RETRACTED CHAPTER: Apharsemon, Myrrh and Olibanum: Ancient Medical Plants

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Abstract Among the most reputed ancient medical plants were the: olibanum – frankincense, derived from *Boswellia* spp., myrrh, derived from *Commiphoras* spp., both from southern Arabia and the Horn of Africa, and apharsemon of Judea, derived from *Commiphora gileadensis* that had its origin also in these territories. The demand for these medical plants that were also important spices was met by scarce and limited sources of supply. The incense trade and trade routes were developed to carry this precious cargo over long distances through many countries to the important foreign markets of Egypt, Mesopotamia, Persia, Greece, and Rome. The export of the frankincense and myrrh made Arabia extremely wealthy, so much so that Theophrastus, Strabo, and Pliny all referred to it as *Felix* (fortunate) *Arabia*. At present, this export hardly exists, and the spice trade has declined to around 1,500 t, coming mainly from Somalia; both Yemen and Saudi Arabia import rather than export these frankincense and myrrh.

Apharsemon, known also as the Judaean balsam, grew only around the Dead Sea Basin in antiquity and achieved fame by its highly reputed aroma and medical properties but has been extinct in this area for many centuries. The resin of this crop was sold, by weight, at a price twice that of gold, the highest price ever paid for an agricultural commodity. This crop was an important source of income for the many rulers of ancient Judea; the farmers' guild that produced the apharsemon survived over 1,000 years. Currently there is interest in a revival based on related plants of similar origin. These three ancient plants now are under investigation in many countries for medicinal uses. Many publications and patents on these three plants appeared in recent years.

Keywords *Commiphora gileadensis* • *Boswellia* spp. • *Commiphora* spp. • *Judaean balsam* • Frankincense • Spice trade • Traditional medicine • Modern medicine • Current research

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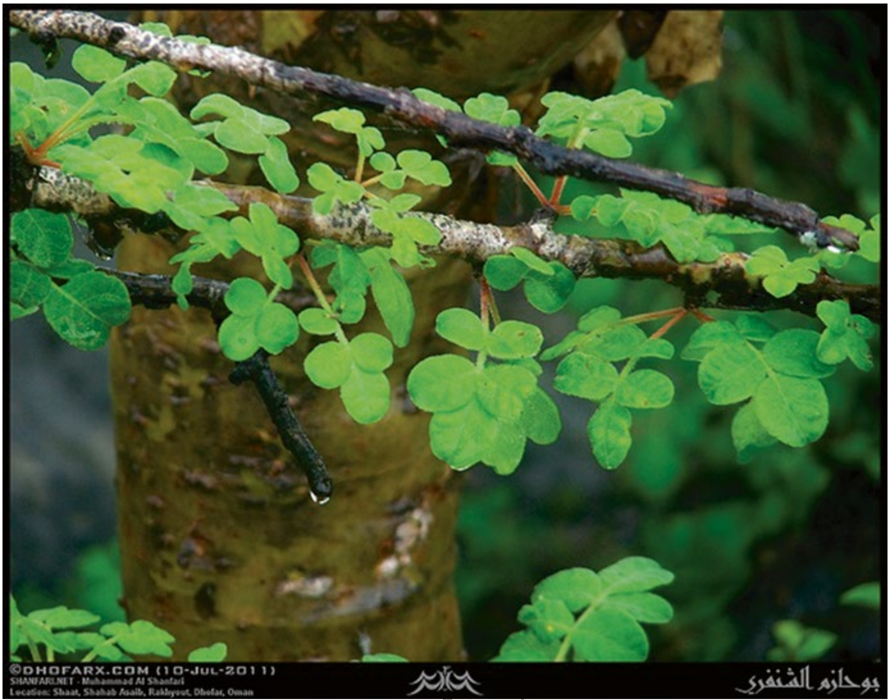
Taxonomy Characteristics (Botanical Classification)

Taxonomical Characteristics: Apharsemon

The history of the plant, Apharsemon, is a complicated and ancient story, involving ancient sources and exciting medical plant with long historical documents as a source of drugs with many medical benefits recorded by eminent physician along over two millennia. This plant was described in much detail by the great biologists as Theophrastus – (372–287 BCE) (Birdwood 1862; Hort 1916) and Pliny (23–79 AD) (Bostock 1855) and many others whose reports would be discussed later (Ben-Yehoshua et al. 2012). The plant is known in the Bible as tzori or *tzori Gilead* (Hebrew) (Genesis 37, 25; Jeremiah 8, 22) which is derived from the Hebrew word *tzori*, meaning balm (Miller 1998; Amar 2002), and Gilead, a geographical area east of the Jordan River in the center of present day Jordan. The apharsemon was identified as *Commiphora opobalsamum* (Forssk) *Engl*. (Pictures 1 and 2), and belonged to the family *Burseraceae*. The word apharsemon is probably related to the similar word opobalsamum in Greek (Feliks 1968). It has many synonyms: *C. gileadensis* (L.) Chr., *C. gileadensis* (L.), *Balsamodendron opobalsamum* Kunth, and *Amyris*

Picture 1 *Commiphora opobalsamum* fruits (Taken by Muhammad Al Shanfari on May 20, 2011 at Shihait Sinkhole, Taqah, Dhofar Governorate, Sultanate of Oman)



Picture 2 *Commiphora opobalsamum* plant (Taken by Muhammad Al Shanfari on July 10, 2011 in Shaat, Shahab Asaib, Rakhyout, Dhofar Governorate, Sultanate of Oman)

gileadensis L. Due to the many names that this plant bears, in this chapter the Latin names used are *C. gileadensis*, *C. opobalsamum*, and *C. gileadensis opobalsamum*. The term "opobalsamum" refers to the fact that the resin of this plant is juice (opo). This species is known for its fragrant resin (Wood 1997). Linnaeus (1767) claimed it was the source of Tzori and Mecca balsam.

The identification of this plant with the Hebrew names *Apharsemon*, *kataf*, *nataf*, and *tzori Gilead* can be traced to several sages, including Shimon Ben-Gamliel, Rambam (Maimonides), Saadia Gaon, and the modern biblical botanist Yehuda Feliks. The identification of these Hebrew names with the botanical classification of Forsskal and Linnaeus was done by Zohary (1982).

The present authors used *Commiphora gileadensis* as the Latin name of the apharsemon plant that the Queen of Sheba brought to King Solomon (Chronicles II 9:9) and that was domesticated in the Dead Sea Basin. As discussed by Ben-Yehoshua and Rosen (2009), it appears that the apharsemon that grew in Judea was a new variant or cultivar, much improved over its original ancestor. We believe that this ancestor, *C. gileadensis*, from Yemen, had been naturalized in Judea and became the apharsemon after over 1,000 years of cultivation around the Dead Sea by a special guild of farmers who aimed at achieving the best yield of the specific products they had derived from this plant: incense, perfume, and specific medicinal drugs. The present authors conclude that these *Commiphora* plants introduced from the Arabian Desert were domesticated and continuously improved over about 1,000 years in the Dead Sea Basin, to become the true apharsemon. This plant was a unique cultivar, not found in other places, as already suggested by several Greek and Roman experts in this subject (Ben-Yehoshua and Rosen 2009). Although the ancient apharsemon may be an improved cultivar of the tree identified by Forsskal, we suggest that all these plants – those identified by Forsskal in Yemen as well as the ancient plants grown in Judea – be referred to henceforth as apharsemon. Relevant contradicting opinion in this respect was given by Groom (1981). He said that the "Apharsemon of classical times was a very different product than the Arabian tree, that had quite different qualities, and that the *Commiphora* grew only in southern Arabia, Somalia and parts of Ethiopia. However, Groom ignored Josephus information and the Biblical report about the Queen of Sheba visit to King Solomon. Although the timing of her visit to the Kingdom of Israel is controversial, the rationale for the visit of a queen of a kingdom that sells spices to a country that has just established a new temple, which needs large quantities of spices for routine rituals, cannot be disputed. Recently, Lemaire (2010) wrote a special essay about Queen of Sheba in Yemen who traveled to King Solomon and reported there several archeological findings that support this Biblical story.

The Forsskal Taxonomical Expedition

With the aim of identifying the *opobalsamum*, "the apharsemon" of the Bible (1911), which had been produced in Jericho and Ein Gedi around the Dead Sea in Judea, in 1763, Peter Forsskål, on behalf of the King of Denmark and Norway, collected and described an apharsemon tree on an expedition to Oude, Yemen. Following the biblical stories and also those of the many Greek and Roman writers, geographers, and historians, including Josephus Flavius, Forsskål had knowledge of philology, Arabic and natural sciences. He traveled to Yemen, where the Kingdom of Sheba was located, hoping to find this tree, which had become extinct in Judea. Many of the eminent botanical writers of antiquity, such as Theophrastus, had reported that the apharsemon, from which the opobalsamum was collected, grew only at two sites in Judea (Birdwood 1862) but over time, this plant had become extinct in Judea. Knowing the biblical story of the gift of spices by the Queen of Sheba to King Solomon, Forsskal's journey to Yemen in search for the Kingdom of Sheba was a logical choice. The known features that could help his search were fragrance, exudation of a liquid resin – the opobalsamum – and the medicinal tradition for which the apharsemon was famous. The local Yemen experts were not aware of all these apharsemon stories according to Niebuhr (1792). After a long and stressful journey, Forsskål eventually found one small tree at Oude whose leaves (Picture 2) emitted a special fragrance when crushed. Forsskål sent his "eureka" message to his respected mentor Linnaeus: "Now I know the genus of the '*opobalsamum*.' The tree grows in Yemen. It is not *Pistacia*, not *lentiscus*" (Picture 1) (Hepper and Friis 1994).

However, the death of Forsskål during this expedition, and the subsequent publication of his results by others, has made the herbarium specimen and the publications complicated to use. Although Linnaeus based *A. gileadensis* on a specimen sheet by Forsskål sent from Yemen with a letter dated June 9, 1763, no type specimen is in herb. Linn.

Carsten Niebuhr was the Forsskål expedition's cartographer/astronomer. Following the death of Forsskål, Niebuhr took upon himself to summarize the expedition's report. The preparation of Forsskål's research for publication constituted a distinct challenge for Niebuhr and the unknown assistant who aided him. Sifting through unorganized bundles containing almost 2,000 slips of paper, with notes on a particular species sometimes on multiple sheets the task of editing was made very difficult. In his book "Travels to Arabia and other countries in the East" Niebuhr (1792) said: "An Arabian tree, famous from the most remote antiquity, and nevertheless but little known, is that from which the balsam of Mecca is obtained". We found one of these trees in the open fields; and under its shade Mr. Forsskal wrote the first botanical description of the species. He […] named it, as a new species, *Amyris*; a name which has since been adopted by other botanists. The tree has not a beautiful appearance and what is surprising, its qualities are not known to the inhabitants of Yemen, in which we met with it…" (Niebuhr 1792. Vol. 2, p. 355–6)

Hepper and Friis (1994), in the preface to their book, *The Plants of Pehr Forsskål's Flora Aegyptiaco-Arabica*, summarized Forsskål's botanical results and the assertion of Linnaeus (1764) that the *A. gileadensis* produces the balm or opobalsamum of the Bible. However, since the plant that produced opobalsamum in Judea was extinct then, Forsskål's assertion is open to question (Hepper and Friis 1994). In a subsequent letter to his mentor Linnaeus, Forsskål was able to give more specific information, and pointed out that opobalsamum belonged to the genus *Amyris* P. Browne. Other reports (Arnott 1839) bring out that several previous suggestions were presented by Alpinus and others, but Linnaeus did not accept them as wholeheartedly as he did with Forsskål.

Baack (2013) wrote a monograph about Forsskål in which he said:

> His [Forsskål] biological work stands out for the large number of species identified, its attention to detail, the expansiveness of his descriptions, his knowledge and use of Arabic and his early ideas on plant geography.
>
> "Niebuhr was not a natural scientist" – he continued. "Thus despite his dedication to the task […] the published work has deficiencies. The terminology and descriptions are inconsistent, its organization is confusing and unwieldy, there is no concordance with the surviving herbarium, and the volume has no index to aid the reader".

The taxonomic and nomenclatural aspects regarding the plant discovered by Forsskål which is currently known as *Commiphora gileadensis* (L.) Chr.Engl remained rather controversial. Forsskål and Linnaeus named the genus *Amyris* and related it in the Octandria class.

However, there is a difference in the epithet of the species' name: Forsskål named it *opobalsamum*, whereas Linnaeus gave the name *gileadensis*. Linnaeus used the term *opobalsamum* for the plant with the pinnate leaves.

In 1782 the botanist J.G. Gleditsch obtained dried specimens from Achmet Effendi near Mecca and named the plant *Balsamea meccanensis*. Gleditsch contrasted the characteristics of this plant with those of *Amyris gileadensis*, Linn. He claimed that the two plants could not belong to the same genus. The leaves of his plant are bipinnate, the calyx and corolla each of five parts, and larger than in the Linnean plant; the stamens ten, though they may be eight or nine, exceeding the corolla, and the immature fruit with a basal pentagonal stipe. He also points out that Linnaeus's plant is not *Amyris* (see Balfour 1888). Gleditsch's plant has been a subject of controversy in the botanical community.

Willdenow (1799) considered that the problem causing the difficulty in identifying the plant lies in the manner in which the filaments are united to the flower: "It is difficult to ascertain the true position of the filaments; because the boundary between the calyx and the receptacle cannot, in all instances, be accurately distinguished."

According to Linnaeus, the filaments are joined to the edge of the receptacle, while Gleditsch insists that this edge is a part of the calyx itself. Willdenow concludes that the plant described by Gleditsch does not form a distinct genus, but is the same as that which Linnaeus has given under the name of *Amyris*.

Moreover, Willdenow showed how leaves change their form in the different stages of the tree's age. Thus, Forsskål's plant was probably an old tree, while Gleditsch's plant could have been a very young tree.

Woodville (1810) also expresses uncertainty regarding Gleditsch's plant: "The description of the Balsam of Mecca-tree, lately given by Gleditsch, differs from that of all other writers."

The authors of the Dictionnaire des sciences naturelles (1825) note that the successors of Linnaeus didn't accept the name *Balsamea meccanensis*.

Meanwhile, the generic name *Balsamodendron* ("balsam tree" Kunth 1824) has come into general use (Balfour 1888). The names given by Forsskål and Linnaeus became synonyms.

Bentley and Trimen (1880) claim, in the section of *Balsamodendron opobalsamum*:

> Prof. Baillon adopts the name *Balsamea* Gleditsch, for this genus, the date of which is 1782 (Berlin Gesellsch. Naturforsch. Freunde, vol. iii, p. 103, t.3, fig. 2). It does not, however, appear from the description and figure given, that Gleditsch really had this plant under his observation.

Balfour (1888) doesn't recognize in Gleditsch's description and figure the characteristics of a *Balsamodendron*. In a correspondence with Engler on this issue, Engler admits that the floral characters of the *Balsamea* are not met with any of the species of balsamodendron. The flowers do not belong to the *Burseraceae* at all. But Engler considers the branching and inflorescence agree well with the characters of the Balsamodendron, and the bipinnate leaves are no barrier to such an identification.

The nineteenth century has seen the abundance of botanical systems, each influenced by its own philosophical concept.

For example, between 1825 and 1845 various botanists proposed some 24 or more systems of classification (Bell 1967).

The shift from *Amyris* to *Commiphora* took place in 1883, when Engler published the section on the *Burseraceae* in the framework of De Candolle's Monographiae phanerogamarum, Vol. 4.

Engler makes changes within the family: he deviates from the classification of Bentham and Hooker (1862–1883) by excluding the Amyridaceae and assigning them to the Rutaceae. One of these excluded species is *Amyris* L.

By this change the family of *Burseraceae* becomes a very natural group that differs enough from the Rutaceae and Simarubaceae in terms of anatomical structure, but is still closer to these two families than to the Anacardiaceae, regarding the arrangements of ovules, the ventral raphe and the micropyle.

Most of the 13 genera recognized by Engler are very closely related and can be distinguished almost only by the fruit.

The number of floral parts varies often within the same genus very strongly, so that generic differences can't be based on the number of petals and stamens (Uhlworm and Behrens 1883).

One of the genera on Engler's list is *Commiphora* Jacq. The genus *Commiphora* was discovered by N.J. Jacquin in 1797.

In Engler's work the genus *Commiphora* includes *Balsamea meccanensis* Gleditsch and *Balsamodendron* Kunth.

As to Gleditsch, he adds the following observation: Gleditsch is right when he claims that *Amyris gileadensis* doesn't belong to the American Amyrids.

On the other hand, the Balsamea of Gleditsch doesn't belong to the genus Balsamodendron Kunth. Finally, Engler decided to prefer the name *Commiphora* over *Balsamodendron*, because Jacquin proposed the best description and figure.

The species *Commiphora opobalsamum* (Engl.) comprises the following synonyms: *Balsamea meccanensis* Gleditsch *Balsamodendron opobalsamum* Oliver

The variants: kunthii (pinnate leaves, rarely ternate)

Amyris opobalsamum Linn

Balsamodendron opobalsamum Kunth

Gileadensis (ternate leaves, rarely pinnate)

Amyris opobalsamum Forsk

Amyris gileadensis Linn

Balsamodendron gileadense Kunth

Balfour (1888) criticizes Engler for preferring the name *Commiphora* over *Balsamodendron*:

> Undoubtedly the plant described and figured by Jacquin […] as *Commiphora madagascariensis* is a *Balsamodendron* […] The significant name Balsamodendron is now commonly accepted, not only by botanists but by pharmacists and physicians, and is indeed current in general literature, and the substitution of another name would be almost impossible, and would certainly lead to much confusion. How poor, too, is the name *Commoiphora* beside the suggestive *Balsmodendron* [sic]!
>
> Bentham and Hooker [1862–1883], with set purpose, place Jacquin's name as a synonym of *Balsamodendron*, and their lead will be generally followed. Were *Commiphora* to be now accepted, it would entail the renaming of all the species, some thirty-six, and as they have been already renamed by Baillon and Engler under Balsamea, we should have an addition of some seventy specific names to the nomenclature.

Despite the above objection, the genus *Commiphora* was accepted.

When botanists describe the natural order of Amyridaceae, they refer to trees and shrubs, abounding in a balsamic juice, and having alternate or opposite leaves, which are ternate or unequally pinnate, sometimes with stipules, and occasionally with pellucid dots. According to Griffith (1847), they are all natives of tropical climates; one species only is found in the United States.

Nevertheless, the status of the Amyrids is still problematic.

The genus *Amyris* P. Browne has enjoyed a confused taxonomic history, having been classified in both the *Burseraceae* and in the family *Rutaceae*. It is now considered to belong to the latter family, but certain species have been transferred to the genus *Commiphora*, which belongs to the *Burseraceae*. Thus, Yucatan elemi derived from *Amyris plumieri* DC. is a product of the family Rutaceae, while balm of Mecca is derived from *Amyris opobalsamum* L. which is now considered to be a synonym of *Commiphora opobalsamum* Engl., fam. *Burseraceae*. (Botanical dermatology database)

The controversy persists along the twentieth and twenty-first centuries:

The Rutaceae family has been placed in many orders including the Sapindales, the Geraniales and the Rutales.

The first comprehensive classification within the Rutaceae was made by Engler in 1896. He later divided the family into seven sub-families. Four of these subfamilies have been subject to significant controversy with regard to their placement, and two of the subfamilies have since been combined. The seventh subfamily, Citroideae, has remained unchanged.

> The controversial history of the subfamilies has resulted in considerable movement of subfamilies in and out of the Rutaceae. (Scott et al. 2000)

In a research done by Clarkson et al. (2002), the authors studied the phylogenetic relationships in *Burseraceae*.

Burseraceae were first described by Kunth in 1824. In more recent classifications they have been placed in Sapindales. The family is closely allied with Anacardiaceae, Rutaceae, Simaroubaceae and Meliaceae and comprises trees or shrubs, with the inner bark having resin ducts and, unlike Rutaceae, distinctively absent foliar pellucid glands. The family is distributed throughout the tropics but is especially diverse in Malaysia, South America and Africa.

There have been various attempts to divide the family, each using different characters or character combinations such as flowers, embryos, anatomy, fruit, germination and seeds. The first comprehensive subdivision of the family was made by Engler in 1931. He split the taxa into three tribes based exclusively upon the structure of the fruits: *Protieae*, *Boswellieae* and *Canarieae*. This system was accepted and slightly modified by Lam in 1932, producing the classification used today. Lam renamed the tribe *Boswellieae* as *Bursereae* (because the latter is older than the former).

Since then new taxa have been discovered and assigned to these tribes, but some of them were so morphologically distinct that they justified the creation of entirely new genera.

Authors of more recent works on the family have concentrated on particular geographic areas or genera, often using newer characters, such as pollen morphology.

Clarkson and his colleagues, who used genetic methods in their study, assert that there is a close association between the African genus *Commiphora* and the South American genus *Bursera*.

Present reviewers consider the recent article by Gachathi (1997) who also examined the *Burseraceae* as a base to stress the problem of the present controversy:

> *Burseraceae* is a family of 17 genera with some 560 species which are widespread in the tropics especially in Africa, Malaysia and South America. These are trees or shrubs characterised by aromatic resins from the bark used even in Biblical times for frankincense, myrrh and perfumes. The main resin-producing species are found in the genera *Boswellia* and *Commiphora* and others which are common in the hot drylands. Despite their early recognition, classification and nomenclature of members of the two genera, and particularly those of *Commiphora* have remained unstable. They have been described by botanists as taxonomically difficult, frustrating or confusing. This is largely because of the nature of the plants themselves, appearing leafless and in a drought-dormant condition for much of the year. This situation has led to the practice of describing species from inadequate and often sterile material. As a result, some species have been described by different botanists under different names. Moreover, sterile plants from other genera have been described as species of either *Boswellia* or *Commiphora*. For example, six plants described by Engler (the chief worker on the genus *Commiphora*) as new species of *Commiphora* belonged in fact to other genera and in other families. Several plants within the two genera therefore have been known by two or more different names. This instability of plant names is a real disadvantage as all information about plants and their products is communicated by name. Recent taxonomic revisions of the family *Burseraceae* have resulted in the union of two or more species previously considered distinct, splitting what was considered previously to be one species into two or more species or outright rejection of wrong names brought about by misidentification. Most names of the members of the family *Burseraceae* are therefore presented with numerous synonyms, subspecies, varieties, long descriptions and additional notes.

Furthermore, different plants at different parts of the world are called at present *Commiphora gileadensis* which definitely do not belong to the same species.

In conclusion, the disorder in the taxonomy and nomenclature of the resinous plants presents problems in determining the true balm of Gilead. Therefore, there is a need to examine carefully and thoroughly the different species and separate those mistakenly put together.

This is the old classification of the Apharsemon of Stephenson (1831)

Class VIII. Octandria – *OrderI*. Monogynia. *Nat. Ord*. Terebintaceae, *Juss*.

Gen. Char. *Calyx* four-toothed. *Petals* four, oblong. *Stigma* quadrangular. *Berry* drupaceous.

Spec. Char. *Leaves* ternate; leaflets entire; peduncles, one-flowered, lateral.

Syn.-Balsamum. *Theophr. I*. 9. c. 6; *Plin. I*. 12. c. 25; *Justin*, *I*. 36. c. 3; *Bellon*. 110.

Balsamum syriacum, rutae folia. *Bauh. Pin*. 400.

Balsamum verum. *Bauh. Hist*. 1.298; Raii. *Hist*. 1755.

Balsamum Alpini cum Carpobalsamo. *Ger. Em*. 1528.

Balsamum, ab sagyptiis Balessan. *Alpin.AEgypt*, *p*. 48. *t*. 60.

Balsamea meccanensis. *Gleid. Act. Soc. Berol*. 3. *p*. 127. *t. 3.f*. 2.

Balsamodendron Gileadense. *Decand. Prodr. t. 2.p*. 76.

Amyris Opobalsamum. *Forsk. Aegypt. p*. 79; *Niebuhr. v. i*. 307.
Theophrasti et Dioscoridis.
Amyris gileadensis. *Lin. Mantis*. 65; *Diss*, *de Opobals*. 1764; *Willd.v.2*.
p. 333. *Vahl. Symb*. i. 28 t. II; *Lam. III. t*. 303.f. 2;Woodv. *v*. 3. t. 192;
Stokes, 2.357.
Foreign. – *Balsamier de la Mecque*, *Fr*.; *Balsamino di Gilead*, It.; *Gileadischer Balsamstrauch*, Ger.
Present Taxonomy
http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=896045. Accessed July 14, 2014
***Commiphora gileadensis* (L.) C. Chr.**

Taxonomy and Nomenclature

Kingdom:	**Plantae**:
Taxonomic rank:	Species
Synonym(s):	*Commiphora opobalsamum* (L.) Engl.
Common name(s):	
Taxonomic Status:	
Current standing:	Accepted
Data quality indicators:	
Record credibility rating:	verified – standards met

Taxonomic Hierarchy

Kingdom	**Plantae** – plantes, Planta, Vegetal, plants
Subkingdom	Viridaeplantae – green plants
Infrakingdom	Streptophyta – land plants
Division	Tracheophyta – vascular plants, tracheophytes
Subdivision	Spermatophytina – spermatophytes, seed plants, phanérogames
Infradivision	Angiospermae – flowering plants, angiosperms, plantas com flor, angiosperma, plantes à fleurs, angiospermes, plantes à fruits
Class	Magnoliopsida
Superorder	Rosanae
Order	Sapindales
Family	*Burseraceae* – burseras
Genus	*Commiphora* Jacq. – myrrh
Species	*Commiphora gileadensis* (L.) C. Chr.

