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# Frankincense, Myrrh, and Balm of Gilead: Ancient Spices of Southern Arabia and Judea

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**ABSTRACT**

Ancient cultures discovered and utilized the medicinal and therapeutic values of spices and incorporated the burning of incense as part of religious and social ceremonies. Among the most important ancient resinous spices were frankincense, derived from *Boswellia* spp., myrrh, derived from *Commiphoras* spp., both from southern Arabia and the Horn of Africa, and balm of Gilead of Judea, derived from *Commiphora gileadensis*. The demand for these ancient spices was met by scarce and limited sources of supply. The incense trade and trade routes

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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 tonnes, coming mainly from Somalia; both Yemen and Saudi Arabia import rather than export these frankincense and myrrh. Balm of Gilead, 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 balm of Gilead survived over 1,000 years. Currently there is interest in a revival based on related plants of similar origin. These three ancient spices now are under investigation for medicinal uses.

**KEYWORDS:** Apharsemon; *Boswellia* spp.; *Commiphora* spp.; Judaean balsam; olibanum; spice trade; traditional medicine

## I. SPICES AND THE SPICE TRADE

Traditionally, spices have had many important uses. Ancient cultures discovered the medicinal and therapeutic value of herbs and spices as well as their ability to enhance food flavors, and incorporated the burning of incense as part of religious and social ceremonies. Currently spices are used mainly as condiments but are also important in traditional medicine, perfumes, cosmetics, and special therapies.

Frankincense, myrrh, and balm of Gilead, three highly regarded biblical spice plants, will be emphasized in this chapter. 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). Balm of Gilead (*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. This chapter reviews these three ancient spice plants from a historical, horticultural, and pharmaceutical perspective, emphasizing the trade and routes from the Arabian Peninsula to the foreign markets in the Middle East and southern Europe.

## A. Early History and Economic Importance

Spices and perfumes are mentioned in the records of ancient Sumer, which developed in the region of Mesopotamia around 3000 BCE. The Sumerian word for perfume is made up from the cuneiform signs representing ''oil'' and ''sweet.'' From that early period, and for millennia afterward, spices were added to natural oils to produce perfumes. The Sumerian song ''The Message of Lu-dingir-ra to His Mother'' refers to ''a phial of ostrich shell, overflowing with perfumed oil'' (Civil 1964). During the Bronze Age, the consumption of perfumes was confined to the upper and ruling classes. Perfume makers are known to have operated in Mesopotamia in the palace of Mari as early as the 18th century BCE (Bardet et al. 1984; Brun 2000). A growing body of archaeological evidence indicates that the volume of trade between Arabia and the surrounding areas accelerated during the Assyrian Empire. 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). 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.

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 (Zinger-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 Judean 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 ($7 \times 8$ 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.

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 (Fig. 1.1) of the expedition of Queen Hatshepsut (1473–1458 BCE) are recorded on the walls of the temple at Deir-el-Bahri (Lucas 1930; Phillips 1997). Five ships loaded with many treasures are depicted in the Temple in Thebes. One ship has 31 young trees that some scholars believed to be frankincense in tubs (Hepper 1969; Zohary 1982; Dayagi Mendels 1989). 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

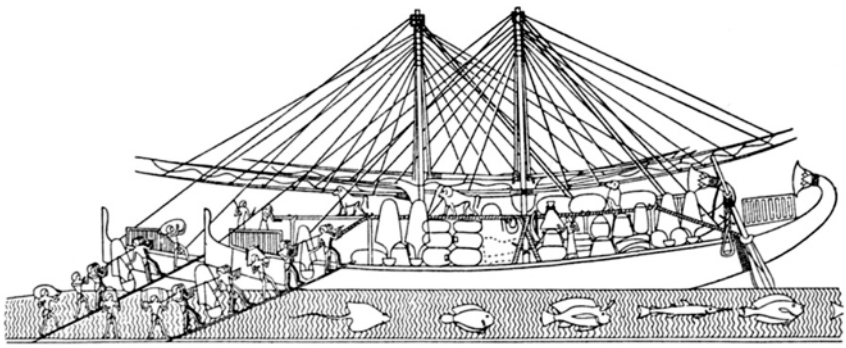

**Fig. 1.1.** Queen Hatshepsut's expedition in 1500 BCE leaving Punt, northeast coast of Africa, with myrrh plants destined for Egypt. (Source: Singer et al. 1954.)

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).

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. Recently, Punt 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 (*American Scientist* 2010).

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.

## B. Spices in Ancient Israel

The most important spices used in religious ritual in ancient Israel were:

balm of Gilead, called also Judaean balsam, Hebrew—*tzori, nataf*, or *Apharsemon* (Exodus 30:34)
onycha, Hebrew—*tziporen* or *shchelet* (Exodus 30:34)

galbanum, Hebrew—*chelbna* (Exodus 30:34)
frankincense or olibnum, Hebrew—*levonah* (Exodus 30:34)
myrrh, Hebrew—*mor* (Exodus 30:23)
cassia, Hebrew—*kida* or *ktzeeha* (Psalms 45:8)
spikenard, Hebrew—*shibolet nerd* (Song of Solomon 1:12)
saffron, Hebrew—*karkom* (Song of Solomon 4:14)
costus, Hebrew—*kosht* (Critot 6:71, Babylonian Talmud, Yoma 41:74, Jerusalem Talmud)
calamus, Hebrew—*klufa* (Song of Solomon 4:14)
cinnamon, Hebrew—*kinamon* (Song of Solomon 4:14)

The identification of these 11 spices was described and discussed in detail by Amar (2002) showing the existing different versions with their exact botanical identification. These spices were an essential element in the worship of the ancient Hebrews, and incense and perfumed oils containing these spices in proportions exactly described were required in the sacred rituals stipulated in the Law of Moses. This incense, called in Hebrew *ketoret,* was burned on the altar twice a day; it originated in various parts of the world.

The interest of the ancient Israelis in the expensive spices of southern Arabia and the Horn of Africa can be established on the basis of several biblical statements:

Isaiah 60:6: ''The multitude of camels shall cover thee, the dromedaries of Midian and Ephah; all they from Sheba shall come; they shall bring gold and incense.''
Jeremiah 6:20: ''To what purpose cometh there to me incense from Sheba.''

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).

## C. Production Sites

**1. Myrrh and Frankincense.** 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 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 Horn 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.

**2. Other Spices.** Evidence from Mediterranean shipwrecks shows that black pepper (*Piper nigrum*) was imported from the East in the second millennium BCE (Parker 2002). This spice, which in ancient times grew only in the tropical climates of southeast Asia, probably first reached the Mediterranean Basin by way of Persia (Crawfurd 1867).

Cassia (*Cinnamomum aromaticum*), a forest tree found throughout China, India, Sri Lanka, Malaysia, and Vietnam, was a substance considered by the Chinese to be of great antiquity, and cinnamon (*Cinnamomum verum,* syn. *C. zeylanicum*), usually derived from bark, appears in the earliest Chinese herbal, by tradition considered to have been written around 2700 BCE (Miller 1998). The word ''cassia'' apparently is derived from the Chinese word for cinnamon branch, *kwei-shi*, while that ''cinnamon'' probably derives from the Malay word *kayu manis*, or sweet wood (Miller 1998). The word ''cinnamon'' made its way into the Mediterranean world, possibly through the Phoenicians, from where it was adopted by the Hebrew, Greek, and Latin languages. In spite of the superiority of cinnamon over cassia, both spices usually appear together in ancient sources. The earliest classical reference to cinnamon was recorded by the fifthcentury BCE historian Herodotus (Rawlinson 1859, Book I), and by 300 BCE both cinnamon and cassia appear to have become common commodities.

Most experts accept the cinnamon plant to be *Cinnamomum zeylanicum*, which grows in Sri Lanka and India, and was probably imported to Palestine. The Jewish scriptures describe another cinnamon spice that was grown in Jerusalem and other locations in Palestine. Several eminent Jewish sages, including Rambam, Saadia Gaon, and others, suggest that this plant, whose bark has an aroma similar to that of cinnamon, was known as *Hood Aquilaria agallocha* (Amar 2002).

## D. The Incense Road

The connection between the source of ancient spices, mainly the Arabian Peninsula and India to Mesopotamia and Europe, is known as the Incense Road (Fig. 1.2). Archaeologists placed the date of the beginning of the incense trade sometime around 1800 BCE, but it is more than likely that trade commenced earlier (Rosengarten 1970). Much evidence has been collected about the trade of myrrh from Punt to Egypt in the third millennia BCE (Kitchen 1993). At first, primitive donkey caravans transported the merchandise, but they could carry only small loads for short distances. However, around 900 BCE and possibly earlier, a significant revolution took place in this trade, when the undemanding single-humped Arabian camel (*Camelus dromedarius*) was domesticated and used for local and long-distance land transportation (Fig. 1.3). There were three phases in the course of domesticating the camel. At first, the camel served as a source for milk, wool, meat, hide, and feces for burning. Herds of camels, like sheep and cattle herds, moved along the pasture accompanied by nomads. At the end of the second millennium BCE, camels were used for riding and transportation. Regular stables came into use between 500 and 1000 BCE.

Nothing could fit these long and difficult desert caravans better than this patient animal, which could cover 40 km a day, walking 3.2 km an hour and carrying loads of up to 200 kg. Camels required very little food and water, and since larger loads were possible, the use of the camel cut down on caravan costs (Wapnish 1984; Finkelstein and Silberman 2006).

The Indians would transport spices by sea to Aden, the southern port of Arabia, and from there the Arabians would take the spices by caravan north to the city of Petra. There the traders could go to Gaza, Egypt, or Syria. The distance between south Arabia and Gaza is about 1800 km, stretching over 65 different stations separated from each other by the distance that a camel caravan could move during one day. It was better to take goods by caravan over Arabia than by way of the Red Sea, which was not a viable route since it was shallow in some areas, was full of dangerous uncharted rock outcroppings, and there were pirates.

The great empires of the first millennium BCE, including Assyria, Persia, Greece, and Rome, each tried to gain control of the Arabian spice trade. Due to the harsh conditions of the desert region and difficulties in sailing through the Red Sea, these attempts generally were unsuccessful until the later part of the first century BCE.

Diodorus of Sicily referred to Arabia and the Nabateans in this way: ''On the East, the Arabians called Nabateans inhabit a country partly desert. . . and therefore these Arabians (being that they are not conquered) are never

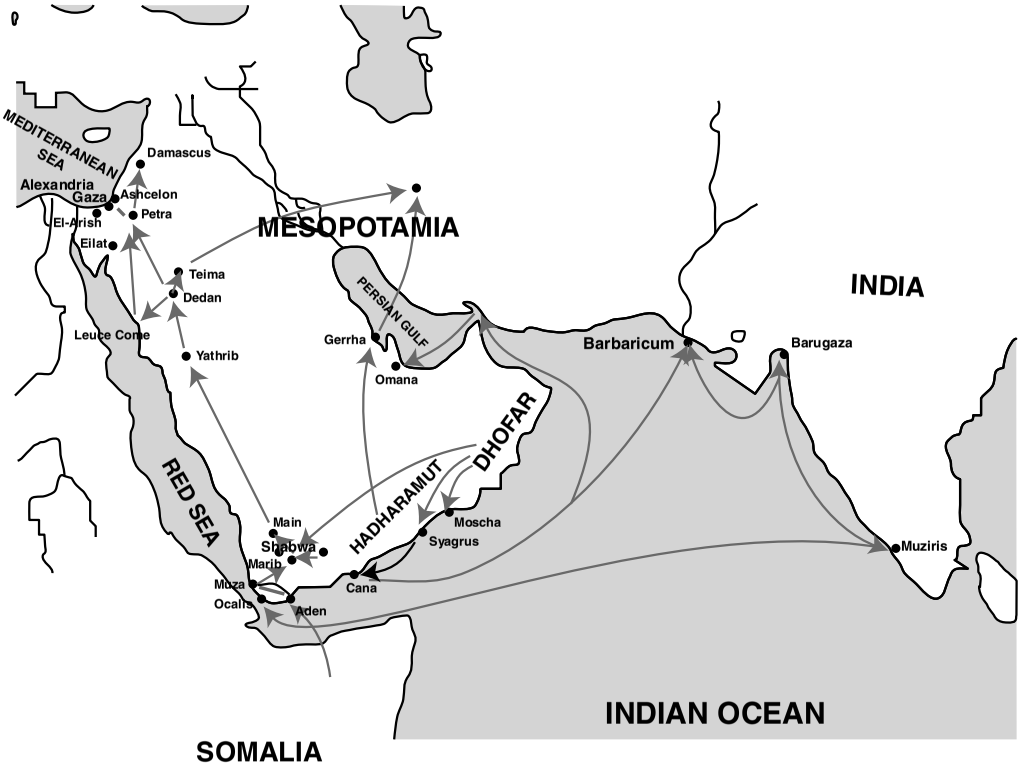


**Fig. 1.2.** Map of the incense trade road from the Arabian Peninsula to their international markets. (*Source*: Wysinfo Docuwebs.)

**Fig. 1.3.** Camel caravans in the desert. (Source: Photobucket.)

enslaved, nor ever admit any foreign princes over them, but preserve themselves continually in perfect liberty; and therefore neither the Assyrians, nor the Medes and Persians, nor the very Macedonians themselves, were ever able to conquer them; who, though they often marched large armies against them, they ever failed in their designs'' (Oldfather 1935, Book II).

By the middle of the first millennium BCE, Darius I from Persia (521–485) had conquered the northern part of India. This reinforced the direct trade between India and Mesopotamia via the Persian Gulf and the Euphrates and Tigris rivers. The Persians aimed at creating a naval link between the Persian Gulf and Egypt and the Mediterranean, via the Red Sea. For that purpose, Darius sent Greek sailors, commanded by Scylax of Caryanda, from the Indus River in India to the Indian Ocean and thereafter to the west through the Arab Peninsula into Egypt. A demonstration of the importance of the spices in the interaction between countries in the past is the fact that King Darius I of Persia received an annual tribute of over 2.7 tonnes of frankincense from the Arabs (Rosengarten 1970).

The use of spices for personal and ritual use was common among the Persians by the sixth century BCE. The consumption of luxury goods became possible by the vibrant trade that was supported by an improved road structure. From the correspondence of a Jewish family from Nippur, Mesopotamia, which traded with the Chaldeans, Aramaeans, Edomites, and Shebaeans, the scope of the trade during the Persian era can be evaluated (Rostovtzeff 1932).

The trade prospered following the conquest of Alexander the Great in the East during the first half of the fourth century BCE. Like the Persian king Darius, Alexander wanted to itensify the naval link between the Persian Gulf and Egypt via the Indian Ocean. He was also considering taking over Arabia Eudaemon (Blissful Arabia) for its great wealth

(Jones 1924). The Hellenistic era was marked with prosperity that lasted from the beginning of the third century until the middle of the second century BCE. This prosperity can be attributed to the unprecedented use of the Persian treasure, by the successors of Alexander the Great, to build new urban centers and public facilities throughout the Middle East (Heaton 1936). The Greek culture and rituals included extensive use of spices. Due to the increase in demand for these goods, industrial centers were constructed along the Mediterranean Sea in the Phoenician and Egyptian cities where the raw material was processed into ornaments, goods, perfumes, incense, spices, and medicines for the plutocracy.

A secondary trade route that developed around the same time was the overland route from Gerrha, around Bahrain, to Petra. The Arab tribes controlled that route from the northern part of the Arabian Peninsula to the southern part of Jordan, and it was used for transporting commodities from India to Egypt and Damascus. Chaldaeans, who were expelled from Babylon, in the sixth century BCE settled the city of Gerrha along the coast of Saudi Arabia, in the Gulf of Bahrain. According to Strabo, they were the powerful traders of the wasteland (Jones 1924, Book 1, Chapter 2, Section 34).

