Mediterranean Archaeology and Archaeometry, Vol. 11, No. 2, pp. 129-150

A REVIEW ON THE MATERIALS USED DURING THE MUMMIFICATION PROCESSES IN ANCIENT EGYPT

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Received: 13/01/2011
Accepted: 29/05/2011
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ABSTRACT

Mummification is considered one of the most important in the history of ancient Egyptian civilization. The artificial mummification process started in the Fourth Dynasty during the Old Kingdom reached its peak in the New Kingdom. This review focuses on the usage of mummification materials such as Natron salt, Coniferous resin, Mastic, Myrrh, Beeswax, Bitumen, Cassia, Onions, Lichen, Henna and Gum Arabic in ancient Egypt to determine their effectiveness in the preservation of the body. For each material, the chemical formula, the history, and the role in the preservation of the body are presented. It is shown that natron salt was the most important material to desiccate a corpse, and that the vegetable materials mentioned above have anti-bacterial properties that protected the body from microbial attack.

KEYWORDS: Mummification, Natron salt, vegetable materials, beeswax, bitumen, lichen

1. INTRODUCTION

Ancient Egyptian civilization was distinguished by a clearly defined belief in a human existence which continued after death, but this individual immortality was considered to be dependent in part on the preservation of the body in as lifelike a form as possible (David, 1990). Their religious concepts concerning the afterlife made it necessary to preserve the body as a place for the `soul' to return to (Jansen et al., 2002). This belief came from observations that the dry sand of the desert acted to preserve buried bodies. Such beliefs were extant as early as the Neolithic and Predynastic periods of 5000–4000 B.C.

An example of the importance of the preservation of the body is seen in the invocation from the ancient Egyptian mortuary texts referred to as the "Book of the Dead": 'My body is everlasting, it will not perish and it will not decay for ages' (Kłys et al., 1999). Even though mummification was practiced in Egypt for nearly 3500 years, from the Old Kingdom, ca. 2600 BC to the Christian Period, an end was put to this practice only after the Arab conquest of Egypt in the 7th century AD (Maurer et al., 2002).

According to the Greek historian Herodotus, three main types of mummification were available, and the client chose the method he could afford (David, 2001). The most important elements of mummification, which were crucial to arresting the decomposition of the body were evisceration and dehydration of the tissues. Some authors (Smith & Dawson, 1924; Lauer & Iskender, 1955; Leek, 1969; Iskander & Shahin, 1973; Hamilton-Paterson & Andrews, 1978; Iskander, 1980; D'Auria, 1988; Taylor, 1995; Ikram and Dodson, 1998; Aufderheide, 2003; Salter-Pedersen, 2004; Taconis, 2005; Sivrev et al., 2005; Dunand & Lichterberg, 2006) have written on the ideal technique and most expensive method of mummification, which involved many stages.

In the second method, oil of cedar was injected into the anus, which was plugged to prevent the escape of the liquid, and the body was then treated with natron. Once this was complete, the anal plug was removed and the liquefied stomach and intestines were drained out with the oil (Hamilton-Paterson & Andrews, 1978; Abdel-Maksoud, 2001). In the third and cheapest method, the body was purged so that the intestines came away, and the body was then treated with natron (David, 2001).

It can be said that most authors have agreed on the description of three methods of mummification, but they differed among themselves in the description of the mummification materials. Some authors described the mummification materials depending on the description of old references and this may be due to the lack of analysis tools. All these references were in the first half of the twentieth century. Other authors described these materials depending on the analysis and investigation. Most analysis has occurred from the end of the twentieth century to present day. Since the end of the twentieth century, archaeologists have long found themselves faced with the difficult problem of identifying unknown materials used with mummies. Most analyses were done on resinous materials. This may be due to: (1) most authors have analyzed wrapped mummies; (2) most resinous materials have been used on the bandages; (3) from a conservation point of view, it was difficult to remove bandages of mummies (to look for other mummification materials) because this will lead to the deterioration of mummies. In this study, some materials of mummification were identified through analyses and investigations and other materials were written through literatures.

In recent years, Egyptian mummies have been the subject of a fairly large number of scientific studies (Maurer et al., 2002), but at the same time have always been a matter of controversy. The analyses were based on high performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS). However, most of these methods are directed to the identification of a few of the substances that are simultaneously present in the sample, and thus only partial information can be obtained (Colombini et al., 2000). Gas chromatography-mass spectrometry (GC/MS) and other analysis studies allowed the elucidation of a great number of clearly separated compounds found in ancient embalming materials.

Phenols, guaiacols, naphthalenes, monoterpenes, sesquiterpenoids, oxidised diterpene resin acids and triterpenoids were identified; through these intergradients, the materials used in mummification could be determined. These compounds also have antibacterial and antifungal effects and also prevent against deterioration caused by insects. Meanwhile analytical investigations have revealed a reasonably clear picture of the process of mummification and the materials used (Maurer et al., 2002).

This study aims to focus on the mummification types and to discuss the materials used in the mummification processes (history, chemical composition, and their effectiveness in the preservation of the body).

2. TYPES OF MUMMIFICATION

Naturally or artificially preserved bodies, in which desiccation (drying, dehydration) of the tissues has prevented putrefaction, have been discovered in Egypt (David, 2001). Most probably, the natural preservation of the body was noticed by the proto-dynastic people, perhaps when they were burying a new corpse in the sand near a previously buried one and it might have inspired them to believe that the body could be preserved and could more or less retain its human likeness (Iskander, 1980). True mummification (artificial methods) can be identified as a method, which incorporates several sophisticated techniques, making use of chemical and other agents. Many years of experimentation would be required to perfect such methods. The artificial preservation of the corpse was practiced in Egypt from the Old Kingdom to the Christian era (David, 1990). According to Herodotus account, there were a set of men who practiced the true mummification method and made it their business. When a body was brought to them, the embalmers showed the family of the deceased wooden models of corpses, so that they could choose the level of mummification they wanted. The mummification techniques were classified into three types. The first method which was the most expensive, was typically reserved for royalty and very wealthy nobles. The second method was inferior to the first and did not include wrapping of the body and the third method was the cheapest of all (Iskander, 1980).

The first method of mummification can be summarized as follows:

1- The body was stripped of its garments, laid out on the embalming couch and purified. This was performed in a temporary structure close to the Nile or a canal (Taconis, 2005).

2- An incision was then made in the left side of the abdomen with a knife of obsidian or other kind of stone (Lauer & Iskender, 1955; Iskander & Shahin, 1973). Once the embalmers inserted their hand through the incision and removed the liver, stomach and intestines, they cut the diaphragm and pulled out the lungs (Ikram and Dodson, 1998). The heart wasn't removed as the heart was believed to be weighed in the afterlife to determine the goodness of the individual (Iskander, 1980). It is thought that the kidneys were also left in the body. The liver, stomach, intestines and lungs were washed and rinsed out with spices and palm wine (Sivrev et al., 2005). The spices were probably used as a deodorant (Hamilton-Paterson & Andrews, 1978), and a sterilizing material (Iskander, A.E, Shahin, 1973; Taconis, 2005). Each of these organs was then individually dried, wrapped in linen and placed in a canopic jar. Each jar held a different organ and in later periods, the jar lids were shaped to represent one of the four sons of Horus (Aufderheide, 2003).

3- The brain was not believed to have any importance, so it was cut into small pieces to facilitate removal and discarded (D'Auria, 1988). An examination of ancient Egyptian skulls in the Macalister Collection at Cambridge showed that 56 percent had a hole made in the base of the skull through the plate of the ethmoid bone. In 5 percent it had been made through the left nostril, and in 3 percent through the right one. In others the nasal septum had been wholly or partially removed, which resulted in significant perforation to the base of the skull (Leek, 1969). Brain removal was often incomplete, and modern studies provide evidence that some tissue was usually left behind.

4- In order to completely dehydrate the body, the body cavities were packed with natron and then the entire corpse was covered in natron and left on a slanting embalming couch (Winlook, 1930). The body was placed in natron for seventy days, but some scholars argue that the body was only dried for forty days. The natron salt was first used in a liquid state but from the Middle Kingdom it was used as solid natron, which resulted in a shorter desiccation process (D'Auria, 1988). The natron salt not only caused the rapid desiccation of the body, thus avoiding the process of decomposition, but also entailed the saponification of the fatty tissues, assuring 'the chemical stability of the mummy' (Dunand & Lichterberg, 2006).

5- After the complete dehydration of the body, the thoracic and abdominal cavities were evacuated of their temporary stuffing materials (Sivrev et al., 2005). Recent examination of various samples of refuse embalming materials showed that stuffing materials included dry natron powder contained in linen packets, packs of linen impregnated with gum risen, straw and vegetables remains, and coarse powders containing quartz sand. Such packing would speed the dehydration of the body tissues, prevent the collapse of the abdominal wall, and combat the odor of putrefaction [Lauer & Iskender, 1955; Iskander & Shahin, 1973; Iskander, 1980; David, 1990).

6- After the temporary stuffing materials were removed from the body cavities, the body was washed with water and dried with towels or alcoholic liquid (Iskander, 1980).

7- Then embalmers began to pack the body with permanent dry stuffing materials. The cranial cavity was filled with resin (Iskander, 1980; Salter-Pedersen, 2004). The body could be filled with several different materials, including crushed myrrh, cinnamon, frankincense (Ikram and Dodson, 1998), sawdust packets mixed with resin, cassia (Arya et al., 2001), and occasionally one or more onions (Iskander, 1980). Hot liquid resin was also poured over the body, which served to prevent the growth of bacteria and acted as a disinfectant and deodorant. The inside and outside of the body was prepared with all kinds of oils, aromatic resins, unguent and perfumes to prevent the re-entry of moisture and to strengthen the skin (Taconis, 2005). Layers of beeswax were used for covering the mouth, eyes and ears (Ikram and Dodson, 1998).

8- Often the embalmers painted the face and sometimes the whole body with ocher: red for men and yellow for women (Hamilton-Paterson & Andrews, 1978). The final touches of verisimilitude come with the elaborate cosmetic detailing of the face and fine coiffures. Hair was often dyed back to its natural color and made thicker with extensions woven onto existing strands (David & Archbold, 2000). The abdominal incision was normally left open, but in some cases was covered with a plate of wax or copper alloy. Occasionally the incision was sewn shut.

9- Amulets were essential in transcending to the afterlife. During all steps of the mummification process, amulets were placed in specific locations including around the neck, waist, and limbs, as well as between the layers of the wrappings (Andrews, 1894).

