) was the dominant component, followed by nonadecane (23.1%) and (+)-3-carene (17.3%). Citronellol is a key fragrance compound in rose oil and is used extensively in perfumery [32]. The high citronellol content indicates good quality for cosmetic applications.

4.2.2. Rosa Damascena - Mixed Sample

Table 5. Summay of identified components from rosa Damascena sample two.

RT (min)	Area (%)	Component	Quality
5.5968	32.2967	Phenylethyl Alcohol	94
9.1063	3.2124	Heptadecane	94
RT (min)	Area (%)	Component	Quality
10.4850	3.7439	9-Nonadecene	93
10.5775	32.3460	Nonadecane	99
12.3063	19.7088	Heneicosane	98
14.5739	8.6922	Heptacosane	83

Six components were identified. Nonadecane (32.3%) and phenylethyl alcohol (32.3%) were the major components. Phenylethyl alcohol is known for its rose-like odor and antimicrobial properties [37].

4.2.3. *Rosa abyssinica* - Pure Pollen Sample

Table 6. Summary of identified components from rosa abysinnuca.

RT (min)	Area (%)	Component	Quality
12.6087	13.5578	Caryophyllene	99
17.5357	8.6492	Nonadecane	95
20.4124	39.5423	1-Pentacosene	95
23.9525	9.5888	Tridecane, 7-hexyl-	94

Nineteen components were identified. The major components were 1-pentacosene (39.5%), caryophyllene (13.6%), and tridecane (9.6%). Caryophyllene is a bicyclic sesquiterpene with documented antibacterial, antioxidant, anti-inflammatory, and neuroprotective activities [21, 24]. This is the first report of caryophyllene in *R. abyssinica* oil.

4.3. Quality Comparison

Table 7. Quality comparison of R. damascena with respect to the previous work.

Component	Previous work (%) [48]	Current study - R. damascena (%)
2-Phenylethyl alcohol	1.0-1.3	3.1648
Heptadecane	0.8-3.0	4.3626
Nonadec-9-ene	14.9-30.2	14.9593
Heneicosane	5.8-18.6	4.8327

The quality of essential rose oil, especially for cosmetic and perfume purposes, is determined by high content of 2-phenylethyl alcohol and heptadecane, and low content of nonadec-9-ene and heneicosane. The current *R. damascena* oil showed superior quality with higher 2-phenylethyl alcohol and heptadecane levels compared to previous reports [49], indicating good potential for fragrance applications.

5. Comparison

5.1. Yield Comparison

Table 8. Yeild comparision of R. damascena and R. abyssinica.

Sample	R. damascena yield (%)	R. abyssinica yield (%)
Pure petal	0.0964	0.064
Mixed (petal + pollen)	0.064	0.064
Pure pollen	0.064	0.114

1) Pure pollen of *R. abyssinica* yielded the highest overall oil content (0.114%).
2) Pure petals of *R. damascena* yielded the highest for that species (0.0964%).
3) Mixed samples gave lower yields for both species.

5.2. Quality Comparison

Rosa damascena oil exhibited higher levels of 2-phenylethyl alcohol (3.16%) and heptadecane (4.36%), components associated with desirable fragrance properties. This makes *R. damascena* oil more suitable for the cosmetics and perfume industry.

Rosa abyssinica Oil Was Rich in Caryophyllene (13.6-17.1%) and 1-pentacosene (39.5-55.4%). Caryophyllene Has Documented Therapeutic Benefits Including Anti-inflammatory, Analgesic, and Neuroprotective Activities, Suggesting Potential Pharmaceutical Applications.

Limitations of the Study

One Specific Objective of the Study Was to Test the Physico-chemical Properties (specific Gravity, Refractive Index) of Both Essential Oils and to Compare Them. However, Since the Laboratory Work Was Performed Outside the Center, the Study Was Unable to Achieve This Analysis.

5.3. Recommendations

1) As a Country with Abundant Natural Resources, Especially Plants, the Government and Individuals Should Focus on Intensively Using These Resources for Economic Growth.
2) Middle Eastern Countries, Especially Iran, Earn Up to 150-200 Million USD Annually from the Export of Essential Rose Oil, Even with Lower Quality Oil. Since Ethiopia Is Located Near the Equatorial Region, Which Is Highly Suitable for Rose Cultivation, It Is Possible to Earn Significant Amounts from Essential Rose Oil with Better Quality.
3) Rose Plants Planted in Equatorial Regions Have Larger Blooms (up to 3 G) and Higher Essential Oil Yields During Extraction.
4) Currently, There Are No More Than Three Rose Farms in Ethiopia (Debrebirhan, Bale, and Korem), All of Small Size, and Their Economic Contribution Is Insignificant.
5) *Rosa abyssinica* Is Commonly Used Only for Firewood, Eaten by Children (fruit), or Planted Near Farms to Prevent Land Degradation. The Availability of This Plant Is Continually Decreasing. This Study Revealed That Essential Oil Extracted from R. Abyssinica Has Many Scientific Uses, and the Country Could Benefit from Exporting This Oil.
6) The Annual Tree Plantation Program Should Include This Plant to Increase Its Coverage.
7) Further Studies Are Needed on the Health Benefits of Essential Oil from R. Abyssinica.

Abbreviations

CAGR	Compound Annual Growth Rate
COMTRADE	Commodity Trade Statistics Database
EOs	Essential Oils
FDA	Food and Drug Administration
GC-MS	Gas Chromatography Mass Spectrometry
ha	Hectares
MAP	Medicinal and Aromatic Plants
MT	Metric Tons
R. abyssinica	*Rosa abyssinica*
R. damascena	*Rosa Damascena*
R. sericea	*Rosa Sericea*
USD	United States Dollar
WHO	World Health Organization

Author Contributions

Samuel Tesfahun: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing

Dessie Abeje: Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflict of interest.

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