Reference
Germplasm Resources Information Network (GRIN), 2007–2011, database (version 2011)
USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network – (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland
URL: http://www.ars-grin.gov/cgi-bin/npgs/html/paper.pl?language=en

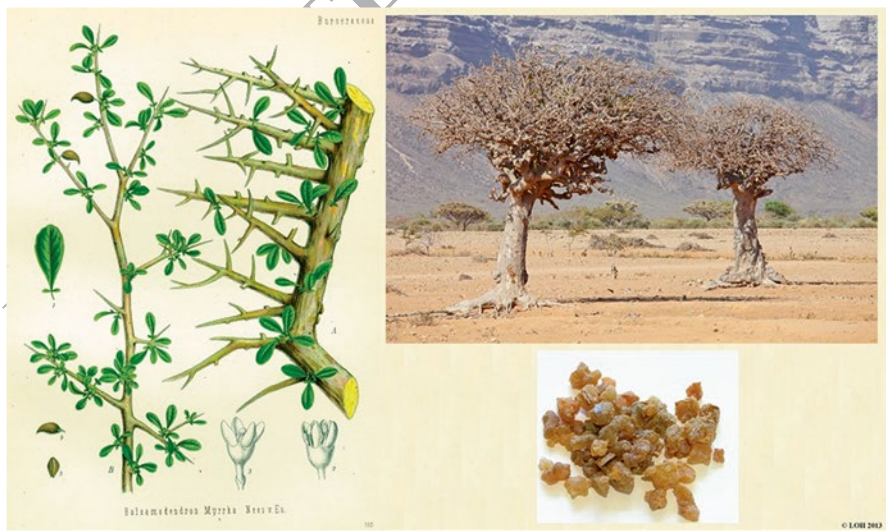
Taxonomical Identification: Myrrh

The oleo-gum resin myrrh (so named from the ancient Acadian *murru*, Arabic mur, and Hebrew mar, meaning "bitter") is obtained from the *Commiphora myrrha* (Nees) Engler tree (Picture 3) and called *Apharsemonodendron myrrha* by Nees von Esenbeck in 1826 (Orwa et al. 2009). It also has other synonyms, such as: *Commiphora molmol* (Engl.) Engl. and *Commiphora myrrha* var. *molmol* Engl.

There is still discussion regarding from which *Commiphora* tree myrrh was harvested in biblical times. Feliks (1968) and Zohary (1982) identified the myrrh of the Bible with the *C. abyssinica* Berg and *C. schimperi* Berg, both growing in Africa, where the resin is still used today medicinally and socially among local traditional communities; others suggest *C. africana*. Engl. (African myrrh) and *C. myrrha* (Nees) Engl. (Moldenke and Moldenke 1952).

Taxonomical Identification: Olibanum

The genus *Boswellia* was named after John Boswell in 1846, and his associate H. J. Carter (1851) was responsible for the first scientific survey of these trees in the same year, refined by Birdwood in his article in 1870. According to van Beek (1958), there are five species, but only *B. carterii* (Picture 4) and *B. frereana* yield frankincense of commercial value.



Picture 3 Myrrh, *Commiphora myrrha* – drawings of botanical details (Köhler), tree, and natural aromatic resin

Picture 4 Frankincense, *Boswellia carterii* – drawings of botanical details (Köhler), tree, and natural aromatic resin

Boswellia carterii is also referred to as olibanum and dragon's blood. Some authorities regard this species as the biblical frankincense and the same species as the *B. sacra*, but there is some dispute over this. Thulin and Warfa (1987) determined that the *B. carterii* is a variable form of *B. sacra*.

Boswellia frereana (Birdw.) and *B. thurifera* (Roxb. Ex Flem. 1810) grow in northern Somalia (Thulin and Warfa 1987) and are the source of the Maydi frankincense, also called Coptic frankincense, as it is highly esteemed by the Coptic church, but the main part of its production is purchased by Muslim pilgrims in Saudi Arabia. These resins have a pleasant lemon scent and are also manufactured into a popular chewing gum. The smell of the *B. frereana* is different from *B. sacra*, but they are often marketed together for different uses (Bowen 1989).

Boswellia papyrifera Hochst grows in Ethiopia and Sudan but is not marketed in the western world. The resin is transparent and oilier than the other resins.

Boswellia serrata Triana & Planch. (Roxb.) Colebr. is the Indian frankincense, considered by some to be of inferior quality. The golden brown color resin is soft and hardens slowly; it is mainly burned as incense but also used in Ayurvedic medicine (Miller and Morris 1988). *B. serrata* is taller than the other *Boswellia* trees and has a straight trunk. The scent of the resin extracted from *B. serrata* is quite distinct from that obtained from the other *Boswellia* trees and is heavier than the African resins, more of an orange type of scent, while the *B. sacra* resins have a lighter, lemon scent. The difference in odor between the various *Boswellia* tree resins is due to their complex sesquiterpenes (Tucker 1986).

Crude Drug Uses

Apharsemon

The crude drug of apharsemon was a special fragrant resin that exuded from the branches after cutting the branch. The exudates were processed into various products: incense, perfume, and different medical drugs. This resin was the most expensive agricultural product, with a price twice its weight in gold during the Middle Ages and twice its weight in silver during the Roman period. Documents show that the apharsemon plants were guarded in order to prevent theft (Picture 5).

Pliny describes just how expensive this rare spice was in classical times: For a sextarius (equaling about 20 fluid ounces or half a liter) of apharsemon which is sold by the fiscal authorities at 300 dinars (denarii), is sold again for a thousand, so vast is the profit to be derived from increasing this liquid by sophistication. The price of xylobalsam is six dinars per pound (Book 12, Chapter 34). In other words, a sextarius of apharsemon sold at the source for the equivalent of nearly the yearly wages of one laborer in the early Roman period and later sold for over three times that amount. Even the wood cuttings of the plant (xylobalsam) were coveted and sold for the price of 6 days wages. Oil of Apharsemon was considered to be the most valuable oil used for medicinal purposes. Strabo refers to it as a remedy for headaches, cataracts, and dimness of sight (Jones 1924). Pliny lists 15 different ailments that could be cured with apharsemon oil (Book 12, Chapter 54).

Picture 5 A Janissary guarding the balsam tree (Cartwright 1760)

Apharsemon in Judea

The Bible refers to the transport and trade of apharsemon (*tzori*) in the time of the Patriarchs, about 1850–1550 BCE. Joseph was sold by his brothers to a caravan of Ishmaelites carrying balm and other spices down to Egypt (Genesis 37:25). Also, in another Biblical story Jacob, asked his children to collect the Tzori described there as one of special crops of Israel as a gift to Pharaoh King of Egypt. However, according to specific version, which is in my opinion a concensus among experts dealing with this issue, during the time of Jacob – early beginning of the second millennium BCE, apharsemon was not yet grown in Israel as it was brought to Israel by the Queen of Sheba as a gift to King Solomon at the end of the tenth century BCE. This unexplained Biblical story may relate to a possible mistake, for example in considering the word Tzori always as representing the Apharsemon (Pictures 6, 7, and 8). It is possible that Tzori may be at times used to describe a natural medical product. Such a disagreement with the biblical story occurred at the period of the first Temple. At a post Biblical period no such problem of lack of agreement between the accepted history of the apharsemon and the many written historical documents existed.

Present Day Investigations to Find the Apharsemon

Currently, no residue of the ancient apharsemon has been discovered, and all archaeological attempts to find it have failed (Hirschfeld 2007).

Picture 6 *Commiphora gileadensis* leaves and fruits (Taken by Lumír Hanuš on August 1, 2013 in Kibbutz Almog, Jordan Rift Valley, West Bank. Notice the different shape of the leaves between the Israeli and the Oman plants. Explanation is not yet available)

Picture 7 *Commiphora opobalsamum* male flowers (Taken by Lumír Hanuš on May 11, 2013 in Kibbutz Almog, Jordan Rift Valley, West Bank)

Picture 8 *Commiphora gileadensis* seeds (Taken by Lumír Hanuš on August 1, 2013 in Kibbutz Almog, Jordan Rift Valley, West Bank)

In one of the many archaeological projects carried out to locate residues of apharsemon, Patrich and Arubas (1990) discovered a juglet, half full of a dense liquid, in a cave near Qumran, in the Dead Sea Basin. They suggested that this oil might be made from the apharsemon. However, two chemical studies negated this suggestion; one was performed by Eizenstadt and Ashengraw and reported as an appendix in the paper by Patrich and Arubas (1990), and the other was unpublished data by S. Ben-Yehoshua and L. Hanuš. This oil, according to our data, had none of the chemical markers of the *Commiphora* species or, for that matter, of *Boswellia*. Nevertheless, Vendyl Jones, one of the initiators of the Qumran expedition, claimed in several of his reports to his financial sponsors for the lost treasures of the Holy Temple in the Qumran region that he had found the oil of the biblical apharsemon inside the juglet that Patrich had discovered. However, no data confirming this claim have been presented.

In another work of the Vendyl Jones Research Institute (Jones 1995), a hidden silo in the bedrock in a cave at Qumran was found during the 1992 excavation, which contained a reddish material that appeared to be organic in nature. Tests allegedly indicated that the reddish material was a mixture of 11 ingredients of the holy incense (*pitum haqetoret* in Hebrew) used in the Temple in Jerusalem, which also contains the oil of the apharsemon. Over 400 kg of the reddish material were removed that year from the cave. These two items are listed in the Copper Scroll, one of the Dead Sea Scrolls, which Vendyl Jones studied. In his work, he further claimed that this incense was prepared in the precise order as had been written in the Torah. However, Vendyl Jones's reports were greatly criticized by many researchers. The late Yehuda Feliks (see Amar 1998) said that the reliability of this article is dubious and the finding of the holy incense is just a fantasy. Amar (1998) also analyzed this report in detail and concluded that the silo was possibly a factory to produce soap from the local Dead Sea Basin herbs.

<u>The precious perfume boxes</u>: Four powder boxes made of gold and silver were given to the senior author for chemical evaluation by a famous antiques collector, one box bearing the inscription "Balsam". Analysis of the top layer of the material of all four boxes did not reveal any of the chemical markers of the *Commiphora or Boswellia* species. However, a chemical that is a known component of the aromatic gum *ladanum* from *Cistus creticus* was found in one box. The ladanum spice (*lot* or *lotem* in Hebrew) was one of the important ancient spices of Canaan and of the Israelites. Furthermore, it was one of the spices that the Ishmaelites who had purchased Joseph from his brothers carried on the backs of their camels: astragalus, balm, and ladanum ("*nechot*, *tzori velot*" Hebrew, (Genesis 37:25). This is the first time that both the apharsemon and ladanum are mentioned in the Bible. It was suggested that these chemical markers could be used to identify the ladanum spice (Ben-Yehoshua and Hanuš, unpublished data 2007).

Crude Drug Uses of Myrrh

Myrrh was a central factor in religious ceremonies in ancient Egypt. Plutarch wrote: "Every day they make an offering …to the Sun …of myrrh at midday." Animal sacrifices and rituals were accompanied by the burning of myrrh, to mask smells and disperse evil spirits (Babbitt 1928).

The resin *bdellium* (*b'dolach* in Hebrew) is obtained from *Commiphora africana* (A. Rich.) Engl., named the "African myrrh" by Duke (2008). This resin is mentioned in the Bible (Genesis 212) and was regarded as a costly gum. It was well known in the ancient world, and Theophrastus (*Historia Plantarum* IV: 2.1 and 2.6) (Theophrastus Eresius 2009), Pliny (*Historia Naturalis* Book 12), and Galen (*Opera Omnia* Vol. 14) all mentioned it.

Stacte (*nattaf* in Hebrew), which appears in the Bible in Exodus (30:34), probably refers to the liquid form of myrrh, a solution of myrrh resin in oil. Pliny (Book 12, Chapter 35) refers to a naturally flowing gum, called stacte, which sometimes flows from the bark of the tree without any cutting, before the actual harvest. However, Dioscorides (Osbaldeston, Book I, 73) and Theophrastus (Hort., Chapter 9) interpret stacte as distilled myrrh. Johnson (1987) suggested that stacte is the myrrh resin dissolved in oil of *Balanites aegyptiacus* (L.) Delile.

Embalming in ancient Egypt was an elaborate process, involving many different materials. The inclusion of frankincense and myrrh from Punt was symbolic as originating from the land of the Egyptian gods. Great quantities of myrrh and frankincense were employed to treat the dead body and preserve it from decay and deterioration. The antibacterial properties of these resins were important in protecting the body from putrefaction. The embalming procedure of ancient Egypt, as described by Herodotus in the fifth century BCE, used myrrh extensively, as evidenced from archaeology, where myrrh can still be smelled in newly excavated burial tombs. Myrrh was a very effective antiputre-faction and antimicrobial agent in corpses, its efficiency allowing the examination of intact mummies several thousands of years old. Tomb paintings at the tomb of Petosiris show ancient Egyptian perfumers preparing resins to perfume the air and mask the odors of the embalming process and generally the unsanitary conditions of life in those times.

The New Testament mentions myrrh in John 19:39, where Nicodemus brought about 45 kg myrrh and aloes for treating the crucified body of Jesus before his burial. This huge quantity of such an expensive material demonstrates the esteem conferred on Jesus. Matthew 2:11 relates that the Magi traveled to the birthplace of Jesus and they opened their treasures and presented him with gifts – "gold, incense, and myrrh."

Olibanum

The name given to the natural oleo gum resin of *Boswellia* was olibanum, not indicating oil from Lebanon but most probably taken from the Arabic *laben* or *alluban*, meaning "white," since the clear white drops of resin are the most valuable (Miller and Morris 1988). The Hebrew name is *levonah*, also suggesting "white" (Hebrew: *lavan*). The other name – "frankincense" has its origin either from the French crusaders ("frank" or "French incense") or from the Old French *franc encens*, meaning "pure incense". The chemical composition of olibanum or frankincense oil has been investigated by Hamm et al. (2003, 2005). Incense burning at religious ceremonies is one of the chief uses of frankincense which will be described later.

Chemical Constituents, Bioactive Compounds and Current Research

Apharsemon

It is worth mentioning, that it is not entirely certain that all the publications cited, referring to *C. opobalsamum*, describe the same plant. Since there are chemical differences between *C. opobalsamum* from Saudi Arabia or Yemen, and from Israel and from China. The exudates of Apharsemon measured there were imported to China from India. It is therefore questionable if the researchers are dealing with the same plant – *C. opobalsamum*.

Structures of typical known terpenic compounds from *C. opobalsamum* – linalool, α–terpineol, and 4-terpineol (Al-Massarany et al. 2007), α-cubebene, β-cubebene, α-copaene, β-selinene, γ-muurolene, germacrene D, δ-cadinene, β-caryophyllene, spathulenol, cembrene, and α-cadinol (Al-Massarany et al. 2007; Hanuš 2012) – are presented at Fig. 1.

The other compounds, typical for *C. opobalsamum* – 5β,10α-hydroxy-2α-methoxy-6-oxoguaia-7(11),8-dien-8,12-olide, and 2α-methoxy-6-oxogermacra-1(10),7(11)-dien-8,12-olide (Shen et al. 2008a), cycloartane-24-ene-1α,2α,3β-triol (Shen et al. 2008b), guaia-6α,7α-epoxy-4α,10α-diol (Shen et al. 2007), cycloartane-24-ene-1α,2α,3β-triol-1,2-acetonide, 1β, 8β-epoxy-2α-methoxy-6-oxogermacra-9(10), 7(11)-dien-8,12-olide, and ent-4(15)-eudesmene-1β,6α-diol (Yang and Shi 2012) – are in Fig. 2.

Chemical Constituents and Bioactive Compounds of Myrrh

There are several compounds which are typical for *C. myrrha* – curzerene, 2-hydroxyfuranodiene (Morteza-Semnani and Saeedi 2003), furanoeudesma-1,3-diene (Brieskorn and Noble 1983; Jingai and Shangwei 1996; Dolara et al. 1996), lindestrene, curzerenone, furanodiene (Brieskorn and Noble 1982; Provan et al. 1987), 2-methoxyfuranodiene, 2-acetoxyfuranodiene (Brieskorn and Noble 1983; Monti et al. 1986), germacrene B (Baser et al. 2003), germacrene D (Brieskorn and Noble 1982), and T-cadinol (Zhu et al. 2003). Their structures are in Fig. 3.

Ahmed et al. (2006) succeeded in isolation of six new compounds from the oleo-gum resin of *Commiphora myrrha*, which were identified as myrracadinol A–C and myrracalamene A–C (Fig. 4).

The resin of *C. myrrha* gave a new cycloartane-type triterpene, cycloartane-1α,2α,3β, 25-tetraol (neomyrrhaol; Fig. 5), along with four known compounds, sandaracopimaric acid, abietic acid, 2-methoxy-5-acetoxyfruranogermacr-1(10)-en-6-one, and dehydroabietic acid (Shu-Lan et al. 2009). 2-methoxy-5-acetoxyfruranogermacr-1(10)-en-6-one, and dehydroabietic acid exhibited significant aromatase inhibitory activity with IC_{50} values at 0.2 μM and 0.3 μM, respectively. The four

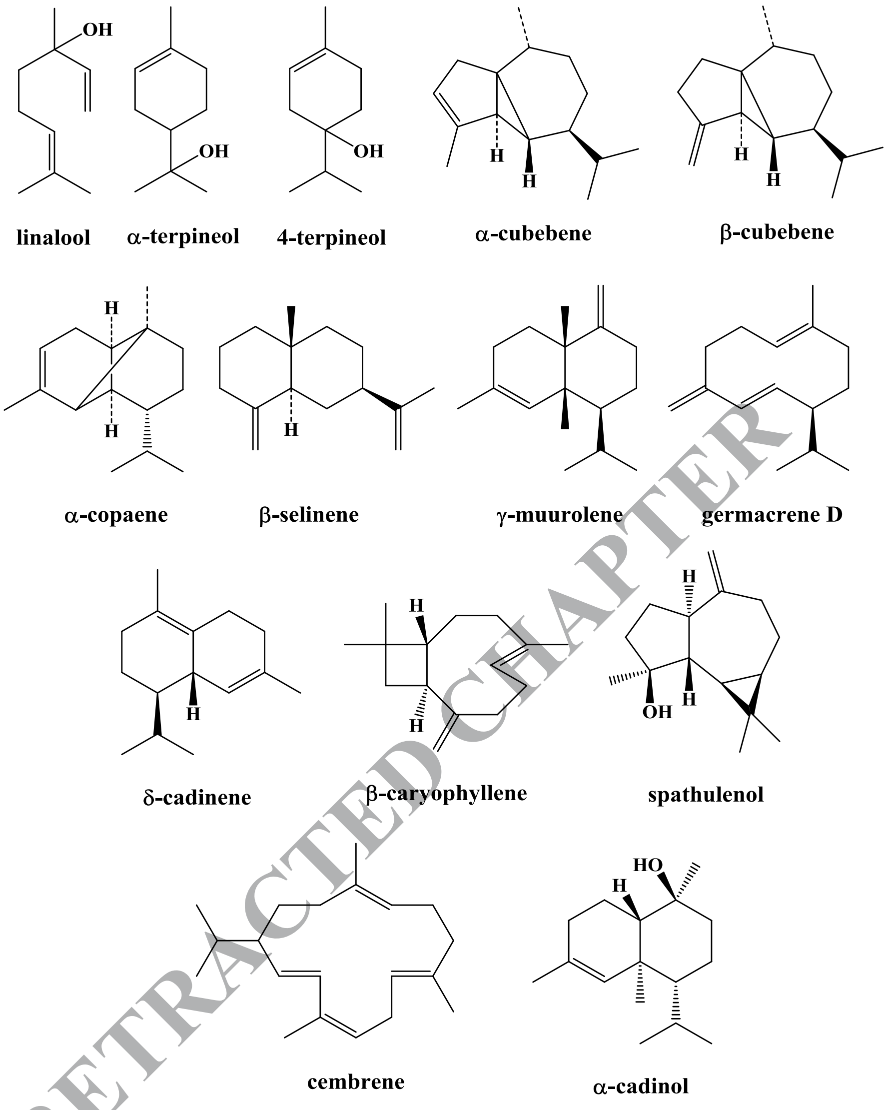


Fig. 1 Structures of typical known terpenic compounds extracted from *C. opobalsamum* (Al-Massarany et al. 2007; Hanuš 2012)

known terpenes had inhibitory effects on human umbilical vein endothelial cells growth with IC_{50} values of 0.122 μM (2), 0.125 μM (3), 0.069 μM (5).

After isolation from methanol extract, the air dried oleo-resin of *Commiphora myrrha* revealed n-dodecanyl myristate, henetriacosanyl laurate, and three new tetraterpenyl esters, myrrhatetraterpenolyl salicylate, myrrhatetraterpenolyl salicylate triacetate, and myrrhatetraterpenolyl vanillic acetate (Shuaib et al. 2013) (Fig. 6).

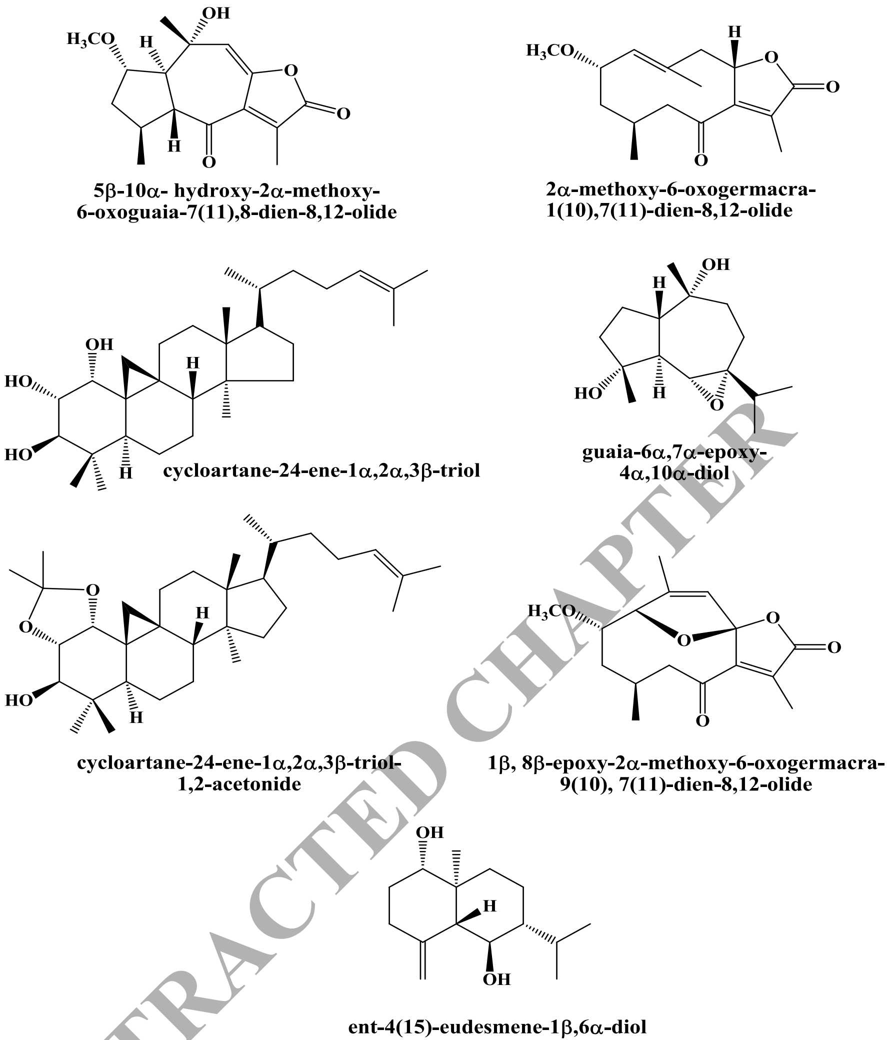


Fig. 2 Structures of typical apharsemon compounds extracted from *C. opobalsamum* (Shen et al. 2007, 2008a, b; Yang and Shi 2012)

Methanolic extract of the resin of *Commiphora erythraea* gave after isolation a new cadinene sesquiterpenoid named agarsenone, which easily decompose to the agarsenolides A and B and myrrhone (Santoro et al. 2013). The isolation revealed also already known compounds, 1,10(15)-furanogermacra-dien-6-one, 1(10),4-furanodien-6-one, rel-3*R*-methoxy-4*S*-furanogermacra-1*E*,10(15)-dien-6-one, rel-2*R*-methoxy-4*R*-furanogermacra-1(10)*E*-en-6-one, dihydropyrocurzerenone, curzrenone, alismol, fura-

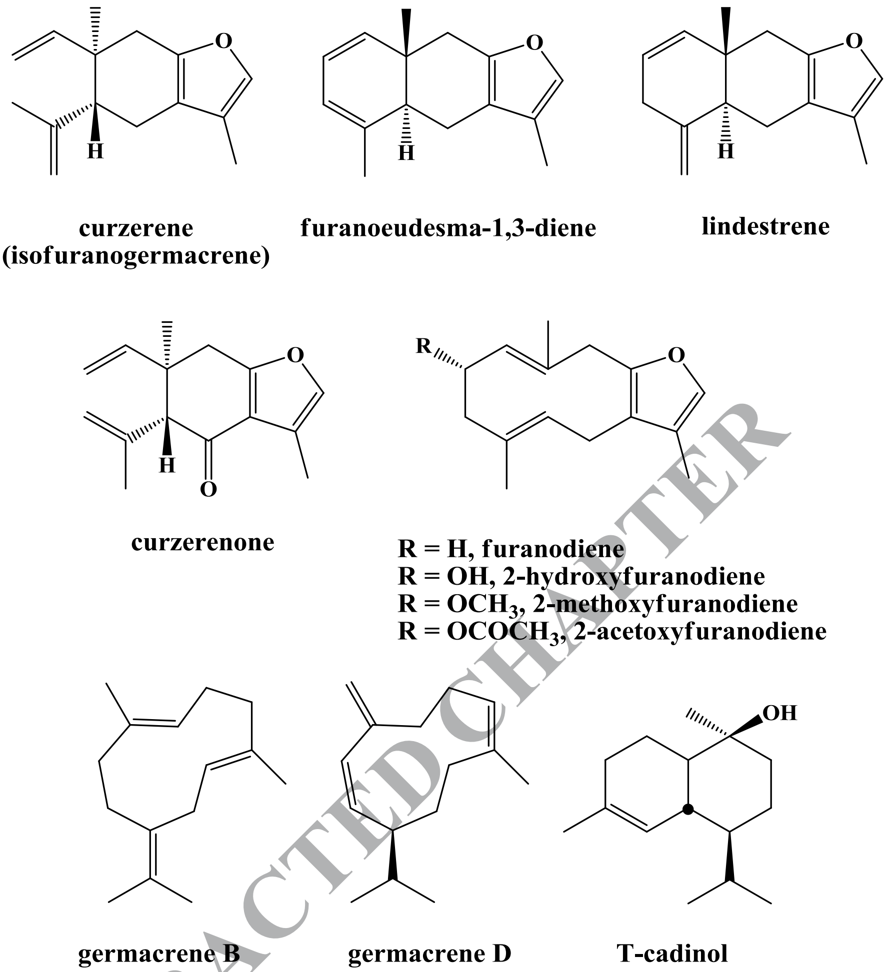


Fig. 3 Structures of typical myrrh compounds extracted from *C. myrrha* (Morteza-Semnani and Saeedi 2003; Brieskorn and Noble 1983; Jingai and Shangwei 1996; Dolara et al. 1996; Brieskorn and Noble 1982; Provan et al. 1987; Monti et al. 1986; Baser et al. 2003; Zhu et al. 2003)

noeudesma-1,4-dien-6-one and rel-1*S*,2*S*-epoxy-4*R*-furanogermaca-10(15)-dien-6-one (Fig. 8). Myrrhone, 1,10(15)-furanogermacra-dien-6-one, 1(10),4-furanodien-6-one, rel-3*R*-methoxy-4S-furanogermacra-1*E*,10(15)-dien-6-one, and rel-2*R*-methoxy-4*R*-furanogermacra-1(10)*E*-en-6-one are known for their antiradical, anti-inflammatory, and antiviral activity (Fig. 7).