10- Bandaging the mummy: the fingers and toes were individually wrapped, then layer after layer of linen was wound around the limbs and the torso (David & Archbold, 2000). In many cases, a thick 'carapace' of resinous paste and linen was applied over the whole body, separating the outer and inner layers of wrapping. After wrapping was a complete, red linen shroud was draped over the body (Taylor, 1995).

The second method of mummification was a less expensive method of mummification according to Herodotus. It did not include complete evisceration. In the second mummification method (which was also used in animal mummification) oil of cedar was injected into the anus, which was plugged to prevent the escape of the liquid, and the body was then treated with natron. Once this was complete the oil was drained off and the intestines and the stomach come away with the oil; the flesh had also been dessicated, so only the skin and the skeleton remained (D'Auria, 1988; David, 2001; Taconis, 2005).

In the third method of mummification, the stomach and internal organs were removed through an abdominal incision on the left side of the body. The body cavities were sterilized by ethyl alcohol. The whole body was then buried in natron salt (Iskander, 1980, David, 2001).

3. MUMMIFICATION MATERIALS USED

The authors divided the materials used in the mummification processes into two groups:

- Materials used based on analyses and investigations. Most of these materials were resinous materials and oils;

- Materials used based on the descriptions of some authors and literatures

3.1. Materials used based on analyses

3.1.1. Natron salt

The first use of the term "natron" appears to be in the glazing of quartz and steatite. The word (in Egyptian hieroglyphics "*ntry*") is most likely derived from the root "ntr", indicating its association with religious and funerary rituals.

Natron is a white, crystalline, hygroscopic, and natural material mined at Wadi Natrun in the Nile Delta, and it was an essential component in the mummification process in ancient Egypt. Natron was considered one of the most important materials. It was used in the removal of water from the tissues, prior to their treatment with resins, and prevented or retarded the biological deterioration and putrefaction of the body through fungal and bacterial attack (Edwards et al., 2007).

Some analysis and investigation had been performed on natron for different purposes. The following analysis had been done:

• Lucas (1914) had performed chemical analysis on natron taken from different mummies to know the main components of natron used especially in the mummification processes; he stated that sodium compounds (chloride, carbonate, bicarbonate and sulphate) were identified

• Sandison (1963) stated by chemical analysis that the essential process in artificial mummification is dehydration of the body, and for this common salt would have proved successful. The choice of natron may have depended on its superior ability to break down body fat. He also stated that the composition of natron varies widely since it is a naturally occurring mixture of salts, but it contains sodium carbonate, sodium bicarbonate, sodium chloride and sodium sulphate in varying proportions. Sandison (1963) when on to say that this was true of modern natron from Wadi Natrun and El Kab, as well as ancient natron from tombs of the Eleventh and Eighteenth dynasties

• Iskander and Shaheen (1973) performed quantitative chemical analysis on three samples taken from pottery jars (one sample taken from Tura El-Asmant excavation 1960, and the two other samples were taken from The Qurna excavation 1960). They identified the chemical composition of natron as the same compounds that were mentioned by Sandison (1963) ; Ikram and Dodson (1998) mentioned that the chemical composition (as mentioned above) of the various natron samples varies widely;

• Abdel-Maksoud (2001) used artificial sodium components (6 parts of hydrated sodium carbonate, 3 parts of sodium chloride, 1 part sodium sulphate and 1 part sodium bicarbonate) in the experimental studies on mummification techniques used in ancient Egypt. He conducted an experimental study on the mummification process applied on rats, and noted that the natron components used were highly effectiveness in the desiccation of the rats' bodies.

• Edwards et al (2007) analyzed eight samples by the Raman spectroscopic analyses. The analysis clearly indicates that the natron specimens are of indefinite composition, comprising sodium sulfate and sodium carbonate, with several containing sodium bicarbonate and gypsum. Halite, sodium chloride, does not have a first-order Raman spectrum

• Cosmacini and Piacentini (2008) mentioned that the mixture of natural sodium carbonate and bicarbonate known as natron, were used as desiccating agents in the sophisticated methods of perfect artificial mummification in ancient Egypt.

Desiccation with natron has been identified as the seventh stage in a thirteen-stage process used during mummification. During the dehydration process, the body, probably on a slanting bed, was completely covered with natron. This had the effect of removing any remaining body liquid and consequently ensuring against any further putrefaction (Peck, 1980). Some authors argue that the drying-out process lasted 40 days (Peck, 1980; Cockburn et al., 1980) and some authors argue that it lasted 70 days [Sandison, 1963; Hamilton-Paterson & Andrews, 1978). Abdel-Maksoud (2001) mentioned that Sandison (1986) proved that the mummification process did not take forty days, as was mentioned by Herodotus. Complete dehydration of the body could have taken twenty-eight days or less, as this process depended on one or more of the following factors:

1. The condition of the body prior to natron treatment

Since a body, which has already begun to exhibit signs of putrefaction may take a long time to achieve a suitable dry condition.

2. The composition of the salt mixture which makes up the natron.

A high quality mixture of salt, especially sodium carbonate and bicarbonate, would produce the best quality results.

3. The re-use of natron salt for more than one body

If natron is used for more than one body, the result after the first use will deteriorate.

4. The ratio of natron volume to body volume

Under ideal conditions, the volume of natron used should be at least ten times greater than the body volume.

5. The duration of the natron treatment

It was found that the ideal treatment depends on the climatic conditions.

Many authors and scientists varied in their dealing with the use of natron in the mummification process. Lucas (1914) said that natron was used by the ancient Egyptians in connection with their dead, certainly in a solid state, and possibly also as a solution. Abdel-Maksoud (2001) wrote that Smith and Dawson (1924) and David (1978) confirmed that the Egyptians used natron in the solid form and supported their opinions with the following reasons:

It was thought by some scholars that during the mummification process, a solution of liquid natron was applied to the body. However, this is based on an incorrect translation and the accepted medium of desiccation was dry natron (Cockburn et al., 1980).

3.1.2. Coniferous resin

The widespread use of plants oils indicates that the embalmers were aware of the special properties of unsaturated oils that allow them to`dry', or rather, to polymerize spontaneously. This polymerization would have produced a highly crosslinked aliphatic network, which would have stabilized otherwise fragile tissues and/or textile wrappings against degradation by producing a physico-chemical barrier that impedes the activities of microorganisms (Buckley and Evershed, 2001; Davies, 2011).

According to arguments presented by some scientists, the resin used on the human body at the end of the mummification process, was derived from coniferous trees, specifically the cedar, juniper, and pine trees (Kłys et al., 1999). It should be noted that coniferous materials had been used in Egyptian mummies, but there had been confusion regarding the actual trees materials used. Lucas (1931) Herodotus, Diodorus and Pliny mentioned in their writings that the resin employed by the Egyptians in mummification was certainly from a conifer, although probably never from the true cedar but from the juniper tree instead. The materials mentioned by Pliny as used for mummification were *cedri succus*, the natural resinous product of a coniferous tree, probably juniper, and cedrium, which contained pyroligneos acid that was composed of a mix of oil of turpentine and wood tar. Baumann (1960) mentioned that throughout ancient times, junipers were confused with cedars. Iskander (1980) mentioned that in the second method of mummification, oil of cedar was injected into the body through the anus, which was afterwards stopped up to prevent the liquid from escaping. Amoros and Vozenin-Serra (1998) mentioned that coniferous material (in the form of sawdust) came from the cedar tree and was found in mummies dating to different periods (Eleventh, Twelfth, Eighteenth, Nineteenth, and Twenty-first Dynasties and the Greco-Roman period). Taconis (2005) noted that in the First Intermediate Period, evisceration was practiced, either by incision of the abdominal wall or by means of an enema of cedar (or more probably juniper) oil.

Some analytical techniques have greatly increased the accuracy of the identification of ancient natural materials such as oils or resin. The following analytical techniques have identified the resin material used on mummies as coming from a conifer:

- Proefke and Rinehart (1992) used fast atom bombardment combined with mass spectrometry (FAB/MS), high resolution FAB/MS, FAB tandem mass spectrometry (MS/MS), and gas chromatography/mass spectrometry (GC/MS), to determine the composition of the resinous material recovered from the wrappings of an Egyptian Greco-Roman mummy dating to approximately 350 A.D.

The three oxidation products of abietic acid found in the mummy resin clearly indicate that a true conifer resin was used as the base for the embalming fluid.

- Wisseman (1992) stated that chemical analysis of the embalming fuilds of an Egyptian mummy at the World Heritage Museum, University of Illinois, indicated that coniferous resin was used.

- Amoros and Vozenin-Serra (1998) mentioned that sawdust taken from a Late Period mummy was analyzed by traditional wood anatomy methods and investigated under optical microscope. The microscope investigation revealed that the sawdust packing was comprised of 70% coniferous wood, 10% tamarix species and 20% unidentified vegetal remains, possibly gramineae stems and leaf parts.

The radial walls of the larger vertical tracheids of dry untreated sawdust were investigated under high magnification of the optical microscope. In these walls, highly characteristic bordered pits with fringed torus margins were observed, and assigned these woody elements to the Cedrus genus (Pinaceae family, Abietoideae sub-family).

Identification of the Cedrus remains at species level is difficult in view of the anatomical similarities between Cedrus atlantica and Cedrus libani. When compared to other samples, it seems that the sample is closer to Cedrus libani.

- Connan et al. (1999) stated that the analysis of balms from Egyptian mummies (1000 BC to 400 AD) by GC/ MS analysis and GC/C-IRMS reveals complex molecular mixtures which are diagnostic of products such as conifer resin and beeswax mixed with bitumen to prepare each balm.

- Connan (1999) stated that one of the major conclusions of his study, restricted to mummies dated between 1000BC and 400AD, is that the molecular signatures are extremely diverse from one sample to another and that conifer resin is the key ingredient from which most balms were prepared.

- Kłys et al., (1999) mentioned that different ancient resin specimens have recently been analyzed by infrared spectrometry and gas chromatography/ mass spectrometry (GC/MS). It was supposed that the resins used in ancient Egypt were from coniferous trees (cedar, juniper, firs and pines). He also stated that the analysis of the resin samples was performed by means of physicochemical tests, infrared spectroscopy and spectrographic method. The tests were performed on many fragments from different parts of the mummy of Iset-Iri-Hetes belonging to the collection of the Archeological Museum in Krakow, Poland. A pine resin was identified by the analysis mentioned above.