In 285 BCE, Ptolemy II successfully reopened the canal from the Nile to the Red Sea and built ports on the Egyptian side of the Red Sea. In 278 BCE, he exhibited large quantities of spices (myrrh, frankincense, cassia, and cinnamon), gold and silver, exotic African animals, ivory, Indian slaves, and other commodities in a parade in Alexandria.

The early Ptolemaic dynasty in Egypt capitalized on their access to sources of spices and spices in the East, with Alexandria becoming a leading distribution center for perfumed oils. Greek explorers began a systematic survey of both coasts of the Red Sea during the reign of Ptolemy II in an attempt to circumnavigate territories controlled by the Nabateans to reach the source of spices in southern Arabia. The Nabateans, who had previously lost their control of the trade in bitumen collected from the Dead Sea to the Macedonians, responded by raiding and pirating ships in the Red Sea (Tarn 1929). While the Ptolemies concerned themselves with founding ports along the African Red Sea coast at Myos Hormos, Berenice, Philotera, Arsinoe, and Ptolemais Epitheras as well as the Milesian colony of Ampelone on the Arabian coast, the Selucids colonized the upper Persian Gulf, where the Gerrhaeans supplied them with spices (Tarn 1929). Pliny states:

> The incense can only be exported through the Gebanitae, and for this reason it is that a certain tax to their king as well. Thomna, which is their capital, is distant from Gaza, a city of Judea, on the shores of our sea, 4436 miles, and the distance being divided into 65 days' journey by camel. There are certain

> portions also of the frankincense which are given to the priests and the king's secretaries: and in addition to these, the keepers of it, as well as the soldiers who guard it, the gate-keepers, various other employees, have their share as well. And then besides, all along the route there is at one place water to pay for, at another fodder, lodging at the stations and various taxes and imposts besides; the consequence of which is, that the expense for each camel before it arrives at the shores of our sea is 688 dinars; after all this too, there are certain payments still to be made to the farmers of the revenue of our empire. (Book 12:32)

The Assyrians, then the Persians and the Greeks, were at various times in control of part of the Incense Road. The Arab trade for the most part was unaffected, and, under the various occupiers, the Arabs were able to carry out trade with India relatively unhindered until the Romans arrived, since the Arabs demanded gold and silver in exchange for spices and silk. The Romans, rather than trying to control the Arabian Peninsula, simply went around it to trade with India, hiring Greeks to sail south on the Red Sea to the Indies. The Arabs, losing valuable trade, responded by raiding the ships.

Pliny, on whose writings we depend regarding the spice trade in the first century CE, wrote that the Arabs had become ''the richest race on Earth'' (Book 5:12; Book 12:11) owing to their monopoly over the limited areas where the frankincense and myrrh grew wild. He said that they received very high prices for their spices from both the Romans and the Persians, but bought nothing from other nations in return. Increased demand and escalating prices made incense more precious than gold, and Arabia's wealth caused the country to be renamed Arabia Felix (Fortunate or Blessed Arabia). The Greek cartographer Ptolemy (second century CE) divided the Arabian Peninsula into three parts*:* Arabia Deserta, Arabia Petraea, and Arabia Felix, describing the wealth and luxury enjoyed by its population derived from its energetic spice trade (Stevenson transl. 1932, Book 5). Strabo remarked: ''The part of Arabia that produces the spices is small and it is from this small territory that the country got the name *Felix*—because such merchandise is rare in our part of the world and costly'' (Book 16, Chapter 3). Of the 100 million sesterces spent by the Romans on importing merchandise from the East, including Arabia, India, and China, more than half went on incense imported from Arabia (Book 12, Chapters 41, 54).

Theophrastus, some three centuries earlier, said that most frankincense came from Saba (southwestern Arabia, once ruled by the famed Queen of Sheba)—that ancient country became rich from the incense trade. The resources gained from Rome's acquisition of Egypt enabled it

to expand into nearby eastern countries as well as deep into Europe (Fulford 1992). The discovery in the first century CE that the monsoon winds could help boats under sail, at one period in one direction and in another period in the other direction, enabled the Romans to send over 100 ships a year from Red Sea ports to India, nearly six times as many as the Ptolemies had operated in the early Hellenistic period (Casson 1989). Augustus developed ports along the Red Sea coast of Egypt and roads with fortified stations, diverting some amount of trade away from the overland routes controlled by the Nabateans in Arabia and the Parthians in Mesopotamia (Sidebotham 1986).

Although the major sources of spices had been Arabia and northern India, a third source, southern India, could be directly accessed by Roman merchants sailing from Egypt (Miller 1998). The goods shipped into Roman-controlled Egypt were heavily taxed at a rate of 25%. Much of this merchandise was processed at Alexandria, and finished products such as perfumed oils were again taxed upon export, albeit at a lower rate (Miller 1998). However, shipping spices by sea and up the Nile still produced a substantial saving due to the heavy costs involved in overland transport. Pliny emphasized the costs involved in the overland trade of frankincense early in the first millennium CE (Book 12, Chapter 41).

### E. Nabatean Trade

In the Hellenistic period, the Nabateans gained the upper hand in the transport and trade of spices, soon replacing the role of other peoples in the Arabian Peninsula, such as the Mineaens and Gerrhaeans. Based in the former Edomite territory at Petra, the Nabateans ruled this territory by the end of the fourth century BCE (Graf 2006). To secure the roads they used in the Negev, they constructed a number of small forts on hilltops commanding the route, such as ʻEn Rahel, Moyat Awad, ʻEn Ziq, and ʻEn Tamar, that could be utilized to supply water for the caravans transferring the spices from south Arabia to Gaza (Erickson-Gini 2006).

As the Macedonian Empire was breaking up, the Nabateans from Petra became increasingly active traders in the vacuum left by Alexander and his feuding generals, transporting spices from the Arabian Peninsula to Mediterranean ports. The Nabateans maintained an army, taking advantage of the strategic position of Petra. In the late second century BCE, as the demand for spices and exotic goods increased with the growing supremacy of Rome, the Nabateans sent trade representatives abroad and received diplomatic missions in Petra from as far away as the island of Delos and possibly China.

The Nabateans quickly monopolized inland trade routes leading through the Arabian deserts and the Negev. In the wake of the growing demand for spices in the Mediterranean Basin, they became a major economic power. In 129 BCE, trade envoys were dispatched to the Nabatean capital of Petra from as far away as Priene in western Asia Minor and by 126 BCE from as far away as ancient China (Graf 1996; Hackl et al. 2003).

Getting control of the incense and spice trade required a great deal of skill. For centuries, the Nabateans had been building secret water collecting systems in the desert, which originally began as protection. When challenged, the Nabateans simply retreated into the desert. After time, however, the Nabatean settlements grew more connected, and these water collection systems became the backbone of the Nabatean trade routes, enabling them to move goods across the desert. Years later, Pliny described laws in southern Arabia that made it a capital offense to deviate from the ''high road'' while conveying frankincense (Book 12, Chapter 32). At the end of the first century BCE, the increasing demand for incense and perfumed oils led to a more intensive trade, and the Nabateans began to specialize in this increased demand and began to settle the major stations of the Incense Road (Johnson 1987).

In addition to processed goods produced in Petra, a steady flow of frankincense, myrrh, and other spices continued from Arabia. A valuable source of geographical information about the trade among Egypt, Arabia, and India is the *Periplus of the Erythraean Sea*, written by an anonymous Greek sea captain in the mid-first century when ''Malchus, king of the Nabateans'' ruled Petra (Miller 1998). The *Periplus* contains some information on the harvesting and marketing of frankincense in the eastern province of Hadhramaut, Dhofar, the southernmost terminus on the Incense Road.

Following the Augustean conquest of Egypt, the Romans built several harbors along the Red Sea and developed a new sea route to southern Arabia. This new lower-cost road presented tough competition for the caravan trade of incense controlled by the Nabateans. The Nabateans responded by themselves producing perfumed oils in Petra from the resins imported from southern Arabia (Johnson 1987). The adulteration of raw resins and spices in natural oils in order to produce perfumed oils and ointments was an obvious way to increase the profit margin involved in the spice trade. The trade in frankincense originally was based on annual transport and sale of this valuable tree resin after it was harvested every spring.

Thus, Nabatean merchants responded by producing unguents of the spices in Petra itself, which increased their profit markedly by allowing

them to deal with the finished product rather with the raw materials. These unguents contained not only the imported myrrh and frankincense but also oils derived from local plants, such as the *Pistacia terebinth* and the *Balanites aegypticus*. The Nabateans developed a whole new method of processing the expensive imported resins that did not grow in their land with locally available products, thus multiplying their profit. Pliny wrote that the balm of Gilead and other spices were adulterated mostly with the ground pine of Petra, which can be detected by its size, hollowness, and long shape and by its weak scent and its pepperlike taste. The extent of these adulterations shows in Pliny Book 12 that the Nabateans used locally available plant products to maximize their profit from the trade of spices imported from Arabia as early as the first century. Danin (1983) reported the presence at Petra of the *Balanites aegypticus* and of *P. terebinth* as well as the juniper tree (*Juniperus phoenici*, Pinaceae). He also said that the local Bedouins extracted the resin of this pine to produce incense for their religious services.

The increased demand for the incense triggered the development of a second harvest of resin by other tribes who harvested from the wild trees. Of this Pliny wrote:

> It used to be the custom, when there were fewer opportunities of selling frankincense to gather it once a year, but at the present time trade introduces a second harvesting. The earlier and natural gathering takes place at about the rising of the Dog star, when the summer heat is intense. The frankincense from the summer crop is harvested in autumn; this is the purest kind, bright white in color. The second crop is harvested in the spring, the juice that comes out on this occasion is reddish, and not to be compared with the former taking, the name of which is ''carfiathum,'' the other being ''dathiathum.'' (Book 12, Chapter 32)

Archaeological and epigraphic evidence of the development of a second harvest in the autumn may be found at Medain Salih, an important Nabatean station leading to southern Arabia. A first-century CE tomb inscription attests the seasonal cycle of trade (Johnson 1987). At first the Nabateans had been middlemen in the transport and sale of raw resins and spices. However, faced with growing demand for spices in the Roman Empire as well as the increase in the volume of trade through Syria, the Nabateans upgraded their economy by becoming producers and exporters of their own products, packaged in ceramic containers (*unguentaria*) made in Petra itself. In this period—the second half of the first century BCE—Petra witnessed a surge in prosperity, and the Nabateans expanded their settlement into the Negev Highlands at Elusa (Chalutza) and Oboda (Ovdat). To facilitate the year-round demand for

perfumed oils, they began to use a more direct route, the Petra–Gaza Road, which ran through the eastern Negev by way of the Ramon Crater. Here they constructed a new pass leading up the Nafha Heights and onward to Oboda, Elusa, and Gaza. By the middle of the first century CE, the Nabateans began to utilize additional roads in other parts of the Negev and built caravanserais. In habitable regions, such as the Negev Highlands, these caravan stops rapidly turned into full-scale settlements, such as Mampsis (Mamshit), Elusa, and Sobota (Shivta).

The Nabateans not only monopolized much of the trade between Rome and the Far East for over 400 years but also managed, as their predecessors did, to keep the sources of their goods secret, to become the sole suppliers of many of the goods that the Romans, flush with the riches of conquest, desired (Hammond 1973; Negev 1986; Johnson 1987).

Once the Nabateans gained a monopoly of much of the spice trade, they began to gently squeeze the Romans for higher and higher prices. Over time, the Nabateans and Arabs, acting as middlemen between India and the Mediterranean, became very wealthy. The Romans, now used to eastern luxuries, paid up. In 106 CE, the Roman army conquered the Nabatean lands and formed a new province named Arabia. It appears that the trade continued with the Nabateans playing their role, but now under the custody of the Roman legions.

### F. Palmyra

This ancient city was not only a caravan stop but also a traders' paradise (Dien 2004). Palmyra (Tadmor), in the middle of the desolate Tadmorean Desert now located in modern Syria, served as a major center of both the spice road and its trade. The Tadmorean mountain range meant that roads either went north or south, and Palmyra became the hub of a series of roads. Geographically, Palmyra was well suited to become an important center of trade if the decision was made to cross this desert rather than take the longer route around.

The beginnings of Palmyra are not clear. A settlement called Tadmor is mentioned as early as the 18th century BCE, when Amorites settled at the natural sulfurous spring that had attracted nomads. The name appears in the Bible (II Chronicles 8:4), which claims it was built by King Solomon, although this is now considered by many to have been a spelling mistake referring to Tamar, a fort city built by Solomon in the Arava, near present Hatseva in the Negev desert.

Palmyra was part of the Parthian Empire. It was located on the Silk Road trade route between the Roman Empire in the Mediterranean Basin and the Han dynasty in China. Accordingly it quickly became a center of

trade and commerce, and by the first century CE, Palmyra had become an urban center because of the development of its caravan trade. Parthian forces captured the whole of the Levant from the Romans. With the standoff between Rome and Parthia, Palmyra in effect came to occupy a no-man's land crisscrossed with caravan routes. Palmyra profited from its location, for there was a demand from Rome for the luxuries of the East—silks and spices—and Parthia, with its growing interest in Hellenistic culture, desired the goods of the West. Some sort of tacit understanding between the two powers enabled Palmyra, a neutral, semi-independent town, to become the middleman in this trade with its enormous profits.

The period of Palmyra's rise coincided with Roman control of Syria. Rome exercised hegemony over Palmyra, and it seems to have become a tributary city with a garrison from 19 CE, with the name Palmyra coming to replace the older Tadmor. Under Hadrian, in 127 CE, the city was renamed Palmyra Hadriana, and was declared a free city, later to become exempt from taxes under Emperor Caracalla. The city remained the chief station on the Strata Diocletiana, a paved road that linked Damascus to the Euphrates, but in 634 CE, it was taken over by Muslim rulers and its importance as a trading center gradually declined.

## G. Spices in Greece and Rome

Over the centuries, the Greeks bought many items from the Arab traders. From Homer's day onward, precious oils, perfumes, cosmetic powders, eye shadows and paints, beauty unguents, and even hair dyes were in near-universal use among the Greeks. The sophisticated Greeks greatly appreciated spice sources such as the turpentine tree (*Pistacia terebinthus*), an important import, and silphion from Cyrene, a culinary herb long extinct. They also valued the older Egyptian fragrant woods and their exudates, such as myrrh and frankincense (olibanum), as well as cinnamon imported from the East. Enormous amounts of money were spent on these exotic imports. The Greek island of Chios was the source of the valued gum exudate mastic, derived from the turpentine tree; the mastic was also used as a sort of chewing gum, and it gave rise to the word ''masticate.'' The more precious perfume incenses and spices came as imports through Arabia along well-established trade routes to be eagerly purchased by Mediterranean merchants who sold them to satisfy the increasing demands of markets throughout Europe.

The Roman Empire was an enormous and powerful force, comprising vast tracts of land, many countries, and diverse populations. The organization of such an entity demanded intricate planning and an infra-

structure sturdy enough to support the scheme. The Romans planned their commercial strategy on the establishment of cities, serving as commercial centers and providing not only produce to support the population but also taxes and tolls to pay for the vast empire. Along with this, the emperors saw weakness in decentralization and loss of their control, which necessitated steps to ensure supervision and domination over all sources of supply and transport in the hands of loyal civil servants. The city of Rome, for example, consumed enormous quantities of wheat; a large body of administrators was required to oversee supply and distribution. This led to a wealthy middle class of landowners all over the empire (Rostovtzeff 1957).

A wealthy urban society is fertile ground for luxuries and certainly did not economize on the purchase of spices, not only for flavoring but also for use in religious and funerary ceremonies. The beauty and lavishness of the funerary towers in Palmyra were a reflection of ''men, who could bear the expense of such buildings and could bequeath money enough for the upkeep of such monuments and of the gardens which were connected with them, were people who had accumulated large fortunes'' (Rostovtzeff 1957). It would appear that materialism and consumerism are the results of a newly rich middle class, seeking new forms of excitement and exotic purchases to justify their exalted status and display their material success.