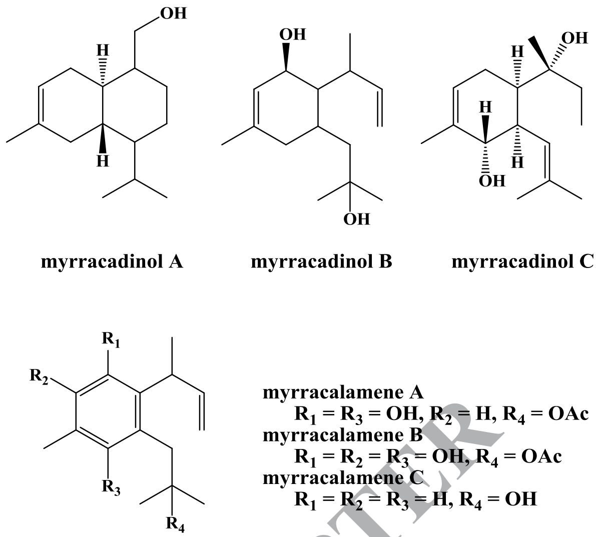


Fig. 4 Structure of new compounds isolated from *C. myrrha*

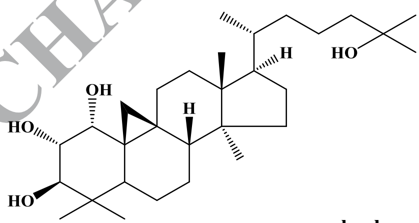


Fig. 5 Structure of compound isolated from *C. myrrha* (Shu-Lan et al. 2009)

Major Chemical Constituents and Bioactive Compounds of Olibanum

Figure 8 shows typical *Boswellia* compounds. These are α-boswellic acid, α-boswellic acid acetate, β-boswellic acid, and β-boswellic acid acetate (Fattorusso et al. 1983), incensole (Klein and Obermann 1978), incensole acetate (Basar et al. 2001), 24-noroleana-3,12-diene and 24-norursa-3,12-diene (Hanuš et al. 2007), incensole oxide and incensole oxide acetate (Hamm et al. 2005; Hanuš et al. 2007).

The analysis of the essential oil of *B. sacra* revealed the main compounds to be β-ocimene and limonene (Table 1; Al-Harrasi and Al-Saidi 2008).

Woolley et al. (2012) compared the main compounds in the essential oils of *B. sacra* and *B. carterii* with α-pinene as the main compound (Table 2).

Morikawa et al. (2010) isolated four new ursane-type triterpenes, olibanumols K, L, M, and N from *Boswellia carterii* (Fig. 9) together with 19 known triterpenes (epilupeol acetate, lup-20(30)-ene-3α,29-diol, glochidiol, lupeol, lup-20(29)-ene-

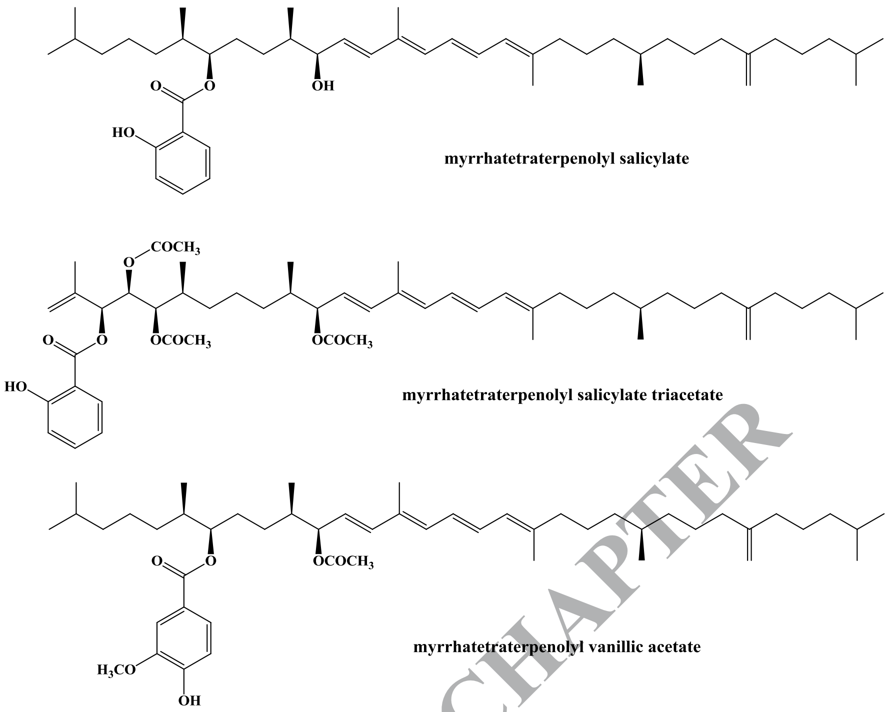


Fig. 6 Structures of compounds isolated from *C. myrrha* (Shuaib et al. 2013)

2α,3β-diol, 3β-acetoxylup-20(29)-en-11β-ol, lupenone, urs-9(11),12-dien-3β-ol, neoilexonol, neoilexonol acetate, urs-12-ene-3β,11α-diol, urs-12-ene-3α,11α-diol, dammarenediol II, dammarenediol II acetate, 3-*O*-acetyl-3β,20S,24-trihydroxydammar-25-ene, isofouquierol acetate, ocotillol acetate, 3β-hydroxymansumbin-13(17)-en-16-one, and mansumbinol).

From the nine compounds isolated from *Boswellia carterii*: 3-keto-tirucall-8,24-dien-21-oic acid and acetyl-11-keto-β-boswellic acid (Fig. 10) showed proliferation inhibition activity against Bel-7402, MCF-7, SMMC-7721, K562 and Hela (Li et al. 2010).

Wang et al. (2011) isolated from the resin of *Boswellia carterii* two new triterpenoids, 3-oxotirucalla-7,9(11),24-trien-21-oic acid (1) and 18Hα,3β,20β-ursanediol (Fig. 11) and another 15 already known compounds: α-amyrin, α-boswellic acid, β-boswellic acid, acetyl α-boswellic acid, acetyl β-boswellic acid, 9,11-dehydro-β-boswellic acid, 9,11-dehydro-α-boswellic acid, acetyl 11α-methoxy-β-boswellic acid, 11-keto-β-boswellic acid, acetyl 11-keto-β-boswellic acid, acetyl α-elemolic acid, 3β-hydroxytirucalla-8,24-dien-21-oic acid, elemonic acid, 3α-hydroxytirucalla-7,24-dien-21-oic acid, and 3α-hydroxytirucall-24-en-21-oic acid.

The Hougari Regular frankincense samples of *Boswellia sacra* were collected from the various locations in Oman and were also supplied by a trustful partner. A new boswellic acid derivative, 11α-ethoxy-β-boswellic acid and a new ursane-type triterpene,

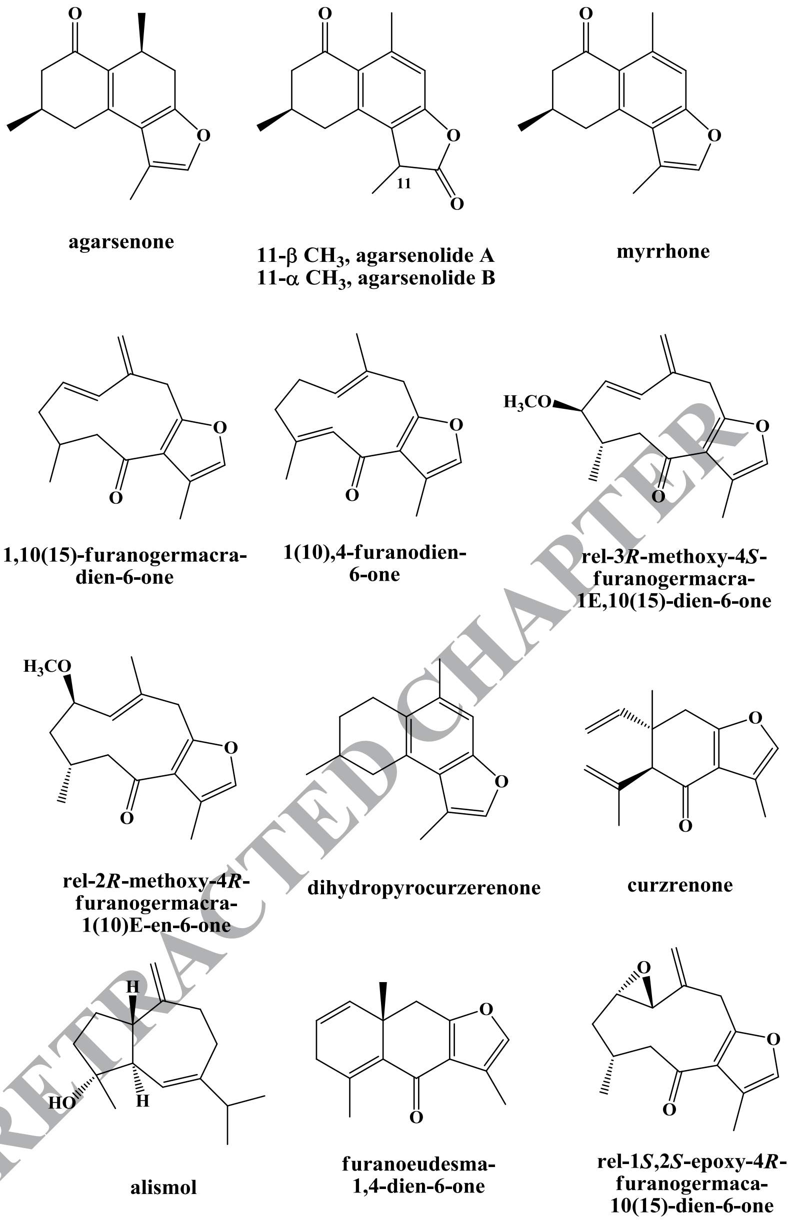


Fig. 7 Structures of compounds isolated from *Commiphora erythraea* (Santoro et al. 2013)

named nizwanone, were isolated from Omani frankincense *Boswellia sacra* Flueck. together with two known compounds papyriogenin B and rigidenol (Fig. 12), which were isolated from *Boswellia* spp. for the first time (Al-Harrasi et al. 2013).

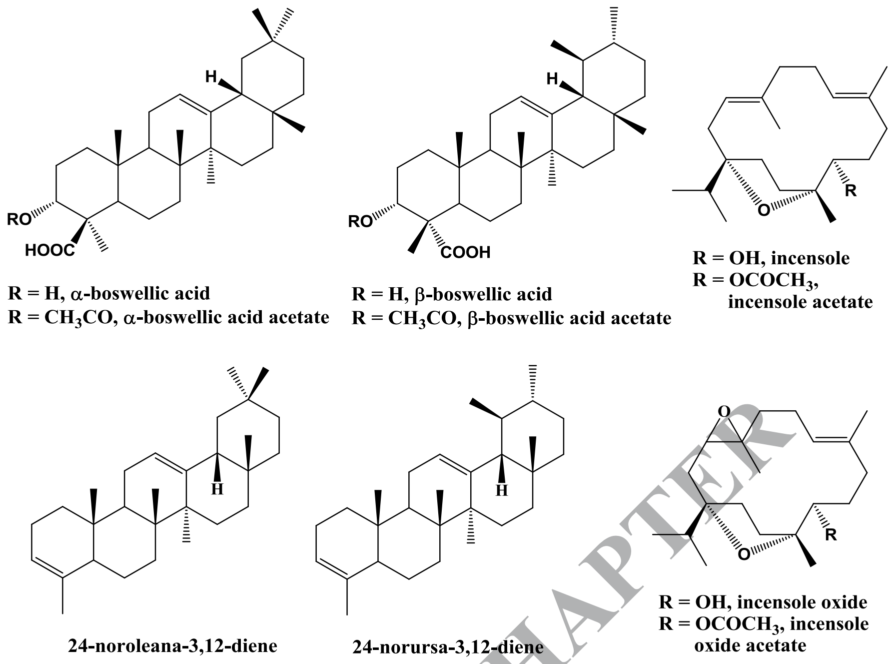


Fig. 8 Structures of typical *Boswellia* compounds extracted from *B. carterii* and *B. sacra* (Fattorusso et al. 1983; Klein and Obermann 1978; Basar et al. 2001; Hamm et al. 2005; Hanuš et al. 2007)

Table 1 The main terpenes identified in *Boswellia sacra*

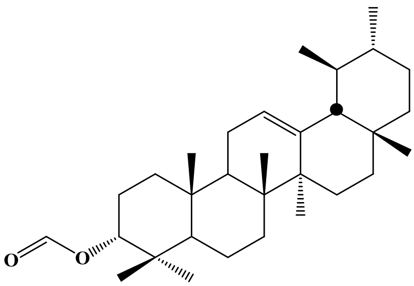
E-β-ocimene (32.3 %)
Sabinene (5.2 %)
β-pinene 1.8 %)
Myrcene (6.9 %)
α-pinene (5.3 %)
Limonene (33.5 %)
γ-terpinene (1.0 %)
E-caryophyllene (0.9 %)

Al-Harrasi and Al-Saidi (2008)

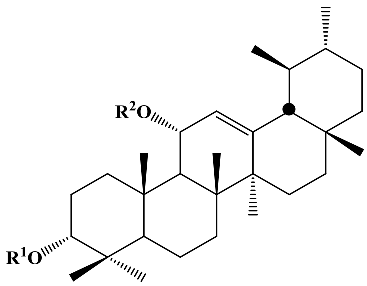
Table 2 Comparison of the main terpenes in *B. sacra* and *B. carterii*

Boswellia sacra	*Boswellia carterii*
α-thujene (0.6 %)	α-thujene (7.9 %)
α-pinene (68.2 %)	α-pinene (37.3 %)
Camphene (2.1 %)	Camphene (0.8 %)
Sabinene (2.9 %)	Sabinene (4.9 %)
β-pinene (2.0 %)	β-pinene (1.8 %)
Myrcene (0.7 %)	Myrcene (7.3 %)
Limonene + β-phellandrene (6.2 %)	Limonene + β-phellandrene (14.4 %)

Woolley et al. (2012)

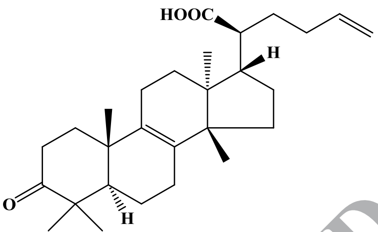


olibanumol K

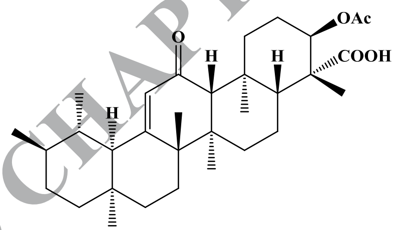


olibanumol L: R^1 = Ac, R^2 = H
olibanumol M: R^1 = H, R^2 = CH$_3$
olibanumol N: R^1 = Ac, R^2 = CH$_3$

Fig. 9 Structures of compounds isolated from *B. carterii* (Morikawa et al. 2010)

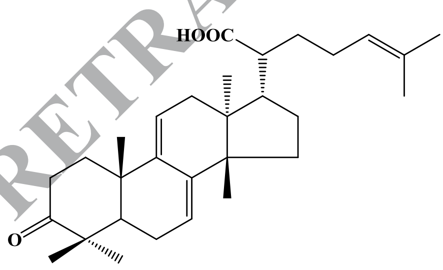


3-keto-tirucall-8,24-dien-21-oic acid

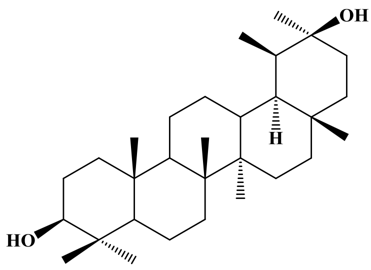


acetyl-11-keto-β-boswellic acid

Fig. 10 Structures of compounds isolated from *B. carterii* (Li et al. 2010)

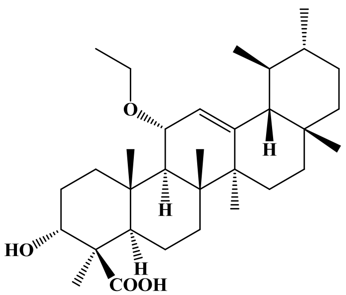


3-oxotirucalla-7,9(11),24-trien-21-oic acid

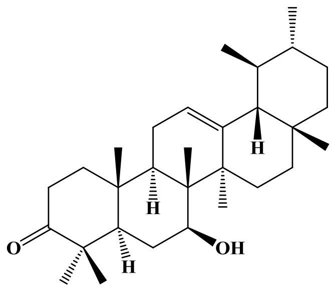


18Hα,3β,20β-ursanediol

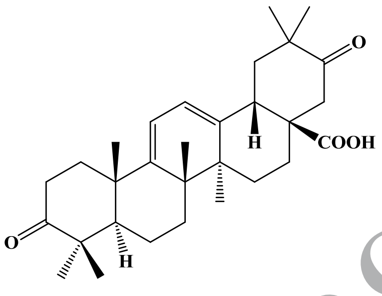
Fig. 11 Structures of compounds isolated from *B. carterii* (Wang et al. 2011)



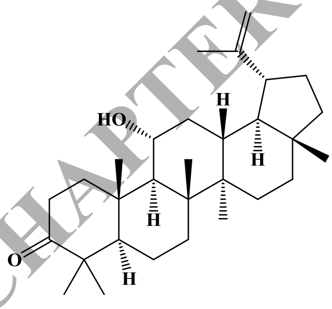
11α-ethoxy-β-boswellic acid



nizwanone
(7β)-7-hydroxyurs-12-en-3-one



papyriogenin B
3,21-dioxo-oleana-9(11),12-dien-28-oic acid



rigidenol
(11α)-11-hydroxylup-20(29)-en-3-one

Fig. 12 Structures of compounds isolated from *Boswellia sacra* (Al-Harrasi et al. 2013)

Morphological Description

Apharsemon

The below description was given by Forsskål, Peter on 1775 in the following report: Flora Aegyptiaco-Arabica, sive, Descriptiones plantarum. Ex Officina Mölleri. Hauniae. Ternate leaves, entire; one-flowered peduncle. Leaves are 3–5 foliate, terminal leaflets obovate (rarely elliptic) about 1 cm long, base attenuate, apex rounded to emarginate; margin entire, lateral leaflets fully developed, about the same size as the terminal leaflets. Leaves are alternate and ternate. Thread-like petiole. Leaflets are close together at the base; the middle ones are great and obovate; the lateral ones are ovate. All of them are glabrous, flat, entire. Description: Medium-sized tree. Branches are strongly divaricate. Bark is smooth, ash grey; when wounded, it produces a balsamic juice (resin) and odor. The plant has long and slender branchlets without spines;

Calyx: Perianth – one-leaved, campanulate, placed underneath, 4-toothed, persistent: short teeth, appressed to the corolla (Picture 6).

Peduncles in branchlets are terminal, solitary or several/many, thread-like, one-flowered

Flowers are in clusters, drupe apiculate (Picture 7).

Corolla: 4 petals, linear, erect, converging to a quadrangulate prism, obtuse, at the margin bent slightly inwards, at the base – more.

Nectary – a fleshy ring between the stamens and the ovary: forming a twisted small channel, circular, close to the ovary, yellow. On the outside there is a little elevation between each stamen.

Filaments – 8, inserted between petals and nectary, thread-like – subulate, in the middle they are curved inwards, shorter than the corolla.

Anthers are oblong, didymous, and yellow.

Ovary is upper/placed above, small.

Style is extremely short, narrow.

Stigma is obtuse, 4-angled.

Pistil is shorter than the filaments.

Pericarp – berry, ovate-acute, glabrous, 4 sutures, or rather valves, Pulp is tough, viscid. With 2 cavities on the inside, one-seeded: often with 1 cavity, empty, often united.

Seed is ovate-acute, solitary (Picture 8).

Flowers seem monoecious. In some of them the anthers were fresh, the ovary – green and the stigma – narrow. In others the anthers were withered, the ovary – dark/dark brown, grooved: the stigma – thick, hyaline, 4-angled: the seed – blackish, abortive: perhaps the balsamic juice hinders fructification; thus several capsules were big, nevertheless empty.

The tree was first seen near the caravanserai/hostel of Oude, not far from the city of Haes in Yemen.

Arabic: Abuscham.

Myrrh

The *Commiphora* species of *gileadensis and myrrh* found in Yemen and Oman share many features. They are typically small trees about 2–4 m high with a relatively stout, dark-green trunk and thin, papery, peeling bark. The genus *Commiphora*, together with *Acacia* and *Grewia*, provides scrub cover on most dry stony hills up to about 1,500 m. Most species are drought resistant. Photographs of several species, including the *C. gileadensis*, growing in Yemen and Oman are found in Al-Hubaishi and Muller-Hohenstein (1984).

Many species in the *Burseraceae* are woody perennial trees or shrubs with fragrant resins in the leaves and/or stems. From a botanical perspective, such resins are known to repel herbivores, and some resinous extracts have insect repellant and insecticidal properties (Birkett et al. 2008; El Ashry et al. 2003). These properties are used by the indigenous peoples where these plants grow naturally. In the New World, the most famous of the resins from the *Burseraceae* are forms of copal, produced from various species of *Bursera* from Mexico and Central America. Like frankincense and myrrh, copal (comes from the sturdy Bursera tree in the regions of southern Mexico) is used as incense and for ritual and medicinal purposes (Alcorn 1984).

Pliny describes the myrrh tree in this way (Book 12, Chapter 34): "The tree grows to a height of five cubits (length of the forearm, 43–53 cm) and has thorns upon it: the trunk is hard and spiral, and thicker than that of the tree, and much more so at the root than at the upper part of the plant." According to van Beek (1958) and Zohary (1982), the myrrh tree normally grows to a height of about 2 m, but, at higher elevations, it is reported to reach a height of about 5 m. The tree is in foliage for only a short time after the rainy season; during the remainder of the year, it is leafless. The leaves are small and single or often 3-foliolate, with two tiny leaflets at the base. The myrrh species is characterized by a terminal leaflet that is up to 1.5 cm long and the lateral leaflets are rudimentary and entire. The myrrh tree is completely different from the frankincense tree, except for its production of spice gum resin (Wood 1997). The myrrh tree has a peeling bark; the underbark is green and photosynthetic. The gum resin of the myrrh tree is yellow to brown red. All myrrh trees grow wild in nature and are not raised in agricultural plantations (Hepper 1992).

Olibanum

The *Boswellia* species "resembles a shrub more than a tree. Some of its species have no central trunk – the branches emerge near the ground – and it grows to a height of seven to eight feet" (Thomas 1932, quoted by van Beek 1958).

Boswellia sacra Flueckiger (syn. *B. carterii* Birdw.) is considered to be the source of the biblical frankincense (Tucker 1986). This tree grows wild, in dry regions, particularly in Somalia, and the Dhofar Valley, Oman (van Beek 1958). The Dhofar Valley, really a high plateau, is a lush, green oasis, watered by the monsoon rains, in contrast to the barren, stony desert surrounding it. It is regarded as having the optimal conditions for *Boswellia sacra* and produces the highest-grade resins, named Silver and Hojari (Ghazanfar 1994).