- Buckley and Evershed (2001) made chemical investigation to a collection of Egyptian mummies dating from the mid-dynastic period (c. 1,900 yr BC) to the late Roman period (AD 395). This study revealed that coniferous resin clearly increase in its prominence through time, and is found in material taken both directly from the bodies and from the wrappings. Coniferous resin is identified by the presence of both functionalized and defunctionalized diterpenoid components. For example, 7-oxodehydroabietic acid and 15-hydroxy-7-oxodehydroabietic acid were usually the dominant diterpenoid components, and the normally abundant dehydroabietic acid was virtually absent. Buckley and Evershed (2001) also stated that, although coniferous resins were clearly used in the embalming process at least as early as 2,200 yr BC (VI dynasty), their use becomes most apparent in later periods; both the tissues and the wrappings of mummies from the Roman period (30 yr BC to AD395) contain appreciable quantities (up to 37%) of coniferous diterpenoids. The increasing use of coniferous resin suggests that the embalmers may have become aware of the ability of specific natural products to inhibit microbial degradation by means of mechanisms (physico-chemical barriers and antimicrobial action) analogous to their protective roles in the plants from which they derived.

- Maurer et al., (2002) have used gas chromatography and gas chromatography-mass spectrometry (GC-MS) to analyze four samples taken from four Roman mummies (4th century AD), which were discovered in the Dakhleh Oasis excavation in the Western Desert of Egypt. The analyses proved that the soluble material on the mummies mainly consisted of plant material. The use of resins of coniferous trees is indicated by the presence of abietic acid and related tricyclic diterpenoid acids.

- Koller et al., (2003) stated that mummy 'Saankh-kare', Eighteenth Dynasty, 1500 B. C. was analyzed by gas chromatography. The analysis proved the presence of coniferous resin according to the recovery of guaiacols without syringols and methoxyphenol derivatives, which are formed when soft coniferous wood is heated. They also stated that the brown solid resinous material found near the mummy 'Saankh-kare' also contained sesquiterpenoid components normally detected in organic solvent extracted wood from *cedar atlantica* called cedar oil which is composed of junipene, cadalene, cadinatriene, α-curcumene, cuparene etc. Koller et al., (2003) stated that the analysis on bone fragments, now deposited in the Naturhistorisches Museum at Vienna, and the mummy of Idu II from the Old Kingdom, suggested that diterpenoid resin acids found on the fragments were evidence of the use of pine resin.

- Charrié-Duhaut et al., (2007) analyzed a sample from a canopic jar in the Louvre with gas chromatography-mass spectrometry and liquid chromatography-mass spectrometry (GC-MS and LC-MS) and absolute dating by Carbon-14. The results revealed that the sample, scraped from the interior face of the jar, was identified as an unguent made of coniferous oil and animal fat, dating from the Third Intermediate Period.

- Davies (2011) mentioned that many sources suggest that cedar was used for mummification and ancient texts by the Roman scholar Pliny and Greek historian Herodotus link a wood called 'cedrium' to embalming. Cedar materials were found in unused ancient Egyptian embalming materials from Deir el-Bahari, an Egyptian complex of mortuary temples and tombs dating from about 1500BC. GC-MS analysis revealed the presence of phenols and sesquiterpenoids and, importantly, a compound found in wood smoke called guaiacol. The guaiacol was attributed to tar oil produced from cedar wood, known to be rich in the compound. The embalming material would have had 'powerful bactericidal and fungicidal activity.

Through the previous studies and analytical methods performed, the coniferous oils can be divided into the following:

1. pine oil: pine oil (Table 1A) comes from the pine tree (Family: Pinaceae, *Pinus* sp.) which reaches a height of over 40m, has evergreen leaves (needles), a straight trunk with a rather spreading, irregular crown and bark that is scaly and cracked. The leaves set in pairs on the branchlets, are aromatic, needle-like, sheathed and glaucous. Medicinally useful parts are gathered in summer (Chiej, 1988).

2. Cedar wood oil (Table 1B): the famous cedar of Lebanon is a true cedar. For thousands of years its 70-100 foot height and 16-25 foot girth have inspired men with thoughts of strength and solidarity and the trees have always been regarded with what Franklin Lamb calls "sacred awe." Lebanese cedar usually grows in association with pines and firs. The forests were extensive in Biblical times, but only five small groves exist today-about 6000 feet up Mount Lebanon. These are under the care of a Christian sect called the Maronites. The wood is fragrant, insect-repellent, quite durable and rot-resistant. It was highly esteemed by the Egyptians for many kinds of wood-work and very much so for coffin-making. It was first used in coffins sometime around the tenth dynasty an-id persisted well into the Ptolemaic period (Baumann, 1960). Sawdust made from this cedar was also used as a body packing for mummies.

3. Juniper (Fig. 1A, Table 1C): A shrub or small tree (Family: Cupressaceae), about 10 feet (3m) in height. The bluish-green leaves are narrow, leathery and very pungent; there is a pale, concave line running the whole length of the

upper surface of each leaf. Male and female flowers are born on separate trees. The fruit is a false berry formed by the bracts surrounding the flower. The medicinally useful parts are gathered in the summer and autumn (Chiej, 1988).

Juniper cones (generally being *Juniperus phoenicea* L.) have often been found in ancient Egyptian graves. An account of Coptic burials at the Monastery of Epiphanius in Thebes relates that handfuls of juniper cones and coarse rock salt were put between the legs and over the body of the deceased. Cones of *J. phoenicea* were plentiful enough to be utilized in large amounts as an embalming substance in the burials (Brussell, 2004).

Fig. 1. Mummification materials used: (A) Juniper, (B) Mastic, (C) Myrrh, (D) Cassia

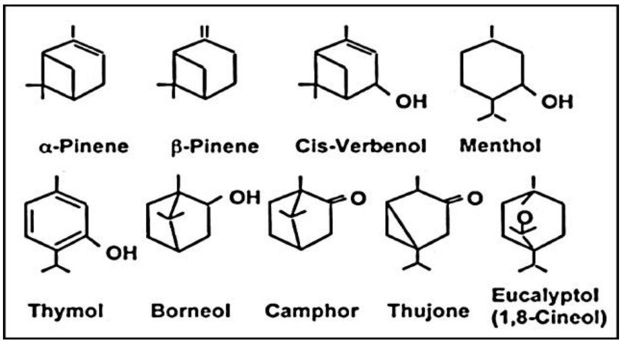

Fig. 2. Structural formulas of the monoterpenes, the major components of essential oils (Mühlbauer et al., 2003).

3.1.3. Mastic

Mastic is a light yellowish (Fig. 1B), semi-transparent, natural resin that is exuded from cuttings made on the trunk of mastic trees (*Pistacia lentiscus var. Chia*) every year, from July to October. These trees belong to the Anacardiaceae family, which is traditionally cultivated in the south of Chios, a Greek island in the Aegean Sea.

This material remains under the trees for many days and coagulates through the local environmental conditions (Table 1D). The coagulated product is then collected and is called mastic gum. Mastic oil is produced by the steam distillation of mastic (Mills & White, 1989; Paraskevopoulou, 2009).

The Egyptians used mastic in embalming and in religious capacities. It probably had religious significance even when used for embalming (Baumann, 1960). There are several studies proving the presence of mastic resin in mummification materials. The following analyses have been done:

- Colombini et al., (2000) used gas chromatography-mass spectrometry to analyze Merneith's mummy balms (plant resins, oils and their degradation products). He compared Merneith's unguents with several natural pure substances, which were collected and used as reference materials. He proved that the main components found on the balm of Memeith's mummy was mastic resin.

- Buckley and Evershed (2001) Indicated that the former include the isomasticadienonic, masticadienonic, moronic and oleanonic acids that are diagnostic of the presence of *Pistacia* resin and are found in a female mummy of the Third Intermediate Period (XXI to XXV dynasty; 1,069-664 yr BC).

The analyses that were carried out on one of the blue-glazed faience jars with the cartouche of Ramesses II by Charrie´-Duhaut et al., (2007), which entered the Louvre in 1905, proved that the substance stored in the jar was likely an embalming substance, made of pure vegetable resin *(Pistacia*) and dating from the Ptolemaic Period.

- Stern et al. (2003) studied resin taken from some bowls found at Amarna. He suggested that on the basis of the molecular composition the resin is from a species of *Pistacia*. He mentioned that there is also some evidence of the use of pistacia resin during mummification, at least as early as the Third Intermediate Period.

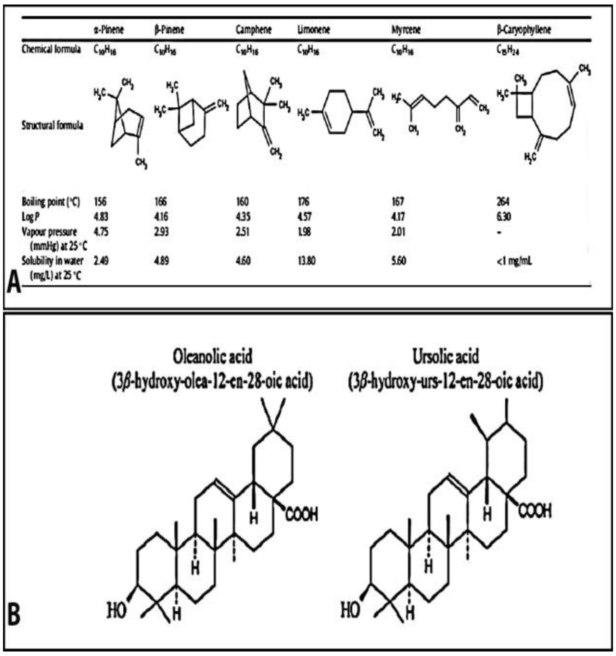

Fig. 3. Mastic gum: (A) Physicochemical characteristics of aroma compounds (B) Chemical structure of the triterpenes (Assimopoulou et al., 2005).

3.1.4. Myrrh

Myrrh is an oleo-gum resin (Fig. 1C, Table 1E), freely discharged from natural fissures or from incisions made to collect this product. It flows as a pale yellow, bitter, odorous gum, which hardens as it dries to yield a reddish-brown or orange irregular mass. In commerce, myrrh is found as a powder or as granular pieces of many. Myrrh resinous exudates are obtained from trees of certain Commiphora species of the Burseraceae family. Myrrh oils are occasionally used as flavouring agents. Myrrh contains the resin myrrhin (23–40%), the volatile oil myrrhol (2–8%), gum (40–60%) and a bitter unidentified component (Hamm et al., 2003).