The emergence of the Roman Empire stimulated economic activity throughout the Mediterranean and the East. A major factor in this development was the conquest of Egypt by Octavian in the first century BCE. The spice trade had developed rapidly during the Roman era due to the relative tranquillity along the borders, a strong and stable administration, and the imperial law system that unified currency, measurements, and weights. A stable tax system combined with relatively low taxation over imported goods allowed the Roman Empire to develop successful export markets, and an efficient financial system provided services to trading activities. Romans established military posts in key places, to control pirates on both land and sea. Security prevailed throughout the empire. Furthermore, the network of roads and harbors built outside the empire allowed effective trade routes throughout.

In the first millennium BCE, the Greeks popularized sports and bathing. By the sixth century BCE, perfumed oils were as popular as they were in Egypt. Greek philosophers like Socrates, as well as Greek rulers, were opposed to the widespread popularity of perfumes. The Athenian ruler Solon propagated laws prohibiting their sale to men (Ziegler 1932). However, laws did little to stand in the way of popular demand.

Public baths became popular in Rome in the later first century BCE, and the fad spread throughout the empire, increasing public demand for perfumed oils in daily use. Cinnamon leaves, or oil produced from cinnamon leaves (*malabathrum*), imported from India, was used to sweeten one's breath and to scent clothing. Roman cuisine became highly developed in the imperial era with emphasis placed on the use of imported spices, particularly black pepper. Throughout the first half of the first millennium CE, the use of black pepper was evidently considered a necessity rather than a luxury since it was not taxed (Miller 1998). The Roman emperor Domitian constructed special warehouses for pepper (*horrea piperataria*) in Rome in 92 CE. In Apicius' *De Re Coquinaria*, black or white pepper imported from India was used in nearly every recipe, and *piperatoria* (pepper pots) were popular in the western province of Gaul (Miller 1998).

Pepper has been a popular spice since prehistoric times. It was probably first cultivated on the Malabar coast of India in what is now the state of Kerala. The 18th-century British historian Edward Gibbon in his renowned *History of the Decline and Fall of the Roman Empire* describes pepper as ''a favorite ingredient of the most expensive Roman cookery.'' It is commonly believed that during the Middle Ages, pepper was used to conceal the taste of partially rotten meat. It was also traded during this period by Arabs in the profitable Indian Ocean spice trade. In fact, pepper was so valuable that it often was used as collateral or even currency, and workers who handled pepper were issued clothes without pockets or cuffs to prevent theft.

Until well after the Middle Ages, virtually all of the black pepper found in Europe, the Middle East, and North Africa traveled there from India's Malabar region. By the 16th century, pepper was also being grown in Java, Sunda, Sumatra, Madagascar, Malaysia, and elsewhere in southeast Asia, but these areas traded mainly with China or used the pepper locally. Ports in the Malabar area also served as a stopping-off point for much of the trade in other spices from farther east in the Indian Ocean.

Spices had other uses in addition to their use as unguents. Romans, according to Pliny, esteemed wine flavored with myrrh beyond any other (Book 13, Chapter 5). Spices sometimes had more mundane uses. Pliny recommended perfuming wine jars and wine cellars with myrrh when carrying out a regular summer cleaning (Book 14, Chapter 27), and he shamefacedly admits that the Romans of his day esteemed tree resins, the best of which were imported from the Arabia, Judea, and Syria, principally for their use as a depilatory to remove unwanted hair from men's bodies. Processing expensive spices and merchandising incense was fraught with problems of theft. Laborers in the workshops of Alexandria

were strip-searched at the end of their workday. The volume of trade was so great that Pliny expressed concern over the enormous amount of revenue spent to import spices into the Roman Empire in his time (Book 13, Chapter 4). For this reason he supported the emperor Nero's devaluation of currency (Miller 1998). However, this devaluation marked the beginning of a trend that was responsible in part for ruining the economy of the Roman Empire in later centuries.

**1. Economic Importance.** Several contemporary historians and geographers (Benbenisty 2004) discussed the importance of the spice trade for the Roman economy. The large scope of this lucrative import created a trade imbalance in the Roman Empire, since its extensive demand for spices was far higher than the demand for western goods (metals, colored glass, wine, olive oil, wool fabrics, glue, and papyrus) by the spice-exporting countries. This trade imbalance was paid with gold and silver, leading to economic recession (Benbenisty 2004).

Of the 100 million sesterces spent by the Romans on importing merchandise from the East, including Arabia, India, and China, more than half went on incense imported from Arabia. This compares with the total annual budget of the Roman treasury during Augustus (27–14 BCE) of 400 million sesterces; the total income from Egypt was 50 to 60 million sesterces (Benbenisty 2004).

The exorbitant prices of the spices involved all kinds of levies. The Arab rulers of southern Arabia who controlled the zones where the wild spice trees grew monopolized the production and marketing of spices. The naval trade of southern Arabia and east Africa was in the hands of the traders from southern Arabia. Arab navigators took control over the trade along the coastline of east Africa, southern Arabia, and Somalia and managed to gain command over ports in east Africa that provided perfumes, preventing the access of Greek sailors to certain ports in southern Arabia. According to Pliny, no more than 3,000 families enjoyed the right to trade in perfume (Book 12, Chapter 30).

Early historians and geographers agreed that the source of perfumes came from the Arabs. The Arabs kept the real source secret for two reasons: (1) to make the products seem mysterious and to generate the desire to use them and pay the high price and also (2) to prevent the emergence of competing forces in that market. This trade secret pertaining to the source of the perfumes and spices allowed the Arabs of southern Arabia to monopolize the production and trade of that market (Benbenisty 2004).

During the Hellenistic time, the spice trade probably was monopolized by the different governments (Rostovtzeff 1941). During the Roman era,

the manufacturers were organized in trade unions (guilds) by their skills. The objective was to secure common interests—that is, to obtain raw materials at a fair price and to obtain protection from authorities and other contenders. There is evidence to support the emperor's control over the spice and perfume market. Flavius Vespasianus (69–79 BCE) established the perfume market in Rome, where he also dominated the trade and market prices (Frank 1959). Diocletian (310 CE) set forth a price decree for luxury goods, the baseline being wheat price equal to 100 dinar for 1 modius (two gallons). The price of the best-quality frankincense was 100 dinar for one pound (Frank 1959).

Pliny detailed the ground shipping transportation costs of luxury goods, describing the transportation of frankincense from its source in southern Arabia, up to its port of destination in the Mediterranean:

> After collecting the Frankincense it travels on camels to Sabota in the Negev. Kings have stated clearly that camels loaded with spices must move through the main road or the carriers put their lives at risk. In Sabota, the priests also took a fee for the load by its size. The fee was given to the God Sabis. The spice would not proceed before the priests get their share also which is used to finance public affairs. The spices must go via the Gebbanitae province and King's tax is paid as well. Thus fixed parts of the frankincense load are given to the priests and King's secretaries along the way. Moreover, the guards and their aides, gatekeepers and attendants get their part. The merchants continuously pay down the way. One stop the payment is for water, another for hay or for storage during breaks, or various taxes. The total expenses climb up to 688 dinar for one camel before the convoy reaches its final destination by the Mediterranean.

Pliny (Book 12, Chapter 32) provides information about the cost of perfume transportation from southern Arabia to Gaza. The carrying load of each camel was 600 Roman pounds, and the market value of raw Frankincense was 6 dinar per pound. Thus, the travel cost of one pound Frankincense was 1.15 dinar, or, in other words, 19% of its final market cost. Pliny contends that the merchant paid 25% of the load to the Roman authorities in Gaza, which means that the cost of transporting frankincense to Gaza's market was 44% of its market value. Similar calculations were done on prices during the Deocletian period, which resulted in similar value for the transportation cost of 45% of the final market price.

The trade traffic was subjected to taxes (*portorium*), which were paid at the entrance to specific tax zones (port or border of province) at city gates (*octroy*) and as transportation levies for crossing bridges or roads. The purpose of the fees was only to provide income to the rulers, not to

protect local traders. A customs rate of 25% was collected upon entering the empire boundaries. Moreover, local rulers and villages demanded additional taxes from merchants. By the end of the second century another tax was added—the military *Annona,* paid for soldiers on the trade roads. Special places for storing the merchandise were set up for taxation purposes. Eventually, the heavy tax resulted in decline in trade capacity during the third and fourth centuries.

In addition to the cost involved in the transportation of spices from southern Arabia to Rome, traders were required to obtain operating capital. Borrowers with high-risk trade were charged interest of 24% to 48% per year (Cary 1975; *see* Benbenisty 2004). The monopolistic status of some groups involved in certain phases of trade and production of luxury goods explains the high price of these goods within the empire's market.

**2. Decline of the Spice Trade.** The international trade of spices and the production of perfumed oils in Petra continued well beyond the annexation of Nabatea by the Romans in 106 CE. The decline of the spice trade and the cessation of trade along the Petra–Gaza road appear to have been the result of the general economic crisis of the Roman Empire in the third century CE. The collapse of the international finance system and drop in demand for expensive, exotic goods imported from distant lands virtually wiped out Petra's role in the spice trade. Archaeologically, this crisis marks the end of the production of Nabatean ceramic *unguentaria*, and with it, the production of perfumed oils at Petra (Johnson 1987).

## H. Uses of Spices

**1. Perfume and Incense.** From earliest history until today, fragrant, alluring scents have been regarded as essential elements in many cultures. Exotic plant odors and the scents that could be utilized for body application have inspired explorers, aristocrats, writers, poets, merchants and priests, and they have been of fundamental relevance to religious practices, funerary rites, and courtship. In many societies, the burning of fragrant woods provides an ideal, ethereal token of appreciation to the gods. The liberation of incense smoke was a source of perfume: the very word of which derives from the Latin *per fumum*, ''by smoke.'' ''Incense'' is a word that means ''that which is lit.''

**2. Spices as Medicines.** The essential oils and terpenoid alcohols of spices contribute to their smell, taste, and tactile sensation. One of the medical qualities of eugenol found in cinnamon, clove, and pimento is

a local anesthetic effect, which is utilized in dentistry. Menthol, from mints, has a cooling effect as well as a characteristic fresh taste and smell. Anise contains anethole, cinnamon produces cinnamaldehyde, mace contains myristin, and so on; all have specific pharmacological effects that are generally mild. However, some—such as myristicin—are more potent, and large doses can result in harmful effects, such as hallucinations.

The ancient civilizations of the Near East utilized all types of plant, animal, and mineral products as medicines to treat disease. The ancient Egyptians developed a somewhat more sophisticated pharmacopoeia, although magic and religion were always utilized as part of therapy. Egyptian priests, physicians, and embalmers became familiar with a significant number of herbs and spices, some of which (such as the expensive import, myrrh) were employed in embalming preparations. A wealth of information concerning ancient herbs and spices was discovered by the German Egyptologist Georg Ebers on a papyrus from about 1550 BCE that mentions the use of several spices as medicines, including coriander, cumin, fenugreek, and mint (Rosengarten 1970). The biblical anointing oil consisted of myrrh, cinnamon, cassia, and calamus in olive oil.

**3. Spices as Aphrodisiacs.** In the Bible's Song of Solomon, Proverbs, and Psalms, romantic verses extolled the sensory excitement offered by the use of spices, particularly myrrh and frankincense, in stimulating the senses. In the Song of Solomon, spices and incense are an integral part of a rich, sensuous picture of love:

3:6: ''perfumed with myrrh and frankincense''
4:6: ''I will get me to the hill of frankincense''
4:14: ''Thy plants are an orchard . . .with all trees of frankincense.

*The Perfumed Garden* of the Arabs and the Hindu *Kama Sutra* were rich in fragrant spicy temptations.

Cinnamon, and the similar bark, cassia, when burned give off a delightful fragrance; this is also readily obtained by grinding the bark. The phenolic compounds, such as cinnamic acid, are biocidal, and fumes from their resins may well have served as fumigants as well as pleasing incenses.

The Bible refers to the esteem in which myrrh was held for perfume as well as its use in religious ceremonies:

Psalms 45:8: ''all thy garments smell of myrrh''
Proverbs 7:17: ''I have perfumed my bed with myrrh''

> Exodus 30:23, discussing anointing oil: ''Take thou also unto thee principal spices, of pure myrrh five hundred shekels''

The Song of Solomon has several references to the use of myrrh as an enticing and sensuous perfume:

3:6: ''Who is this perfumed . . .with myrrh''
4:6: ''I will get thee to the mountain of myrrh''
4:14: ''myrrh and aloes with all the chief spices''
5:1: ''I have gathered my myrrh with my spice''
5:13: ''his lips like lilies dropping sweet smelling myrrh''

The Book of Esther 2:12 relates the expensive and elaborate ritual of preparing the girl before her presentation to the king: ''six months with oil of myrrh, and six months with sweet odors, and with other things for the purifying of the women.''

**4. Spices as Condiments and Preservatives.** Spices have long been used as seasonings to flavor foods and are the silent helpers to cooks the world over. As taste enhancers for food, exotic spices from the East became popular commodities early in history. The issue of the capacity of spices to delay the deterioration processes of foods and thus to extend their life or delay their spoilage remains controversial. The UCLA Library of Information asserts:

> Although it is often claimed that exotic spices were also sought as valuable food preservatives, this is not correct. There is little evidence that pepper, cloves, nutmegs, ginger and other expensive spices were used as alternatives to garlic to preserve food or to delay the spoilage of cooked dishes. Despite the contrasting opinions of different experts, there is little evidence of any specific benefit from most spices. (Darling 2002)

However, the authors of this chapter do not accept this position. New research points out that many of the spices used in antiquity, such as myrrh and frankincense, do have strong antimicrobial properties that could have reduced the microbial load causing deterioration of food. Thus, foods were treated with spices not only to improve their flavor but to retard spoilage. Modern studies suggest that garlic, thyme, cinnamon, cloves and chile peppers, cardamom, black pepper, ginger, anise, and celery seeds are all potent antibacterial and antifungal agents (Davidson and Naidu 2000; Ben-Yehoshua and Mercier 2005).

## II. FRANKINCENSE

The 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 former 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 *al luban*, 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 chemical composition of olibanum and frankincense oil has been investigated by Hamm et al. (2003, 2005).

### A. Botany

The genus *Boswellia* was named after John Boswell in 1846, and his associate H. J. Carter 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* and *B. frereana* yield frankincense of commercial value.

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). Frankincense trees are also 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, disklike swelling of the trunk. This disklike 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 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, the database of the Royal Kew Gardens, Kew, UK).

*Boswellia sacra* Flueckiger (syn. *B. carterii* Birdw.) is considered to be the source of the biblical frankincense (Plate 1.1) (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. The valley is still the world's leading source of frankincense. It is regarded as having the optimal conditions for *Boswellia sacra* and produces the highest-grade resins, named Silver and Hojari (Ghazanfar 1994).

*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). 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).

## B. Folklore

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.

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 yeares [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).

### C. Harvest

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 to this day. 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 two 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. These first tears are 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 harvesttime 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, which gives 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. Recent studies have indicated that frankincense tree populations are declining due to overexploitation, 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).

### D. Economic Importance

Out of all resins used in the ancient world, and with the exception of the balm of Gilead, which grew only around the Dead Sea in Judea, frankincense and myrrh were the most common and sought after. Pliny

reports that, all along the trade route, taxes and fees had to be paid out, raising the price of olibanum to that of an expensive luxury (Book 12, Chapter 32). He confirms that the 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.

By the 11th 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 1500 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, the Silver frankincense 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 (Morris 1989). *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).

### E. Religious Uses

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).