The Silver frankincense of the B. *sacra* gives a better scent in the dry desert air. The color of the resin and size of the tears also dictates its commercial value – the pale, large clumps are more expensive. *Boswellia sacra* also grows in the Nejd district of southern Oman, where the foggy climate produces an even more expensive resin and very slow tree growth, resulting in large white clumps of resin (Morris 1989).

B. serrata is taller than the other *Boswellia* trees and has a straight trunk. The scent of the resin extracted from *B. serrata* is quite distinct from that obtained from the other *Boswellia* trees and is heavier than the African resins, more of an orange type of scent, while the *B. sacra* resins have a lighter, lemon scent. The difference in odor between the various *Boswellia* tree resins is due to their complex sesquiterpenes (Tucker 1986).

Geographical Distribution

Apharsemon

Trees of the *Commiphora* genus are found in southern Arabia and northeast Africa and India (Hanuš et al. 2005). Like *Boswellia*, they belong to the resinous *Burseraceae* family, which occurs in tropical and subtropical areas in both the Old and New World. There are about 18 genera and 700 species in the family (Weeks and Simpson 2007).

Sometime during the Iron Age, probably at around 1000 BCE, after the Queen of Sheba gave King Solomon incense plants, the cultivation of a few wild plants producing incense had begun in the kingdom of Judea, in the region of Jericho and Ein Gedi (Josephus, see Ben-Yehoshua et al. 2012). Archaeological evidence suggesting the extraction of this special incense plant was found by Mazar et al. (1973) at Tel Goren near Ein Gedi, and some of the equipment used in the processing of this plant to obtain the spices has been discovered (Dayagi-Mendels 1989). These strange plants were brought to an arid ecological system much different than their original location at the Kingdom of Sheba. The farmers living in Jericho and Ein Gedi and their kings realized the economic potential of adapting the new plant to their land. They domesticated the wild plants, intensified their cultivation, created and developed unique production, advertising, and marketing systems that made the apharsemon a most lucrative crop.

Its other unique feature was the fact that it was cultivated by farmers around the Dead Sea Basin in Judea, unlike the other spices derived from myrrh and olibanum that were wild trees. This new plant apharsemon may be considered as a Judean-developed substitute for the classical spices, myrrh and frankincense, which were expensive imports from Sheba. Regardless of the cost of these spices, the Children of Israel were commanded in the Bible to use these spices and many others (e.g., Exodus 30, 34; Leviticus 2,1 and 24, 7). Thus, the gift of the spice plants the Queen of Sheba gave King Solomon the opportunity to try growing his own spices. This ability became especially important with his establishment of the Holy Temple in Jerusalem, replacing the old and much more humble tabernacle located at Shilo. The ritual ceremonies and animal sacrifices in the temple demanded a much larger supply of deodorant, incense, and preservatives of animal meat from rapid spoilage (Ben-Yehoshua and Rosen 2009). It made sense for Solomon to grow these plants, rather than import their products at very high prices, and to establish their cultivation around the Dead Sea Basin in a climate as similar as possible to their original one.

Facilities for the manufacture of perfumed oils, presumably apharsemon cultivated at the site, were discovered in the Dead Sea oasis of Ein Gedi at Tel Goren, dating to the late seventh and early sixth centuries BCE. The excavators believed that during the reigns of King Josiah and his successors, the oasis was a royal estate, and kings were anointed with apharsemon from the time of Josiah's reign (Mazar et al. 1966). The existence of gatherers of apharsemon at the time of the destruction of the First Temple is recorded in the Book of Jeremiah (52:16), where it is stated that Nebuzaradan, the captain of the guard, left the poorest Jews to be vinedressers (*kormim*). In the Talmud, Rabbi Joseph says that the *kormim* were actually gatherers of the apharsemon from Ein Gedi to Ramah (Tractate *Shabbath 26*, *71* Talmud).

This unique apharsemon bush was cultivated in only few orchards in a very small area around the Dead Sea Basin, and nowhere else in the world. Most probably at the beginning of this domestication with the king's or ruler's command, the relevant protocols were developed for cultivation and for the efficient, complicated methods of resin extraction. Today these special plants are no longer cultivated. Their products are harvested only in the wild from plants growing in special ecological niches in Ethiopia, Somalia, Arabia, and India and possibly a few other neighboring countries (Hepper 1969).

Groom said that in medieval times, there was the Makkah balsam tree and its main center of production was in a region Hijaz, particularly at ak Arg - about halfway between Makkah and Madinah (Groom 1981). Miller and Cope (1996) reported several other locations of growth of the *C. opobalsamum* in Arabia. Indeed the resin of this plant, called in Arabia balasan, was used pharmaceutically throughout the medieval period until the eighteenth century CE (Duncan 1804).

Only after the identification of the *Commiphora opobalsamum* by Forsskal and Linaeous did observations appear that this plant is often associated with *C. myrrha*, growing on dry stony hills in the Tihama foothills in Yemen. It grows up to an elevation of 1,200 m and also on the stony slopes south of the Hays Mountains but has not been found north of Jebel Ash Sharafayn.

Although Pliny states that the Romans themselves did not see the plant that produces frankincense and myrrh (Bostock Book 12, Chapter 31), descriptions by contemporary Greek and Roman historians provided information on these plants. At that time, the source of the incense was from trees that grew wild in southern Arabia and from the kingdom of Sheba, first cited in the biblical description of the visit of the Queen of Sheba to King Solomon (I Kings 10:1–2; II Chronicles 9:1). This nation, Sheba, is in the list of the sons of Joktan (Genesis 10:26–29), and it is interesting that the name of Abraham's last wife was Ketura, meaning "incense" (Genesis 25:1). Furthermore, the names of the children of Ketura are the names of some of the Arab tribes in Arabia: Sheba, Dedan, Midyan, and Aifa (Genesis 25:2–4). The children of Ishmael, the first son of Hagar and Abraham, were Bashmath and Mibsam (Genesis 25:13), meaning, in Hebrew, "spice" (the Hebrew word *bosem* being the root basis for these two names).

The earliest Greek accounts of the Sabaeans and other south Arabian people are of the third century BCE (Groom 1981). Eratosthenes (276–194 BCE), quoted in Strabo XV 4.2 (Jones 1924), indicated that the extreme south of Arabia, opposite Ethiopia, is inhabited by four great nations: the Minaeans on the Red Sea, whose chief city was Carna; the adjacent Sabaeans, whose capital was Mariaba (biblical

Mariab); the Catabanes; and, farther east, the people of Hadramut, with their city Sabota. The Catabanes produced frankincense and Hadramut myrrh, and there was a trade in these and other spices with merchants who made the journey from Aelana (Elath, on the Gulf of Akaba) to Minaea in 70 days. The Gabaeans (Pliny's Gebanitae Book 12, Chapter 32) took 49 days to go to Hadramut (Artemidorus, 100 BCE, quoted in Strabo-Jones 1924, XVI: 4:4). The Minaeans formed a political and linguistic island in the Sabaean country. Pliny states (Book 12, Chapters 30, 51) that frankincense was collected at Sabota (the capital of Hadramut) and exported only through the Gebanites, whose kings received custom dues on it (Pliny, Book 12, Chapter 32).

Strabo provides a similar account of the wealth and trade of the Sabaeans and their capital, Mariaba, adding that each tribe received the wares and passed them on to its neighbors as far as Syria and Mesopotamia (Jones 1924-XVI: 4:19). The Sabaeans also had colonies in Africa. Abyssinia probably was settled by the Sabeans from south Arabia, as indicated by the similar language and writing. This interrelation between the Kingdom of Sheba and the Horrn of Africa also contributed to the spice trade, as the plants were grown in both areas (Groom 1981).

The source of these important ancient spices was not commonly known in antiquity, and the Arabians involved preferred to keep this information secret. This led to confusion among classical writers such as Theophrastus, Artimedorus (as related by Strabo), and Diodorus Siculus (of Sicily), a first-century Greek historian, who maintained that frankincense grew in the land of the Sabaeans (Van Beek 1958).

In actuality, frankincense grew in the Horn of Africa (Somaliland) and farther east in Arabia, in the region of Dhofar, Oman. The Minaeans and other peoples of the Arabian Peninsula, such as the Qedarites, the Gerrhaeans, and the Nabateans, maintained control over the inland trade routes to the Mediterranean and particularly to Egypt. The trade was never the monopoly of one people. According to Strabo: "Those tribes who live close to one another receive in continuous succession the load of spices and deliver them to their next neighbors as far as Syria and Mesopotamia" (Jones 1924, Book XVI).

Biblical citations allude to Sheban trade in incense and perfumes, gold and precious stones, ivory, ebony, and costly garments (Ezekiel 27:15, 20, 22; Job 6:19). These passages attest to the wealth and importance of Saba (Sheba) from the days of Solomon to those of Cyrus.

Myrrh

Classical sources refer to myrrh as growing in the Ma'in, Hadhramaut, Qataban, and other areas of southern Arabia, and these sources, as well as modern investigation, indicate that the production of myrrh was confined to these areas. However, the current growing areas of the myrrh district are centered in the west and central part of Somaliland (Van Beek 1958) and also in India.

Olibanum

Van Beek (1958) concludes that the geographical distribution of the frankincense tree is governed by definite rainfall patterns and soil factors.

Boswellia carterii is also referred to as olibanum and dragon's blood. Some authorities regard this species as the biblical frankincense and the same species as the B. sacra, but there is some dispute over this.

Boswellia papyrifera Hochst grows in Ethiopia and Sudan but is not marketed in the western world. The resin is transparent and oilier than the other resins.

Boswellia serrata Triana & Planch. (Roxb.) Colebr is the *Indian frankincense*, considered by some to be of inferior quality. The golden brown color resin is soft and hardens slowly; it is mainly burned as incense but also used in Ayurvedic medicine (Miller and Morris 1988). The *B. serrata* is taller than the other *Boswellia* trees and has a straight trunk. The scent of the resin extracted from *B. serrata* is quite distinct from that obtained from the other *Boswellia* trees and is heavier than the African resins, more of an orange type of scent, while the *B. sacra* resins have a lighter, lemon scent. The difference in odor between the various *Boswellia* tree resins is due to their complex sesquiterpenes (Tucker 1986).

By the eleventh century BCE, the demand for the resin of the *Boswellia* trees was well developed, resulting in the improvement of overland routes. Historic records of trade in biblical times, and earlier, link this specific shrub with the trade routes. Thesiger (1959) writes: The civilizations of Arabia for 1,500 years had depended for their prosperity on frankincense gathered on the mountains of Dhaufar.

The price of the *B. sacra* varies according to the grade, the most expensive being the Hojari frankincense locally available in Oman. The scent of the Hojari is greatly appreciated in the damp air of Europe, although, to the Arabian dealers.

Recently, the ancient site of Punt, which was the target for the Hatshepsut in her search for spices, has been identified as Eritrea and eastern Ethiopia, based on work of Nathaniel Domino and Gillian Leigh Moritz of the University of California, Santa Cruz, with oxygen isotope tests carried out on the fur of two ancient Egyptian mummified baboons imported by Hatshepsut and compared to baboons found in other countries. The isotope values in baboons in Somalia, Yemen, and Mozambique did not match. It was estimated that the mummified baboons dated from about 3,500 years ago, when Hatshepsut's fleet sailed to Punt and brought them back as pets (Bressan 2013).

Present Day Production in Africa

Teketay (2003) reviewed the frankincense and myrrh resources of Ethiopia suggesting these resources could contribute towards the conservation and management of frankincense as well as local ecosystems. However, a study of *B. papyrifera* in northern Ethiopia in 2002 by Gebrehiwot et al. gave a depressing picture of the decline of this species, despite what had been a flourishing market for extracted incense, and the large demand from churches in Ethiopia and Europe. Human encroachment, and unrestricted grazing and harvesting had greatly reduced the population of this tree.

The Forest Ecology and Forest Management Group, at Wageningen University, the Netherlands, inaugurated a project (2006–2010) to promote natural regeneration of *B. papyrifera* in Eritrea, the semiarid areas of Ethiopia, which is more than half of total land area and became an independent state. In 2007, the estimated mean frankincense annual yield was 127 kg/ha-for closed forest land and 85 kg/ha for open forest land. The price for exported frankincense was estimated at $53 for closed and $39/ha-year for open sites, with rural households earning about 74 % of this for tapping and collecting the resin. This benefit was considered to be superior to alternative land use (Wageningen University). Scholarly historian Thieret (1996) suggests that total yearly production of myrrh is perhaps 500 t, and frankincense, 1,000 t. Recently, U.S. imports ran 5–20 t. The UK imports about 30 t frankincense each year, one perfume manufacturer alone consuming 5 t annually.

Most frankincense comes from Somalia (following bananas and cattle as leading exports) where it provides work for some 10,000 Somali families, and some is gathered in Arabia. The actual export amounted to 1,000–1,500 t annually. Most of the frankincense is marketed in Saudi Arabia, Yemen, and Egypt, which are the major markets, with lesser quantities marketed in other countries.

Despite the evidence that small holders would be able to derive obvious economic benefits from frankincense, constraints have been revealed. Local people have been producing and trading frankincense for centuries to diversify their income sources. However, production of frankincense varies considerably among the producing dryland regions of the country. *Boswellia papyrifera* comprised 51 % of the species composition of the vegetation of the district with a potential of 254 kg/ha/year. The total annual frankincense production potential of the district was estimated to be 79 thousand tonnes. The question is why the export of the Somali amounts only to around 1,500 t. Almost all inhabitants do not benefit economically from the species due to cultural influence, unattractiveness of income from frankincense compared to other economic activities in the area, property tenure, government policy on incense production, poor knowledge on frankincense production, and unawareness of the potential of frankincense as a source of income. The absence of direct economic benefits for the local people from the woodlands is triggering widespread degradation mostly from human induced fire, improper forest use, and agricultural land expansion (Lemenih et al. 2007).

Currently, replanting projects in the wild are underway in Ethiopia and Somalia. However local scientists in these countries report that the future of these projects seemed far from being assured. Examination of various databases of exports from countries that used to sell these spices, such as Oman, Yemen, Ethiopia, Somaliland [Index Mundi, the FAO and USDA], shows that spices are such a minute item in the export lists that they do not appear at all.

Recent studies have indicated that frankincense tree populations are declining due to over-exploitation, since heavily tapped trees have been found to produce seeds that germinate at only 16 %, while seeds of trees that had not been tapped germinate at more than 80 % (Howes 1946; Bergstrom et al. 1982; Miller and Morris 1988; Ghazanfar 1994).

Ecological Requirements

The ecology of the geographical origins of these three medical plants is rather varied. These three plants are growing in the wild in several new locations, but the tendency is to relate these plants to their origin at the Southern Arabian Peninsula and to the African Horn: Somalia, Kenya, Tanzanya and Ethiopia and possibly also India.

The Apharsemon has moved to Judea and was cultivated there for a long period of about 1,500 years. Then it moved to Matariya in Egypt for a period of several hundred years. Consequently it became extinct, but its past reputation and taxonomical research identified several botanically related plants in various parts of the Arabian Peninsula, whose exact taxonomical identification is still waiting for more research.

Olibanum and myrrh trees are considered unusual for their ability to grow in environments so unforgiving that they sometimes appear to grow directly out of solid rock. The means of initial attachment to the stone is not known but is accomplished by a bulbous disk-like swelling of the trunk of the frankincense.

This disk-like growth at the base of the tree prevents it from being torn away from the rock during the violent storms that frequent the region they grow in. This feature is slight or absent in trees grown in rocky soil or gravel. Each species has its particular characteristics and quality, depending on its growth environment, its harvesting procedures and type of resin produced. Van Beek (1958) concludes that the geographical distribution of the frankincense tree is governed by definite rainfall patterns and soil factors. There are various and many grades of the resin extracted from the *Boswellia* trees, related to the exact climatic conditions prevalent where they are grown, often the most deprived soils producing the highest quality resins. A soil containing limestone and dry conditions is the preferred growing environment for the *Boswellia* (Bergstrom et al. 1982, quoted in SEPASAL).

Harvest Practice

Apharsemon

The writings of Pliny, Josephus and others on apharsemon contain details on the special techniques regarding resin harvest of these special plants (Rosen and Ben-Yehoshua 2007; Ben-Yehoshua and Rosen 2009). Pliny noted that the producers of apharsemon possessed special techniques to extract the apharsemon exudates:

> … an incision is made in it with a piece of glass or a stone, or with a knife made of bone – it strongly dislike having its vital parts wounded with steel and die off at once, though it can

stand having superfluous branches pruned with it. The hand of the operator making the incision must be poised under skilful control, to avoid inflicting a wound going below the bark.

Josephus (*Wars of the Jews* 2, 6; 6) mentioned these stone knives (Rosen and Ben-Yehoshua 2007).

Traditional tapping methods, used where the resin is collected from the wild plants, employ crude incisions by axing, which injure the cambium and shorten the tree's life span. In the twenty-first century the axe is still used to extract the resin from both frankincense and myrrh, a crude practice that endangers these trees (Ben-Yehoshua and Rosen 2009). Thus, we conclude that those Judean farmers had solved this injury problem by developing a special tool kit from glass, stone, and bone, to perform harvest operations on the bush. Iron tools were relegated to pruning. There is current support for Pliny's observation of the "the lethal effect of iron on the bush." (Book 12, Chapter 54). Iron tools imbedding in the bark, cambium, and the sap overloads them with soluble iron.

Myrrh

Harvest of myrrh is similar to that of frankincense. Resin exudes from the branches after an incision is made in the bark of the trunk or of branches, allowing the pale yellow liquid gum to run out and accumulate on a mat or container next to the trunk. As the gum hardens it turns a reddish brown color, in the shape of tears. Pliny wrote of a "bundle of tears," the form in which the myrrh is marketed (Book 12, Chapter 32).

Olibanum

Both Theophrastus (372–287 BCE) (Hort 1916) and Pliny (23–79 CE) (Bostock 1855) reported on methods of harvesting the resin, which have hardly changed. The trees were wild plants grown in a few isolated locations and no actual cultivation practices were reported. The resin is harvested by wounding the trunk or big branches by scraping about 2 cm of the bark with a tool (*mengaff*), which results in the resin exuding on to the trunk. This resin hardens into clumps in the shape of tears, as it dries. After 2 weeks the harvester returns to the tree and collects the accumulated resin, which is left to harden for a few weeks before being brought to market. The first tears of clear resin collected are the best quality – the extracts running down the tree or onto the ground are not so fine, as mentioned by Theophrastus. The aroma of the tears is prized for their healing abilities and are also said to be more pleasing to the gods.

Early records of harvesting in the Oman described slaves gathering the resin since it was unpleasant work, in hostile conditions. Later, Pliny added to his records that the harvesting was carried out by a small group of elite natives, the privilege being an inherited one and jealously guarded. This group was celibate during the harvest time and ordered to avoid pollution either by contact with women or dead bodies (Book 12, Chapter 30). Herodotus relates the tall tale of frankincense that the local tribesmen passed off to gullible foreigners: "When they gather frankincense, they burn storax (the gum which is brought into Greece by the Phoenicians) in order to raise a smoke to drive off the flying snakes; these snakes, the same which attempt to invade Egypt, are small in size and of various colors, and great numbers of them keep guard over all the trees which bear the frankincense, and the only way to get rid of them is by smoking them out with storax" (Rawlinson 1859 Book 3:107).

Usually there are two harvests each year, giving the tree ample time to recover, thus ensuring high quality resin. Tapping is done two to three times a year. High quality resin can be visually discerned through its level of opacity.

There is a rich folklore surrounding the harvesting and use of the Dhofar frankincense, and full details are documented in SEPASAL. Daily life, and particularly harvesting in the Dhofar Valley of the Oman, is accompanied by ancient and intricate rituals relating to the wealth attained by the sale of the frankincense and its daily use for medicinal, religious, and social purposes, especially rites of passage, such as childbirth, weddings, and funerals. Childbirth in the Dhofar Valley is accompanied by the burning of incense during the 40-day period following the birth and for treating the mother to prevent infections and other problems. Weddings, religious celebrations, the reception of guests to the home in Dhofar, and formal occasions are accompanied by a welcoming incense-burning ceremony, promoting social harmony and peace. The women of Dhofar use the incense to smooth and oil their hair and also to sweeten their breath. The soot of the burning resin was collected and used for eye makeup. The soot from the incense burner was used in Arab communities to mark tattoos on the skin after piercing.

History, Traditional Use, Ritual and Cosmetic

Archaeology and History

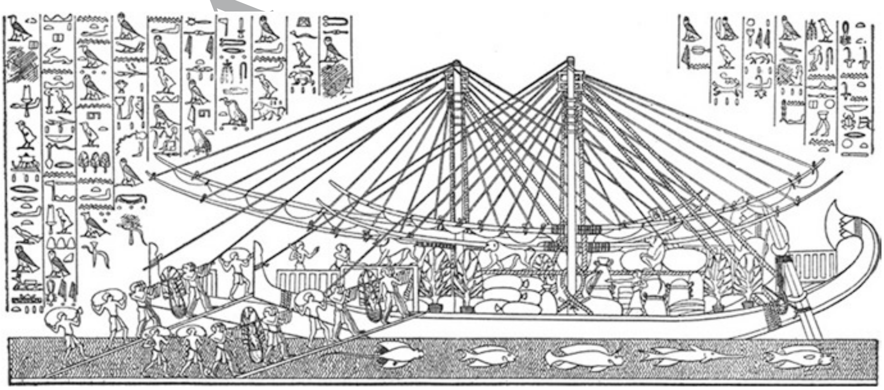
Frankincense and myrrh were available in the biblical period only in limited parts of southern Arabia and the Horn of Africa. Due to the high demand for these spices, trade routes were developed to carry this precious burden over long distances through many countries to their foreign markets (Keay 2006).

In ancient times, the resin of the *Commiphora gileadensis*, the apharsemon, was used to treat many ailments. Although sources of supply of the resin were limited, it was in great demand in the classical and biblical world due to its medical benefits. The increased use of drugs of herbal origin in medicine instead of employing surgery was encouraged in Mesopotamia, perhaps because the Code of Hammurabi threatened amputation if the surgeon was unsuccessful and found responsible (Rosengarten 1970).

Spices and Medical Plants in Ancient Egypt

The ancient Egyptians used spices for their religious ceremonies that they purchased from the Land of Punt, long thought to be in the Horn of Africa (Kitchen 1993). At the beginning of the third millennia BCE, pharaohs went to great lengths to obtain spices, particularly myrrh, from other climes, since they were not grown locally. References to the importation of myrrh to Egypt from Punt appear as early as the fifth dynasty ca. 2800 BCE under King Sahure and King Isesi; later there were expeditions under Mentuhotep III in 2100 BCE and under Amenenhat II and the Sesostris dynasty. Since the price of these spices was exorbitant, the Queen Pharaoh Hatshepsut organized an expedition to Punt about 1500 BCE to investigate the option of importing the spice plants into Egypt The famous depictions (Picture 9) of the expedition of Queen Hatshepsut (1473–1458 BCE) are ships loaded with many treasures are depicted in the Temple in Thebes. In the mortuary temple at Deir el-Bahri, detailed descriptions of trade between Punt and the Egyptians are carved on the wall. On one of the reliefs, the boats from Egypt have arrived at Punt and are stopped on the beaches. "Here we see a flotilla of five large ships sailing from their Red Sea port, the arrival at Punt where the inhabitants lived in grass huts built on piles, the Egyptians offering the trade-goods of all such African adventures ever since – strings of beads, axes, and weapons – and the triumphant return with gold, ivory, apes, and precious myrrh-trees, their root-balls carefully protected by baskets for transplanting in Thebes" (Aldred 1961). One ship has 31 young trees that some scholars believed to be frankincense in tubs (Hepper 1969; Zohary 1982; Dayagi-Mendels 1989; Dominy et al. 2010).

However, Groom (1981) believed them to be myrrh as, according to his opinion, depictions of trees at that period were mainly schematic, presenting an image rather than a specific plant, and he referred also to the opinion of most previous experts that these trees were myrrh. Some scholars, however, find the trees on the Punt reliefs too conventionally drawn to be of any help in identifying them (Nielsen 1986).



Picture 9 Queen Hatshepsut's expedition to the Land of Punt. It was primarily a trading expedition, for Punt, or God's Land, produced myrrh, frankincense, and fragrant ointments that the Egyptians used for religious purposes and cosmetics (From J. Dümichen "Die Flotte einer ägyptischen Königin aus dem 17. Jahrhundert vor unserer Zeitrechnung" 1868)

According to George Rawlinson (1897), the Egyptians entered the incense forests and either cut down the trees for their exuded resin or dug them up. Specimens were carried to the seashore and placed upright in tubs on the ships' decks, screened from sun by an awning. The day of transplanting in Egypt concluded with general festivity and rejoicing. Seldom is any single event of ancient history so profusely illustrated as this expedition, but there is no documentation for the growth of myrrh or frankincense in Egypt following this import.

Spices, an important part of Egyptian life, were used extensively on a daily basis. The Egyptian word for myrrh, bal, signified a sweeping out of impurities, indicating that it was considered to have medicinal and, ultimately, spiritual properties (Schoff 1922). Ancient Egyptians regularly scented their homes and were commanded to perfume themselves every Friday (Ziegler 1932). Idols were regularly anointed with perfumes, and incense became an important element in religious ceremonies; prayers were believed to be transported to the gods by the smoke of incense rising upward (Ziegler 1932). Every large Egyptian temple contained facilities for producing and storing perfumes (Brun 2000). The Egyptians ground the charred resin into a powder called *kohl*, which was used to make the distinctive black eyeliner seen on many females and males too in Egyptian art.