Myrrh, *antiyw* in ancient Egyptian, was fragrant gum, essentially resin in the shape of small yellow-red lumps. Myrrh was imported from Somalia and southern Arabia, and it was commonly used during the New Kingdom to stuff and massage on and into mummies. It was mostly valued for the fragrance that it imparted to the corpse [14]. There are some studies that characterize the presence of myrrh in Egyptian mummies. The following analysis had been done:

Hamm et al., (2003) used Headspace SPME coupled with GC–MS to identify the mono-, sesqui-, and diterpenes of myrrh, provided that diterpenes like incensole or isoincensole and their oxide or acetate derivatives are characteristic biomarkers of myrrh.

3.1.5. Beeswax

Beeswax is a type of wax from the honeycomb of the honeybees. It is yellow, brown, or white bleached solid. The normal color of beeswax varies from shades of yellow, orange, red and brown. The color of beeswax changes with age, for example virgin wax is white but darkens rapidly as it ages, often becoming almost black. It has a faint honey odor. It consists largely of myricyl palmitate, cerotic acid and esters, and some high-carbon paraffins. Beeswax is lipid by nature. It has saturated hydrocarbons, acids or hydroxy-acids, alcohols, pigments, mostly from pollen and propolis, as well as minute traces of brood (http://www.beekeeping.com/leclercq/wax.htm; Hossain et al., 2009).

Beeswax was utilized for a number of purposes in ancient Egypt. For example, it was often used to model figures and was also employed in the mummification process. Lucas (1962) cited a few examples of Middle Kingdom and New Kingdom date where wax had been used as an adhesive. Connan et al. (1999) stated that the analysis of balms from Egyptian mummies (1000 BC to 400 AD) by GC/ MS analysis and GC/C-IRMS revealed complex molecular mixtures, which were diagnostic of products such as conifer resin and beeswax mixed with bitumen to prepare each balm. Serpico and White (2000) reported that the use of beeswax in mummy wrapping dating from the Late Period to the Roman Period had been established. GC and Py-MS. Buckley and Evershed (2001) said that beeswax is characterized chemically by alkanes (C25-C33), wax esters (C40-C50) and hydroxy wax esters (C42-C54). They also stated that the first appears of beeswax notably later than coniferous resin, with its positive identification in a resinous coating taken from the chest cavity of a female mummy of the Third Intermediate Period (XXI to XXV dynasty; 1,069-664 yr BC). In a sample taken from `Pedeamun', a XXVI dynasty (664-525 yr BC) mummy. Goffer (2007) said that the ancient Egyptians used beeswax over 6000 years ago to preserve mummies, by soaking the linen strips used for wrapping in beeswax. They also coated and sealed the coffins with wax.

3.1.6. Bitumen

Bitumen may be either (a) a mixture of hydrocarbons originating in petroleum found naturally impregnating certain porous rocks, generally limestone, but occasionally sandstone, in various parts of the world or (b) a similar material mixed with varying, proportions of mineral matter found in the form of deposits, as in the well-known "pitch". Pitch may be either natural or artificial. Natural pitch is simply bitumen, which has become solid by exposure, and is found in the neighborhood of the Dead Sea (Lucas, 1914).

The bitumen used as a preservative in some ancient Egyptian mummies was previously thought to come only from the Dead Sea area in Palestine. A closer source of bitumen was investigated at Gebel Zeit on the southwestern shore of Egypt's Gulf of Suez (Harrell, 2002).

The origin of the black color of mummies has always been a subject of debate (Connan, 1999). Lucas (1914) and Hammond (1959) studied the writings of the Egyptian, Arab, Greek and Latin authors who studied mummies and mummification, and concluded that either bitumen or pitch, or both, were extensively employed by the ancient Egyptians in the preservation of the dead. Lucas (1914) however could not find any careful or systematic examination or analysis of the material, and apparently nothing of the sort has been done. It seems then that the recognition of the use of bitumen or pitch, was soley based on the appearance of the material on the mummy, and in a few cases, the behavior of mummified material when burned.

Chemical studies were undertaken to find a solution to this controversial problem:

- Connan (1999) stated that gas chromatography, GC/MS and GC/C-IRMS analysis on 20 balms from Egyptian mummies, mainly from the Valley of the Queens and not older than 1000 BC, showed that bitumen from the Dead Sea was the most common bitumen found in balms. This was a result of identifying sterane and terpane patterns and comparing them with bitumen found in the Dead Sea region.

- Harrell (2002) stated that five mummies were analyzed using molecular biomarkers derived from gas chromatography/mass spectrometry. It was found that four of the mummies contained Dead Sea bitumen, and the fifth and oldest one, that of the Libyan Pasehor from about 900 BC, had bitumen from Gebel Zeit. This is the first evidence for the use of an indigenous source of bitumen in ancient Egypt.

- Aufderheide (2003) mentioned that chromatographic techniques proved that bitumen from the Dead Sea, instead of the usual resins, was employed by some Late Egyptian embalmers.

- Koller et al., (2003) stated that bone fragments, now deposited in the Naturhistorisches Museum at Vienna, Department of Anthropology, were analyzed by GC and GC/MS. There is strong evidence that a bituminous material was applied on the surface of the mummy and parts of it have migrated into the bones. This is because of the detection of pristane and phytane together with the alkanes.

3.2. Materials used based on the descriptions of some authors and literatures

Some references mentioned that the following mummification materials were used for different purposes in the mummification processes. Unfortunately, scientific analysis and investigations have not been done for these materials. The authors explained these materials depending on the description of some observations and explanations of archaeologists and scientists. These materials are:

3.2.1. Cassia

Cinnamomum cassia (Nees) Nees ex Blunmie and *Cinnawomum zeyla:nicumn* Breyn. These are the sources of cassia and cinnamon respectively. Various parts such as the fruits, oil, inner bark and leafy twigs of cinnamon are used. The inner bark is a pungent, sweet and spicy herb (Baumann, 1960; Ateş & Erdoğrul, 2003).

During ancient times, cassia (Fig. 1D, Table 1F) and cinnamon were both referred to, although to what extent their botanical terminology aligns with that of modern times is unknown. Cassia was mentioned in Chinese herb-al texts as early as 4,000 years ago (Hernandez, http://www.cinnamoncassia.com/)

There is considerable doubt as to whether cinnamon and cassia were used in ancient Egypt (Baumann, 1960). Ancient records pointing to the use of cinnamon and spices date from the Old Kingdom, around 2,600 BC (Hernandez, http://www.cinnamoncassia.com/). Baumann (1960) mentioned that in the Karnak Reliefs of the Nineteenth Dynasty, it is written: "I gather together all the countries of Punt, all their tribute, of gum of myrrh, cinnamon…" And in the Harris Papyrus from the Twentieth Dynasty, cinnamon is mentioned four times and cassia once in the lists of tributes.

Because of its natural preservative properties and potent scent, Cassia and cinnamon were a part of ancient embalming practices, most notably in Egypt. The art of embalming was often a partly medical and partly spiritual practice, and cinnamon played an important role in both spheres. Its chemical properties make it a practical ingredient in embalming, but its distinctive scent, high price, and vibrant color served symbolic purposes as well (Ikram and Dodson, 1998).

Pettigrew (1834) mentioned that on the surface of a Twentieth Dynasty mummy was "…a thick layer of spicery… (which)… still retains the faint smell of cinnamon or cassia".

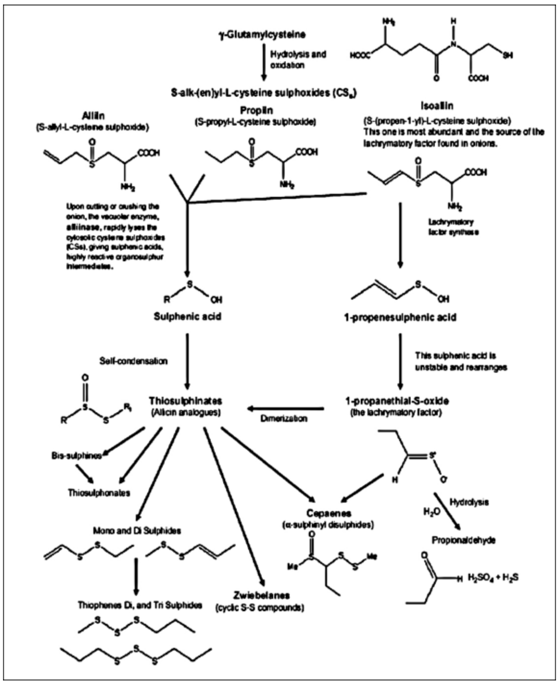

Fig. 4. Formation of organo-sulphur compounds during metabolic pathways in processed onion (Corzo-Martınez et al., 2007).

3.2.2. *Onions*

Onion, (*Allium cepa L.*) is one of the most important and oldest vegetable crops grown in Egypt. Although it is primarily grown for food, it is also used as traditional medicine (Hussein et al., 2007) (Table 1G).

Onions were found in body cavities from the New Kingdom until the Third Intermediate Period. David and Archbold (2000) mentioned that Ramesses IV had onions placed in his eye sockets and his ears, and a piece of onion skin covered with resin was inserted into each nostril. Sandison (1957) mentioned that this is probably the only instance of the use of onions to simulate the eye.

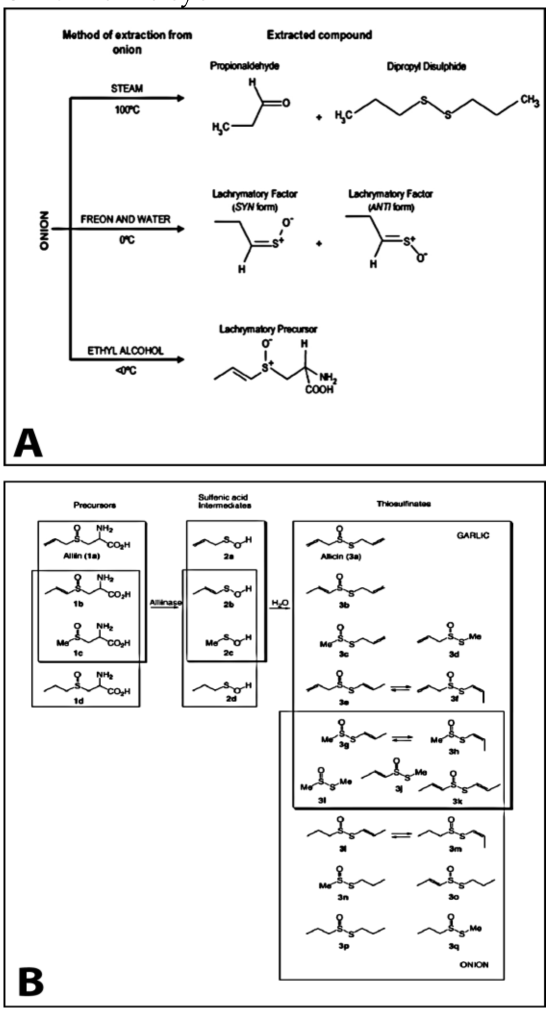

Fig. 5. Onion: (A) Major organo-sulphur compounds present in different onion preparations based on the extraction method (Corzo-Martınez et al., 2007); (B) Biosynthetic pathway of thiosulfinates (Lanzotti, 20

3.2.3. *Lichen*

Lichen (Table 1H) often inconspicuous, hardy and adaptive plants are composed of a fungus and a green or blue-green alga. This union or symbiosis produces a long-lived organism that does not look like either the fungal or algal partners. Both partners contribute to the growth of lichen.