Incense burning at religious ceremonies is one of the chief uses of frankincense. 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 the prayers 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).

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.

### F. Perfumes and Cosmetics

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).

### G. Medicinal Uses

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).

It is recorded that before executions, the condemned was given frankincense in wine to give him courage (Miller and Morris 1988; Talmud, Tractate Sanhedrin 43a, attributed to Rabbi Hiyya ben Ashi).

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 ancient Egyptian medical practices relied strongly on faith and belief in mystical and magical treatments, combined with practical medicinal herbs. 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 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).

Frankincense has strong antibacterial, antibiotic, antifungal, and antiseptic properties, making it a valuable ingredient in natural medicine. The *Boswellia* resin is nontoxic to humans and can be applied externally, in combination with other products or alone. It is especially efficacious in ophthalmic treatment for sore eyes. The bark itself and the fruit can be used; the bark is used in dye preparations and tanning procedures, and the fruit is given as a tonic for indigestion (SEPASAL database). Frankincense is an ingredient in several commercial nutraceutical ointments used in the treatment of arthritic conditions. Burning frankincense repels mosquitoes and thus helps protect people and animals from mosquito-borne illnesses, such as malaria, West Nile virus, and dengue fever.

## H. Patents and Current Research

**1. Patents.** There are a number of recent patents involving frankincense and its derivatives (Fig. 1.4), indicating a wide range of suggested applications in medicine. Relevant patents are described next.

US Patent 2005163815 (2004). This patent, by inventors A. Ali 2005163815 and I. D. Bowen, relates to the use of plant material of the *Burseraceae* as a terrestrial molluscicidal and/or molloscrepellant agent.

US Patent Application 20050209169 (2005). Inventors H. P. T. Ammon and H. Safayhi describe the use of boswellic acid and its derivatives

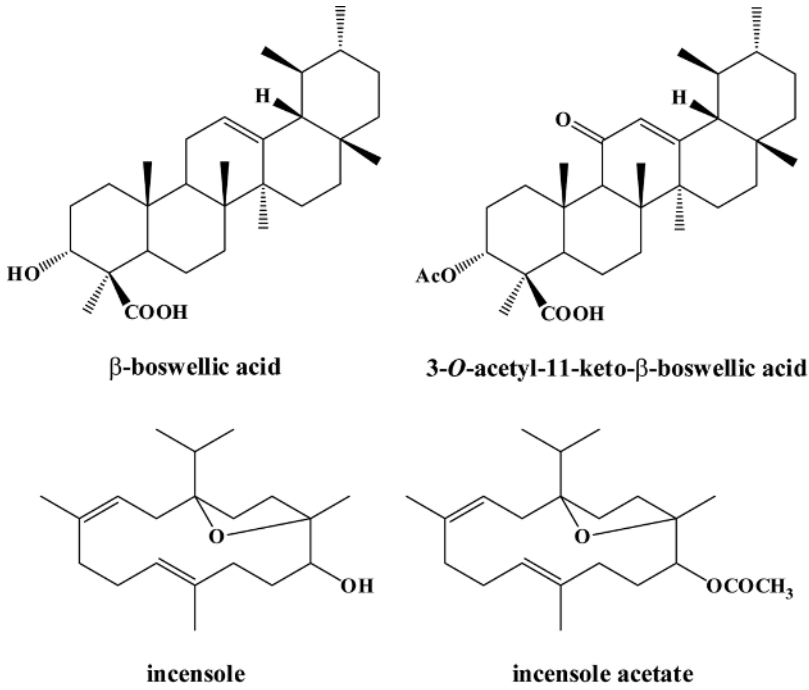


**Fig. 1.4.** Structures of some compounds from frankincense, *Boswellia sacra*.

for inhibiting normal and 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.

US Patent 6465421 (2002). Inventors A. Duranton et al. presented an application for modulating body/cranial hair growth using boswellic acid as a possible ingredient.

US Patent 5720975 (1997). This patent, by inventor R. Etzel, 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.

German patent 085921 (2002). 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.

US Patent Application 0040166178 (2004). This patent, by inventors A. Meybeck 20040166178 and A. Zanvit, 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.

US Patent 20090298938 (2009). This patent, by inventors G. N. Qazi et al., relates to use of anticancer compounds derived from boswellic acids.

US Patent Application 20040092583 (2004). Inventor E. Shanahan-Prendergast 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.

US Patent 6174876 (1999). Inventors T. Simmet and H. P. T. Ammon use boswellic acid, a constituent of the resin, for treating brain tumors.

EP Patent 04721524 (2004). This patent, by inventors F. Striggow et al., 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.

US Patent 5629351 (1997). This patent, by inventors S. C.Taneja et al., discloses a novel fraction comprising a mixture of boswellic acids that exhibit anti-inflammatory and antiulcerogenic activities. A process for isolating a boswellic acid fraction and individual boswellic acids is detailed.

US Patent 5888514 (1999). Inventor B. Weisman uses extracts of *Boswellia serrata* and boswellic acid among other materials for treating bone or joint inflammation.

**2. Current Research.** The 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. 2008a).

The anti-inflammatory action of the boswellic acids is similar to that of the conventional nonsteroidal anti-inflammatory drugs (NSAID), which often cause joint damage by inhibiting glycosaminoglycan synthesis. The boswellic acids do not have this 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). 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).

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 (Tikhonov et al. 2006; Hwa 2007). Chemicals derived from, among others, *Boswellia* plants used as mixed formulations are potent in curing inflammatory diseases (Darshan and Doreswamy 2004).

*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 (2007) concluded that *B. serrata* is a potent and safe alternative to conventional NSAIDs, 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).

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.

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

*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).

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.

## I. African Production

Teketay (2003) reviewed the frankincense and myrrh resources of Ethiopia and suggested that these resources could contribute to 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 have 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/ha-yr for closed and $39/ha-yr for open sites, with rural households earning about 74% of this amount 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 tonnes, and frankincense, 1000 tonnes. Recently, U.S. imports ran 5–20 tonnes. The United Kingdom imports about 30 tonnes frankincense each year, with one perfume manufacturer alone consuming 5 tonnes 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 of Somalia amounted to 1000 to 1500 tonnes 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 smallholders 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 an annual potential of 254 kg/ha. The total annual frankincense production potential of the district was estimated to be 79,000 tonnes. The question is why the Somali export amounts only to around 1,500 tonnes. Not all inhabitants 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 of frankincense production, and unawareness of the potential of frankincense as a source of income. The absence of direct economic benefits from the woodlands for the local people has triggered widespread degradation, mostly from human-induced fire, improper forest use, and agricultural land expansion (Lemenih et al. 2007).

## III. 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 (Plate 1.2) and called *Balm of Gileadodendron myrrha* by Nees von Esenbeck in 1826 (Orwa et al. 2009). It has also other synonyms, such as: *Commiphora molmol* (Engl.) Engl. and *Commiphora myrrha* var. *molmol* Engl. 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).

## A. Botany

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 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 to 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).

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 con-

fined to these areas.The current growing areas of the myrrh district are centered in the west and central part of Somaliland (Van Beek 1958).

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 Modenke 1952).

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 2.12) 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), 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.

### B. Harvest

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 the 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 reddish brown, in the shape of tears. Pliny wrote of a ''bundle of tears,'' the form in which the myrrh is marketed (Book 12, Chapter 32). He also noted that myrrh growers paid a tax of one-quarter of their yield.

### C. Uses

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 antiputrefaction 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.

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 (Plutarch, Babbitt, *Moralia*: Isis and Osiris, Vol. V).

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.''

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 *Annales* 16:6), 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.

For medicinal uses, mithridatum is 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, called megalium, a sweet-smelling mixture 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).

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*) states: ''If you drink from it hot, the vase myrrhina suits the ardent Falernian and gives the wine a better flavor.'' In the 19th 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.

### D. Indian and Chinese Medicine

The Ayurvedic pharmacy contained a large number of herbal remedies and included the Balm of Gileadodendron mukul (myrrh), known as Indian *bdellium* or *gugguthatr*, which was used for skin conditions and as an anti-inflammatory (Hanus 2005). From about the seventh century CE, Indian Ayurvedic medicine was introduced into the Tibetan and Chinese medical systems. The first texts translated into Tibetan during the eighth century were the medical treatises by Chandranandana, the *Gyu-zhi*, or Four Tantras (Hanuš 2005). The Chinese use myrrh (*mo yao*) as a healing agent for all types of wounds and pains, women's ailments, and to dissolve masses and swellings, where its bitter and strong dispersing action breaks up congealed blood. Chinese herbal doctors often use frankincense together with myrrh, as they are considered to have complementary actions: The frankincense acts on the tendons, reducing stiffness, and the myrrh activates the circulation of blood. The most favored combination medicine is Qi Li San, a resinous mixture containing myrrh, frankincense, and six other resins. Shen and Lou (2008) examined the bioactive constituents of myrrh and frankincense, two simultaneously prescribed gum resins in Chinese traditional medicine, for their pharmacological evaluation.

### E. Contemporary Uses

In the 21st century, natural alternative medicine 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 toothpastes 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 U.S. Food and Drug Administration (2009) 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). The structures of *C. myrrha* were elucidated by phytochemical analysis, and six new compounds were revealed (Ahmed et al. 2006). Twelve Chinese medicinal herbs, including *C. myrrha*, were examined for their anticancer activity, and positive results suggested that further studies were warranted (Shoemaker et al. 2005). Extracts of *Commiphora mukul* have proven to be useful in the treatment of allergic and nonallergic inflammation of the skin and external mucosae, in the symptomatic treatment of benign prostatic hypertrophy, and in the treatment of acne (Bombardelli and Spelta 1991).

Gugulipid (registered and marketed by the 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 to protect the skin from free radical damage (McCook et al. 1997). Gugulipid has been used for controlling or preventing cognitive dysfunction, hyperglycemia, and some infectious conditions of the skin (Pratap et al. 2002).

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 (Majeed et al. 2001). 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* (Jindal et al. 2004).

### F. Recent Research and Modern Pharmaceuticals

Analysis and evaluation have been carried out to examine the characteristics of the various derivatives of *C. myrrha* (Fig. 1.5). 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 were examined (Dolara et al. 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 Balm of Gileadodendron or *C. mukul*) displayed potent anti-inflammatory effects and is regarded as a plausible

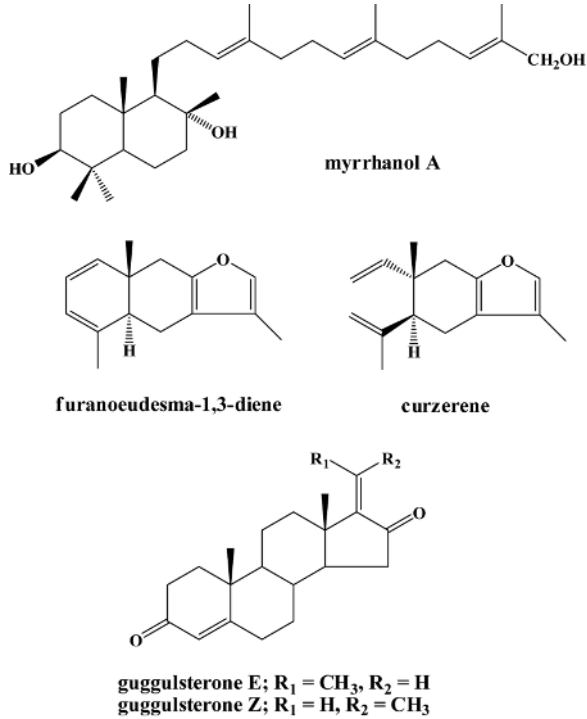


**Fig. 1.5.** Chemical compounds of myrrh (*Commiphora mukul* and *Commiphora myrrha*).

candidate for a potent anti-inflammatory agent (Kimura et al. 2001). Other effects of myrrh resin extracts include studies on diabetes wounds (Lotfy 2006), gingivitis inflammation, and general anti-inflammatory and antibacterial properties (Tipton 2006; El Ashry 2003).

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—had 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).

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. mo'lmol* plant. Schistosomiasis is a parasitic infection attacking millions of people, mainly in Africa and China, but also 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 conquer and eradicate the incidence of parasitic diseases in developing countries (Badria et al. 2001; Abo Madyan 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.''

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). However, 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). The active ingredient of *C. mukul* (gugulipid), which is widely used to treat hyperlipidemia, was examined and positive effects were noted (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).

## IV. BALM OF GILEAD

### A. Botany

The name ''balm of Gilead'' is probably derived from the Hebrew word *bosem*, which means ''to be fragrant'' (Miller 1998; Amar 2002), and Gilead, an area east of the Jordan River in the center of present Jordan. The Hebrew name for balm of Gilead, *apharsemon*, is related to the similar word *opobalsamum* in Greek (Feliks 1968).

Balm of Gilead, also known as *tzori Gilead* (Hebrew) or Judaean balsam, is extracted from *Commiphora opobalsamum* (Forssk) Engl., *Burseraceae*, and has several synonyms: *C. gileadensis* (L.) Chr. or *C. gileadensis opobalsamum* (L.) (Plate 1.3), *Balsamodendron opobalsamum* (L.), and *Amyris 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 a balsam juice (*opo*). This species is known for its fragrant resin (Wood 1997). Linnaeus claimed it was the source of balm of Gilead and Mecca balsam. The plant has long and slender branchlets without spines; 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. Flowers are in clusters, drupe apiculate (Plate 1.3).

*Commiphora opobalsamum* 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. The *Commiphora* species found in Yemen and Oman share many features. They are typically small trees about 2 to 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 opobalsamum*, growing in Yemen and Oman are found in Al-Hubaishi and Muller-Hohenstein (1984).

In 1763, Pehr Forsskal, on behalf of the King of Denmark and Norway, collected and described a balm of Gilead tree on an expedition to Oude, Yemen, whose aim was to identify the ''*opobalsamum*,'' the balm of Gilead of the Bible, that had been produced in Jericho and Ein Gedi around the Dead Sea in Judea. Following the biblical stories and also those of the many Greek and Roman writers, geographers, and historians, including Josephus Flavius, Forsskal traveled to Yemen, where the Kingdom of Sheba was located, hoping to find this tree, which had become extinct in Judea. The known features that could help his search were fragrance, exudation of a liquid resin—the opobalsamum—and traditional medical traits for which the balm of Gilead was famous. Unlike the myrrh tree, the local Yemen experts probably were not aware of all these balm of Gilead stories. After a long and stressful journey, Forsskal eventually found one small tree at Oude whose leaves emitted a special fragrance when crushed. Forsskal 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*'' (Hepper and Friis 1994). Linnaeus accepted the discovery.

However, the death of Forsskal during this expedition, and the subsequent publication of his results by others, has made the herbarium specimen and the publications complicated to use. Hepper and Friis (1994), in the preface to their book, *The Plants of Pehr Forsskal's Flora Aegyptiaco-Arabica*, summarized Forsskal's botanical results and the assertion of Linnaeus (1764) that the *C. gileadensis* produces the balm or opobalsamum of the Bible. However, since the plant that produced opobalsamum in Judea was extinct then, Forsskal's assertion is open to question (Hepper and Friis 1994). Many of the eminent botanical writers of antiquity, such as Theophrastus, had reported that the balm of Gilead, from which the opobalsamum was collected, grew only at two sites in Judea (Birdwood 1862). Thus the journey to Yemen to search in the Kingdom of Sheba was a logical choice, knowing the biblical story of the gift of spices by the Queen of Sheba to King Solomon. In a subsequent letter to his mentor Linnaeus, Forsskal was able to give more specific information, and pointed out that opobalsamum belonged to the genus *Amyris* P. Browne. On the basis of the evidence, we believe that the expedition must be allotted merit. The problem is that, currently, no residue of the ancient balm of Gilead has been discovered, and all archaeological attempts to find it have failed (Hirschfeld 2007).