A growing body of archaeological evidence indicates that the volume of trade between Arabia and the surrounding areas accelerated during the Assyrian Empire. Assyrian documents record a growing interaction with the peoples of the Arabian Peninsula due to Assyrian attempts to control and capitalize on trade emanating from southern Arabia during the fifth century BCE.

Spices in Judea

Archaeological evidence of trade between southern Arabia and the Mediterranean coast has been found as early as the eighth century BCE in Tel Beer Sheva and Arad in Judea and includes the first appearance of alabaster containers and small limestone incense altars (Singer-Avitz 1996, 1999). The containers were a preferred means of storing and transporting raw incense resins, according to the Roman writer Pliny (Bostock 1855, Book 36, Chapter 60). New archaeological findings also indicate commercial relationships between southern Arabia and Judea, along the Incense Road. Much commercial activity existed in the Beer Sheva Basin, serving this trade during the seventh century BCE. In Tel Beer Sheva, several covers used for sealing the alabaster containers were found, as well as a stone object bearing the inscription of Cohen "priest" in a South Arabian language (Singer-Avitz 1999). At Kuntillet Ajrud, located on the Incense Road from Eilat to Gaza, Ayalon (1995) found drawings and inscriptions in two buildings and a large assemblage of Judaean and Israelite tools on sites along this incense road. These were dated to the end of the ninth century BCE. Singer-Avitz (1996) describes an altar, dated to the eighth century BCE, excavated at Tel Beer Sheva, decorated with a one-humped camel. This trade was greatly expanded at the end of the eighth century BCE under the Assyrian kingdom; its track was through the Edomite Mountains and the south of Judea, where security could be controlled. The Assyrians established several fortifications and commercial centers there, such as Ein Hatzeva south of the Dead Sea, Botzera near Petra, Tell el-Kheleifeh (Ezion Geber) at the northern end of the Red Sea, and other sites along the Mediterranean Sea near Gaza (Finkelstein and Silverman 2006). A broken ceramic seal (7 × 8 cm) found in Bethel with the south Arabian inscription *Chamin Hashaliach*, in south Arabian letters of that period, was estimated to date from the ninth century BCE (Van Beek and Jamme 1958). The archaeologists (Hestrin and Dayagi-Mendels 1979; Dayagi-Mendels 1989) suggested that the seal meant Chamin the messenger.

Apharsemon

Apharsemon as a Spice and a Medical Plant

Apharsemon (*tzori Gilead* in Hebrew) is described in the Bible as the gift that the Queen of Sheba gave to King Solomon. In Judea, it was grown around the Dead Sea for about 1,500 years and achieved fame due to its aroma and medicinal properties.

From the Book of Nehemiah 3:8, it is evident that the apothecaries (*roqeah* in Hebrew) who mixed spice substances were organized into guilds similar to those known in earlier periods at Ugarit (Neufeld 1971). In the First Temple period (957–587 BCE), incense was widely used in domestic settings to provide pleasant scents in homes, as insecticides, and as protection against disease (Neufeld 1971).

Apharsemon was one of the several components of the special incense that was used twice daily in the Holy Temple in Jerusalem. Rabbi Shimon Ben-Gamliel president of the Jewish High Court – Sanhedrin said that the apharsemon is the resin that exudes from the trees of *kataf* (ph; *Yoma 41*:*74* Jerusalem Talmud).

"Secret of the Town"

Ben-Yehoshua and Rosen (2009) discussed the relation of the apharsemon to the "secret of the town" mentioned in the Aramaic inscription on the floor of the sixth century CE synagogue at Ein Gedi (Barag et al. 1981).

Anyone causing a controversy between a man and his friend, or whoever slanders his friend before the Gentiles or whoever steals the property of his friend, or whoever reveals the secret of the town to the gentiles – He whose eyes range through the whole earth and Who sees hidden things. He will set his face on that man and on his seed and will uproot him from under the heavens and all the people said: Amen and Amen Selah (Levine 1981).

These authors support the suggestion of Feliks (1981) that the secret involved special technologies of producing and extracting the apharsemon resin. These authors suggested the existence of a special guild of the Judaean farmers that were involved in the production of this special lucrative crop.

Keeping secret the production of the apharsemon must have been a major factor in sustaining the economy and thus the survival of "a very large Jewish village"

Wolf 1971). The complete agrotechnical and legal history of the Judaean balsam since the Iron Age and during Babylonian, Persian, and Ptolemaic rule is unknown.

History of Apharsemon Production

Only a small part of our knowledge concerning the agrotechnology of Judaean balsam production comes from Jewish sources. Talmudic literature did not intend to cover this subject, and if it was supposed to be a secret, as little as possible of it would have been promulgated. Much of our meager knowledge of this agrotechnology comes from Greek and Roman authors. In his record of odiferous trees, Pliny, writing in the second half of the first century CE, supplies us with the most detailed descriptions about apharsemon, describing it as more preferable than any other odor and saying that it was "a plant that has only been bestowed by Nature upon the land of Judea" (Book 12, Chapter 54). He describes at some length the different grades of apharsemon and the care required to harvest the precious resin. Pliny noted that the high price motivated the production of fraudulent merchandise, describing such frauds and their detection, including the adulteration of the resin with hypericon produced at Petra. Josephus comments: "This country bears that apharsemon, which is the most precious drug that there is, and grows there alone" (Ant. XV. 4.2).

It is likely that, Queen Cleopatra, aware of the background of secrecy, after receiving the ownership of the apharsemon in Judea from her lover Anthony, hired King Herod to continue caring for this crop. Thus, despite the hostility between Cleopatra and Herod, she wisely selected him as she knew that as the previous owner he knew how to handle this guild of Judaean farmers that she was anxious to control.

Around this period, the cultivation of apharsemon was introduced farther south at The 'En Boqeq. Here archaeologists have uncovered an *officina* (a workshop) that the excavators believe was used to produce perfumed oils during most of the first and early second century CE (Fischer et al. 2000). The 'En Boqeq *officina* may have constituted part of the Roman imperial *fiscus* in the early Roman period (Cotton and Eck 1997). The Jewish revolt and the subsequent conquest of Judea by the Roman legions under Vespasian and his son Titus marked a traumatic period that affected the production of apharsemon.

According to Pliny, during the revolt, the Jews tried to destroy the trees in order to hurt Roman economic interests. The Jews vented their rage upon this shrub just as they were in the habit of doing against their own lives and persons, while the Romans protected it (Pliny, Book 12, Chapter 54), resulting in conflict in defense of a shrub. The economic and national importance of controlling the apharsemon was aptly demonstrated in the Roman triumph staged following the suppression of the great revolt. Pliny reports that apharsemon plants were paraded in the triumphant victory procession (Book 12, Chapter 54). The Roman rulers were keen to take control of this lucrative source of revenue, and the royal Judaean plantations were confiscated by Rome after Herods' death (Cotton 2001). However realizing the very complicated growth of this crop involved in the secrets that the Judaeans embrace of this special crop the Roman rulers applied a wise policy allowing the Judaeans to keep raising the crop themselves and maintaining their secrets while the Roman administration took over the marketing of this crop so that they completely controlled this crop and even supported the expansion of the areas of this Aparsemon into new locations. It appears that the Jewish Guild that controlled the secrets of growing this crop were able to select these new growers in order to maintain their embrace of the secrets. Thus although the control of the Roman administration was apparently absolute about the marketing still the background of the secrets attached to this special lucrative crop was not broken.

Apharsemon and the Dead Sea Basin

All observers, beginning with Theophrastus and Pliny, stated that this special crop was raised only in the Dead Sea Basin. A casual note of Diodorus Siculus (Oldfather 1935) raised the important question of whether Judea was the sole producer of the apharsemon during ancient periods. He reported that in 300 BCE, myrrh, apharsemon, and frankincense were especially important trade items going through Petra. Was the apharsemon sold in Petra the resin produced around the Dead Sea Basin? In that period, no other spice was called apharsemon. New evidence about this came from Arabia. Pliny did not know of Arabian apharsemon (Groom 1981). Further, it has been suggested that the Arabs of classical times did not regard the apharsemon as worth exploiting at all (referring to the plants that were, in our opinion, the ancestors of the apharsemon), continuing "We do not, at present, know enough about its gum" (Groom 1981).

An outstanding element of this production system was the possession of unique agrotechnical knowledge accumulated by long and intensive study of the environment. Due to the unique climatic conditions required for apharsemon production, similar knowledge could not have been accumulated in other parts of the Roman and Byzantine empires that lacked such a specific climate. The free farmers of Ein Gedi organized in well-established groups and guilds preserved this knowledge and kept trade secrets. Their communities, formed or disbanded at the pleasure of their master, could not have formed such a long-lasting, closed rural society of well-established, affluent manufacturing specialists. Free or semi free specialists organized in guilds are known from several economic environments. The producers at Ein Gedi established the oldest continuous center of cultivated apharsemon production that ever existed in a natural and human environment that was often extremely hostile. Several times these communities were almost completely destroyed. Still, this special crop survived for over 1,000 years developing several systems of new, improved apharsemon cultivars as well as new production techniques (Rosen and Ben-Yehoshua 2007).

Apharsemon was cultivated exclusively in royal gardens in Judea at Jericho and Ein Gedi (Whiston 1737, Josephus *Ant*. XIV.4.1, XV.4.2) and was cultivated during the First Temple period. Pliny refers to the great expense of small quantities of the extracted resin in the time of Alexander the Great. The resin must have been an important source of income for the Hasmoneans – the ruling Jewish dynasty in Judea from mid second century, 164 BCE to 40 BCE – and their plantations were highly coveted. Herod was forced to pay rent for his own plantations for 10 years to the Egyptian Ptolemaic queen Cleopatra under arrangements demanded by his friend Mark Anthony (Josephus Ant. XV.4.1; *Wars* I.18.5). Following the death of Cleopatra and her lover, Herod become one of the wealthiest men in the Roman Empire, and his monopoly on the cultivation, processing, and marketing of this valued substance was one of the sources of his wealth (Erickson-Gini 2007). Herod utilized this great wealth in one of the most ambitious building programs of any ancient monarch. In addition to his many desert palaces, the greatest one being the Northern Palace at Masada, Herod built whole cities in Judea and abroad. His most ambitious project was the construction of the Jewish Temple in Jerusalem. According to the Jewish historian Flavius Josephus (Ant. XV.11.1), Herod funded its construction at his own personal expense (Whiston 1737).

In Aden's trade statistics (Yemen) from the nineteenth and twentieth centuries, apharsemon gum, although technically a bdellium, appears to have been accounted for as "myrrh. As another product of *Commiphora*, it would seem most likely that in classical times, too, it was among the many types of myrrh (Groom 1981).

Diodorus Siculus also discussed the use of apharsemon wood (Book 19, Chapter 98), which indicates that the plant he discussed is the true apharsemon, since the wood of no other spice plant was utilized. This suggests strongly that the source of this apharsemon is the Dead Sea area, as we know from many other sources that only the apharsemon had several products, one of which was the wood taken from the xylem (Ben-Yehoshua and Rosen 2009). Pliny provides the prices of the different spices: strengthened also the option that this resin was the Judaean apharsemon. Those prices, as quoted by Pliny, are to be 300–1,000 dinars for a pint of the apharsemon, as compared to the price 2–6 dinars for frankincense and 11 for myrrh (Book 12). It is highly unlikely that an Arabian spice would fetch such a high price and not to be discussed in any report of that period. Furthermore, it is known that Pliny and all other historians of this Greek and Roman period spoke often of the special apharsemon and its very high price, which was much higher than all other spices. Many also said that the plant grew only in the Dead Sea Basin.

In conclusion, we may discount the possibility that the apharsemon used in Petra was imported with the myrrh and frankincense from Arabia. It suggests that the Nabatean merchants in Petra had also purchased or processed there apharsemon from the Dead Sea despite or, possibly, because of its high price. Presumably, apharsemon continued to be cultivated by the Jews, at least at the Dead Sea oasis of Ein Gedi, as late as the sixth century CE.

Decline of the Aphasemon Production

Ein Gedi was often destroyed between the inception of its special agriculture during the Iron Age and its end in the sixth century CE. However, it was always revived because doing so was economically sensible. The economic crisis of the third century CE undoubtedly affected the demand for apharsemon oil by the late Roman period. Records show that at least one rabbi, Shimon ben Eliezer, was required to explain the nature of apharsemon to his students: "Apharsemon (*tzori*) is merely the sap of resinous trees" (Shabbath 26a). References to mundane uses of apharsemon in the late Roman period – for example, for kindling Sabbath lamps (Shabbath 25b, 26a) – may be another indication that there was no longer a robust demand for this substance as there had been in earlier times.

The last destruction, by marauders or an early breakout of the Justinian pandemic that occurred between 541 and 750 CE (Ziegler 1932), or both, occurred prior to the conquest by Islam. The Islamic-Arab conquest flooded Middle Eastern markets with products of Arabia and the East, such as dates and Arabian balsam; previously free trade in such goods was hindered by political borders. At the same time, a trade barrier was created between Ein Gedi and the traditional markets in Byzantium and Europe. Consequently, the economic advantages of the oasis of Ein Gedi vanished. The well-advertised, deeply ingrained brands – "Ein Gedi," "Jericho," "Gaza," "Ashkelon," "Palaestina." and "Holy Land" – lost much of their value and their customers. Maintaining a productive plantation system on the border of the desert was expensive. Thus the special agrotechnical system of Ein Gedi vanished. Only time will tell if it can be revived.

However, evidence (Lev 2003) of the purchase of apharsemon oil in Jerusalem by the Bishop Wilibald at the beginning of the eighth century testifies to the fact that the region of Palaestina remained a source for apharsemon oil, either because the trees continued to grow there or because the region served as a place of transit for this trade.

Apharsemon Production in Matariyya, Egypt

Another center of production of the apharsemon was developed later in the Coptic Church garden in Matariyya, Egypt (Milwright 2003). The dating of this place is not well documented, but the pricing of the resin was double its weight in gold.

In spite of the glorified aura that once surrounded apharsemon oil in ancient times, its production and medicinal uses nearly ceased altogether. The end of apharsemon production in Judea is probably related to the Arab conquest in the seventh century. The markets of this new Arab-controlled country were opened to the myrrh and olibanum from Arabia, which probably were sold at much lower prices. The earlier lucrative markets of Rome and Byzantium were now closed to the Judaean producers of the apharsemon. Furthermore, the Arab rulers expected these farmers to produce the newly introduced crop of cane sugar.

With time, the established reputation of the Judaean apharsemon, the great past demand for its products, and its high prices, alerted the Arabians to consider whether this apharsemon is indeed related to the ancestor plants of *Commiphora* growing wild in the kingdom of Sheba as the Bible suggested, but they did not accept this theory. Thus, they started to harvest and sell the balm of these ancestor plants and introduced this balm as a new product of their spice trade, in addition to the myrrh and olibanum that they had monopolized. In all likelihood, this ancient successful trade item was the reason why other balms of Gilead are now sold in several parts of the world. The Arabians also sold the Mecca balsam that was produced from a resin extracted from, a close relative, or the ancestor of the source of apharsemon.

Many corporations have utilized the name "apharsemon" for their own products. Thus, a healing compound (a balm) made from the resinous gum of the North American tree species *Populus candicans* is sold as apharsemon. However, the Remingon edition of the *Dispensory of the United States of America* (Remington and Wood 1918) defines the Judaean balsam of Gilead and the Mecca balsam as the resinous juice of *Commiphora opobalsamum*. Poplar buds (tears) are often, incorrectly, called apharsemon buds. At present, several corporations sell products under the name of apharsemon and claim that all the best fortunes would happen to consumers of their product; these commercial medications are extracted from other trees, and their sellers do not suggest any relation to the apharsemon. Persimmon is the name given to another Japanese fruit tree called in Japan *kaki* – *Diospyros kaki* – probably trying to make use of the fame of this ancient biblical plant which was then extinct.

Apharsemon oil or balsam of Mecca is still used as incense and in the preparation of perfumes. Its world supply is limited, and it is inexpensive (Hill 1952; Uphof 1968).

Myrrh

Religious Rituals, Myrrh and the Embalming

Pliny wrote that "there commeth not so much incense of one whole year's yield in Saba [the land of Saba or Sheba was the provider of the spice] as the Emperor Nero spent in one day when he burnt the corpse of his wife Poppea" (Book 12, Chapter 41). According to Tacitus (Church and Broadribb 1876), her body was filled with fragrant spices before the cremation. Strabo the Roman geographer wrote of Alexander: "His army used spikenard (*Valerianaceae*) and myrrh for tent covering and bedding, thus at the same time enjoying sweet odor and a more healthy air" (Dalby 2002). In the Roman Empire, myrrh was valued highly as a perfume and exotic fragrance and was burned as incense.

The ancient Egyptian perfume *kyphi* was an important material used for religious and medical purposes; frankincense and myrrh were among its 16 ingredients, and it was mixed according to a special prescription, accompanied by readings from sacred writings. Kyphi was first mentioned in the *Pyramid Texts*, a collection of religious texts from the time of the Old Kingdom, which describe the afterlife of the ancient Egyptians and, especially, the divine pharaoh (Faulkner 1969). The Papyrus Harris I, found in a tomb and purchased for the British Museum in 1855, records a delivery of ingredients for the manufacture of kyphi in the temples of Ramses III. Detailed instructions for its preparation decorate the walls in the temples at Edfu and Dendera. Dioscorides' *Herbal* Book One, Aromatics I, 24 (Osbaldeston 2000) presents the first description of kyphi in Greek. Galen wrote a poem on the medicinal uses of kyphi, and Plutarch notes that the mixture of kyphi could be used as a medicine and an ointment.

Myrrh was also mixed into wine (Fabius Dorsennus, writer of plays, quoted by Pliny Book 13, Chapter 5, referred to myrrh-wine in his play *Acharistio*) and served it at feasts in wine cups named *vasa murrina*, made of fluorspar from the eastern land of Parthia. The delicate fluorspar was reinforced with myrrh resin, giving the wine the taste of myrrh. Martial (*Epigrams XIV:113*) (Bohn 1897) states: "If you drink from it hot, the vase myrrhina suits the ardent Falernian and gives the wine abetter flavor." In the nineteenth century, some alcoholic drinks containing myrrh were commercialized: Becherovka, invented in 1807 by Josef Becher, is an herbal spirit drink made in the Czech Republic. Its 32 herbs including myrrh make it a popular remedy for digestive problems. Fernet Branca, invented in 1845 (Fratelli Branca Company, Milan), contains 40 different herbs, including myrrh. This drink is very popular in South and North America, where it is served neat, with ice, or mixed with other drinks; it is also promoted as a home herbal remedy for indigestion problems and colic.

Olibanum

Incense burning at religious ceremonies is one of the chief uses of frankincense. Frankincense (*levonah* in Hebrew) was an ingredient in the grain offering (Leviticus 2:1) and the showbread (Leviticus 24:6–8), while liquid myrrh or *stacte*, cinnamon, and cassia were prepared with olive oil "according to the art of the perfumer" to make the anointing oil (Exodus 30:22–30). Perfumers were employed in the palaces of the early Israelite kings (I Samuel 8:13).

The Bible has many references to incense that accompanied the sacrificial rites in the Temple in Jerusalem:

Exodus 30:34–5: "and the Lord said unto Moses: Take unto thee sweet spices… these sweet spices with pure frankincense"
Leviticus 2:1: "and he shall pour oil upon it and put frankincense thereon"
Leviticus 2:15: "and thou shall put oil upon it and lay frankincense thereon"
Leviticus 2:16: "and the priest shall burn …with all the frankincense thereof"
Leviticus 6:15: "and all the frankincense which is upon the meat offering"
Leviticus 24:7: "and thou shall put pure frankincense upon each row"
Numbers 5:15: "nor put frankincense thereon for it is an offering of jealousy"
I Chronicles 9:29: "all the instruments of the sanctuary…and the frankincense"
Nehemiah 5:15: "and they laid the meat offerings, the frankincense" Malachi 1:11: "and in every place incense shall be offered unto my name"
Psalms 141: "Let my prayer be set before thee as incense"

The sacrificial altar dating from the eighth century BCE excavated at Tel Dan, and exhibited at the Skirball Museum in Jerusalem, shows the marks of soot from the incense burned at the ceremonies: I Kings, 12:28–30: "Whereupon the King made two calves of gold. He set the one in Beth-el and the other he put in Dan …and he offered upon the altar and burnt incense."

In the New Testament, in the lament over the final fall of Babylon, Revelations 18:13, mourns: "there is no one left to buy her goods …spice, incense, myrrh, frankincense." Frankincense was burned to accompany prayer:

Luke 1:10: "the crowded congregation was praying at the actual time of the incense burning" Revelations 5:8: "golden bowls full of incense, which are theprayers of the saints"

Revelations 8:3: "and the smoke of the incense rose up before God mingled with the prayers of the saints"

The growth of Christianity depressed the market for frankincense during the fourth century, but the Roman Catholic Church later adopted the use of incense for religious services (Howes 1946). It was also thought that the white smoke carried the prayers up to heaven (Armenian Orthodox). By the Middle Ages, frankincense was incorporated into regulated use, with detailed instructions on its use (Catholic Encyclopedia).

Olibanum and Folklore

The growth of Islam curtailed the use of frankincense in the Middle East, since Islam does not require the burning of incense in religious rites and ceremonies. However, the aroma of frankincense is said to represent life, and the Judaic, Christian, and Islamic faiths have often used frankincense mixed with oils to anoint newborn infants and individuals moving into a new phase in their spiritual lives.

In Yemen, the home is fumigated and perfumed by burning the incense on a special implement. Pots and jars are mended and cleaned by pouring the resin inside, where it hardens in the cracks, making the article watertight. A frankincense candle is burned in the house during the night to give light and also keep evil spirits away – perhaps commercial rivals, seeking to steal the precious harvest.

The bark of the *Boswellia* tree was used as a dye for the cotton gowns worn daily; the bark was cooked until a red-brown color was obtained, and then the garment was lowered into it. It was also used for dyeing leather, and the red-brown color was very popular. Frankincense can also be added to coffee to give a "spicy" flavor. Frankincense is a staple household medicinal for dental problems, swellings, bronchitis and coughs. It is claimed that memory can be enhanced by soaking some incense with iron in water overnight and drinking it in the morning of exams. Perhaps this has a calming effect, overriding panic (Hepper 1992).

Frankincense has been long associated with the phoenix, a mythical and mysterious bird. The Roman poet Ovid (43 BCE–18 CE), exiled for his uninhibited verse, describes the phoenix in this way: "The Assyrians call it the Phoenix. It does not live on fruit or flowers, but on frankincense and odoriferous gums. When it has lived five hundred years, it builds itself a nest in the branches of an oak, or on the top of a palm tree. In this it collects cinnamon, and spikenard, and myrrh" (Melville 1998). This is repeated by Pliny: "In Arabia he is held a sacred bird, dedicated unto the Sunne: that he liveth 660 years [modern texts have 540 years]: and when he growth old, and begins to decay, he builds himself a nest with the twigs and branches of the Canell or Cinnamon, and Frankincense trees: and when he hath filled it with all sort of sweet Aromaticall spices, yee yieldeth up." (Book 10, Chapter 2).

Pliny (Book 12, Chapter 32) describes that the olibanum trees grew in isolated and inhospitable areas, and their harvest was surrounded by myths and fables, mainly to deter rivals eager to enter into the trade and share the enormous profits. Because of the dangerous routes for delivery of the harvest, the merchants were selected carefully, mostly from the nomadic tribes of Arabia and Nabatea who were familiar with the terrain and its perils.

Frankincense is used in perfumery and aromatherapy. Olibanum essential oil is obtained by steam distillation of the dry resin, some of the smell of the olibanum smoke resulting from the products of pyrolysis.

At present, frankincense is in demand as a component in some perfumes and colognes and particularly also in the currently fashionable aromatherapy procedures, promoting serenity and well-being. The "perfume amouage" is based on frankincense and produced in the Oman, using a combination of fragrant resins (Hepper 1969). Frankincense is also used in soaps, powders, and creams, especially for the treatment of skin problems and for softening (Rees 1995).

Modern Research Based on Traditional Medicine Uses

Apharsemon

In traditional and popular medicine, apharsamon has long been considered both as a panacea and an important component in the treatment of a wide range of ailments. Muntner (1971), quoting Asaph Harofeh (Asaph the Physician, nineth or tenth century BCE from his "Sefer Harefuot"), states the apharsemon was used against "evil vapors of the stomach and also as an antidote against poisons". Lev (2003), in reviewing medieval medicine, mentions that, in addition to its antidotal properties, apharsemon was also used for pain relief, dissolving urinary tract stones and curing infertility.

Hooper (1937) conducted a comprehensive survey of "Useful plants and drugs of Iran and Iraq" in 1934, scouring the local markets and examining the uses of his finds there. For *Commiphora opobalsamum* Kunth, locally known as "balasan", he concluded that "the fruits are carminative, stomachic, expectorant and stimulant; in Isfahan, for shivering and colds". These observations are supported by Feliks (1968) and Uphof (1968).

According to Lev (2003), apharsemon was considered efficacious against the venom of all kinds of serpents, beneficial to the eyesight, disperses films on the eyes, assuages hardness of breathing, acts as an emollient, prevents the blood from coagulating, acts as a detergent on ulcers, and is beneficial for diseases of the ears, headache, trembling, spasms, and ruptures. Taken in milk, it is an antidote to the poison of aconite, and used as a liniment upon the onset of the shivering fits in fevers, modifying their violence. However, it should be used sparingly, since it is very caustic, and, if not used in moderation, is apt to augment the malady.