The alga uses photosynthesis, like other plants, to produce food, while the fungus supplies water and essential minerals producing a structure that protects the alga from extreme environmental conditions. Together they thrive in some of the harshest environments on earth where few other plants and neither partner alone can survive (Hagan, 2004).

Lichen was used to fill out body cavities (Ikram and Dodson, 1998), such as the lichen used in the cavities of Ramesses IV (Hamilton-Paterson & Andrews, 1978), and also lichens were inserted under the skin to try to give the body a more 'fleshy' appearance (Knight, 2009).

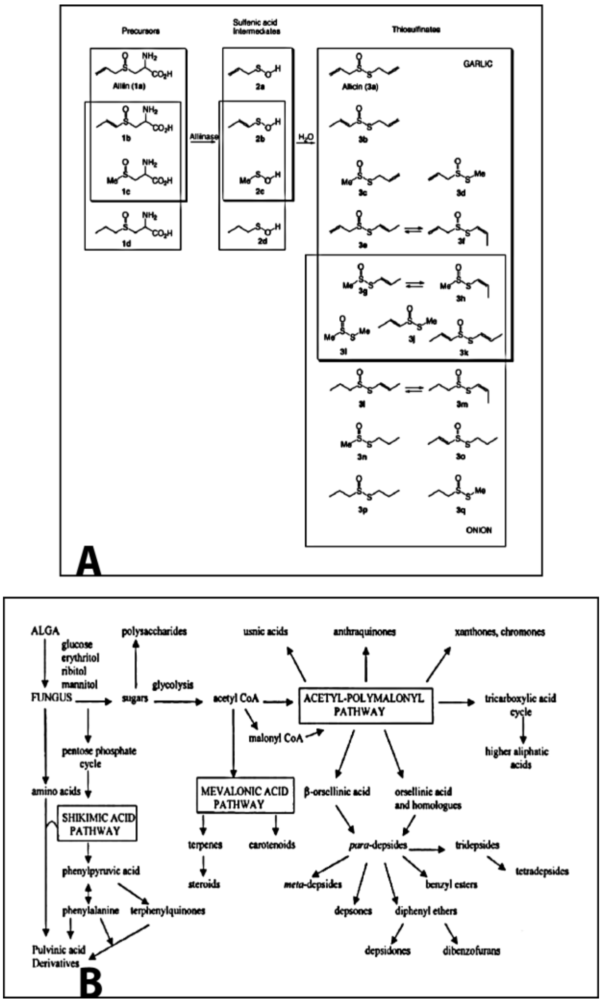

Fig. 6. Lichen: (A) Probable pathways leading to the major groups of lichen products (Edwards et al., 2003), (B) Proposed biosynthetic route for usnic acid (Ingólfsdóttir, 2002).

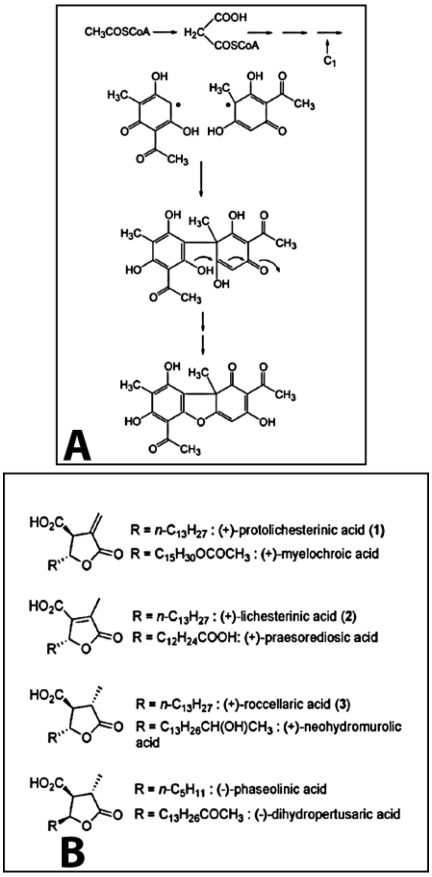

Fig. 7. Lichen: (A) Structure of various paraconic acids (Horhant et al., 2007), (B) Structure of lichen compounds, sphaerophorin (depside) and pannarin (depsidone) (Russo et al., 2008).

3.2.4. Henna

The henna plant *Lawsonia inermis* Linn (Table 1I) is a fragrant shrub native to Asia and northern Africa. The species is sometimes referred to as *L. alba* or *L. rubra* and is cultivated in India, the Middle East, Egypt and tropical America (Avijit, 2002). The henna plant is a glabrous, many-branched shrub or quite a small tree with grayish-brown bark. Leaves are opposite, sub sessile, elliptic or broadly lanceolate, entire, acute or obtuse, 2-3cm long and 1-2cm wide. Flowers are numerous, small, white or rose colored and fragrant (Muhammad & Muhammad, 2005). Henna dye is prepared by grinding the fresh leaves of this plant or by powdering the dried leaves and then mixing into a grayish-green paste with water. The resulting brown dye is extensively used as decorative skin paint, for nail coloring and as hair dye and conditioner (Cordeiro et al., 2008).

A variety of analyses on Ramesses II's mummy showed that the embalmers dyed the pharaoh's hair, probably with henna (Brier, 1994).

3.2.5. Gum Arabic

Gum Arabic is a naturally occurring exudate collected from *Acacia senegal* trees and, to a lesser extent, from *Acacia seyal* trees. It is one of the oldest and most important industrial gums (Yadav et al., 2007). It is a high molecular weight macromolecule that can easily be dissolved and dispersed in water under appropriate conditions. About 70% of the world production of gum arabic is in Sudan, the rest is in the French-speaking countries of West Africa. Gum Arabic is used in the production of food, pharmaceuticals and cosmetics; it has also seen some use in medicine (Zaied et al., 2007).

Gum Arabic is a branched-chain, complex polysaccharide, either neutral or slightly acidic, found as a mixed calcium, magnesium and potassium salt of a polysaccharidic acid (Arabic acid). The backbone is composed of 1,3-linked b-D-galactopyranosyl units.

The side chains are composed of two to five 1,3-linked b-D-galactopyranosyl units, joined to the main chain by 1,6-linkages. Both the main and the side chains contain units of a-L-arabinofuranosyl, a-L-rhamnopyranosyl, b-D-glucuronopyranosyl and 4-O-methyl-b-D-glucuronopyranosyl, the last two mostly as end units (Buffo et al., 2001; Ali et al., 2009). Gum Arabic was comprised of 39–42% galactose, 24–27% arabinose, 12–16% rhamnose, 15–16% glucuronic acid, 1.5–2.6% protein, 0.22–0.39% nitrogen, and 12.5–16.0% moisture (lslam et al., 1997; Zaied et al., 2007).

The chemical composition of Gum Arabic can vary with its source, the age of the trees from which it was obtained, climatic conditions and soil environment (Ballal et al., 2005). The Ancient Egyptians used gum Arabic as an adhesive when wrapping mummies (Yadav et al., 2007).

4. CONCLUSION

Through previous studies, it is apparent that bodies mummified by the third method were more damaged by bacteria, fungi and insects than others mummified by the second and royal methods. The bodies mummified by the most expensive, royal method were the most protected. This can be explained by the use of plant materials in the second and royal methods.

- Cedar oil was used in the second method. It was injected into the body, and was also used in the ideal method to treat the body cavities after washing by palm wine. It contains essential oil and some essential ingredients (αpinene, myrcene, limonene, terpinolene and α-terpinene), which have a major effect against bacteria, fungi and some insects. This may explain the reason why the mummies were protected.

- **Pine oil** was used in the Third Intermediate and Roman Periods. Some ingredients of the essential oil (β-thujene, α-pinene, β-pinene and bornyl acetate) have antibacterial effects against gram-positive and gram-negative, in addition to antifungal effects.

- **Juniper** was used in the First Intermediate Period and has the same effects as that of conifer oil.

- **Mastic** was used in the New Kingdom, Third Intermediate Period and Ptolemaic Period. Some essential oil ingredients (verbenone, α-terpineol, linalool and pentacyclic triterpenes) have antiseptic and antimicrobial effects.

- **Myrrh** was used in the New Kingdom. Some of its essential oil ingredients (α-pinene, sesquiterpene hydrocarbons, δ-elemene and β-bourbonene, furanosesquiterpenes and germacrene - type compounds) are used to kill and repel pests, and these compounds are effective arthropod repellents.

- **Cassia** was used around 2,600 BC. Some of the essential oil compounds (cinnamaldehyde, linalool, eugenol and 1,8 cineol) have antimicrobial, antiseptic and antifungal effects in addition to a major effect against insects.

- **Onions** were used from the New Kingdom until the Third Intermediate Period. Some of the onion compounds (alliin, γ- glutamlcysteins, steroid, saponins and sapogenins) have antimicrobial effects and have a significant effect against UV light.

- **Lichen** was used in the New Kingdom. Some of its compounds (usnic acid, sphaerophorin, pannarin and paraconic acid) have antibacterial and antifungal effects. Usnic acid enantiomers caused significant antifeedant activity and toxicity towards larva.

- **Henna** was used in the New Kingdom. Some of its compounds (lawsone, 2-hydroxy-1,4 naphthaquinone) have antibacterial effects.