**1. Attempts to Find a Residue.** In one of the many archaeological projects carried out to locate residues of balm of Gilead, 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 balm of Gilead. 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 Arubus (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 balm of Gilead 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 VJRI 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 balm of Gilead. 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 criticised 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.

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 had on their camels' backs: astragalus, balm, and ladanum (''*nechot, tzori velot*'' Hebrew), Genesis 37:25. This is the first time that both the balm of Gilead and ladanum are mentioned in the Bible. It was suggested that these chemical markers could be used to identify the ladanum spice (S. Ben-Yehoshua and L. Hanuš, unpublished data).

**2. Balm of Gilead in Judea.** The Bible refers to the transport and trade of balm (*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).

Balm of Gilead 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 said that the balm of Gilead is the resin that exudes from the trees of *kataf* (ph; *Yoma 41:74* Jerusalem Talmud). The identification of the balm of Gilead 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).

Facilities for the manufacture of perfumed oils, presumably balm of Gilead 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 balm of Gilead from Ein Gedi to Ramah (Tractate *Shabbath 26, 71* Talmud).

We accept *Commiphora gileadensis* as the Latin name of the balm of Gilead 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 balm of Gilead that grew in Judea was a new variant or cultivar, much improved over its original ancestor. We believe that this ancestor, *C. gileadensis opobalsamum*, from Yemen, had been naturalized in Judea and became the balm of Gilead 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. We 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 balm of Gilead. 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 balm of Gilead 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 balm of Gilead. Relevant contradicting opinion in this respect was given by Groom (1981). He said that the ''Balm of Gilead 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, Somaliland, and parts of Ethiopia.'' However, Groom ignored the gift of various spice plants from the Queen of Sheba to King Solomon that introduced the balm of Gilead to Judea. 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.

## B. Economic Importance

The ancient product was a special fragrant resin that exuded from the branches after cutting and was 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 balm of Gilead plants were guarded in order to prevent theft (Fig. 1.6).

Pliny describes just how expensive this rare spice was in classical times: ''In no commodity are there practiced more palpable frauds than in the marketing of this resin, for a sextarius (equaling about 20 fluid ounces or half a liter) of balm of Gilead 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 balm of Gilead 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


**Fig. 1.6.** A Janissary guarding the balm of Gilead tree. (Source: Cartwright 1760.)

cuttings of the plant (xylobalsam) were coveted and sold for the price of six days' wages. Oil of Balm of Gilead 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 balm of Gilead oil (Book 12, Chapter 54).

Its other unique feature was the fact that it was cultivated around the Dead Sea Basin in Judea, and not grown wild, unlike the other spices derived from myrrh and olibanum. This new plant producing balm of Gilead 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 by 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, and to establish their cultivation around the Dead Sea Basin in a climate as similar as possible to their original one.

### C. Cultivation by Judean Farmers at the Dead Sea Basin

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. The archaeological evidence for 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, and the king and the farmers living in Jericho and Ein Gedi realized the economic potential of adapting the new plant to their land. They domesticated the wild plants, intensified their cultivation, and created and developed unique production, advertising, and marketing systems that made the balm of Gilead a most lucrative crop.

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 balm of Gilead 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 semifree specialists organized in guilds are known from several economic environments. The producers at Ein Gedi established the oldest continuous center of cultivated balm of Gilead 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. Through many centuries of diligent cultivation, the community had developed a unique system of new, improved balm of Gilead cultivars as well as new production techniques (Rosen and Ben-Yehoshua 2007).

Balm of Gilead 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 ten 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)

This unique balm of Gilead 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).

### D. Harvesting

Pliny and Josephus and other writings on balm of Gilead contain details on the special techniques regarding resin harvest (Rosen and Ben-Yehoshua 2007; Ben-Yehoshua and Rosen 2009). Pliny noted that the producers of balm of Gilead possessed special techniques to extract exudates:

> [A]n 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 and, like Pliny, did not credit the Romans with this technique (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 21st century, the ax 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 the Judean farmers 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 embedding in the bark, cambium, and sap overloads the plants with soluble iron.

Ben-Yehoshua and Rosen (2009) discussed the relation of the balm of Gilead 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 stealsthe property of his friend, or whoever reveals the secret of the townto the gentiles—He whose eyes range through the whole earthand 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 Felix (1971) that the secret involved special technologies of producing and extracting the balm of Gilead resin.

Keeping secret the production of the balm of Gilead must have been a major factor in sustaining the economy and thus the survival of ''a very large Jewish village'' (Eusebius Wolf 1971; Taylor et al. 2003). The complete agrotechnical and legal history of the Judaean balsam since the Iron Age and during Babylonian, Persian, and Ptolemaic rule is unknown.

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 balm of Gilead, 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 balm of Gilead 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 balm of Gilead, which is the most precious drug that there is, and grows there alone'' (*Ant. XV. 4.2*).

The Romans were keen to take control of this lucrative source of revenue, and the royal Judaean plantations were confiscated by Rome after Herod's death (Cotton 2001). Around this period, the cultivation of balm of Gilead was introduced farther south at '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 balm of Gilead. 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 balm of Gilead was aptly demonstrated in the Roman triumph staged following the suppression of the great revolt. Pliny reports that balm of Gilead plants were paraded in the triumphant victory procession (Book 12, Chapter 54).

### E. Defining the Production Period

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 balm of Gilead during ancient periods. He reported that in 300 BCE, myrrh, balm of Gilead, and frankincense were especially important trade items going through Petra. Was the balm of Gilead sold in Petra the resin produced around the Dead Sea Basin? In that period, no other spice was called balm of Gilead. New evidence about this came from Arabia. Pliny did not know of Arabian balm of Gilead (Groom 1981). Further, it has been suggested that the ''Arabs of classical times did not regard the balm of Gilead as worth exploiting at all'' (referring to the plants that were, in our opinion, the ancestors of the balm of Gilead), continuing ''We do not, at present, know enough about its gum'' (Groom 1981).

In Aden's trade statistics from the 19th and 20th centuries, balm of Gilead 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 balm of Gilead wood (Book 19, Chapter 98), which indicates that the plant he discussed is the true balm of Gilead, since the wood of no other spice plant was utilized. This suggests strongly that the source of this balm of Gilead is the Dead Sea area, as we know from many other sources that only the balm of Gilead 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 balm of Gilead. Those prices, as quoted by Pliny, are to be 300 to 1,000 dinars for a pint of the balm of Gilead, as compared to the price 2 to 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 balm of Gilead 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 balm of Gilead 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 balm of Gilead from the Dead Sea despite or, possibly, because of its high price. Presumably, balm of Gilead continued to be cultivated by the Jews, at least at the Dead Sea oasis of Ein Gedi, as late as the sixth century CE.

The economic crisis of the third century CE undoubtedly affected the demand for balm of Gilead oil by the late Roman period. Records show that at least one rabbi, Shimon ben Eliezer, was required to explain the nature of balm of Gilead to his students: ''Balm of Gilead (*tzori*) is merely the sap of resinous trees'' (Shabbath 26a). References to mundane uses of balm of Gilead 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.

Ein Gedi was destroyed often 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 last destruction, by marauders or an early breakout of the Justinian pandemic that occurred between 541 and 750 CE (Ziegler 1979), 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 balm of Gilead 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 balm of Gilead oil, either because the trees continued to grow there or because the region served as a place of transit for this trade. Another center of production of the balm of Gilead 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 balm of Gilead oil in ancient times, its production and medicinal uses nearly ceased altogether. The end of balm of Gilead 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 Judean producers of the balm of Gilead. Furthermore, the Arab rulers expected these farmers to produce the newly introduced crop of cane sugar.

However with time the established reputation of the Judean balm of Gilead, the great past demand for its products, and its high prices, alerted the Arabians to consider whether this balm of Gilead 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. 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 balm of Gilead.

Groom said that in medieval times, there was the Makkah balsam tree and its main center of production was in Hijaz, particularly at ak Argabout, halfway between Makkah and Al-Medinnah (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 18th century CE (Duncan 1804).

Many corporations have utilized the name ''balm of Gilead'' 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 balm of Gilead. 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.* The definition continues: ''Poplar buds (tears) are often, incorrectly, called balm of Gilead buds.'' At present, several corporations sell products under the name of balm of Gilead 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 balm of Gilead. 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.

Balm of Gilead 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).

## F. Medicinal Uses

In ancient times, the resin of the *Commiphora gileadensis opobalsamum*, the balm of Gilead, 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.

**1. Medieval Period.** Asaph Harofe reported on the use of ''balm of Gilead'' oil to treat diseases of many organs, such as the spleen, kidneys, liver, womb, and lungs, and also for treating cough, tuberculosis, obstructions in the urinary tract, skin diseases, bites, and stings (Muntner 1971). In Europe during the Middle Ages, balm of Gilead oil was an important component in medicines (Lev 2003). Maimonides wrote that balm of Gilead bark was a component in a medication called ''the great atriphal,'' used to strengthen various organs, mainly the heart and the senses, to delay aging, and as an aid in coitus (Rosner 1984; Lev 2003).

Balm of Gilead was an important component in medication against ''evil vapors of the stomach'' and was used as an antidote against poisons, although it was noted that it was hard to obtain, being only available in Egypt (Muntner 1971; Lev 2003). Several authorities mentioned that ''the balm of Gilead'' is ''Apharsemon'' whose oil has many excellent qualities and whose effects are ''marvelous.'' Among its uses are for pain relief, dissolving stones in the urinary tract, curing infertility, and against poisons (Lev 2003).

**2. Traditional Medicine.** Balm of Gilead has long been considered a panacea. In Iraq, the fruit of the balm of Gilead tree (Hooper 1937) called ''balsan,'' is used; it is identified with Apharsemon. From this fruit, a substance is produced that is used as a drug to dispel gases and to relieve stomachaches and as a stimulant. In Iran, it is used as a component in a medication to treat colds and tremors. In Arabia, the resin of the tree is used to treat poisoning and stings and to cure wounds (Hooper 1937; Feliks 1968; Uphof 1968). It is 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 (Lev 2003).

For general and external use, balm of Gilead is recommended as a painkiller (Budge 1913; Brunet 1933; Said 1973; Malandin 1986); an anti-inflammatory (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; Bos 1977; Qataya 1981; Sayyid 1985; Malandin 1986). It is considered beneficial for lethargy and tiredness (Qataya 1981); to lower blood pressure (Abdul-Ghani and Amin 1997); for cases of paralysis, spasms, and dizziness (ibn al-Baytar 1874; Budge 1913; Said 1973; Haefeli-Till 1977; Qataya 1981); and to reduce heart rate (Abdul-Ghani and Amin 1997). For skin conditions, balm of Gilead 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; Kuhn 1965; Said 1973; Rubin 1974).

Balm of Gilead was administered: for internal problems and for bladder and digestive problems (Budge 1913; Said 1973; de Fenoyl and Sauneron 1979; Qataya 1981); as a diuretic (Budge 1913; Gunther 1933; Bos 1977; Haefeli-Till 1977; Qataya 1981; Malandin 1986); for relief from flatulence (Budge 1913; Said 1973; de Fenoyl 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; Kuhn 1965; 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; de Fenoyl and Sauneron 1979); and in the preparation of medicines and mixtures (Costeo and Mongio 1608; Starkey and Pitt 1678; Bonwicke 1725; Spencer 1938; Kuhn 1965; Watson 1966;

Anawati 1987). Furthermore, it was considered effective as an abortifacient (Gunther 1933), for menstrual problems (de Fenoyl and Sauneron 1979), and to encourage sexual potency (Levey 1966a).

### G. Current Research

The chemical composition (Fig. 1.7) and biological evaluation of the essential oil of *Commiphora opobalsamum* was evaluated using essential oil samples from stored aerial parts, fresh aerial parts, and fresh flowering tops, obtained by hydrodistillation (Abbas et al. 2007). The essential oil from the fresh aerial parts exhibited antimicrobial activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Candida glabrata*, *C. krusei*, *Cryptococcus neoformans*, and *Mycobacterium intracellulare* (Al-Massarany et al. 2007). 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 preliminarily 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.

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 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. Similar anticancer activity against lung and blood cancer cell lines was found by studying extract from the resin of *C. gileadensis opobalsamum*. The activity was detected by testing for apoptotic activities as well (Ofir et. al 2010)

Extracts of *C. opobalsamum* exhibited anti-inflammatory, analgesic, and diuretic activities in rats and mice and hepatoprotective ability and ulcer protective effects (Al-Howiriny et al. 2004; 2005). The hypotensive effect of aqueous extract from the branches of *C. opobalsamum* on blood pressure and heart rate in rats is due to the activation of muscarinic

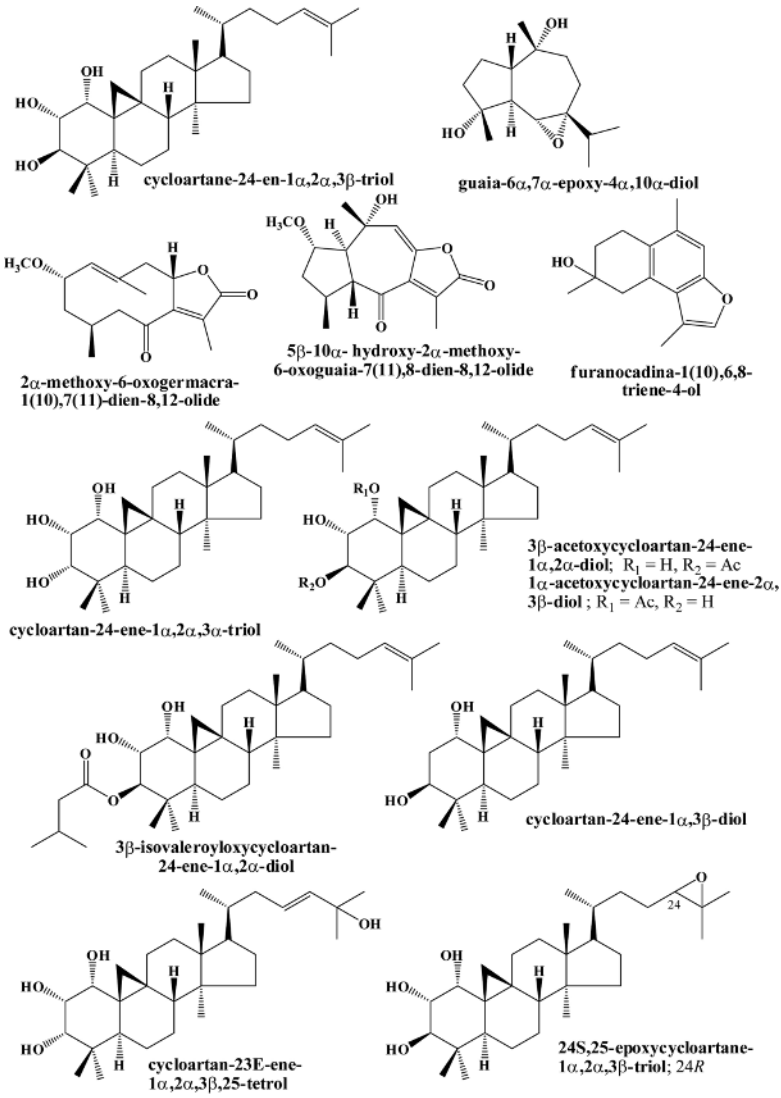


**Fig. 1.7.** New sesquiterpenoids isolated from exudates of *Commiphora gileadensis opobalsamum*.

cholinergic receptors (Abdul-Ghani 1997). However, it is surprising that the authors 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 that of the Dead Sea Basin. Possibly that article is discussing another species.