For general and external use, apharsemon is recommended as a painkiller (Budge 1913; Brunet 1933; Said 1973; Malandin 1986); an antiinflammatory (Budge 1913; Said 1973; Majno 1975; Haefeli-Till 1977; Qataya 1981) and for treating general diseases in the body (Greenhill 1705). It reduces the temperature of fevers (Greenhill 1705; ibn al-Baytar 1874; Stannard 1966; Temkin 1973; Malandin 1986) but is also recommended for raising the body temperature (Adams 1844; ibn al-Baytar 1874; Budge 1913; Meyerhoff and Sobhy 1932; Brunet 1933; Gunther 1933; Cahen 1947; Levey 1966a; Temkin 1973; Said 1973; Qataya 1981; Sayyid 1985; Malandin 1986). It is considered beneficial for lethargy and tiredness (Qataya 1981); for cases of paralysis, spasms, and dizziness (ibn al-Baytar 1874; Budge 1913; Said 1973; Haefeli-Till 1977; Qataya 1981). For skin conditions, apharsemon was applied as an antidote to stings, bites, and allergies (Postlethwayt 1766; Langkaevel 1868; ibn al-Baytar 1874; Jones and Omerod 1918; Siddiqui 1928; Gunther 1933; Levey 1966b; Watson 1966; Rosner 1984); as an astringent; and to heal wounds, prevent rotting and putrefaction, and heal skin blemishes and warts (Starkey and Pitt 1678; Greenhill 1705; Postlethwayt 1766; Low 1924; Kühn 1964; Said 1973; Rubin 1974).

Apharsemon was administered: for internal problems and for bladder and digestive problems (Budge 1913; Said 1973; DeFenoyl and Sauneron 1979; Qataya 1981); as a diuretic (Budge 1913; Gunther 1933; Haefeli-Till 1977; Qataya 1981; Malandin 1986); for relief from flatulence (Budge 1913; Said 1973; DeFenoyl and Sauneron 1979); for removing obstructions and hardness of the liver (Pagel 1893; Budge 1913); as a laxative (Aldredge 1996); for cataracts (Hassler 1843; Adams 1844; ibn al-Baytar 1874; Budge 1913; Meyerhoff 1928; Brunet 1933; Wood 1936; Kühn 1964; Levey 1973; Nielsen 1974; Rubin 1974); to relieve cough, breathing difficulties, pneumonia, and asthma (Gunther 1933); as a disinfectant in protection against infection (Greenhill 1705; DeFenoyl and Sauneron 1979); and in the preparation of medicines and mixtures (Costeo and Mongio 1608; Starkey and Pitt 1678; Bonwicke 1725; Spencer 1938; Kühn 1964; Watson 1966; Anawati 1987). Furthermore, it was considered effective as an abortifacient (Gunther 1933), for menstrual problems (DeFenoyl and Sauneron 1979), and to encourage sexual potency (Levey 1966a).

As present reviewers have faith in these species as medical plants whose products shall be developed in the close future, we bring forth reports that evoke some alarm about the use of these plants: *Balsamodendrum gileadense* (spelling is original and unusual), was suspected of producing allergic effects (Bardel 1935). This plant is the source of Balm of Mecca (Genders 1972) which was a favourite beauty preparation in the Middle East but could produce alarmingly violent reactions on the face (Montagu 1717, cited by Woods and Calnan 1976).

Balm of Gilead is likely to be a source of confusion because a number of other plants and plant products may be referred to under the same name. For example, the shrubby *Cedronella canariensis* Willd. ex Webb (syns *Cedronella triphylla* Moench, *Dracocephalum canariense* L.; fam. Labiatae) is popularly known as balm of Gilead. Also, the oleoresin from *Abies balsamea* Mill., fam. Pinaceae, which is usually called Canada balsam, may also be known as balm of Gilead, as may the resinous matter coating the buds of certain *Populus* L. species (fam. Salicaceae). Stuart (1979) asserts that the balm of Gilead of commerce is now derived from *Populus candicans* Aiton, *P. balsamifera* L. and possibly other *Populus* species, for example *P. tremuloides* Michaux. Probably some of these changes are due to commercial reasons of available markets and easier marketing due to the high reputation that the Balm of Gilead provides. The hypotensive effect of aqueous extract from the branches of the *C. opobalsamum* tree on blood pressure and heart rate in rats is due to the activation of muscarinic cholinergic receptors (Abdul-Ghani and Amin 1997). However, it is surprising that this author found plants of *Commiphora opobalsamum* growing wild in the mountains of Ramallah, Palestine, since, according to past data, these plants do not grow at such relatively high altitudes in climates different from those of the Dead Sea Basin. Possibly another species is involved in that article (probably *Lycium* spp. ?).

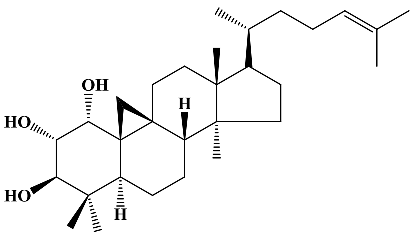
Extracts of *C. opobalsamum* exhibited anti-inflammatory, analgesic and diuretic activities in rats and mice, hepatoprotective ability and ulcer protective effects (Al-Howiriny et al. 2004, 2005).

The essential oil from the fresh aerial parts exhibited anti-microbial activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Candida glabrata*, *C. krusei*, *Cryptococcus neoformans* and *Mycobacterium intracellulare* (Al-Massarany et al. 2007).

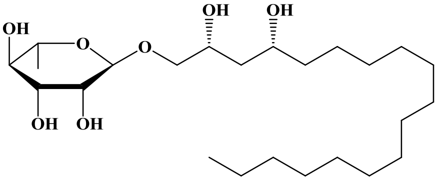
The chemical composition and biological evaluation of the essential oil of *Commiphora opobalsamum* was examined for its identified constituents using essential oil samples from the stored aerial parts, fresh aerial parts and fresh flowering tops, obtained by hydrodistillation. Following a photochemical investigation of the aerial part of *C. opobalsamum* growing in Saudi Arabia, six compounds were isolated and identified: friedelin, canophyllal, oleanonic acid, mearnsetin, quercetin, and syringic acid. Extracts and isolated compounds were preliminary assayed in vitro for antimicrobial, antimalarial, antitumor, anti-inflammatory, antioxidant and estrogenic activity. The ethyl acetate extract was moderately active against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Plasmodium falciparum*, while the petroleum ether and chloroform extracts inhibited COX-2 at 5 and 10 μg mL^{-1}, respectively. Mearnsetin and quercetin exhibited antioxidant activity and syringic acid showed moderate antimalarial, anticandidal, and antimycobacterial activity (Abbas et al. 2007).

The antiproliferative effect of resinous exudates of *Commiphora opobalsamum* was examined on human prostate cancer cells and secondary metabolites were isolated (Shen et al. 2007): cycloartane-24-en-1α,2α,3β-triol, octadecane-1,2*S*,3*S*,4*R*-tetrol, 1-*O*-α-*L*-rhamnopyranoside, eudesmane-1β,5α,11-triol, and guaia-6α,7α-epoxy-4α,10α-diol (Fig. 14) along with six known sesquiterpenoids (guaianediol, myrrhone, dihydropyrocurzerenone, 2-methoxy-5-acetoxy-furanogermacr-1(10)-en-6-one, (1(10)*E*,2*R*,4*R*)-2-methoxy-8,12-epoxygermacra-1(10),7,11-trien-6-one, and curzerenone) (Fig. 13).

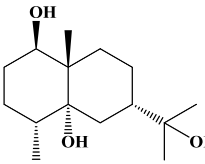
Two sesquiterpenoids – [(1(10)*E*,2*R*,4*R*)]-2-methoxy-8,12-epoxygemacra-1(10),7,11-trien-6-one and 2-methoxy-5-acetoxyfuranogermacr-1(10)-en-6-one (Fig. 14) were isolated from the resinous exudates of *C. opobalsamum* by Kai et al. (2008). With the help of MTT assay, they evaluated the cytotoxicity of these compounds against the colorectal cancer cell line, hormone-independent human prostate cell lines and immortalized liver normal cell line. An inhibitory effect on the proliferation of hormone-independent prostate cancer cell lines in a concentration-dependent manner was proved for both compounds.



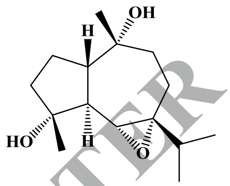
cycloartane-24-en-1α,2α,3β-triol



octadecane-1,2*S*,3*S*,4*R*-tetrol 1-*O*-α-L-rhamnopyranoside

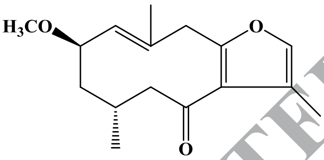


eudesmane-1β,5α,11-triol

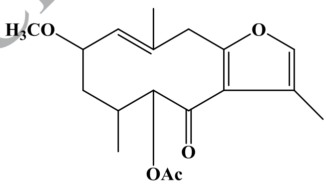


guaia-6α,7α-epoxy-4α,10α-diol

Fig. 13 Structures of compounds isolated from *C. opobalsamum* (Shen et al. 2007)



[(1(10)*E*,2*R*,4*R*)]-2-methoxy-8,12-epoxygemacra-1(10),7,11-trien-6-one



2-methoxy-5-acetoxyfuranogermacr-1(10)-en-6-one

Fig. 14 Structures of compounds isolated from *C. opobalsamum* (Kai et al. 2008)

Studies of Iluz et al. (2010) have shown that *C. gileadensis* possesses antibacterial activities that validate its usage in the local treatment of wound infections. The results showed that the thick milky, viscous C. gileadensis sap significantly inhibited *B. cereus* growth. Investigations of the antimicrobial activity of *C. gileadensis* showed the plant sap blocking of *Pseudomonas aeruginosa* lectins

Inhibition of Cancer Cell Proliferation by a *C. Gileadensis* Extract

Anticancer activity against lung and blood cancer cell lines was found by studying extracts from leaf and stem extracts and from the resin of *C. gileadensis*. Apharsemon extracts were investigated for anticancerous activity against tumor cell lines (Amiel et al. 2011, 2012; Ben-Yehoshua et al. 2013). The effect *C. gileadensis* extract was assessed against two Limphoma cancer cell lines: mouse (BS-24-1) and human (MoFir) using ethanol based stem extracts.

The results obtained from ethanol-based extracts and from essential oils of apharsemon indicated that β-caryophyllene is a key component – 20.12 % – in the essential oil extracted from the apharsemon. β-Caryophyllene can be found also in spice blends, citrus flavors, soaps, detergents, creams, and lotions, as well as in a variety of plants, food and beverage products, and it is known for its anti-inflammatory, local anaesthetic, and antifungal properties. Beta caryophyllene was found to be a potent cytotoxic compound over two cell lines of Lymphoma cancer. Apharsemon – *Commiphora gileadensis* stem extracts and essential oil of this plant have an antiproliferative proapoptotic effect against tumor cells and not against normal cells. β-caryophyllene caused a potent induction of apoptosis accompanied by DNA ladder and caspase-3 catalytic activity in tumor cell lines. In summary, apharsemon – *C. gileadensis* plant contain an apoptosis inducer that acts, in a selective manner, against tumor cell lines and not against normal cells (Amiel et al. 2011, 2012; Ben-Yehoshua et al. 2013).

Amiel, E., N. Dudai, T. Rabinsky, S. Rachmilevitch, R. Ofir, and S. Ben-Yehoshua. US patent No. 20140030289 A1 (WO2012104845 A1). Compositions Comprising Beta–Caryophyllene and Methods of Utilizing the Same.

Yang and Shi (2012) isolated several new compounds from a resin of *C. opobalsamum* imported from India. The compounds were tested for their cytotoxic activity and were identified as cycloartane-24-ene-1*S*,3*R*-diol, cycloartane-23-ene-1S′,3*R*′, 25-triol,cycloartane-24-en-1α,2α,3β-triol-1,2-acetonide,1β,8β-epoxy-2α-methoxy-6-oxogermacra-9(10),7(11)-dien-8,12-olide, 1β,8β-epoxy-2α-methoxy-12α-hydroxy-6-oxogermacra-9(10),7(11)-dien-8,12-olide,1β,8β-epoxy-2α-methoxy-12β-hydroxy-6-oxogermacra-9(10),7(11)-dien-8,12-olide,2α-methoxy-8α-hydroxy-6-oxogermacra-1(10),7(11)-dien-8,12-olide, guaia-4β,7β,10α-trihydroxy-5-ene, commipholinone, 1β,4β-epoxy-eudesmane-11-ol (Fig. 15), and five already known compounds. Guaia-4β,7β,10α-trihydroxy-5-ene showed the most potential cytotoxic activity aganist HeLa and HepG2 cancer cell lines.

Myrrh

Traditional medicine uses the resins of the *Commiphora* species for the treatment of inflammation, arthritis, obesity, microbial infection, wound, pain, fractures, tumor and gastrointestinal diseases (Shen et al. 2012).

A special formulation of myrrh is the mithridatum, a poison antidote containing myrrh, named after King Mithradates (first century BCE) who was terrified of being poisoned or falling sick, and took a dose of strengthening antidote daily (Milwright 2003). The mithridatum is based on a mixture described by Theophrastus,

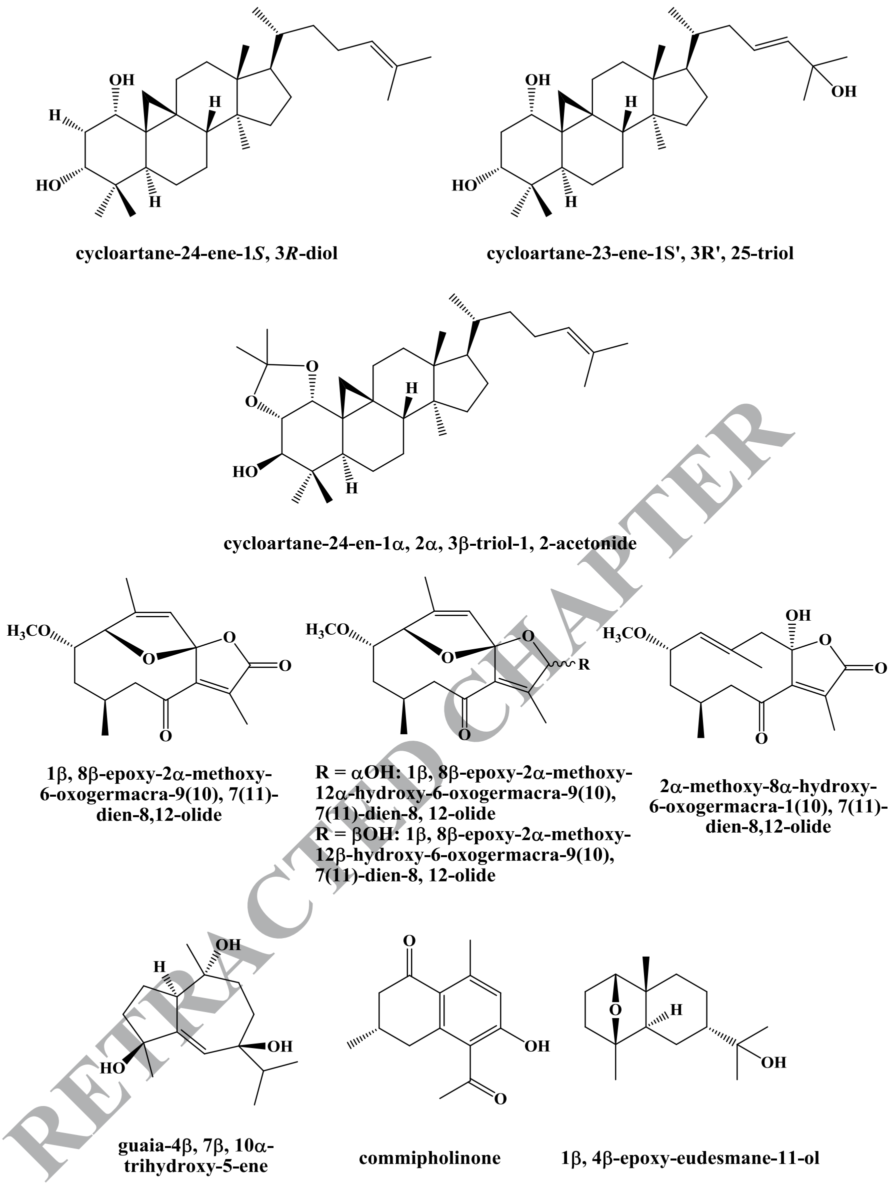


Fig. 15 Structures of compounds isolated from *C. opobalsamum* (Yang and Shi 2012)

called megalium, a sweet-smelling potion containing myrrh to relieve wounds. Plutarch mentioned a similar mixture named Egyptian kyphi, and Ptolemy's doctor, Zopyrus, detailed a combination of megalium and Egyptian kyphi in a letter to Mithridates. With some more additions, the combination became mithridatum, especially recommended for recovery from serious falls as well as an antidote to food poisoning. A century later, Galen created his own version and named it theriac, recommended for all internal indispositions. This formulation was continuously developed throughout the ages, and by 1659, mithridatum contained 63 ingredients (*Pharmacopoeia Londonensis*). It is interesting to note that Jerusalem was a major site of its production during all these ages, possibly due to the presence of many ingredients in plants nearby and also the city's reputation of holiness, which could contribute to the marketing of mithridatum (Lev 2003).

Research in Egypt and Saudi Arabia into parasitic diseases (mainly schistosomiasis – bilharzias – but also fascioliasis and monieziasis) has yielded a new treatment, based on an alcohol extract from the *C. molmol* plant. Schistosomiasis is a parasitic infection attacking millions of people, mainly in Africa and China, but also in other countries; the infection is debilitating and sometimes fatal, attacking and damaging the kidney and liver. Research has focused on an extract from *C. molmol*, mirazid. Despite some side effects, a complete cure has been realized, not only for the bilharzia parasite but for several others, in both humans and animals. This cure, coupled with projects to increase production of the *C. molmol* tree, could possibly be an effective and economically feasible solution to help eradicating the incidence of parasitic diseases in developing countries (Badria et al. 2001; AboMadyan et al. 2004; Hamed and Hetta 2005; Southgate et al. 2005). However, data on the control of these parasitic diseases has been controversial, and Fenwick and Webster (2006) reported that myrrh is ineffective against schistosomiasis.

Additional conflicting reports are found in the literature about the efficacy of Mirazid as an antischistosomal drug. Contrary to the other positive studies this study gave negative effectiveness as antischistosomal drug (Ramzy et al. 2010).

In the twenty-first century, natural alternative medicine for many ailments has increased in popularity in the Western world, and myrrh has been revisited. The stringent and antiseptic properties of myrrh have been promoted as useful for cleansing and healing wounds, including bedsores. Traditionally, myrrh was used as a dressing for skin ulcers and sores. Myrrh is also a common ingredient in therapies for tonsillitis and sore gums; several commercially available tooth pastes contain *Commiphora myrrha* extract. It is considered useful as an ingredient in cough mixture, and as an effective and speedy expectorant in cases of catarrh and bronchitis. In small doses myrrh can promote digestion, but larger doses cause excessive sweating and gastric heat. Myrrh is often prescribed in combination with iron and aloes, for anemia, in connection with "female disorders". Since myrrh is a stimulant, especially to the mucous tissues, it can provoke prostration, nausea, and vomiting, if taken in excess. Myrrh is not taken alone as an internal medicine but is approved by the USDA as flavoring, fragrance, or stabilizing ingredient in beverages, cosmetics, drugs, and foods.

As is the case with other traditional herbal treatments, recent research has centered on the examination and evaluation of the unique properties of the resin, concluding that myrrh has considerable antimicrobial activity and is medicinally used in a variety of cures (El Ashry et al. 2003).

Gugulipid has been used for controlling or preventing cognitive dysfunction, hyperglycemia and some infective conditions of the skin (Pratap et al. 2002).

Gugulipid **–** the active ingredient of *C. mukul* (gugulipid), is widely used to treat hyperlipidemia, and positive effects were noted after examination (Cui et al. 2003).

Hypolipidemic activity of the phytosteroid extract from *C. mukul* was also observed (Urizar and Moore 2003). This hyperlipidemic agent represents a possible mechanism for the guggulsterone-mediated hypolipidemic effect (Deng et al. 2007). The chemistry and pharmacological activity of guggul derived from *C. wightii* was related to the isolates of material claimed to be efficacious for rheumatism, arthritis, hyperlipidemia, obesity, inflammation, atherosclerosis, wrinkles, and acne (Anurekha and Gupta 2006).

Extracts of *Commiphora mukul* have proved to be useful in the treatment of allergic and non-allergic inflammation concerning skin and external mucosae, in the symptomatic treatment of benign prostatic hypertrophy, and in the treatment of acne (Bombardelli and Spelta 1991).

In 1996, a team of chemists and pharmacologists at the University of Florence in Italy reported that two compounds of myrrh have pain-relieving properties. The researchers initially observed that mice injected with a myrrh solution were slower than a control group in reacting to the heat of a metal plate. They tested three main compounds of myrrh and found that two of them – furanoeudesma-1,3-diene and curzerene – have pronounced analgesic effects. Additional tests suggested that these compounds interact with the opioid receptors in mice brains to decrease the sensation of pain (Freese 1996).

Analysis and evaluation have been carried out to examine the characteristics of the various derivatives of *C. myrrha*. Eight sesquiterpene fractions were extracted, purified, and characterized from *C. molmol* (Dolara et al. 2000), and local anesthetic, antifungal, and antibacterial properties were recorded. The analgesic effects of myrrh had been examined by Dolara et al. already in 1996.

Toxicity studies on *C. molmol* were conducted in mice to determine external morphological, biochemical, and hematological changes, but no significant difference in mortality compared to controls was detected (Rao et al. 2001).

Myrrhanol A (isolated from *C. mukul*) displayed potent anti-inflammatory effects and is regarded as a plausible candidate for a potent anti-inflammatory agent (Fig. 16, Kimura et al. 2001).

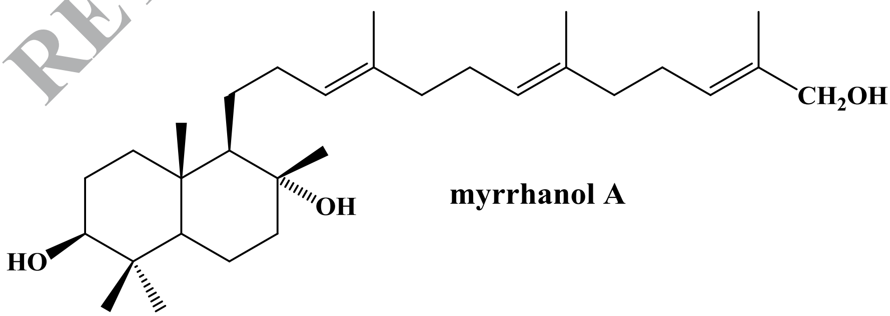


Fig. 16 Structure of myrrhanol A isolated from *C. mukul* (Kimura et al. 2001)

The active ingredients responsible for the maintenance of healthy cholesterol levels are the guggulsterones, specifically guggulsterone E and Z. These resins reduce serum lipids and cholesterol in the bloodstream, thus helping to avoid stroke (Owsley and Chiang 2003).

A randomized controlled trial performed in 2003 to study the short-term safety and efficacy of the extract concluded that cholesterol levels were not improved (Szapary et al. 2003).

Twelve Chinese medicinal herbs, including *C. myrrha*, were examined for their anticancer activity and positive results suggest that further studies were warranted (Shoemaker et al. 2005).

Other effects of myrrh resin extracts include studies on diabetes wounds (Lotfy et al. 2006), gingivitis inflammation, and general anti-inflammatory and antibacterial properties (Tipton et al. 2006; El Ashry et al. 2003).

Essential oil of *C. myrrha* (0.0001–5 %) was examined in cosmetic composition used for skin firmness, improvement of contractile properties and maturation of fibroblasts and myofibroblast, angiogenesis stimulation, weight reduction, against leg pain and circulation problems (Aurrens and Laperdrix 2008).

Compounds with antibacterial activity against *Staphylococcus aureus* strains, several *Salmonella enterica serovar Typhimurium* strains and two *K. pneumoniae* strains were isolated from oleo resin of C. molmol. The compounds were identified as mansumbinone, 3,4-seco-mansumbinoic acid, β-elemene and T-cadinol (Fig. 17, Rahman et al. 2008).

The substance responsible for toxic effect on the fourth stage larvae of Culex pipien in the essential oil of *Commiphora molmol* was found to be dl-limonene (Habeeb et al. 2009).