Table 1: Scientific data of mummification materials

No.	Scientific name	Common Name	Major constituents	Essential oil	Effectiveness compound on mummy's body	Effectiveness against biological activity
1A	Pinus sp.	Pine	Monoterpenes (α-pinene, camphene, β-pinene, sabinene, myrcene, D-3-carene, limonene, p-cymene, 1,8-cineole, tricyclene and b-phellandrene) (Räisänen et al., 2009), Δ8 isopimaric acid, abietic acid, and dehydroabietic acid (Keulen, 2009).	B-thujene, α- pinene, β-pinene, bornyl acetate, myrcene, limonene, camphene, tricyclene, α- terpinolene, thymol methyl ether, α-terpineol and phellandrene.	B-thujene, α-pinene, β-pinene, bornyl acetate	Essential oil from pinus sp. has antibacterial effects against gram-positive and gram-negative bacteria in addition to antifungal effects against fungi (Hong et al., 2004).
1B.	Cedrus libani A. Rich subsp. atlantica	Cedar	Essential oil, monoterpenes, sesquiterpenes, atlantol (Li, 2000)	△3-carene, limonene, myrcene, α-pinene, β-pinene, α-pinene, camphene, β-phellandrene, a-thujene, terpinolene, α-terpinene, γ-terpinene, p-cymene, and ocimene (Geron et al., 2000)	α-pinene, β myrcene, limonene, terpinolene, α-terpinene, γ-terpinene	Cedar oil is used in pet care products to repel fleas and ticks [Craiga et al., 2004].
1C.	Juniperus communis L.	Juniper (Fig. 2)	Resin, pinene, borneol, inositol, juniperin, limo-nene, cymene, terpinene (Fady et al., 2008).	sabinene, α-pinene, β-pinene, myrcene, cineole, γ-terpinene, borneol, β phellan-drene, γ-terpineol and limonene (Ochocka et al., 1997; Milojevi, 2008)	sabinene, α-pinene, β-myrcene, cineole, γ-terpinene, borneol, β-phellan-drene, γ-terpineol and limonene (Adams, 1998)	Essential oils have been reported to possess strong antimicrobial properties and antimicrobial activity against both gram-negative and gram-positive bacteria (Chaves et al., 2008). Essential oils that come from juniper leaf can be used as pesticides (George et al., 2008).
1D.	Pistacia lentiscus var. chia	Mastic gum	triterpenes of the oleanane, euphane and lupine type, alpha tocopherol and polyphenols (Triantafyllou et al., 2007), monoterpenes (α-pinene and β-myrcene).	α -pinene, β-pinene, R-(+)-limonene, β-myrcene, camphene (Fig. 3A) (Mills & White, 1989),verbenone, α-terpineol, linalool and caryophyllene (Daferera et al., 2002).	verbenone, α-terpineol, and linalool (Stern et al., 2003), pentacyclic triterpenes (Fig. 3B) (Assimopoulou et al., 2005).	It is used as an antiseptic (Connan et al., 1999), infection and antimicrobial material (Doi et al., 2009).
1E.	Commip-hora spp.	Myrrh	Gum, acidic polysaccharids, resin (isolinalyl acetate, 3-epi-lupenyl acetate, lupeone, 3-epi-α-amirin, α-amirone, acetyl β-eudesmol and a sesquiterpenod lactone)	heerabolene, eugenol and furanosesquiterpenes (David & Archbold, 2000), α-pinene, dipentene, limonene, cuminaldehyde, cinnamic aldehyde, eugenol, m-cresol, heerabolene (probably tricyclic sesquiterpene), cadinene (?), a sesquiterpene (?), a bicyclic sesquiterpene ($C_{15}H_{24}$), a tricyclic sesquiterpene ($C_{15}H_{24}$), formic acid, acetic	α-pinene, -sesquiterpene hydrocarbons (δ-elemene and β-bourbonene), furanosesquiterpenes, and germacrene-type compounds (predominantly (+) - germacrene-D)(Dekebo et	C. myrrha is used to kill and repel tick pests, and it is effective as an arthropod repellent, e.g., germacrene-D has been shown to be an effective aphid repellent. C. myrrha has been used for its antiseptic properties (Tipton, 2006).

				acid, myrrholic acid ($C_{16}H_{21}O_3.COOH$) and palmitic acid.	al., 2002; Birkett et al., 2008).	
1F.	Cinnamomum cassia)	Cassia	Camphor, camphene, dipentene, limonene, phyllandrene, pinene, monoterpenoids, sesquiterpenoids, diterpenoids, sterols, cinnamaldehyde (Liao et al., 2009)	A-pinene, camphene, β-myrcene, camphor, α-terpineol, linalool, (+)-limonene, linalool (Cheng et al., 2009), cinnamaldehyde, linalool, eugenol and 1,8 cineol.	Cinnamalde-hyde, linalool, eugenol and 1,8 cineol (Tzortzakis, 2009)	Antimicrobial (Cheng et al., 2009), antiseptic and fungicide. Pharmacological investigations showed that the crude extract or compounds isolated from this species possesses a wide variety of uses, including insecticidal (Duke et al., 2002).
1G.	Allium cepa L.	Onion (Figs 4 and 5 A, B)	Thiamin, riboflavin, beta-carotene, ascorbic acid, sterols, alliin, allicin, quercetin (the most abundant flavonols), caffeic acid, linoleic acid (Caridi et al., 2007).	dipropyl disulphide, methylaliin, cycloalliin, dihydroalliin, dipropyl trisulphide.	alliin, γ glutamylcysteins (ACSOs), certain steroid saponins and sapogenins, such as β-chlorogenin	Possesses many biological activities, including antimicrobial and antioxidant (Corzo-Martınez et al., 2007), against UV light and pathogens (David & Archbold, 2000). An Egyptian medical papyrus reports several therapeutic formulas based on onions as a useful remedy against worms (Lanzotti, 2006).
1H.	Peltigera canina L.	Lichen (Fig. 6A)	Usnic acid, thamnolic, nostolide I and II		Usnic acid (Fig. 6B) -sphaerophorin (depside) and pannarin (depsidone) (Fig. 7A) - paraconic acids (Fig. 7B) (Horhant et al., 2007). - Xanthones (Peres et al., 2000).	It is used against infections, and it is used as antibacterial and antifungal (Russo et al., 2008), in addition to antigrowth agents. Usnic acid enantiomers caused significant antifeedant activity and toxicity towards larvae of the herbivorous insect (Ingólfsdóttir, 2002), its antiproliferative action was shown in a variety of biological systems (Campanella et al., 2002). Xanthones possess antifungal and antibacterial activity (Cordeiro et al., 2008).
1I.	Lawsonia inermis L.	Henna	mannite, tannic acid, mucilage gallic acid, and 2-hydroxynapthoquinone (lawsone).		lawsone, 2-hydroxy-1,4-naphthaquinone (Ali et al., 2009; Jallad & Espada-Jallad, 2008)	It is used as an antibacterial material [Brier, 1994; Kazandjieva et al., 2007).

REFERENCES

Abdel-Maksoud, G.M.M., (2001) Conservation of Egyptian Mummies, Part I: Experimental Study on the Ancient Egyptian technique of Mummification, *Mummy Result of Interdisciplinary Examination of the Egyptian Mummies of Aset-iri-khet-es from the Archaeological Museum in Cracow*, Cracow, Poland, 225-234.

Adams, R.P., (1998) The leaf essential Oils and Chemotaxonomy of Juniperus Sect. Juniperus, *Biochemical Systematics and ecology* 26, 637-645.

Ali, B.H., Ziada, A., Blunden, G., (2009) Biological effects of gum arabic: A review of some recent research, *Food and Chemical Toxicology* 47, 1–8.

Ali, S., Hussain, T., and Nawaz, R., (2009) Optimization of Alkaline Extraction of Natural Dye from Henna Leaves, and its Dyeing on Cotton by Exhaust Method, *Journal of Cleaner Production* 17, 61-66.

Amoros, V.A., Vozenin-Serra, C., (1998) New Evidence for the Use of Cedar Sawdust for Embalming by Ancient Egyptians, *The Journal of Egyptian Archaeology* 84 (1998), 228-231.

Andrews, C., (1894) *Egyptian Mummies, The Trustees of the British Museum, Atlas of Ancient Egypt*, London, 31.

Arya, A., Shah, A.R., Sadasivan S., (2001) Indoor aeromycoflora of Baroda museum and deterioration of Egyptian mummy, *Current Science* 81 (7), 793-799.

Assimopoulou, A.N, Zlatanos, S.N. and Papageorgiou, V.P., (2005) Antioxidant Activity of Natural Resins and Bioactive Triterpenes in Oil Substrates, *Food Chemistry* 92, 721-727.

Ateş, D. A. and Erdoğrul, Z.T., (2003) Antimicrobial Activities of Various Medicinal and Commercial Plant Extracts, *Turk J Biol* 27, 159.

Aufderheide, A.C., (2003) *The Scientific Study of Mummies*, London, 255.

Avijit, H., (2002) Correspondence: Adverse Reactions to Henna, Indian *Journal of Pharmacology* 34 (6), 436-437.

Ballal, M.E., El Siddig, E.A., Elfadl, M.A., Luukkanen, O., (2005) Relationship between environmental factors, tapping dates, tapping intensity and gum Arabic yield of an Acacia senegal plantation in western Sudan, *Journal of Arid Environments* 63, 379–389.

Baumann, B.B. (Jan. - Mar., 1960), The Botanical Aspects of Ancient Egyptian Embalming and Burial, *Economic Botany* 14 (1), 84-104.

Birkett, M.A., Al Abassi, S., Kröber, T., Chamberlain, K., Hooper, A.M., Guerin, P.M., Pettersson, J., Slade, J.A.P.R., and Wadhams, L.J., (2008) Antiectoparasitic Activity of the Gum Resin, Gum Haggar, from the East African plant, *Commiphora holtziana, Phytochemistry* 69, 1710-1715.

Botros, S., William, S., Ebeid, F., Cioli, D., Katz, N., Day, T.A., Bennett, J.L., (2004) Lack of Evidence for an Antischistosomal Activity of Myrrh in Expremintal Animals, *Am. J. Trop. Med. Hyg.* 71 (2), 206-210.

Brier, B., (1994) Egyptian Mummies Unraveling the Secrets of Ancient Art, New York, 200.

Brussell, D. E., (winter, 2004) Medicinal Plants of Mt. Pelion, Greece, *Economic Botany* 58, Supplement, 174-202.

Buckley, S.A., and Evershed, R.P., (2001) Organic chemistry of embalming agents in Pharaonic and Graeco-Roman mummies, *Nature* 413, 837-841.

Buffo, R.A., Reineccius, G.A., Oehlert, G.W., (2001) Factors affecting the emulsifying and rheological properties of gum acacia in beverage emulsions, *Food Hydrocolloids* 15, 53-66.

Campanella, L., Delfini, M., Ercole, P., Iacoangeli, A., and Risuleo, G., (2002) Molecular Characterization and Action of Usnic Acid: a Drug that Inhibits Proliferation of Mouse Polyomavirus in Vitro and Whose Main Target is RNA Transcription, *Biochimie* 84, 329-334.