Three new sesquiterpenoids were isolated from the exudates of *Commiphora opobalsamum* (Shen et al. 2008a): 2α-methoxy-6-oxogermacra-1(10),7(11)-dien-8,12-olide, 5β-10α-hydroxy-2α-methoxy-6-oxoguaia-7(11),8-dien-8,12-olide, and furanocadina-1(10),6,8-triene-4-ol; as were six known compounds: (1*E*)-3-methoxy-8,12-epoxygermacra-1,7,10,11-tetraen-6-one, *rel*-(1*S*,2*S*)-epoxy-(4*R*)-furanogermacr-10(15)-en-6-one, 6α,7α-epoxy-1β-guai-10(14)-en-4α-ol, (1*R*,4*S*,5*R*)-guaia-6,10(14)-diene, cerotic acid, and β-sitosterol. Isolation and identification of the resinous exudates of *C. opobalsamum* revealed new cycloartane-type triterpenoids: cycloartan-24-ene-1α,2α,3α-triol, 3β-acetoxycycloartan-24-ene-1α,2α-diol, 1α-acetoxycycloartan-24-ene-2α, 3β-diol, 3β-isovaleroyloxycycloartan-24-ene-1α,2α-diol, cycloartan-24-ene-1α,3β-diol, cycloartan-23*E*-ene-1α,2α,3β,25-tetrol, 24*R*,25-epoxycycloartane-1α,2α,3β-triol, and 24*S*,25-epoxycycloartane-1α,2α,3β-triol (Shen et al. 2008a).

## V. FUTURE PROSPECTS

Many of the spices of antiquity are in widespread use for culinary and medicinal purposes. Examples include the alliums (onions and garlic), black pepper, and ginseng. The ancient resinous species 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 earned Arabia a great fortune, has dwindled down to 1500 tonnes of export, collected by nomadic people from wild trees mainly in Somaliland, 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 ethnopharmacognosy as guides to lead chemists toward different sources and classes of compounds (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 21st 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 Somalia, 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 these countries report that the future of these projects are far from being assured. Today spices are such a minute item of export from Oman, Yemen, Ethiopia, and Somaliland 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—balm of Gilead—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 gileadensis* or *C. opobalsamum* by Forsskal 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. opobalsamum* 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. Such a project could lead to the restoration of the production of the ancient balm of Gilead 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 over 500 plants of *Commiphora gileadensis opobalsamum*, which are the closest candidates available for the ancient balm of Gilead. The exact identity of these plants is studied by learning their chemical profile. These plants exude the exclusively fragrant liquid resin that resembles what has been described for the

ancient balm of Gilead. Furthermore, these plants grow well in the Dead Sea Basin, both in Ein Gedi and elsewhere. The resin from these plants has exhibited activity against several cancer cell lines. This research is just beginning, but the enthusiasm of the researchers is high.

## LITERATURE CITED

Abbas, F.A., S.M. Al-Massarany, S. Khan, T.A. Al-Howiriny, J.S. Mossa, and E.A. Abourashed 2007. Phytochemical and biological studies on Saudi *Commiphora opobalsamum L.* Natural Prod. Res. 21(5):383–391.

Abdul-Ghani, A.S., and R. Amin. 1997. Effect of aqueous extract of *Commiphora opobalsamum* on blood pressure and heart rate in rats. J. Ethnopharmacol. 57(3):219–222.

Abo Madyan, A.A., T.A. Morsy, and S.M. Motawea. 2004. Efficacy of myrrh in the treatment of schistosomiasis in Esbet El-Bakly, Egypt. J. Egypt. Soc. Parasitol. 34(2):423–426.

Adams, F. (transl. and ed) 1844. The seven books of Paul of Aegina, VII:22. Sydenham Soc., London.

Adelakun, E.A., E.A. Finbar, S.E. Agina, and A.A. Makinde. 2001. Antimicrobial activity of *Boswellia dalzielii* stem bark. Fitoterapia 72(7):822–824.

Ahmed, F., M. Ali, and O. Singh. 2006. New compounds from *Commiphora myrrha* (Nees) Engl. Pharmazie 61(8):728–731.

Alcorn, J. 1984. Huastec ethnobotany. Univ. of Texas Press, Austin.

Aldredge, L.M. (transl. and ed.). 1996. Benvenutus Grassus. The wonderful art of the eye. Michgan State Univ. Press, E. Lansing.

Alemika, T.E., G.O. Onawunmi, and T.A. Olugbade. 2004. Isolation and characterization of incensole from *Boswellia dalzielii* stem bark. J. Pharmacy Bioresources 1(1):7–11.

Al-Howiriny, T., M. Al-Sohaibani, M. Al-Said, M. Al-Yahya, K. El-Tahir, and S. Rafatullah. 2004. Hepatoprotective properties of *Commiphora opobalsamum* (Balessan). Drugs Expt. Clin. Res. 30(5–6):213–220.

Al-Howiriny, T., M. Al-Sohaibani, M. Al-Said, M. Al-Yahya, K. El-Tahir, and S. Rafatullah. 2005. Effect of *Commiphora opobalsamum* (L) Engl. (Balessan) on experimental gastric ulcers and secretion in rats. J. Ethnopharmacol. 98(3):287–294.

Al Hubaishi, A., and K. Müller-Hohenstein. 1984. An introduction to the vegetation of Yemen. Ecological basis, floristic composition, human influence. GTZ, Eschborn.

Ali, A., and I.D. Bowen. 2004. US Patent Application No. 20050163815. Use of plant materials as a terrestrial molluscicidal and/or molloscrepellant agent.

Al-Massarany, S.M., F.A. Abbas, B. Demirci, K.H.C. Baser, S.I. Khan, A.J. Al-Rehaily, J.S. Mossa, and E.A. Abourashed 2007. The chemical composition and biological evaluation of the essential oil of *Commiphora opobalsamum* L. J. herbs, Spices Med. Plants 13(4):111–121.

Amar, Z. 1998. The ash and the red material from Qumran. Dead Sea Discoveries 5(1):1–15.

Amar, Z. 2002. The book of incense (in Hebrew). Erez, Tel Aviv.

American Scientist May 2010. http://heritage-key.com.

Ammon, H.P. 2006. Boswellic acids in chronic inflammatory diseases. Planta. Med. 72(12):1100–1116.

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.

Anawati, G. 1987. La traite d'Averroes sur la theriaque et ses antecedents Grecs et Arabes. Quaderni di Studi Arabi 5-6:36-38. Venice.

Anurekha, J., and V.B. Gupta. 2006. Chemistry and pharmacological profile of Guggul: A review. Indian Journal of Traditional Knowledge 5(4):478–483.

Ayalon, E. 1995. The Iron Age II pottery assemblage from Horvat Teiman (Kuntillet Ajrud). The Journal of the institute of Archaeology of Tel Aviv University 22:141–205.

Babbitt, F.C. (transl.) 1928. Plutarch. Moralia: Isis and Osiris. Harvard Univ. Press, Cambridge, MA.

Badria, F., G. Abou-Mohamed, A. El-Mowal-fy, A. Masoud, and O. Salama. 2001. Mirazid: A new schistosomicidal drug. Pharm. Biol. 39(2):127–131.

Barag, D., Y. Porat, and E. Netzer. 1981. The synagogue at Ein Gedi. In: L.I. Levine (ed.), Ancient synagogues revealed. Jerusalem. The Israel Exploration Society, p. 116–119.

Bardet, G., F. Johannes, B. Lafont, D. Soubeyron, and P. Villard. 1984. Archives administratives de Mari I. Editions recherche sur les civilisations. Paris.

Benbenisty, R. 2004. The influence of political and economic factors on the trade in luxury goods and its routes in the Roman Empire period. M.Sc. Diss. Dept of Geography, Hebrew Univ. of Jerusalem.

Ben-Yehoshua, S., and J. Mercier. 2005. UV irradiation, biological agents, and natural compounds for controlling post-harvest decay in fresh fruits and vegetables. p. 265–301. In: S. Ben-Yehoshua (ed.), Environmentally friendly technologies for agricultural produce quality. CRC Press, Boca Raton, FL.

Ben-Yehoshua, S., and B. Rosen. 2009. The secret of Ein Gedi (in Hebrew). Cathedra 132:77–100.

Bergstrom, T., A. Persson, M. Thulin, and A.M. Warfa. 1982. Domestication of the frankincense trees. Unpublished travel report. Quoted in SEPASAL.

Bible—The holy Bible—Genesis to Malachi. British and Foreign Bible Society, London.

Birdwood, G.C.M. 1862. Catalogue of the economic products of the Presidency of Bombay. Division I: Raw products. SOC Press, Bombay.

Birdwood, G.C.M. 1870. On the genus *Boswellia.* Trans. Lin. Soc. 27:143.

Birkett, M.A., S.A. Abassi, T. Krober, K. Chamberlain, A.M. Hooper, P.M. Guerin, J. Petterson, J.A. Pickett, R. Slade, and L.J. Wadhams. 2008. Antiectoparasitic activity of the gum resin, gum haggar, from the east African plant *Commiphora holtziana*. Phytochemistry 69(8):1710–1715.

Bishnoi, M., C.S. Patil, A. Kumar, and S.K. Kulkarni. 2005. Protective effects of Nimesulide (COX inhibitor), AKBA (5-LOX inhibitor) and their combination in aging associated abnormalities in mice. Methods Find. Expt. Clin. Pharmacol. 27(7):465–470.

Bohn, H.G. (transl.) 1897. Martial. Epigrams. www.ccel.org.

Bombardelli, E., and M. Spelta. 1991. Phospholipids-polyphenol complexes: A new concept in skin care ingredients. Cosmet. Toilet. 106:69–76.

Bonwicke, J. (transl.). 1725. P. Pomet 1694. A compleat history of drugs. Printed for J. & J. Bonwicke, S. Birt, W. Parker, C. Hitch, and E. Wicksteed. London.

Borrelli, F., F. Capasso, R. Capasso, V. Ascione, G. Aviello, R. Longo, and A. Izzo. 2006. Effect of *Boswellia serrata* on intestinal motility in rodents: inhibition of diarrhea without constipation. British J. Pharmacol. 148(4):553–560.

Bos, G. (transl. and ed.). 1997. Ibn al-Jazzar. Sexual diseases and their treatment. Musafir wa-qut al-hadir. Provisions for the traveler and nourishment for the sedentary. Kegan Paul, London.

Bostock, L. (transl.) 1855. Pliny the Elder. The natural histories. Bohn, London. penelope.uchicago.edu.

Bowen M.R. 1989. Forestry research in Somalia. Mogadishu: National Range Agency, Ministry of Livestock, Forestry and Range, British Forestry Project Somalia, research section, Working Paper 16.

Brun, J.P. 2000. The production of perfumes in antiquity: The case of Delos and Paestum. Am. J. Archaeol. 104(2):277–308.

Brunet, F. (transl). 1933–1957. Alexander of Tralles. Oeuvres medicales d'Alexandre de Tralles. 4:270–283. Geuthner, Paris.
Budge, E.A.W. (transl. and ed.) 1913. Syrian anatomy, pathology and therapeutics. Oxford Univ. Press, London.
Cahen, C. 1947. Une traite d'armurerie compose pour Saladin. Bull. d'Etudes Orientales (Damascus) 12. p. 163.
Carter, H.J. 1851. Comparative geography of the south-east coast of Arabia. J. Bombay Branch of the Royal Asiatic Soc., iii.
Cartwright, J. 1760. An essay upon the virtues of the balm of Gilead. Kearsly, Gale ECCO, London.
Cary, M., and H.H. Scullard. 1975. A history of Rome. Macmillan, New York.
Casson, L. (transl.) 1989. The Periplus Maris Erythraei. Princeton Univ. Press, Princeton, NJ
Catholic Encyclopedia. www.newadvent.org.
Church, A.J., and W.J. Broadribb. (transls.) 1876. Tacitus. Annals. http://Classics.mit.edu.
Civil, M. 1964. The ''message of Lu-dingir-ra to his mother'' and a group of Akkado-Hittite proverbs. J. Near Eastern Stud. 23(1):1–11.
Costeo, I., and I. Mongio. (eds.). 1608. Gerard of Cremona. Avicennae arabum medicorum principis, canon medicinae. Venetis, Apud Juntas, Venice.
Cotton, H.M. 2001. Ein Gedi between the two revolts. Scripta Clasicca Israelica 20:139–154.
Cotton, H.M., and W. Eck. 1997. Ein staatsmonopol and und seine folgen: Plinius Naturalis Historia 12, 123 und der preis fur Balm of Gilead. Rheinisches Museum fur Philologie 140:153–161.
Crawfurd, J. 1867. On the history and migration of cultivated plants used as condiments. Trans. Ethnolog. Soc. London 6:188–206.
Cuaz-Perolin, C., L. Billiet, E. Bauge, C. Copin, D. Scott-Algara, F. Genze, B. Buchele, T. Syrovets, T. Simmet, and M. Rouis. 2008. Antiinflammatory and antiatherogenic effects of the NF-KB inhibitor acetyl–11-keto-beta-Boswellic acid in LPS-challenged ApoE-mice. Arteriosclerosis, Thrombosis Vascular Biol. 28(2):272–277.
Cui, J., L. Huang, A. Zhae, J.L. Lew, J. Yu, S. Sahoo, P.T. Meinke, I. Royo, F. Pelaez, and S.D. Wright. 2003. Guggulesterone is a farnesoid X receptor antagonist in coactivator association assays but acts to enhance transcription of bile salt export pump. J. Biol. Chem. 278(12):10214–10220.
Dalby, A. 2002. Dangerous tastes: The story of spices. Univ. California Press, Berkeley.
Danin, A. 1983. Desert vegetation of Israel and Sinai. Cana, Jerusalem.
Darling Biomedical Library. UCLA. History and special collections, online spices Exhibit 2002.www.library.ucla.edu/libraries/biomed.
Darshan, S., and R. Doreswamy. 2004. Patented anti-inflammatory plant drug development from traditional medicine, Phytother. Res. 18(5):343–357.
Davidson, P.M., and A.S. Naidu. 2000. Phyto-phenols. p. 265–295. In: A.S. Naidu (ed.), Natural food antimicrobial systems. CRC Press, Boca Raton, FL.
Dayagi-Mendels, M. 1989. Perfumes and cosmetics in the ancient world. Israel Museum, Jerusalem.
de Fenoyl, R., and S. Sauneron. (transl. and eds.) 1979. Alpin Prosper. Histoire naturelle de l'Egypte par Prosper Alpin. p. 1581-1584. Collection des Voyageurs en Egypte. Archeolog Caire, Cairo.
Deng, R., D. Yang, A. Radke, J. Yang, and B. Yan. 2007. The hypolipidemic agent guggulsterone regulates the expression of human bile salt export pump: dominance of transactivation over farsenoid X receptor-mediated antagonism. J. Pharmacol. Expt. Ther. 320(3):1153–1162.
Dien, A.E. 2004. Palmyra as a caravan city. The Silkroad Foundation 2:1. http://depts.washington.edu.

Dolara, P., B. Corte, C. Ghelardini, A.M. Pugliese, E. Cerbai, S. Menichetti, and A. Lo Nostro. 2000. Local anesthetic, anti-bacterial and anti-fungal properties of sesquiterpenes from myrrh. Planta. Med. 66(4):356–358.

Dolara P., C. Luceri, C. Ghelardini, C. Montserrat, S. Aiolli, F. Luceri, M. Lodovici, S. Menichetti, and M.N. Romanelli. 1996. Analgesic effects of myrrh. Nature 379: Scientific Correspondence, p. 29.

Duke, J.A. 2008. Handbook of medicinal plants of the Bible. CRC Press, Boca Raton, FL.

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.

Duncan, A. 1804. Edinburgh new dispensatory. Bell and Bradfute, Edinburgh.

El Ashry, E.S., N. Rashed, O.M. Salama, and A. Saleh. 2003. Components, therapeutic value and uses of myrrh. Pharmazie 58(3):163–168.