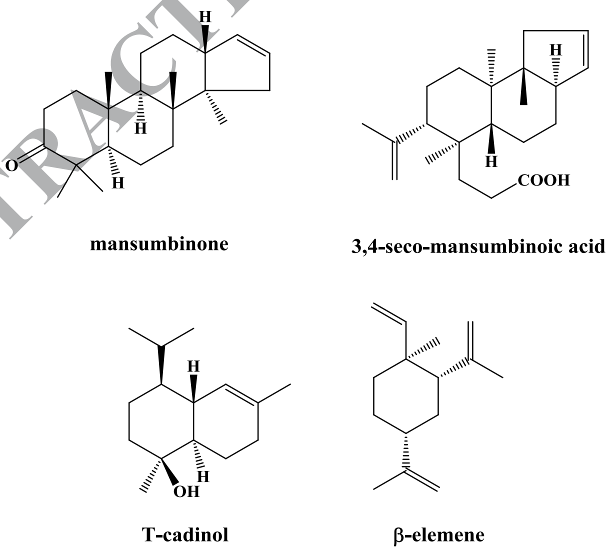


Fig. 17 Structures of compounds isolated from *C. molmol* (Rahman et al. 2008)

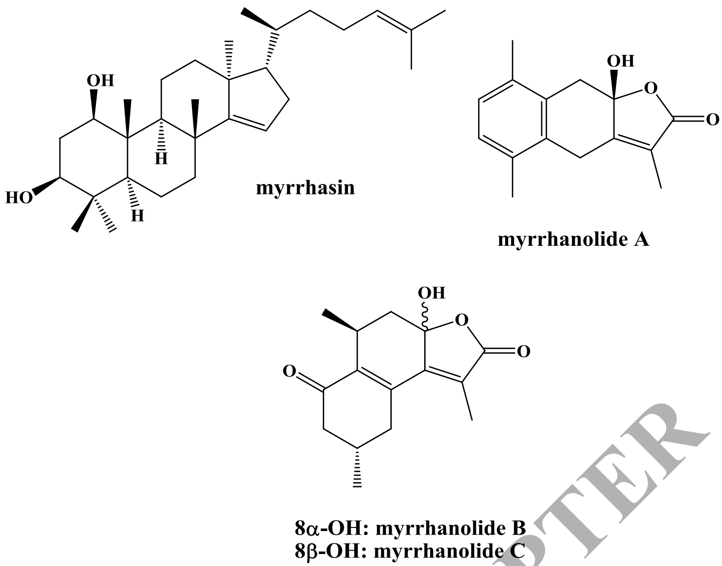


Fig. 18 Structures of compounds isolated from *C. myrrha* (Shen et al. 2009)

Shen et al. (2009) succeeded in isolating four new compounds from the resinous exudates of *Commiphora myrrha*: myrrhasin and myrrhanolide A–C (Fig. 18), as well as nine known sesquiterpenoids. Cytotoxic activities of these compounds were tested against the PC3 and DU145 human prostate tumor cell lines with the help of the MTT assay. Myrrhanolide A and the mixture of myrrhanolide B and C exhibited weak cytoxicity against the PC3 cell line with IC_{50} values of 38.3–46.0 μM, respectively.

Protection of *Commiphora molmol* emulsion against against PbAc-induced hepatic oxidative damage and immunotoxicity was successfully studied by Ashry et al. (2010). They found that myrrh treatments resulted in elevated leukocyte levels even in the absence of injury throughout healing (Haffor 2010). Masking of the bitter and disagreeable taste of the essential oil of *C. molmol can* improve patient acceptance and compliance (Etman et al. 2011). A stable MEO (myrrh essential oil) emulsion with an acceptable taste was formulated using Cremophore as an emulsifier and a combination of anise oil, peppermint oil, and glycerol as flavoring agents.

Plant extract of *C. molmol* was found to be efficient against *Trichomonas vaginalis* infection (El-Sherbiny and El-Sherbiny 2011).

Three new compounds were recently isolated from the resinous exudates of *C. myrrha*, named commiterpenes A–C (Fig. 19) (Xu et al. 2011a). These cadinane sesquiterpenes revealed moderate neuroprotective effects against 1-methyl-4-phenylpyridinium -induced neuronal cell death in human dopaminergic neuroblastoma SH-SY5Y cells (CRL-2266).

The resinous exudates of *Commiphora myrrha* were used for isolation of ten new furanosesquiterpenoids, myrrhterpenoids A–J (Fig. 20, Xu et al. 2011b). Their structures and relative configurations were elucidated by spectroscopic methods and

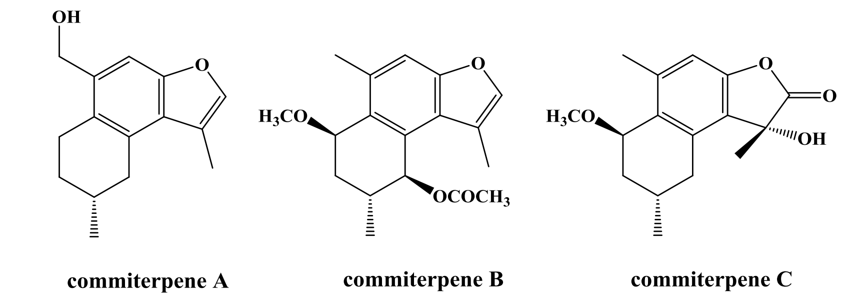


Fig. 19 Structures of compounds isolated from *C. myrrha* (Xu et al. 2011a)

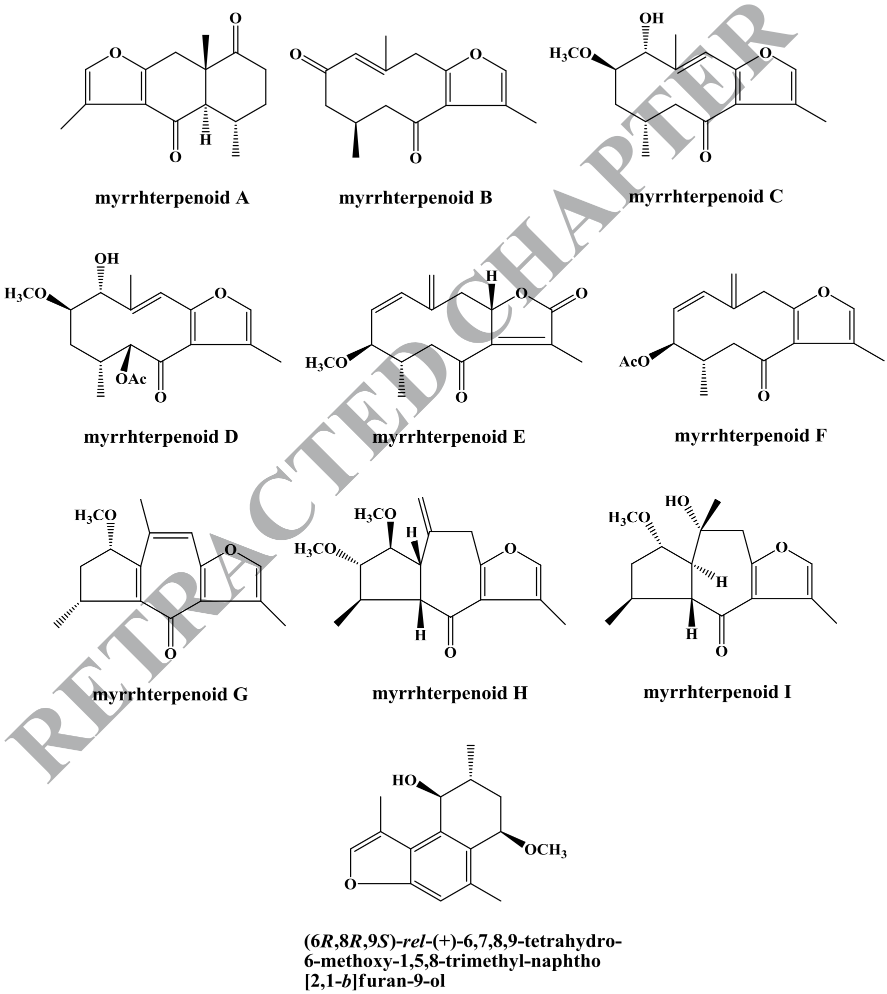
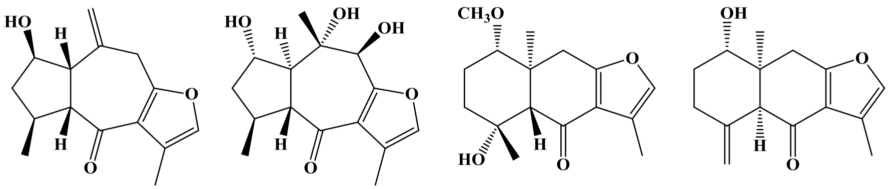


Fig. 20 Structures of compounds isolated from *C. myrrha* (Xu et al. 2011b)



myrrhterpenoid K myrrhterpenoid L myrrhterpenoid M myrrhterpenoid N

Fig. 21 Structures of compounds isolated from *C. myrrha* (Xu et al. 012)

by the ChemDraw 3D modeling using MM2. All isolated furanosesquiterpenes showed neuroprotective effects against MPP^+-induced neuronal cell death in SH-SY5Y cells.

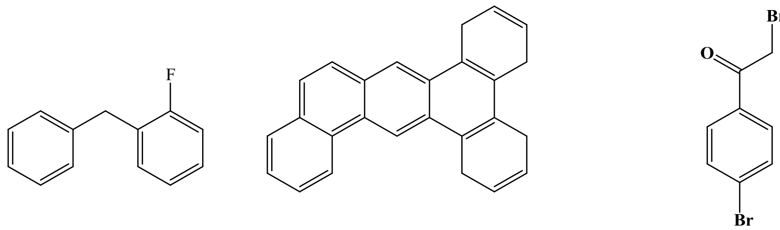
One year later this scientific group isolated four new sesquiterpenes from *C. myrrha* resin: myrrhterpenoids K–N (Fig. 21) (Xu et al. 2012). Myrrhterpenoids K and N revealed neuroprotective effects against 1-methyl-4-phenylpyridinium -induced neuronal cell death in dopaminergic neuroblastoma SH-SY5Y cells.

Anti-inflammatory and analgesic activity of *C. myrrha* extracts were proved by Shulan et al. (2011). The authors identified seven main compounds in these extracts: 2-methoxy-8,12-epoxygermacra-1(10),7,11-trine-6-one, 2-methoxy-5-acetoxy-furanogermacr-1(10)-en-6-one, myrrhone, sandaracopimaric acid, abietic acid, dehydroabietic acid, and mansumbinone. Later Su et al. (2012) studied myrrh, frankincense and their combination for the treatment of inflammatory pain. The combined extract exhibited significant anti-inflammatory and analgesic activities. Twelve potentially active compounds in both extracts were identified – 2-methoxy-8,12-epoxygermacra-1(10),7,11-trine-6-one, 7-methoxy-3,6,9-trimethyl-6,6α,7,8,9,9α-hexahydroazuleno[4,5-β]furan-4(5H)-one, 2*R*-methoxy-4*R*-furanogermacr-1(10)E-en-6-one, 2-acetoxyfuranodiene, 3,17-dihydroxy-3β-pregn-5-en-20-one, 1,2,3-trihydroxyurs-12-en-28-oic acid, 3-keto-tirucall-7,24-dien-21-oic acid, 3-hydroxytirucall-8,24-dien-21-oic-acid, 3-keto-tirucall-8,24-dien-21-oic acid, acetyl-11-keto-β-boswellic acid, 9,11-dehydro-β-boswellic acid, and α-boswellic acid.

De Rapper et al. (2012) studied the in vitro antimicrobial activity of three essential oil samples of frankincense (*Boswellia rivae*, *Boswellia neglecta* and *Boswellia papyrifera*) and two essential oil samples of myrrh and sweet myrrh (*Commiphora guidotti* and *Commiphora myrrha*). In this study several microorganisms were used, namely *Staphylococcus aureus*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *C. albicans* and *Cryptococcus neoformans*. Antimicrobial activity was improved for 80 % for frankincense and myrrh essential oil samples, with the best one just for *C. myrrha* oil.

C. molmol did not improve the biochemical parameters of the hepatocarcinogenesis in rats (El-Shahat et al. 2012).

Al-Abdalall (2013) showed that fresh aqueous extracts of *Commiphora myrrha* and *Commiphora molmol* inhibit pathogenic bacteria: *Micrococcus luteus*, *Neisseria*



1-benzyl-2-fluorobenzene **tribenzo-1,2,3,4,5,6-anthracene** **2-bromo-1-(4-bromophenyl) ethanone**

Fig. 22 Structures of compounds isolated from *C. myrrha* and *C. molmol* (Al-Abdalall 2013)

siccca, *Proteus mirabilis* and *Pseudomonas aeruginosa*. With the longer storage time of the extracts the inhibition of bacterial growth decreased. Three compounds with inhibitive effect were identified, namely 1-benzyl-2-fluorobenzene, tribenzo-1,2,3,4,5,6-anthracene, and 2-bromo-1-(4-bromophenyl)ethanone (Fig. 22).

El-Mekkawy et al. (2013) isolated from the hexane extract the oleogum resin of *Commiphora wightii* (guggul) three new compounds, epi-mukulin, (Z)-Δ1,2 -dehydroguggulsterone and Δ6,7-dehydro-20-hydroxyguggIsterone. They isolated also six known compounds, diasesartemin, (+)-epi-magnolin, (+)-diayangambin, guggIsterol I, (E)-guggulsterone and (Z)-guggulsterone (Fig. 23). α-Glucosidase inhibitory effects of the isolated compounds were evaluated calorimetrically. The hexan soluble fraction showed significant α-glucosidase inhibitory effect. Under the assay conditions, diasesartemin was found to be more potent than the positive control, acarbose, a known α-glucosidase inhibitor.

Commiphora myrrha essential oil showed remarkable in-vitro cytotoxic activity against MCF-7 breast cancer cells (MCF-7 cell line is a plural effusion from human mammary gland adenocarcinoma) using a MTT-based cytotoxicity assay (Simmons et al. 2013).

Patents

Majeed, M., V. Badmaev, K.R. Bammi, B. R. Kumar, S. Prakash, and S. Natarajan. 2002. US Patent No. 20020061929. Composition and method containing products extracted from *Commiphora* sp. for prevention and treatment of abnormal cell growth and proliferation in inflammation, neoplasia, and cardiovascular disease.

Two ferulic acid esters from *Commiphora wightii* were used for the prevention and treatment of abnormal cell growth and proliferation in inflammation, neoplasia, and cardiovascular disease.

Jindal, K. C., C. B. Rao, M. Ramanathan, and B. Suresh. 2005. Patent WO2004069262. Herbal composition comprising *Commiphora mukul*, *Allium sativum* and *Cucuma longa*.

The treatment and/or propylaxis of hypercholesterolemia, atherosclerosis, hyperlipidemia, and hypertension in mammals uses a herbal composition comprising *Commiphora mukul*, *Allium sativum*, and *Curcuma longa*.

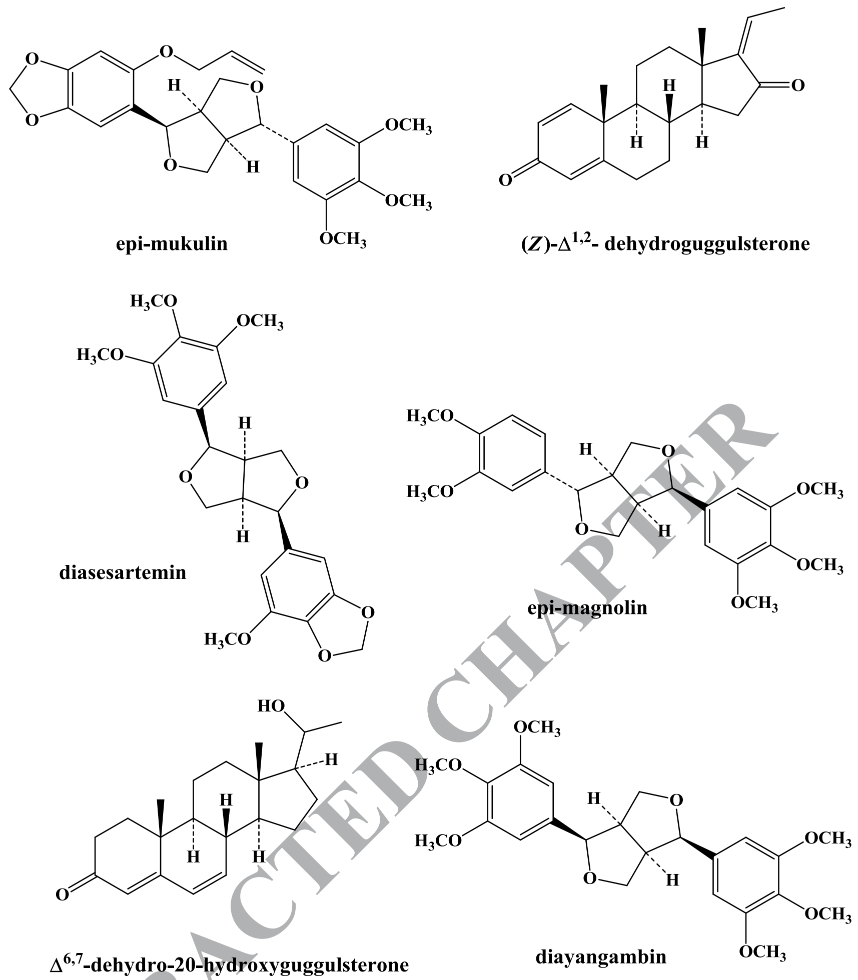


Fig. 23 Structures of compounds isolated from *Commiphora wightii* (El-Mekkawy et al. 2013)

McCook, J.P., J.M. Corey, P.L. Dorogi, J.S. Bajor, H.E. Knaggs, B.A. Lange, E. Sharpe, and E. Tallman. 1997. US Patent No. 5690948. Antisebum and antioxidant compositions containing gugulipid and alcoholic fraction thereof.

Gugulipid (registered and marketed by Sabinsa Corporation) is a standardized extract prepared from the oleogum resin (gum resin) of *C. mukul*, an ingredient in traditional Ayurvedic medicine. The product is claimed to be beneficial for lowering serum cholesterol. Gugulipid (from *C. mukul* or *C. wightii*) may be used in the control of oily skin conditions and protecting the skin from free radical damage.

Pratap, R., R. Pal, S. Singh, G. Shankar, C. Nath, H.K. Singh, D. Raina, A.K. Srivastava, A.K. Rastogi, P.S.R. Murthy, S. Srivastava, O.P. Astana, N. Singh, and N. Nand. 2002. US Patent No. 2003099729. Novel uses of gugulipid as cognition enhancer, antihypergly-cocemic, and for dermal conditions.

Use of an extract from the stem of *Commiphora molmol* (Family *Burseraceae*) comprising additional or alternatively a volatile oil (containing heerabolene, cadinene, elemol, eugenol, cuminaldehyde, numerous furanosesquiterpenes including furanodiene, furanodienone, curzerenone, lindestrene, 2-methoxyfuranodiene and other derivatives), resin (including α-, β-and γ-commiphoric acids, commiphorinic acid, heeraboresene, α- and β-heerabomyrrhols and commiferin) or gum (composed of arabinose, galactose, xylose and 4-0-methylglucuronic acid) and particularly oleogum-resin (Myrrh) in the preparation of a medicament for the treatment of schistosomiasis. Myrrh contains approximately 7–17 % of volatile oil, 25–40 % of resin, 57–61 % of gum and some 3–4 % of impurities. Pharmaceutical compounds are provided together with a pharmaceutically acceptable carrier diluent or excipient.

Olibanum

Major aim of recent research is the therapeutic possibilities of the oleo-gum-resins of *Boswellia*. Boswellic acids, a group of medicinally important compounds, were reviewed and referenced in 276 studies. The studies emphasized anti-inflammatory properties and anticancer potential (Shah et al. 2009). Boswellic acids were found to be effective through topical application in inflammatory disorders (Singh et al. 2008).

The ancient Egyptian medical practices relied strongly on faith and belief in mystical and magical treatments, combined with practical medicinal herbs The Egyptian Ebers Papyrus (1500 BCE), which contains 876 prescriptions, states: Magic is effective together with medicine. Medicine is effective together with magic" (Wreszinski 1912). The Ebers Papyrus cites the use of frankincense in cases of throat and larynx infections, stopping bleeding, reducing phlegm, asthmatic attacks, and stopping vomiting. Pliny (Book 25, Chapter 82) mentioned frankincense as an antidote to hemlock (*Conium maculatum*). The SEPASAL database cites at least 20 different systems of medical disorders for which frankincense has been or is still used as a remedy.

Ibn Sina (Avicenna) in his *Canon of Medicine* of the tenth century (Jahier and Noureddine 1956) recommended frankincense for tumors, ulcers, vomiting, dysentery, and fevers.

Use of frankincense in China was first mentioned in the sixth century CE in the *Mingyi Bielu* (Needham and Lu 1974). Frankincense was called *fanhunxiang* and was used in memorial ceremonies. The prefix "fan-," which means "foreign" or "devil," should be interpreted to mean that the substance was imported. Frankincense is used in herbal medicine in a similar way to myrrh, to quicken the blood circulation and relieve pain. However, unlike myrrh, frankincense also acts on *qi* (the physical life force). An ancient Chinese prescription (*Qi Li San*) is prescribed for all injuries and is made up of dragon's blood, catechu, myrrh, frankincense, carthamus, cinnabar, musk, and borneol. This ointment is the base for Yunnan Bai Yao, a popular remedy today, reputedly carried by the Vietcong during the Vietnam War to stop bleeding from wounds, with apparently amazing success (Yunnan Baiyao Company).

The psychoactivity of *Boswellia* was recognized in ancient times in the Near East and Europe. In India, the traditional Ayurvedic medical systems refer to the use of the gum extracted from *Boswellia serrata*, which is recommended for arthritic and inflammatory conditions, gastric disorders, pulmonary diseases, and skin ailments. It also is reported to have a strong action on the nervous system. Yoga tradition uses frankincense oil for massage and stimulation in arthritic conditions (Miller and Morris 1988).

Patents

There are a number of recent patents involving frankincense and its derivatives, indicating a wide range of suggested applications in medicine. Relevant patents are described next.

Etzel, R. 1997. US Patent 5720975. Use of incense in the treatment of Alzheimer's disease.

This patent concerns the use of incense in the treatment of Alzheimer's disease, citing the production of a medicament composed of olibanum and boswellic acid combined with physiologically acceptable salts.

Simmet, T., and H.P.T. Ammon. 1999. US Patent 6174876. Use of Boswellic acid for treating brain tumors.

Weisman B. 1999. US Patent No. 5888514. Natural composition for treating bone or joint inflammation.

Inventor uses extracts of *Boswellia serrata* and boswellic acid among other materials for treating bone or joint inflammation.

Duranton, A., and O. De Lacharriere. 2002. US Patent 6465421. An application for modulating body/cranial hair growth, using boswellic acid as a possible ingredient.

Inventors presented an application for modulating body/cranial hair growth using boswellic acid as a possible ingredient.

Meybeck, A., and A. Zanvit. 2004. US Patent 20040166178. 3-O-acetyl-11-ketoboswellic acid for relaxing the skin.

The present invention relates to the use of 3-O-acetyl-11-ketoboswellic acid (AKBA), a plant extract of *Boswellia serrata*, as an agent to soften lines and/or relax the skin.

This patent relates to the use of 3-O-acetyl-11-ketoboswellic acid (AKBA)), a plant extract of *Boswellia serrata*, as an agent to soften lines and/or relax the skinand reduce wrinkles.

Ali, A. Y., and I. D. Bowen. 2007. US Patent 20070264363. Molluscicidal and Anti-Barnacle Compounds.

This patent, by inventors A. Ali and I. D. Bowen, relates to the use of plant material of the *Burseraceae* as a terrestrial molluscicidal and/or molloscrepel-lant agent.

Shanahan-Prendergast, E. 2004. US Patent Application No. 20040092583. A treatment for inhibiting neoplastic lesions using incensole and/or furanogermacrens.

Inventor describes a treatment for inhibiting neoplastic lesions using incensole and/or furanogermacrens. The invention discloses the use of incensole and/or furanogermacrens, derivative metabolites, and precursors thereof in the treatment of neoplasia, particularly resistant neoplasia, and immunodysregulatory disorders.

Ammon, H.P.T., and H. Safayhi. 2005. US Patent Application No. 20050209169. Use of boswellic acid and its derivatives for inhibiting normal and increased leucocyte elastase or plasmin activity.

Inventors describe the use of boswellic acid and its derivatives for inhibiting nor-maand increased leucocyte elastase or plasmin activity, for treatment especially in the case of pulmonary emphysema, acute respiratory distress syndrome, shock lung, cystic fibrosis, chronic bronchitis, glumerulonephritis, and rheumatoid arthritis.

Hwa, J.Y. 2007. US Patent 7223423. Skin treatment composition.

A skin treatment composition, comprising an effective combination of ingredients selected from cumin, cloves, peach kernel, olibanum, eagle wood, giant hyssop, almond, and pachira macracarpa is provided. The composition can be used as a skin cleanser, as a deodorant, and to treat a wide array of skin problems, including signs of aging, such as wrinkles, and skin sagging, dark spots, skin infections, skin irritation, cuts, scarring, acne, cold sores, chapped lips, and varicose veins. The composition is preferably formulated in water, as a mud pack, or bath preparation. Other suitable delivery systems may be included. The composition can further be used for hair treatment, to thicken hair roots, and to prevent hair loss. The composition can also be used for vaginal treatment, including for yeast and other infections, vaginal discharge, and to promote recovery after a vaginal birth and episiotomy. Such treatment is especially effective when the composition is used as a bath preparation. The composition further has a soothing and relaxing effect especially when used in a bath.

Qazi, G.N., S.C. Taneja, J. Singh, A.K. Saxena, V.K. Sethi, B.A. Shah, B.K. Kapahi, S.S. Andotra, A. Kumar, S. Bhushan, F. Malik, D.M. Mondhe, S. Muthiah, S. Singh, M. Verma, and S.K. Singh. 2009. US Patent Application 20090298938. Use of semi synthetic analogues of boswellic acids for anti-cancer activity.

Jauch, J. 2002. German Patent No. 085921. A simple method for the synthesis of Boswellic acids and derivatives thereof.