Caridi, D., Trenerry, V.C., Rochfort, S., Duong, S., Laugher, D. and Jones, R., (2007) Analytical, Nutritional and Clinical Methods. Profiling and Quantifying Quercetin Glucosides in

Onion (Allium cepa L.) Varieties Using Capillary Zone Electrophoresis and High Performance Liquid Chromatography, *Food Chemistry* 105, 691-699.

Charrié-Duhaut, A., Connan, J., Rouquette, N., Adam, Pi., Barbotin, Chr., Rozières, M., Tchapla, A., Albrecht, P., (2007) The canopic jars of Rameses II: real use revealed by molecular study of organic residues, *Journal of Archaeological Science* 34, 957-967.

Chaves, A.V., Stanford, K., Dugan, M.E.R., Gibson, L.L., McAllister, T.A., Van Herk, F. and Benchaar, C., (2008) Effects of Cinnamaldehyde, Garlic and Juniper Berry Essential Oils on Rumen Fermentation, Blood Metabolites, Growth Performance, and Carcass Characteristics of Growing Lambs, *Livestock Science* 117, 215-224.

Cheng, S., Liu, J., Huang, C., Hsui, Y., Chen, W. and Chang, S., (2009) Insecticidal Activities of Leaf Essential Oils from Cinnamomum Osmophloeum Against Three Mosquito Species, *Bioresource Technology* 100, 457-464.

Chiej, R., (1988) The *Macdonald Encyclopedia of Medicinal Plants*, Macdonald & Co (Publishers) Ltd, 164.

Cockburn, A., Peck, W.H., Barraco, R.A., Reyman, T.A., (1980) A classic mumy: PUMII, *Mummies, disease, and ancient cultures*, Aidan and Cockburn, E. (Eds.), Cambridge University Press, London, 52-70.

Colombini, M.P., Modugno, Fr., Silvano, Fl., and Onor, M., (2000) Characterization of the Balm of an Egyptian Mummy from the Seventh Century B.C., *Studies in Conservation* 45 (1), 19-29.

Colombini, M.P., Modugno, Fr., Silvano, Fl., Onor, M., (2000) Charactrization of the Balm of an Egyptian Mummy from the Seventh Century B.C., *Studies in Conservation* 45 (1), 19-29.

Connan, J., (1999) Use and trade of bitumen in antiquity and prehistory: molecular archaeology reveals secrets of past civilizations, *Phil.Trans. R. Soc. Lond. B* 354, 33-50.

Connan, J., Evershed, R.P., Biek, L., Eglinton, G., (Jan. 29, 1999) Use and Trade of Bitumen in Antiquity and Prehistory: Molecular Archaeology Reveals Secrets of Past Civilizations [and Discussion], *Biological Sciences*, Vol. 354, No. 1379, Molecular Information and Prehistory, 33-50.

Cordeiro, L.M.C., de Oliveirab, S.M., Buchi, D.F., and Iacomini, M., (2008) Galactofuranose-rich Heteropolysaccharide from Trebouxia sp., Photobiont of the Lichen Ramalina Gracilis and its Effect on Macrophage Activation, *International Journal of Biological Macromolecules* 42, 436-440.

Cordeiro, L.M.C., De Oliveirab, S.M., Buchi, D.F., Iacomini, M., (2008) Galactofuranose-rich Heteropolysaccharide from Trebouxia sp., Photobiont of the Lichen Ramalina Gracilis and its Effect on Macrophage Activation, *International Journal of Biological Macromolecules* 42, 436-440.

Corzo-Martınez, M., Corzo, N., and Villamiel, M., (2007) Biological properties of onions and garlic, *Trends in Food Science and Technology* 18, 609-625.

Cosmacini, P., Piacentini, P., (2008) Notes on the history of the radiological study of Egyptian mummies: from X-rays to new imaging techniques, *La Radiologia Medica* 113, 615–626.

Craiga, A.M., Karchesy, J.J., Blythe, L.L. and Del Pilar, M., (2004) Toxicity Studies on Western Juniper Oil (Juniperus occidentalis) and Port-Orford-Cedar Oil (Chamaecyparis lawsoniana), Extracts Utilizing Local Lymph Node and Acute Dermal Irritation Assays, *Toxicology Letters* 154 (2004) 217-224.

D'Auria, S., (1988) Mummification in Ancient Egypt, *Mummies and Magic: The Funerary Arts of Ancient Egypt*, D'Auria, S., Lacovara, P., Roehrig, C. (Eds.), Boston, 16.

Daferera, D., Pappas, C., Tarantilis, P.A. and Polissiou, M., (2002) Analytical, Nutritional and Clinical Methods Section Quantitative Analysis of α-Pinene and β-Myrcene in Mastic Gum Oil Using FT-Raman Spectroscopy, *Food Chemistry* 77, 511-515.

David, A.R., (1990) The History of Mummification, *The Mummy's Tale*, A.R. David, A.R., Tapp, E. (Eds.), London, 37-46

David, A.R., (2001) Mummification, *The Oxford Encyclopedia of Ancient Egypt*, Vol. 2, Redford, D.B. (Ed.), Cairo, 439-444.

David, R., (1978) The fauna, *Mysteries of the Mummies. The Story of the Manchester University Investigations*, David, A.R. (Ed.), London, 160–167.

David, R., Archbold, R., (2000) *Conservation with Mummies. New Light on the Lives of Ancient Egyptians*, Hardcover, 65-87

Davies, E., (2011) Mummified remains from Egypt and beyond hold chemical information about the Daily lives of ancient civilizations, Chemistry World, chemistryworld.org.

Dekebo, A., Dagne, E. and Sterner, O., (2002) Furanosesquiterpenes from Commiphora sphaerocarpa and Related Adulterants of True Myrrh, *Fitoterapia* 73, 48-55.

Doi, K., Wei, M., Kitano, M., Uematsu, N., Inoue, M. and Wanibuchi, H., (2009) Enhancement of Preneoplastic Lesion Yield by Chios Mastic Gum in a Rat Liver Medium-Term Carcinogenesis Bioassay, *Toxicology and Applied Pharmacology* 234, 135-142.

Duke, J.A., Bogenschutz-Godwin, M.J., Cellier, J. and Duke, P.K., (2002) *Handbook of Medicinal Herbs*, 2nd edition, Boca Raton, London, New York and Washington, 527.

Dunand, F., Lichterberg, R., (2006), *Mummies and Death in Egypt*, trans. David Lorton (Ithaca: Cornell University Press, P. 26.

Edwards, H.G.M., Currie, K.J., Ali, H.R.H., Villar, S.E.J., David, A.R., Denton, J., (2007) Raman spectroscopy of natron: shedding light on ancient Egyptian mummification, *Anal Bioanal Chem* 388, 683–689.

Edwards, H.G.M., Newton, E.M., and Wynn-Williams, D.D., (2003) Molecular structural studies of lichen substances II: atranorin, gyrophoric acid, fumarprotocetraric acid, rhizocarpic acid, calycin, pulvinic dilactone and usnic acid, *Journal of Molecular Structure* 651–653, 27-37.

Fady, B., Lefèvre, F., Vendramin, G.G., Ambert, A., Régnier, C., Bariteau, M., (2008) Genetic Consequences of Past Climate and Human Impact on Eastern Mediterranean Cedrus libani Forests. Implications for their Conservation, *Conserv Genet* 9, 85-95.

George, D.R., Smith, T.J., Sparagano, O.A.E. and Guy, J.H., (2008) The Influence of 'Time since Last Blood Meal' on the Toxicity of Essential Oils to the Poultry Red Mite (Dermanyssus gallinae), *Veterinary Parasitology* 155, 333–335.

Geron, C., Rasmussen, R., Arnts, R.R. and Guenther, A., (2000) A Review and Synthesis of Monoterpene Speciation from Forests in the United States, *Atmospheric Environment* 34, 1761-1781.

Goffer, Z., (2007) *Archaeological Chemistry*, Second edition, John Wiley & Sons, Inc., Canda, 317-318.

Hagan, A., (July, 2004) lichens on Woody Shrubs and Trees, Extension Plant Pathologist, *ANR* 857, www.aces.edu.

Hamilton-Paterson, J., Andrews, C., (1978) *Mummies (Death and Life in Ancient Egypt)*, London.

Hamm, S., Lesellier, E., Bleton, J., and Tchapla, A., (2003) Optimization of headspace solid phase microextraction for gas chromatography/mass spectrometry analysis of widely different volatility and polarity terpenoids in olibanum, *Journal of Chromatography A* 1018, 73–83.

Hammond, Ph.C., (May, 1959) The Nabataean Bitumen Industry at the Dead Sea, *The Biblical Archaeologist* 22/ 2, 40-48.

Harrell, J.A., (2002) Archaeological Geology in Egypt: Ancient Oil Wells and Mummy Bitumen, Earliest Geological Map, First Paved Road, Pyramid Temple Pavements, and the Sphinx Age Controversy, Northern California Geological Society, *NCGS Newsletter*.

Hernandez, M., The History and Trade of Cinnamon Spice Trade World History, http://www.cinnamoncassia.com/

Hong, E., Na, K., Choi, I., Choi, K. and Jeung, E., (2004) Antibacterial and Antifungal Effects of Essential Oils from Coniferous Trees, *Biol. Pharm. Bull.* 27(6), 863-866.

Horhant, D., Lamer, A.C., Boustie, J., Uriac, P., and Gouault, N., (2007) Separation of a Mixture of Paraconic Acids from Cetraria Islandica (L.) Ach. Employing a Fluorous Tag-catch and Release Strategy, *Tetrahedron Letters* 48, 6031-6033.

Hossain, M.E., Ketata, Ch., Mann, H., Islam, M.R., (2009) SEM-Based Structural and Chemical Analysis of Paraffin Wax and Beeswax for Petroleum Application, *JCDNM*, Vol. 1, Issue 1, 21-38.

Hussein, M.A.M., Hassan, M.H.A., Allam, A.D.A., Abo-Elyousr, K.A.M., (2007) Management of Stemphylium Blight of Onion by using Biological Agents and Resistance Inducers, *Egypt. J. Phytopathol* 35 (1), 49.

Ikram, S., Dodson A., (1998) *The mummy in ancient Egypt (equipping the dead for enterity)*, Cairo.

Ingólfsdóttir, K., (2002) Molecules of Interest Usnic Acid, *Phytochemistry* 61,729-736.

Iskander, Z., (1980) Mummification in Ancient Egypt: Development, History, and Technique, *An X Ray Atlas of the Royal Mummies*, Harries, J.E., Wente, E.F. (Eds.), Chicago and London, 6.