Erickson-Gini, T. 2006. Down to the sea: Nabatean colonization in the Negev highlands. p. 157–166. In: P. Bienkowski and K. Galor (eds.), Crossing the rift. Resources, routes, settlement patterns and interaction in the Wadi Arabah. British Academy Monographs in Archaeology, Oxford.

Erickson-Gini, T. 2007. The transformation of Nabatean society: Acculturation or self-organization? In: B.A. Saidel and E.J. van der Steen (eds.). On the fringe of society: Archaeological and enthnoarchaeological perspectives on pastoral and agricultural societies. BAR Intl. Series 1657, p. 45–55.

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

Fabre, A. 2003. Use of ancient texts in modern therapeutic research (in French). Revue d'Histoire Pharmacie 51(338):239–250.

Faulkner, R.O. 1969. The ancient Egyptian pyramid texts. Oxford Univ. Press, Oxford.

Feliks, Y. 1968. Plant world of the Bible (in Hebrew). Massada, Tel Aviv.

Fenwick, A. and J.P. Webster. 2006. Schistosomiasis: Challenges for control, treatment and drug resistance, Curr. Opin. Infec. Dis. 19(6):577–582.

Finkelstein, I., and N.A. Silberman. 2006. David and Solomon. Simon & Schuster, New York.

Fischer, M., M. Gichon, and O. Tal. 2000. 'En Boqeq. Excavations in an oasis on the Dead Sea shore. Vol. 2: The officina: An early Roman building on the Dead Sea shore. Phillip von Zabern, Mainz.

Frank, T. (ed.) 1959. An economic survey of ancient Rome. Paterson. Pageant Books, N.J..

Freese, B.L. 1996. Medicinal myrrh. Archaeology (Publication of the Archaeology Institute of America) 49(3) May/June newsbrief.

Fulford, M. 1992. Territorial expansion and the Roman empire. Archaeology of empires. World Archaeol. 23(3):294–305.

Gayathri, B., N. Manjula, K.S. Vinaykumar, B.S. Lakshmi, and A. Balakrishnan. 2007. Pure compound from *Boswellia serrata* extract exhibits anti-inflammatory property in human peripheral blood mononuclear cells. Int. Immunopharmacol. 7(4):473–482.

Gebrehiwot, K., B. Muys, M. Haile, and R. Mitloehner. 2002. *Boswellia papyrifera* (Del.) Hoechst: A tropical key species in northern Ethiopia. Conference on International Agricultural Research for Development. Deutscher Tropentag, Kassel-Witzenhausen.

Ghazanfar, S.A. 1994. Handbook of Arabian medicinal plants. CRC Press, Boca Raton, FL.

Graf, D.F. 1996. The Roman East from the Chinese perspective. Palmyra and the Silk Road (in Arabic). Les Annales Archéologiques Arabes Syriennes 42:199–216[English text], 169–180[Arabic text].

Graf, D.F. 2006. The Nabateans in the early Hellenistic period: The testimony of Posidippus of Pella. Topoi 14:47–68.

Greenhill, T. 1705. Nekrokedeia or the art of embalming. London.

Groom, N. 1981. Frankincense and myrrh: A study of the Arabian incense trade. Longman, London and New York.

Gunther, R.T. (transl.). 1933. Dioscorides. Materia Medica. Hafner, Chicago.
Gupta, I., A. Parihar, P. Malhotra, S. Gupta, R. Ludtke, H. Safayhi, and H.P. Ammon. 2001. Effects of gum resin of *Boswellia serrata* in patients with chronic colitis. Planta Med. 67(5):391–395.
Gurib-Fakim, A. 2006. Medicinal plants: Traditions of yesterday and drugs of tomorrow. Mol. Aspects Med. 27(1):1–93.
Hackl, U., H. Jenni, and C. Schneider. 2003. Quellen zur Geschichte der Nabatäe. NTOA, Fribourg, Jarman.
Haefeli-Till, D. (ed.). 1977. Constantine the African. Der liber de oculis des Constantine Africanus. Zircher Medizingeschichtliche, Zurich, Jarman.
Hamed, M.A., and M.H. Hetta. 2005. Efficacy of citrus reticulata and Mirazid in treatment of schistosoma mansoni. Mem. Inst. Oswaldo Cruz, 100(7):771–778.
Hamm, S., E. Lesellier, J. Bleton, and A. Tchapla. 2003. Optimization of headspace solid phase microextraction for gas chromatography/mass spectrometry analysis of widely different volatility and polarity terpenoids in olibanum. J. Chromatography 1018 (1):73–83.
Hamm, S., J. Bleton, J. Connan, and A. Tchapla. 2005. A chemical investigation by headspace SPME and GC-MS of volatile and semi-volatile terpenes in various olibanum samples. Phytochemistry 66:1499–1514.
Hammond, P.C. 1973. Nabateans: Their history, culture and archaeology. Studies in Mediterranean Archaeology Series, Gothenburg. p. 129.
Hanuš, L.O., T. Rêzanka, V.M. Dembitsky, and A. Moussaieff. 2005. *Commiphora* chemistry. Biomed. Pap. Med. Fac. Univ. Palacky Olomouc Czech Repub. 149(1):3–27.
Hassler, C. (ed.). 1843. Fabri. Evagatorium in Terrae Sanctae, Arabiae et Egypti peregrinationem. Sumptibus Societatis Litterariae, Stuttgart.
Heaton, H. 1936. The economic history of Europe. Harper, New York.
Hepper, F.N. 1969. Arabian and African frankincense trees. J. Egyptian Archaeology 55:66–72.
Hepper, F.N. 1992. Illustrated encyclopedia of Bible plants. Baker Encyclopedia, Leicester.
Hepper, F.N., and I. Friis. 1994. The plants of Pehr Forsskal's Flora Aegyptiaco-Arabica. Royal Botanical Gardens, Kew.
Hestrin, R., and M. Dayagi-Mendels. 1979. Inscribed seals. First temple period: Hebrew, Ammonite, Moabite, Phoenician and Aramaic. The Israel Museum and the Israel Department of Antiquities and Museums, Jerusalem.
Hill, A.F. 1952. Economic botany. McGraw-Hill, New York.
Hirschfeld, Y. 2007. Ein Gedi Excavations II 1996-2002 Final Report. Israel Exploration Soc., Jerusalem.
Hooper, D. 1937. Useful plants and drugs of Iran and Iraq. Field Museum Natural History, Chicago.
Hort, A.F. (transl.) 1916. Theophrastus: Enquiry into plants. Loeb Classical Library. Harvard Univ. Press.
Howes, F.N. 1946. Vegetable gums and resins. Chronica Botanica Co., Waltham, MA.
Hwa, J.Y. 2007. US Patent 7223423. 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.
Ibn al-Baytar. 1874. Kitab al-jami li-mufradat al-adwiya wa'l-aghdiya. Cairo.

Jahier, H., and Noureddine, A. (eds.). 1956. Ibn Sina Avicenne. Poeme de la medecine. Ed des ''Belles Lettres'', Paris.
Jauch, J. 2002. German Patent No. 085921. A simple method for the synthesis of Boswellic acids and derivatives thereof.
Jindal, K., C. Rao, M. Ramanathan, and B. Swesh. 2004. International Patent 669262. A herbal composition comprising *Commiphora* mukul, *Allium sativum* and *Cucuma longa*.
Johnson, D.J. 1987. Nabatean trade: Intensification and culture change. Ph.D. Diss., Univ. Michigan, Ann Arbor.
Jones, H.L. (transl.). 1924. 1. Strabo geography. www.perseus.tufts.edu.
Jones, V. M. 1995. Qumran excavations, Cave of the column complex & environs, Vendyl Jones Research Inst., Arlington.
Jones, W.H.S., and H.A. Omerod. (transl.) 1918. Pausanias. Description of Greece. Loeb Classical Library. Harvard Univ. Press, Cambridge.
Jourdan, A.J.L. 1828. Pharmacopée universelle ou Conspectus des pharmacopées d'Amsterdam. Balliere, Paris.
Keay, J. 2006. The Spice Route—a History. Univ. California Press, Berkeley.
Kimura, I., M. Yoshikawa, S. Kobayashi, Y. Sugihara, M. Suzuki, H. Oominami, T. Murakami, H. Matsuda, and V.V. Doiphode. 2001. New triterpenes, myrrhanol A and myrrhanone A, from guggul-gum resins, and their potent anti-inflammatory effect on adjuvant-induced air-pouch granuloma of mice. Bioorganic Medicinal Chemistry Lett. 11(8):985–989.
Kitchen, K.A. 1993. The land of Punt. In: T. Shaw et al (eds.). The archeology of Africa: Food, Metals, Towns. Routledge, London.
Koehler, F.E. Koehler's botanical drawings. www.cafepress.com.
Krieglstein, C.F., C. Anthoni, E. Rijcken, M. Laukotter, H.U. Spiegel, S. Boden, S. Schweizer, H. Safayhi, N. Senninger, and G. Schurmann. 2001. Acetyl-11-keto-Boswellic acid, a constituent of a herbal medicine from *B. serrata* resin, attenuates experimental ileitis. Int. J. Colorectal Dis. 16(2):88–95.
Kuhn, C.G. (transl.). 1821. Title of Work: Claudii Galen Opera Omnia, Leipzig.
Langkaevel, B. (ed.) 1868. Simeonis Seth. Syntagma per elementorum ordinem, de alimentorum facultate. Leipzig.
Lemenih, M., S. Feleke, and W. Tadesse. 2007. Constraints to smallholders production of frankincense in Meteme district, north-western Ethiopia. J. Arid Environ. 71(4):393–403.
Lev, E. 2003. Medicinal substances in Jerusalem from early times to the present day. Archaeopress, Oxford.
Levey, M. (transl. and ed.) 1966a. al-Kindi. The medical formulary or aqrabadhin of al-Kindi. Univ. Wisconsin, Madison.
Levey, M. (transl. and ed.). 1966b. Ibn Wahshiyya. Medieval Arabic toxicology: The book of poisons of Ibn Wahshiyya and its relation to early Indian and Greek texts. Tran. Am. Phil. Soc. 56(7):1–30.
Levey, M. 1973. Early Arabic pharmacology. Brill, Leiden.
Levine, L.I. (ed.) 1981. Ancient synagogues revealed. The Israel Exploration Society, Jerusalem.
Linnaeus, C. 1764. Species plantarum. Stockholm.
Lotfy, M., G. Badra, W. Burham, and F.Q. Alenzi. 2006. Combined use of honey, bee propolis and myrrh in healing a deep, infected wound in a patient with diabetes mellitus. British J. Biomed. Sci. 63(4):171–173.
Low, I. 1924. Die Flora den Juden. Lowit, Vienna.
Lucas, A. 1930. Cosmetics, perfumes and incense in ancient Egypt. J. Egyptian Archeology 16(1/2):41–53.

Lui, J.J., A. Nilsson, S. Oredsson, V. Badmaev, W.Z. Zhao, and R.D. Duan. 2002. Boswellic acids trigger apoptosis via a pathway dependent on caspase-8 activation but independent on Fas/Fas ligand interaction in colon cancer HT-29 cells. Carcinogenesis 23(12):2087–2093.

Majeed, M., V. Badmaev, K.R.Bammi, S. Prakash, and S. Natarajan. 2001, Nov. 29. 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. World Patent No. 2001090064. Sami Chemicals & Extracts (P). Abstract from TOXCENTER 2001:299438. [World patent number updated Sept. 12, 2003. Abstract from CAPLUS 2001:868411.].

Majno, G. 1975. The healing hand: Man and wound in antiquity. Harvard Univ. Press, Cambridge.

Malandin, G. (ed.) 1986. Platearius. 1232. Le Livre des simple medicines d'apres le manuscrip francais. Bibliotheque Nationale, Paris.

Martial. Epigrams. Bohn 1897 transl. http://ccel.org.

Mazar, B., T. Dothan, and I. Dunayevski. 1966. Ein Gedi. The first and second seasons of excavations, 1961–1962. Israel Exploration Soc. J. Atiquot 5, Jerusalem.

Mazar, B., T. Dotan, and A. Dunayevski. 1973. Ein Gedi: Archeological excavations during the years 1961–1962. Israel Exploration Society J. Atiquot 5, Jerusalem.

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.

Melville, A. 1998. (transl.). Ovid—Metamorphosis. Oxford Univ. Press, Oxford.

Meybeck, A., and A. Zanvit. 2004. US Patent Application No. 0040166178. 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.

Meyerhoff, M. 1928. (transl. and ed.). Hunayn ibn Ishaq. The book of ten treatises on the eye ascribed to Hunain ibn Is-Haq (809–877 AD). The earliest existing systematic text book on ophthalmology. Government Press, Cairo.

Meyerhoff, M., and G. Sobhy. (transl. and eds.). 1932-1949. al-Ghafiqi. The abridged version of simple drugs of Ahmad ibn Muhammad al Ghafiqi Abu'l Farag (Barhebraeus) Al-Ettemad, Cairo.

Miller, A.G., and T.A. Cope. (eds.). 1996. Flora of the Arabian peninsula and Socotra. Edinburgh Univ. Press, Edinburgh.

Miller, A.G., and M. Morris. 1988. Plants of Dhofar: Traditional, economic and medicinal uses. Oman, Office of the advisor for conservation of the environment. Diwan of the Royal Court Sultanate of Oman. p. 360.

Miller, J.I. 1998. The spice trade of the Roman Empire, 29 BC to AD 641. Oxford Univ. Press, Oxford.

Milwright, M. 2003. The balm of Gilead of Matariyya: An exploration of a medieval panacea. SOAS Bull. 66(2):193–209.

Moldenke, H.N., and A.L. Moldenke. 1952. Plants of the Bible. Chronica Botanica Co., Waltham, MA.

Morris, M. 1989. Trees of knowledge (2): Frankincense. PDO News 1:16–19.

Moussaieff, A., N. Rimmerman, T. Bregman, A. Straiker, C.C. Felder, S. Shoham, Y. Kashman, S.M. Huang, H. Lee, E. Shohami, K. Mackie, M.J. Caterina, J.M. Walker, E. Fride, and R. Mechoulam. 2008. Incensol acetate, an incense compound, elicits psychoactivity by activating TRPV3 channels in the brain. FASEB J. 22:3024–3034.