Inventor J. Jauch relates to a method for producing a pure boswellic acid from a boswellic acid mixture, comprising these steps: acetylation by a suitable acetylation reagent or deacetylation by a suitable deacetylation reagent and oxidation by a suitable oxidation reagent or reduction by a suitable reduction reagent.

Striggow, F., W. Schmidt, and T. Mack. 2004. Patent EP 04721524. Use of incense or hydrogenation products for preventing and/or treating a cerebral ischemia, and/or cerebral traumatic lesion, and/or Alzheimer's disease.

This patent relates to the use of incense or hydrogenation products for preventing and/or treating cerebral ischemia and/or cerebral traumatic lesion and/or Alzheimer's disease.

Taneja, S.C., V.K. Sethi, K.L. Dhar, and R.S. Kapil. 1997. Patent No. 5629351. Boswellic acid compositions and preparation thereof.

Disclosed herein is a novel fraction comprising a mixture of boswellic acids, wherein the fraction exhibits anti-inflammatory and antiulcerogenic activities. Also disclosed is a novel boswellic acid compound exhibiting anti-inflammatory, antiathritic and antiulcero-genic activities. Also disclosed is a process for isolating a boswellic acid fraction and individual boswellic acids therefrom.

Recent Additional Research

Boswellic acid extracted from *B. serrata*, in an experimental model of irritable bowel syndrome, reduced inflammation after administration. The conclusion was that the anti-inflammatory actions of the *Boswellia* extract may be due in part to AKBA, e.g. acetyl-11-keto-boswellic acid (Krieglstein et al. 2001).

In cases of chronic colitis, a gum resin from *B. serrata* was shown to be an effective treatment, with minimal side effects (Gupta et al. 2001).

Compared to indomethacin, AKBA significantly inhibited angiogenesis (Singh et al. 2007) and was found to have antiproliferative and apoptotic effects on metastases in human HT-29 cells (Lui et al. 2002).

Chemicals derived from, among others, *Boswellia* plants used as mixed formulations are potent in curing inflammatory diseases (Darshan and Doreswamy 2004).

Incensole obtained from the dried bark of *Boswellia dalzielii*, a species growing in West Africa, contained strong antimicrobial and antioxidant activity, but incensole itself was only moderately active (Alemika et al. 2004). Similar results were obtained with olibanum from *B. carterii* and *B. sacra* (Hamm et al. 2003, 2005) while *B. serrata* contained an unidentified sesquiterpene. Broad-spectrum inhibition against bacteria and fungi was obtained with *B. dalzielii* (Adelakun et al. 2001).

In research on aging-associated abnormalities in mice, it was suggested that acetyl-11-keto-boswellic acid (AKBA) may provide a new therapeutic innovation for the treatment of aging-related brain disorders, such as Alzheimer's disease and different motor dysfunctions with adequate gastrointestinal tolerability (Bishnoi et al. 2005).

Boswellic acid and its derivatives were used for inhibiting normal and increased leucocyte elastase or plasmin activity (Ammon and Safayhi 2005).

Gum resin extracts of *Boswellia* species experimentally tried in animal models and studies in human subjects confirmed their potential for the treatment of not only inflammations but also of cancer (Poeckel and Werz 2006).

Ammon (2006) concluded that oleogum resins from *Boswellia* species have efficacy in some autoimmune diseases, including rheumatoid arthritis, Crohn's disease, ulcerative colitis, and bronchial asthma. Side effects were not severe when compared to modern drugs used for the treatment of these diseases.

B. serrata gum resin extract prevents diarrhea and normalizes intestinal motility, which explains the clinical efficacy of this Ayurvedic remedy in reducing diarrhea in rodents with inflammatory bowel disease (Borrelli et al. 2006).

The *Boswellia* resin is the natural defense of the tree reacting to the trauma of a wound; the polyphenols present in the gum offer protection against fungus and pests. As a skin treatment for dyshidrosis and related skin disorders and a wide array of skin problems, including signs of aging, such as wrinkles, skin sagging, dark spots, skin infections, skin irritation, cuts, scarring, acne, cold sores, chapped lips, and varicose veins, olibanum and boswellic acid are combined with other materials for supposedly safe and effective therapy (Hwa 2007).

The anti-inflammatory action of the boswellic acids is similar to that of the conventional nonsteroidal anti-inflammatory drugs (NSAID). However the NSAID often cause joint damage by inhibiting glycosaminoglycan synthesis, whereas boswellic acids do not have this undesirable action, making them a potential choice for long-term treatment. The crude methanolic extract and the isolated pure compound are capable of carrying out a natural anti-inflammatory activity at sites where chronic inflammation is present (Gayathri et al. 2007).

Boswellia serrata is the subject of many research studies in India, where this species grows. A double-blind, randomized, placebo-controlled study of the efficacy and safety of 5-Loxin (an enriched *Boswellia serrata* extract) for treatment of osteoarthritis of the knee was performed on 75 patients. 5-Loxin was observed to reduce pain and improve physical functioning and considered safe for human consumption (Sengupta et al. 2007).

A photochemical study by Sharma et al. (2007) concluded that *B. serrata* is a potent and safe alternative to conventional NSAIDs

Research on the effects of incense on humans at the Hebrew University of Jerusalem indicated that one of the major active ingredients of frankincense is incensole acetate (Moussaieff et al. 2007, 2008). The researchers demonstrated that incensole acetate lowers anxiety and causes antidepressive-like behavior in mice.

The effect of AKBA from *B. carterii* on the development of atherosclerotic lesions showed a significant reduction in the expression of several proathero-genic genes, NF-kB activity, and lesion size in treated mice (Cuaz-Perolin et al. 2008).

The inhibitory effect of AKBA-containing drugs on prostate cancer cells showed that this material could be used for the development of novel therapeutic chemicals (Yuan et al. 2008).

Boswellic acids from *B. serrata* gave a protective effect on gastric ulcers in rats (Singh et al. 2008).

Boswellic acids were found to be effective through topical application in inflammatory disorders (Singh et al. 2008).

Studies carried out by Shah et al. (2009) emphasized the anti-inflammatory properties and anticancer potential.

Six new terpenes, olibanumols A, B, C, H, I, and J (Fig. 24), were isolated from an extract of exuded gum-resin of *Boswellia carterii*, together with seven known terpenoids (3,6-dihydroxy-*p*-menth-1-ene, *p*-menth-1-en-4α,6β-diol, (−)-*trans-sobrerol*, *p*-menth-4-en-1,2-diol, *p*-menth-5-en-1,2-diol, isofouquierol, and epilupeol) (Yoshikawa et al. 2009). The extract showed anti-inflammatory effect. Olibanumols A, H, and I, and isofouquierol, revealed inhibitory effects on production of NO in LPS-activated macrophages.

Frankincense oil appears to distinguish cancerous (bladder transitional cell carcinoma J82) from normal bladder cells (urothelial cells) and suppress cancer cell viability (Frank et al. 2009)

Three purified tetracyclic triterpenoids: 3-oxo-tirucallic acid, 3-α-acetoxy-tirucallic acid, and 3-β-acetoxy-tirucallic acid (Fig. 25) from the oleogum resin of *Boswellia carterii* induced apoptosis in prostate cancer, but not in nontumorigenic cells. Thus, tirucallic acid derivatives represent a new class of Akt inhibitors with antitumor properties (Estrada et al. 2010).

Van Vuuren et al. (2010) compared nine samples of *B. carterii* and two samples of *B. sacra* for the main terpenes (see Table 3) and evaluated their antimicrobial

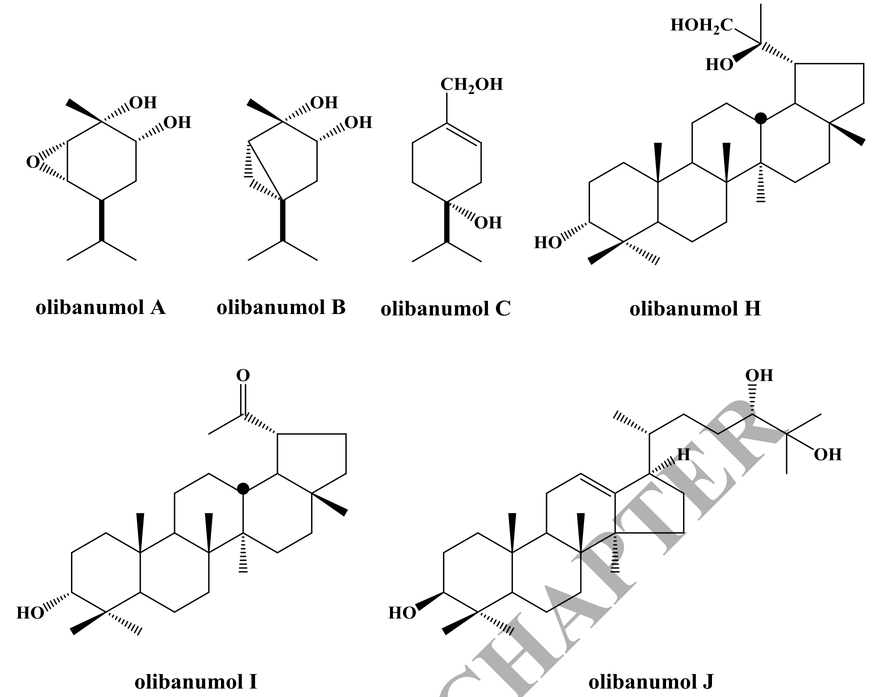


Fig. 24 Structures of compounds isolated from *B. carterii* (Yoshikawa et al. 2009)

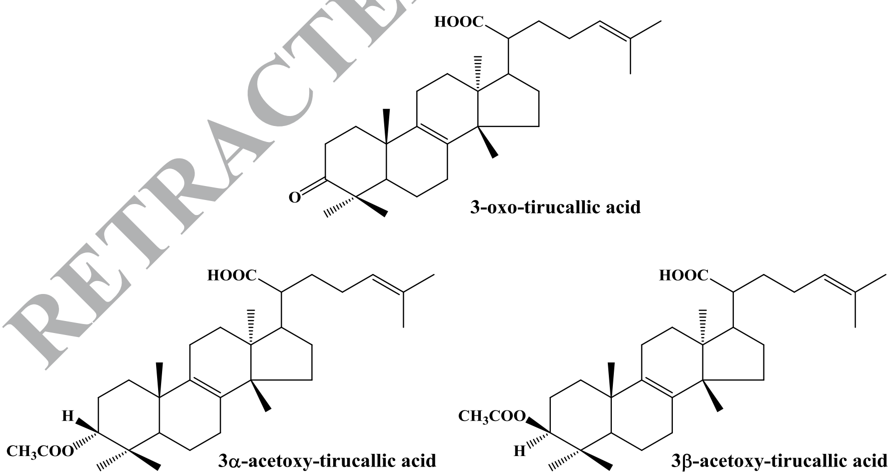


Fig. 25 Structures of compounds isolated from *B. carterii* (Estrada et al. 2010)

Table 3 Comparison of *B. carterii* and *B. sacra* samples for the main terpenes

Boswellia carterii	*Boswellia sacra*
α-pinene (4.8–40.4 %)	α-pinene (18.3–22.5 %)
α-thujene (1.6–52.4 %)	α-thujene (3.9–11.2 %)
Limonene (2.6–20.4 %)	Limonene (11.2–13.1 %)
p-cymene (3.6–6.2 %)	*p*-cymene (4.7–5.9 %)
β-caryophyllene (0.3–10.5 %)	β-caryophyllene (7.2–7.6 %)

Van Vuuren et al. (2010)

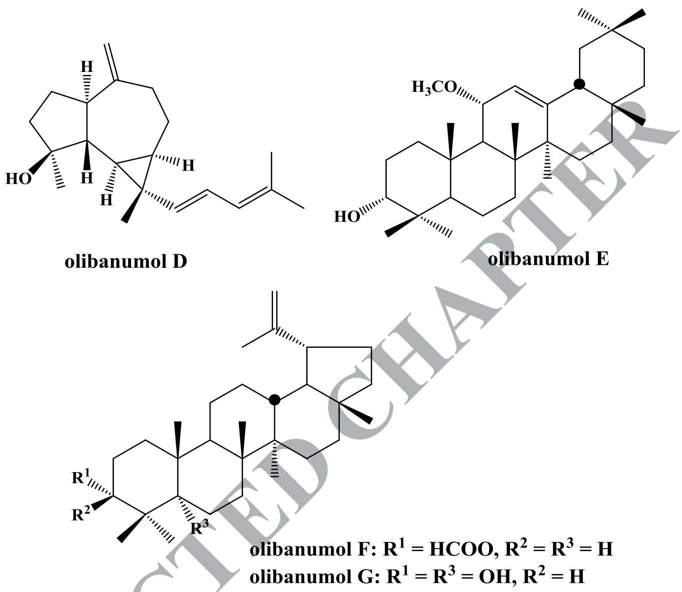


Fig. 26 Structures of compounds isolated from *B. carterii* (Morikawa et al. 2011)

activity against *S. aureus*, *B. cereus*, *E. coli*, *P. vulgaris*, and *C. albicans*. The essential oils exhibited good to poor in vitro antimicrobial activity.

Four new compounds, olibanumol D–G (Fig. 26), were isolated from the exuded gum-resin from *Boswellia carterii* (Morikawa et al. 2011). Olibanumols D and E showed significant inhibitory effects on nitric oxide (NO) production in lipopolysaccharide (LPS)-activated mouse peritoneal macrophages.

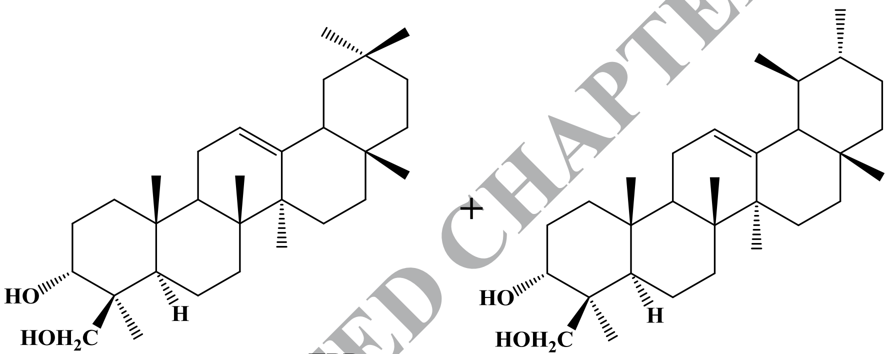
Boswellia sacra essential oil has tumor cell-specific cytotoxicity in multiple cancer cell types. Suhail et al. (2011) proved that this essential oil may induce breast cancer cell-specific cytotoxicity and may be effective for advanced breast cancer.

Four different oleo-gum resins from *Boswellia sacra* from the Dhofar region of Oman, with the presence of α-pinene as the principal constituent (Table 4), revealed pronounced activity against Gram-positive (*Bacillus subtilis*, *Micrococcus luteus*, *Staphylococcus aureus*) and Gram-negative (*Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Enterobacter aerogenes*, *Escherichia coli*, *Proteus vulgaris*) bacteria

Table 4 The main terpenes in the *Boswellia sacra* samples from Oman

α-pinene (46.8–76.0 %)
Camphene (1.4–2.4 %)
β-pinene (1.3–2.0 %)
Myrcene (1.0–8.9 %)
α-phellandrene (0.6–3.2 %)
p-cymene (1.6–2.7 %)
Limonene (1.7–15.9 %)
p-mentha-1,5-dien-8-ol (1.1–3.4 %)
(*E*)-caryophyllene (0.5–1.5 %)
β-elemene (0.9–2.6 %)
β-selinene (1.2–1.8 %)
α-selinene (0.5–1.1 %)

Al-Saidi et al. (2012)



TPD

Fig. 27 Two isomers of a new pentacyclic triterpenediol from *Boswellia serrata* (Bhushan et al. 2013)

(Al-Saidi et al. 2012). The main compounds in essential oil of these four *Boswellia sacra* oleo-gum resins are shown in the following table:

Frankincense essential oil from *Boswellia sacra* suppresses viability and induces apoptosis of a panel of human pancreatic cancer cell lines (Xiao et al. 2012). Thus these authors suggested that this essential oil might be a useful alternative therapeutic agent for treating patients with pancreatic adenocarcinoma, an aggressive cancer with poor prognosis.

A novel anticancer compound was isolated from the gum of *Boswellia serrata* (Bhushan et al. 2013, Fig. 27). This pentacyclic triterpenediol (TPD) has significant cytotoxic and apoptotic potential in a large number of human cancer cell lines (Sarcoma-180 solid tumor bearing mice).

In order to assess the effect of *B. carterii* smoke, after 1 week acclimatization period, rats were randomly divided into three groups, groups 1, 2 and 3 with each group consisting of 11 animals. Each group of rats was housed separately from the other groups to avoid the cross exposure to incense smoke. Rats in group 1 served as control and were kept in normal fresh air, while rats in group 2 and 3 were exposed to *B. papyrifera* and *B. carterii* smoke, respectively, in a smoking chamber. The rats were exposed daily to the smoke emanating from the burning of 4 g of each incense material for 4 months. Smoke exposure durations lasted for 30–40 min/day. The dose and duration of incense exposure followed in this study was based on the optimized conditions from our previous studies. At the end of exposure duration, animals were killed by cervical dislocation. *B. carterii* smoke affects the process of spermatogenesis and sperm parameters in male albino rats and indicates the detrimental effects of these incense materials on the human reproductive system. Sperm analysis in rats exposed to the *B. carterii* smoke exhibited a significant decrease in their sperm count. This fact shows that incense smoke could affect men who are constantly exposed indoors to this incense (Mukhtar et al. 2013).

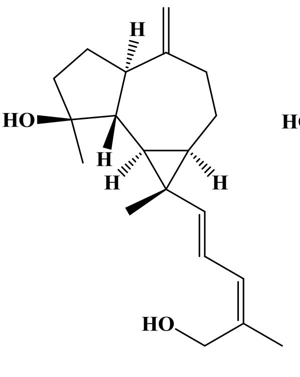
Ethyl alcohol extract of the gum resin of Boswellia carterii from China revealed after isolation nine new prenylaromadendrane-type diterpenes named boscarterol A–I. All compounds (except compounds D and G) exhibited moderate hepatoprotective activity against D-galactosamine-induced toxicity in HL-7702 cells (Wang et al. 2013) (Fig. 28).

Conclusions

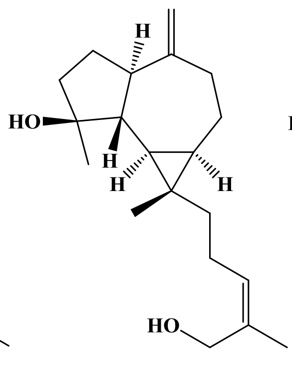
The ancient resinous plants that produce frankincense and myrrh are, at present, in a fragile condition economically and culturally, and their use is declining. This spice industry, which earned enormous sums of money during the classical period and acquired for Arabia a great fortune, has dwindled down to 1,500 t of export, collected by nomadic people from wild trees mainly in Somalia, for a very meager financial value. The major question is whether this industry can be revived at all. Perhaps the modern world is no longer interested in these exotic spices. Our opinion is that a renewal of interest is emerging, not only because of ongoing exotic and religious appeal but due to the medical potential of several ingredients of these ancient spices. The thrust of recent research suggests efficacy of extracts of these spices and supports the documented prescriptions of the famous physicians throughout history, such as Galen, Avicenna, and Maimonides.

The search for new molecules has turned to ethnobotany and ethno-pharmacognosy as guides to lead chemists toward different sources and classes of compounds (Ben Yehoshua and Mercier 2005; Gurib-Fakim 2006). Fabre (2003) conducted a study to analyze the Roman pharmacopoeia of spices "with reference to modern criteria." He concluded that a new discipline is ready to emerge: archeo-pharmacology, aiming towards a drug research based on ancient texts. It remains to be seen if ancient herbal medicines will make a reentry in the twenty-first century.

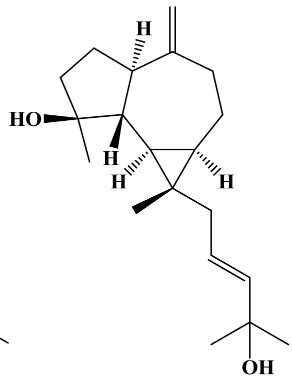
Some attempts have been made to reestablish the roles of frankincense and myrrh in modern natural medicines, and this could promote a revival in interest. If proven efficacious, the medicinal use of these species could provide a new source of income in the disadvantaged societies where these spices grow wild. For example, in Ethiopia,



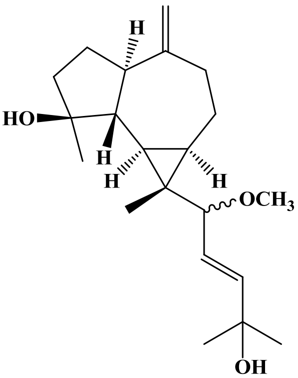
Boscarterol A



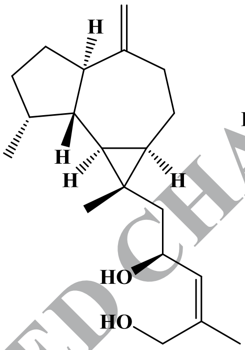
Boscarterol B



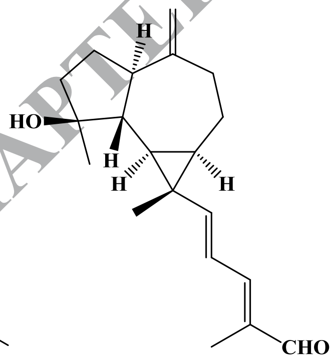
Boscarterol C



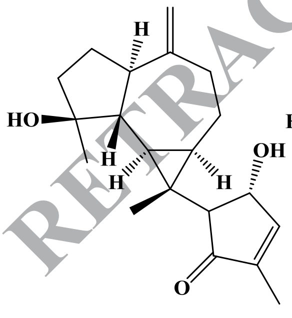
Boscarterol D



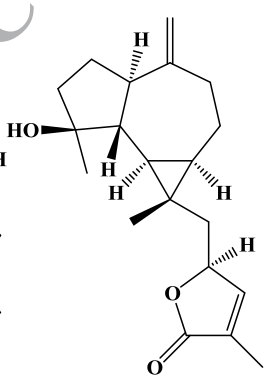
Boscarterol E



Boscarterol F



Boscarterol G



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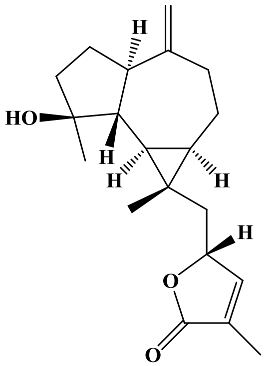

Boscarterol I

Fig. 28 Nine new boscarterols from *Boswellia carteri* (Wang et al. 2013) where some export of spices occurs, rehabilitation of these ancient spice crops could provide a new source of income for the local population. Currently, replanting projects in the wild are under way in Ethiopia and Somalia. However, local scientists in Ethiopia report that the future of these projects is far from being assured. Today spices are such a minute item of export from Oman, Yemen, Ethiopia, and Somalia that they are not listed in databases of exports (Index Mundi, the FAO, and USDA). New initiatives and resources from the developed countries are required to reawaken interest in the neglected treasures of the ancient spices, which could have potential for new drugs. This review suggests that frankincense and myrrh are good candidates to start this effort.

Is it possible to revive the growth of the extinct apharsemon in the Dead Sea Basin in Israel? Most researchers with some familiarity with this highly reputed ancient spice would not consider this likely. This review has presented many reasons for this pessimistic view, including the vague identification of this plant, *Commiphora giIeadensis* or *C. opobaIsamum* by Forsskål and Linnaeus, as well as our lack of any remaining plants or even a residue of the plants that grew in the Dead Sea Basin. Pessimists claim that the glory of *C. gileadensis* belongs only to the past. However, some active researchers, including the present authors, believe that this plant still has a future due to its special medical characteristics established over a period longer than 1,000 years by the best physicians of many cultures.

A common exercise in modern biotechnology is the derivation of new, previously unknown medications from wild plants gathered in remote places, such as the Amazon. However, a more promising approach might be to trace medicinal plants of antiquity that is well adapted to the environment and known by tradition to produce medications. Such a project could lead to the restoration of the production of the ancient apharsemon in the Dead Sea Basin. Strengthened by this thesis, these researchers and several farmers in the Dead Sea Basin and elsewhere have managed, with the help of colleagues in other parts of the world, to raise many thousands plants of *Commphora giIeadensis* opobalsamum, which are the closest candidates available for the ancient apharsemon. The exact identity of these plants is under studies. These plants exude the exclusively fragrant liquid resin that resembles what has been described for the ancient apharsemon. Furthermore, these plants grow well in the Dead Sea Basin, both in Ein Gedi and Almog near Jericho. The new discovery is that the resin from these plants has exhibited impressive cytotoxic activity against several cancer cell lines of lymphoma and carcinoma both of human and of mouse. Furthermore the major component – 20 % – of the essential oil of the apharsemon is β-caryophyllene and this compound was found at the first time to the best of our knowledge, to induce apoptosis in cell culture of the cancer cells studied. These cancer cells died because of this induction of apoptosis. Normal fibroblast cells were not affected by this beta caryophyllene. This compound is allowed by the Food and Drug Administartion of the USA and other countries as a food additive and is present in many foods of our diet. A request for a patent on our finding is pending. All these data would facilitate greatly our research to advance the development of apharsemon and the β-caryophyllene in the struggle against cancer. This research is just beginning, but the enthusiasm of the researchers is high. Other reports about anticancer activity by the resin of *C. gileadensis* were cited in this review.

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