Iskander, Z., Shahin, A.E, (1973) Temporary stuffing materials used in the process of mummification in ancient Egypt, *Annales du Service des Antiquités de l' Égypte* 61, 65-78.

Jallad, K.N., and Espada-Jallad, C., (2008) Lead Exposure from the Use of Lawsonia inermis (Henna) in Temporary Paint-on-Tattooing and Hair Dying, *Science of the Total Environment* 397, 244-250.

Jansen, R.J., Poulus, M., Taconis, W., Stoker, J., (2002) High-resolution spiral computed tomography with multiplanar reformatting, 3D surface- and volume rendering: a non-destructive method to visualize ancient Egyptian mummification techniques, *Computerized Medical Imaging and Graphics* 26, 211-216.

Kazandjieva, J., Grozdev, I., and Tsankov, N., (2007) Temporary Henna Tattoos, *Clinics in Dermatology* 25, 383–387.

Kłys, M., Lech, T., Zie¸ba-Palus. J., Białka, J., (1999) A chemical and physicochemical study of an egyptian mummy 'Iset Iri Hetes' from the Ptolemaic period III–I B.C., *Forensic Science International* 99, 217–228.

Knight, Sh. C., (Spring 2009) Egyptian Funerary Practices, 2.

Koller, J., Baumer, U., Kaup, Y., Schmid, M., Weser, U., (2003) Effective Mummification Compounds Used in Pharaonic Egypt: Reactivity on Bone Alkaline Phosphatase, *Z. Naturforsch*. 58b, 462-480.

Lanzotti, V., (2006) The Analysis of Onion and Garlic, *Journal of Chromatography A* 1112, 3-22.

Lauer, J.P., Iskender, Z., (1955) Dannées nouvelles.sur la momification dans l' Égypte ancienne, *Annales du Service des Antiquités de l' Égypte* 53, 167-194.

Leclercq, B., Beeswax from Beekeeping website: http://www.beekeeping.com/leclercq/wax.htm.

Leek, F., (1969) The problem of brain removal during embalming by the ancient Egyptians, *The Journal of Egyptian Archaeology* 55, 112-116.

Li, T.S.C., (2000) *Medicinal Plants. Culture, Utilization and Phytopharmacology*, Lancaster, PA, 4-122.

Liao, S., Yuan, T., Zhang, C., Yang, S., Wu, Y., Yue, J., and Cinnacassides, A.E., (2009) Five Geranylphenylacetate Glycosides from Cinnamomum Cassia, *Tetrahedron* 65, 883-887.

Lslam, A.M., Phillipsl, G.O., Sljivo, A., Snowden, M.J. and Williamsl, P.A., (1997) A review of recent developments on the regulatory, structural and functional aspects of gum Arabic, *Food Hydrocolloids* 11(4), 493-505.

Lucas, A., (1914) The Use of Natron by the Ancient Egyptians in Mummification, *The Journal of Egyptian Archaeology* 1, 119-137.

Lucas, A., (May, 1931) "Cedar"-Tree Products Employed in Mummification, *The Journal of Egyptian Archaeology* Vol. 17, No. 1/2, 13-21.

Maurer, J., Möhring, Th., Rullkötter, J., (2002) Plant Lipids and Fossil Hydrocarbons in Embalming Material of Roman Period Mummies from the Dakhleh Oasis, Western Desert, Egypt, *Journal of Archaeological Science* 29, 751–762.

Maurer, J., Möhring, Th., Rullkötter, J., (2002) Plant Lipids and Fossil Hydrocarbons in Embalming Material of Roman Period Mummies from the Dakhleh Oasis,Western Desert, Egypt, *Journal of Archaeological Science* 29, 751–762.

Mills, J.S. and White, R., (1989) The Identity of the Resins from the Late Bronze Age Shipwreck at Ulu Burun (Kas), *Archaeometry* 31, 37–44.

Mills, J.S., White, R., (1989) The Identity of the Resins from the Late Bronze Age Shipwreck at Ulu Burun (Kas), *Archaeometry* 31, 37–44.

Milojevi, S.Z., Stojanovi, T.D. and Pali, R., (2008) Kinetics of Distillation of Essential Oil from Comminuted Ripe Juniper (Juniperus communis L.) Berries, *Biochemical Engineering Journal* 39, 547-553.

Mühlbauer, R.C., Lozano, A., Palacio, S., Reinli, A., and Felix, R., (2003) Common herbs, essential oils, and monoterpenes potently modulate bone metabolism, *Bone* 32, 372-380.

Muhammad, H.S., Muhammad, S., (September, 2005) The use of Lawsonia inermis linn. (henna) in the management of burn wound infections, African Journal of Biotechnology 4 (9), 934-937.

Newman, R., Serpico, M., (2000) *Adhesives and binders, In: P.T. Nicholson, I. Shaw (Eds.), Ancient Egyptian materials and technology*, Cambridge University Press, 480.

Ochocka, J.R., Asztemborska, M., Zook, D.R., Sybilska, D., Perez, G. and Ossicini, L., (March 1997) Enantiomers of Monoterpenic Hydrocarbons in Essential Oils from Juniperus Communis, *Phytochemistry* 44, 869-873.

Paraskevopoulou, A., Tsoukala, A., Kiosseoglou, V., (2009) Monitoring Air/Liquid Partition of Mastic Gum Oil Volatiles in Model Alcoholic Beverage Emulsions: Effect of Emulsion Composition and Oil Droplet Size, *Food Hydrocolloids* 23, 1140-1143.

Peck, W.H., (1980) Mummies of ancient Egypt. In: *Mummies, disease, and ancient cultures*, Cambridge: London, 11-28.

Peres, V., Nagem, T.J., and Faustino de Oliveira, F., (2000) Tetraoxygenated Naturally Occurring Xanthones, *Phytochemistry* 55, 683-710.

Pettirew, Th.J., (1834) History of Egyptian Mummies, London, 1834.

Proefke, M.L., Rinehart, K.L., (1992) Analysis of an Egyptian Mummy Resin by Mass Spectrometry, *American Society for Mass Spectrometry* 3 (5) (1992) 582-589.

Räisänen, T., Ryyppö, A. and Kellomäki, S., (2009) Monoterpene Emission of a Boreal Scots Pine (Pinus sylvestris L.) forest, *Agricultural and forest meteorology* 149, 808-819.

Russo, A., Piovano, M., Lombardo, L., Garbarino, J. and Cardile, V., (2008) Lichen metabolites prevent UV light and nitric oxide-mediated plasmid DNA damage and induce apoptosis in human melanoma cells, *Life Sciences* 83, 468-474.

Salter-Pedersen, E., (2004) *The myth of eternal preservation: patterns of damage in Egyptian mummies*, Master thesis dissertation, the Department of geography and Anthropology, Louisiana.

Sandison, A.T., (1963) The Use of Natron in Mummification in Ancient Egypt, *Journal of Near Eastern Studies* 22, 259-267.

Sandison, A.T., (October, 1957) The Eye in the Egyptian Mummy, *Med Hist*. 1 (4), 336–339.

Serpico, M., White, R., (2000) *Oil, Fat and Wax, In: P.T. Nicholson, I. Shaw (Eds.), Ancient Egyptian materials and technology*, edited by, Cambridge University Press, 421.

Sivrev, D., Miklosova, M., Georgieva, A., Dimitrov, N., (2005) Modern day plastination techniques – successor of ancient embalmment methods, *Trakia Journal of Sciences* 3 (3), 48-51.

Smith, G.E., Dawson, W.R, (1924) *Egyptian Mummies*, London.

Smith, G.E., Dawson, W.R., (1991) *Egyptian Mummies*, London and New York.

Stern, B., Heron, C., and Corr, L., (2003) Compositional Variations in Aged and Heated Pistacia Resin Found in Late Bronze Age Canaanite Amphorae and Bowls from Amarna, Egypt, Archaeometry 45 (3), 457–469.

Stern, B., Heron, C., Corr, L., (2003) Compositional Variations in Aged and Heated Pistacia Resin Found in Late Bronze Age Canaanite Amphorae and Bowls from Amarna, Egypt, *Archaeometry* 45 (3), 457–469.

Taconis, W.K., (2005) Mummification in ancient Egyptian with a history of the investigation of Egyptian Mummies, *Egyptian Mummies. Radiological Atlas of the collections in the national Museum of Antiques art Leiden*, Raven, M.J., Taconis, W.K. (Eds.), Prepols, 35-67.

Taylor, J.H., (1995) *Unwrapping a Mummy 'the life, death and embalming of horemkenesi*, London, 57.

Tipton, D.A., Hamman, N.R. and Dabbous, M.Kh., (2006) Effect of Myrrh Oil on IL-1- Stimulation of NF-_B Activation and PGE2 Production in Human Gingival Wbroblasts and Epithelial Cells, *Toxicology in Vitro* 20, 248-255.

Triantafyllou, A., Chaviaras, N., Sergentanis, T.N., Protopapa, E. and Tsaknis, J., (2007) Chios Mastic Gum Modulates Serum Biochemical Parameters in a Human Population, *Journal of Ethnopharmacology* 111, 43,49.

Tzortzakis, N.G., (2009) Impact of Cinnamon Oil-Enrichment on Microbial Spoilage of Fresh Produce, *Innovative Food Science and Emerging Technologies* 10, 97-102.

van Keulen, H., (2009) Gas Chromatography / Mass Spectrometry Methods Applied for the Analysis of a Round Robin Sample Containing Materials Present in Samples of Works of Art, *International Journal of Mass Spectrometry* 284 , 162–169.

Winlook, H.E., (1930) A Late Dynastic Embalmer's Table, *Annales du Service des Antiquités de l' Égypte* 30, 102-104.

Wisseman, S.U., (1992) Embalming Technique in Roman Egypt: Resin Analysis and Three-Dimensional Computer Imaging of a Mummified Child, *AJA* 96 (2), 335.

Yadav, M.P., Igartuburu, J.M., Yan, Y., Nothnagel, E.A., (2007) Chemical investigation of the structural basis of the emulsifying activity of gum Arabic, *Food Hydrocolloids* 21, 297–308.

Zaied, S.F., Youssef, B.M., Desouky, O., Salah El Dien, M., (2007) Decontamination of gum arabic with g-rays or electron beams and effects of these treatments on the material, *Applied Radiation and Isotopes* 65, 26–31.

Zhang, H., Kong, B., Xiong, Y. L. and Sun, X., (2009) Antimicrobial Activities of Spice Extracts Against Pathogenic and Spoilage Bacteria in Modified Atmosphere Packaged Fresh Pork and Vacuum Packaged Ham Slices Stored at 4℃, *Meat Science* 81, 686-692.