Moussaieff, A., E. Shohami, Y. Kashman, E. Fride, M.L. Schmitz, F. Renner, B.L. Fiebich, E. Munoz, Y. Ben-Neriah, and R. Mechoulam. 2007. Incensole acetate, a novel anti-

inflammatory compound isolated from *Boswellia* resin, inhibits nuclear factor-kappa B activation. Mol. Pharmacol. 72(6):1657–1664.
Muntner, S. (ed.) 1971. Asaph Harofeh. Encyclopedia Judaica. Jerusalem.
Needham, J., and G.D. Lu. 1974. Science and civilization in China. Vol. 5: Tao Hongjing: Materia Medica Mingyi Bielu (Miscellaneous records of physicians) Cambridge Univ. Press, Cambridge.
Negev, A. 1986. Nabatean archaeology today. New York Univ. Press, New York.
Neufeld, E. 1971. Hygiene conditions in ancient Israel (Iron Age). Biblical Archaeologist 34(2):41–66.
Nielsen, H. 1974. Ancient ophthalmological agents. Acta Historica Scientiarium Naturalium et Medicinalium 31:117.
Nielsen, K. 1986. Incense in ancient Israel. Brill, Leiden, The Netherlands.
Ofir, R., S. Rachmilevitch, E. Solowey, and S. Ben-Yehoshua. 2010. Unpublished information.
Oldfather, C.H. (transl.) 1935. Diodorus Siculus. Bibliotheca Historica. Loeb Classical Library. Harvard. Univ., Cambridge.
Orwa, C., A. Mutua, R. Kindt, R. Jamnadass, and A. Simons. 2009. Agroforestree database: A tree reference and selection guide. Version 4.0. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp.
Osbaldeston, T.A. (ed.). 2000. The herbal of Dioscorides. Book One: Aromatics. Cancerlynx.com.
Owsley, E., and J.Y. Chiang. 2003. Guggulsterone antagonizes farnesoid X receptor induction of bile salt export pump but activates pregnane X receptor to inhibit cholesterol 7alpha-hydroxylase gene. Biochemical Biophysical Res. Commun. 304(1):191–195.
Pagel, J.L. (ed.). 1893. Die Areolae des Johannes de Sancto Amando. Berlin 68:63–66.
Papyrus Harris. British Museum, London, Serial 9999.
Parker, G. 2002. Ex oriente luxuria: Indian commodities and Roman experience. J. Econ. Social History Orient. 45(1):40–95.
Patrich, J., and B. Arubas. 1990. A juglet with balm of Gilead oil (?) from a cave near Qumran (in Hebrew) Eretz Israel 21:321 332.
Phillips, J. 1997. Punt and Askum: Egypt and the Horn of Africa. J. African History 38(3):423–457.
Photobucket.com/images.
Poeckel, D., and O. Werz. 2006. Boswellic acids: biological actions and molecular targets. Curr. Med. Chem. 13(28):3359–3369.
Postlethwayt, M. (transl.). 1766. Savary des Bruslons. The universal dictionary of trade and commerce. Printed for H. Woodfall, London.
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, antihyperglycocemic, and for dermal conditions.
Qataya, S. (ed.). 1981. Ibn Ridwan. Kitab al-kifaya fi'l-tibb. Maktabat al-Wataniyya, Baghdad.
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.
Rao, R., Z. Khan, and A. Shah. 2001. Toxicity studies in mice of *Commiphora momol* oleo gum resin. J. Ethnopharmacol. 76(2):151–154.
Rawlinson, G. 1897. D. Appleton & Company. The story of the nations: Egypt. Putnam, London.
Rawlinson, G. (transl. and ed.). 1859. The histories of Herodotus. D. Appleton & Company. New York.

Rees, A. 1995. Frankincense and myrrh. New Plantsman 2(1):55–59.
Remington, J.P., and H.C. Wood. (eds.). 1918. The dispensatory of the United States of America. 20th Edn. Lippincott. Online at www.swsbm.com.
Rosen, B., and S. Ben-Yehoshua. 2007. The agriculture of Roman-Byzantine Ein-Gedi and the enigmatic secret of the village. 20: 626–641. In: Y. Hirschfeld (ed.). Ein Gedi excavations—final report 1996-2002. Israel Explor. Soc., Jerusalem.
Rosengarten, F. Jr. 1970. The book of spices. Livingston, Wynnewood, PA.
Rosner, F. (transl.). 1984. Maimonides. Treatise on poisons, hemorrhoids and cohabitation: Maimonides' medical writing. Maimonides Res. Inst., Haifa.
Rostovtzeff, M. 1932. Caravan cities. Oxford Univ. Press, Oxford.
Rostovtzeff, M. 1941. The social and economic history of the Hellenistic world. Oxford Univ. Press, Oxford.
Rostovtzeff, M. 1957. The social and economic history of the Roman Empire. Vol. I. Oxford Univ. Press, Oxford.
Rubin, S. 1974 Medieval English medicine. Barnes & Noble, New York.
Said, H. (transl.). 1973. Al-Biruni's book of pharmacy and medicine. Hamdad Found., Karachi.
Sayyid, A. (ed.). 1985. al-Umari. Masalik al-absar. Institut Francais d'Archeologie Orientale, Cairo.
Schoff, W. H. 1922. Aloes. J. Oriental Soc. 42:171–185.
Sengupta, K., K.V. Alluri, A.R. Satish, S. Mishra, T. Golakoti, K.V.S. Sarma, D. Dey, and S.P. Raychaudhuri. 2007. A double blind, randomized, placebo controlled study of the efficacy and safety of 5-Loxin® for treatment of osteoarthritis of the knee. Arthritis Res. Therapy 10. Online/content/10/4/R85.
SEPASAL Online Database. Survey of economic plants for arid and semi-arid lands. Royal Botanic Gardens, Kew, London. www.kew.org/ceb/sepasal.
Shah, B.A., G.N. Qazi, and S.C. Taneja. 2009. Boswellic acids: A group of medicinally important compounds. Natural Product Rep. 26(1):72–89.
Shanahan-Prendergast, E. 2004. US Patent Application No. 20040092583. A treatment for inhibiting neoplastic lesions using incensole and/or furanogermacrens.
Sharma, A., A.S. Mann, V. Gajbhiye, and M.D. Kharya. 2007. Phytochemical profile of *Boswellia serrata*: An overview. Pharmacognosy Reviews 1(1):137–142.
Shen, T., and H.X. Lou. 2008. Bioactive constituents of myrrh and frankincense, two simultaneously prescribed gum resins in Chinese traditional medicine. Chem. Biodivers. 5(4):540–553.
Shen, T., H.Q. Yuan, W.Z. Wan, X.L. Wang, X.N. Wang, M. Ji, and H.X. Lou. 2008a. Cycloartane-type triterpenoids from the resinous exudates of *Commiphora opobalsamum*. J. Natural Prod. 71(1):81–86.
Shen, T., W. Wan, X.N. Wang, L.M. Sun, H.Q. Yuan, X.L. Wang, M. Ji, and H.X. Lou. 2008b. Sesquiterpenoids from the resinous exudates of *Commiphora opobalsamum* (Burseraceae). Helvetica Chimica Acta 91(5):881–887.
Shen, T., W. Wan, H. Yuan, F. Kong, H. Guo, P. Fan, and H. Lou. 2007. Secondary metabolites from *Commiphora opobalsamum* and their antiproliferative effect on human prostate cancer cells. Phytochemistry 68(9):1331–1337.
Shoemaker, M., B. Hamilton, S.H. Dairkee, I. Cohen, and M.J. Campbell. 2005. In vitro anti-cancer activity of twelve Chinese medicinal herbs. Phytother. Res. 19(7):649–651.
Siddiqui, M. (ed.) 1928. al-Tabari. Paradise of wisdom. Kunstdruckerei ''Sonne,'' Berlin.
Simmet, T., and H.P.T. Ammon. 1999. Patent Application No. 348118, US Patent 6174876. Use of Boswellic acid for treating brain tumors.
Sidebotham, S.E. 1986. Roman economic policy in the Erythra Thalassa, 30 BC–AD 217. Mnemosyne, Suppl. 91. Leiden.

Singer, C., E.J. Holmyard, and A.R. Hall. 1954. A history of technology. Vol. 1 Fall of ancient empires. Oxford Univ. Press, London.
Singer, C., E.J. Holmyard, and A.R. Hall. 1954. A history of technology. Vol. 1 Fall of ancient empires. Oxford Univ. Press, London.
Singer-Avitz, L. 1996. Household activities during the iron period at Tel Beer Sheva and activities. Erez Yisrael 25:166–174 (in Hebrew).
Singer-Avitz, L. 1999. Beer Sheva—a gateway community in southern Arabia for long-distance trade in the 8th century bce. Tel Aviv 26:1–75.
Singh, S., A. Khajuria, S.C. Taneja, R.K. Johri, J. Singh, and G.N. Qazi. 2008a. Boswellic acids: A leukotriene inhibitor also effective through topical application in inflammatory disorders. Phytomedicine 15(6–7):400–407.
Singh, S., A. Khajuria, S.C. Taneja, R.K. Khajuria, R.K. Johri, and G.N. Qazi. 2008b. The gastric ulcer protective effect of Boswellic acids, a leukotriene inhibitor from *Boswellia serrata,* in rats. Phytomedicine 15(6):408–415.
Singh, S.K., S. Bhusari, R. Singh, A. Saxena, D. Mondhe, and G.N. Qazi. 2007. Effect of AKBA on metastatic growth factor responsible for angiogenesis. Vascul. Pharmacol. 46(5):333–337.
Southgate, V.R., D. Rollinson, L.A. Tchuem Tchuente, and P. Hagan. 2005. Towards control of schistosomiasis in sub-Saharan Africa, J. Helminthol. 79:181–185.
Spencer, W.G. (transl.). 1938. Celsus. De medicina. Loeb Classical Library. Harvard Univ. Press.
Stannard, J. 1966. Dioscoridies and renaissance Materia Medica, Analecta Medico Historica I: Materia Medica in the XVI century. Pergamon, Oxford.
Starkey, J., and M. Pitt. (transl.). 1678. Charas. The royal pharmacopoea: Galenical and Chymical. Printed for Starkey and Pitt, London.
Stevenson, E.L. (transl.). 1932. Ptolemy: The geography. Book 5. Dover, New York.
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.
Szapary, P.O., M.J. Wolfe, L.T. Bloedon, A.J. Cucchiara, A.H. Dermarderosian, M.D. Cirigliano, and D.J. Rader. 2003. Guggulipid for the treatment of hypercholesterolemia: A randomized controlled trial. JAMA 290(6):765–772.
Talmud. Tractate Sanhedrin 43a, attributed to Rabbi Hiyya ben Ashi.
Talmud. Tractate Critot 6:71; Babylonian Talmud.
Talmud. Tractate Yoma 41:74 Jerusalem Talmud.
Talmud. Tractate Shabbath 25b, 26a [Laws of the Sabbath and festivals]. Jerusalem Talmud.
Talmud Tractate Yoma 41:74. Jerusalem Talmud.
Taneja, S.C., V.K. Sethi, K.L. Dhar, and R.S. Kapil. 1997. Patent No. 5629351. 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 antiulcerogenic activities. Also disclosed is a process for isolating a Boswellic acid fraction and individual Boswellic acids therefrom.
Tarn, W.W. 1929. Ptolemy II and Arabia. J. of Egyptian Archaeology 15(1/2):9–25.
Teketay, G. 2003. Frankincense and myrrh resources of Ethiopia: Medicinal and industrial use. Ethiopian J. of Science 26(2):161–172.
Temkin, O. 1973. Galenism: Rise and decline of a medical philosophy. Cornell Univ. Press, Ithaca, NY.
Thesiger, W. 1959. Arabian sands. Penguin, London.
Thieret, J.W. 1996. Frankincense and myrrh. Lloydiana 1(4):6–9.

Thomas, B. 1932. Arabia Felix. Scribner, New York.
Thulin, M., and A.M. Warfa. 1987. The frankincense trees of n. Somalia and s. Arabia. Kew Bul. 42(3):487–500.
Tikhonov V.P., A. Rydlovskaya, V.G. Makarov, M.N. Makarova, and O.N. Pozharitskaya. 2006. Investigation of anti-inflammatory activity of complex herbal oil extract in vitro and in vivo. Planta Medica 72:1007–1008.
Tipton, D.A., N.R. Hamman, and M.K. Dabbous. 2006. Effect of myrrh oil on IL-1beta stimulation of NF-kappaB activation and PGE(2) production in human gingival fibroblasts and epithelial cells. Toxicol. In Vitro 20(2):248–255.
Tucker, A.O. Frankincense and myrrh. Econ. Bot. 40(4):425–433.
Uphof, J.C. Th. 1968. Dictionary of economic plants. Verlag Cramer, Wurzburg.
Urizar, N.L., and D.D. Moore. 2003. Gugulipid: A natural cholesterol lowering agent. Annu. Rev. Nutr. 23:303–313.
Van Beek, G.W. 1958. Frankincense and myrrh in ancient south Arabia. J. Am. Oriental Soc. 78(3):141–152.
Van Beek, G.W., and A. Jamme. 1958. An inscribed southern Arabian clay stamp from Bethel. BASOR 151:9–16.
Wageningen University, Forest Ecology and Management Group FRAME project 2006–2010: Myrrh and gum arabic sustainable use of dry woodland resources in Ethiopia. Wageningen, The Netherlands.
Wapnish, P. 1984. The dromedary and bactrian camel in Levantine historical settings: The evidence from Tel Jemmeh. In: C. Grigson and J. Clutton-Brock (eds.), Animals and archaeology 3: Early herders and their flocks. BAR Intl Series 202, London. pp. 171–200.
Watson, G. 1966. Theriac and Mithridatum: A study of therapeutics. Welcome History of Medicine Library, London.
Weeks, A., and B.B. Simpson. 2007. Molecular phylogenetic analysis of *Commiphora* (Burseraceae) yields insight on the evolution and historical biogeography of an ''impossible'' genus. Mol. Phylogen. Evol. 42:62–79.
Weisman B. 1999. US Patent No. 5888514. Natural composition for treating bone or joint inflammation.
Whiston, W. (transl.). 1737. The complete works of Josephus Flavius. Mazin, London.
Wikimedia.org: http://commons.wikimedia.org/wiki/category:boswellia sacra.
Wolf, C.U. 1971. The onomasticon of Eusebius. www.ccel.org.
Wood, C. (transl. and ed.) 1936. Ali ibn Isa al-Kahhal. Memorandum book of a tenth-century oculist for the use of modern ophthalmologists. Northwestern Univ. Press, Chicago.
Wood, J.R.I. 1997. A handbook of the Yemen flora. Royal Botanic Gardens, Kew, UK.
Wreszinski, W. 1912. Der papyrus Ebers, Altagyptische Medizin. British Museum Publications 10059, London.
Yuan, H.Q., F. Kong, X.I. Wang, C.Y. Young, X.Y. Hu, and H.X. Lou. 2008. Inhibitory effect of acetyl-11-keto-beta-boswellic acid on androgen receptor by interference of Sp1 binding activity in prostate cancer cells. Biochem. Pharmacol. 75(11):2112–2121.
Yunnan Baiyao Company. Manufacturers of Yunnan Baiyao Yunnan, China.
Ziegler, G.M. 1932. The diuturnal use of perfumes and cosmetics. Scientific Monthly 34(3):222–237.
Zohary, M. 1982. Plants of the Bible. Cambridge Univ. Press, Cambridge.


**Plate 1.1** Frankincense, *Boswellia sacra*: (A) Resinous bead. (Source: http://en.wikipedia.org/wiki/frankinsense.) (B) Tree. (Source: Duke 2008.) (C) Botanical image. (Source: Koehler.)

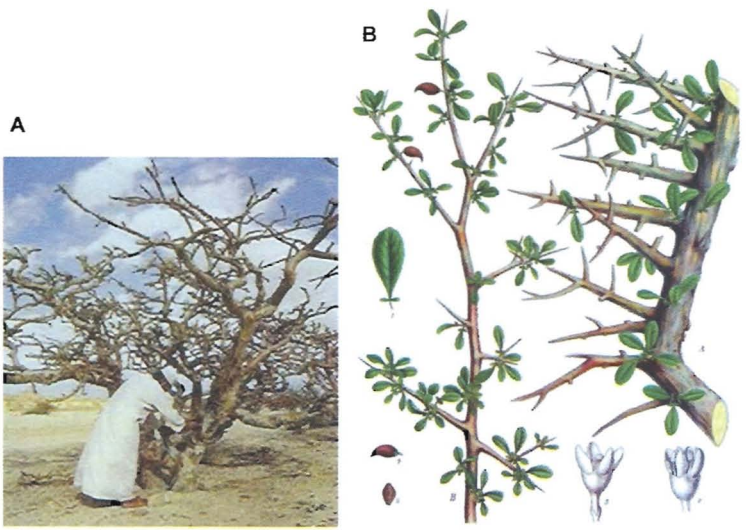


**Plate 1.2** Myrrh tree, *Commiphora myrrha*: (A) Tree. (Source: Duke 2008.) (B) Botanical image. (Source: Koehler.)


**Plate 1.3** Balm of Gilead, *Commiphora gileadenis opobalsamum*: (A) Plant. (B) Botanical image. (Source: Jourdan 1828.)