



# Chemical analyses of Egyptian mummification balms and organic residues from storage jars dated from the Old Kingdom to the Copto-Byzantine period



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## ABSTRACT

Twenty three samples of Egyptian organic materials, spanning from the Old Kingdom to the Copto-Byzantine Period, were investigated by gas chromatography-mass spectrometry. The sample set was comprised of ten balm samples from human mummies, three balms from shrews, and ten samples of residues scraped from jars and amphora from storehouses.

This research program was undertaken with two main goals:

Firstly to provide complementary data on the mummification balms from both humans and animals with an emphasis on the occurrence of bitumen in mummification mixtures.

Secondly to explore whether the jar residues were mixtures that were used for mummification purposes or whether they were pure ingredients stored for various uses including ritual practices.

The analysis highlighted that the most abundant constituents of the mummification balms were: fats or oils, waxes, conifer resin, pitch, mastic resin, castor oil, and bitumen. Balms from animal mummies were not found to be significantly different from the balms from human mummies. Residues from potsherds appeared to belong to two categories: pure products (fats and castor oil) and mixtures containing fats, Pinaceae resin and pitch, mastic resin, and castor oil, i.e. the constituents also identified in mummification balms. The mixtures were thus residues of preparations for ritual practices and embalming.

This study demonstrates that bitumen is underestimated by the chemical approach currently applied in most archaeometric studies of Egyptian organic residues, which are better suited for the identification of lipids and resinous materials. We thus applied a specific analytical design, targeted at bitumen. Bitumen from the Dead Sea was conclusively identified using as reference materials for comparison, i.e. the present day bitumen from the Dead Sea floating blocks, as well as several bitumens from mummification balms and bitumen lumps unearthed from the archaeological site of Tell Yarmouth near Jerusalem in Israel.

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## 1. Introduction

Recent advances in analytical techniques have enabled the chemical composition of various archaeological residues of organic materials from ancient Egypt to be investigated, in order to identify

the ingredients used to prepare human and animal mummies (Brettell et al., 2017; Buckley et al., 2004; Buckley and Evershed, 2001; Colombini et al., 2000; Macke et al., 2002; Ménager et al., 2014, 2013, Perraud, 2012) and to investigate funerary artefacts such as boxes for canopic jars, ushabtis, Osiris statuettes, and coffins (Charrié-Duhaut et al., 2007; Serpico and Raymond, 2001). Even burial food, such as meat and poultry from Pharaonic tombs has been investigated (Clark et al., 2013).

The various recipes used in mummification can be revealed by

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collecting data on the residues of organic materials stored in jars and amphoras. Such residues may be either ingredients stored for the subsequent preparation of mummification balms, or mixtures which were prepared and used for ritual or funerary purposes.

The aim of the study was to provide new data on the chemical composition of various mummification balms ranging from the New Kingdom to the 30<sup>th</sup> dynasty, i.e. between 1550 and 342 BCE, and on several organic residues, scraped from the inside of a stone vase from the Old Kingdom, as well as from potsherds of jars and amphora covering the time range from the New Kingdom (1552–1069 BCE) to the Copto-Byzantine period (395–645 AD).

The molecular profile of the balms was determined by gas chromatography-mass spectrometry (GC-MS). We adopted two different sample pre-treatments. The first is commonly used for characterising lipids and resinous materials in mummification balms, and is based on saponification, the extraction of neutral and acidic fractions, and derivatisation before injection in the GC-MS (Lucejko et al., 2012). For some samples, we also adopted a specific analytical procedure designed for the analysis of petroleum and rock extracts and for the identification of bitumen (Connan, 2012; Connan and Dessort, 1991).

The aim of the work was also to attempt to answer the question raised by the organic residues stuck on various potsherds from the various containers was: were they examples of the storage of pure organic materials (foodstuff? ingredients for special uses?) or mixtures of several natural products prepared for a specific purpose, for instance for embalming practices?

## 2. Experimental

### 2.1. Samples

The samples are described in Table 1 and are subdivided into three classes:

- 1- Samples from the embalming of human mummies. Ten samples were collected from various parts of the mummies (skull, chest, shroud) with an emphasis on samples inside the skull (Fig. 1). One sample came from a Duamoutef canopic jar and was associated with embalmed viscera. The dates of the mummies spanned from the New Kingdom (1550–1070 BCE)

**Table 1**  
Information on the analyzed samples.

Sample number	Sample	Dynasty	Date range	Area	Context
1896	Balm of human mummy collected along the thoracic vertebra, on the right side of a man wrapped in bandages	New Kingdom	1550–1070 BCE	Thebes	Burial vault
2504	Red balm at the level of the neck, probably originally in the mouth. It was also located on the palate	XXIe or XXIIe	1069–945 or 945–715 BCE	Thebes	Tomb excavation
2759	Balm from human mummy	XXI–XXIIe	1069–715 BCE	Thebes	Tomb excavation
2678	Balm from a canopic jar with a jackal head (Duamoutef) containing remains of viscera wrapped in linen soaked with “black resin”	XXIIe	945–715 BCE	Thebes	Burial vault
2679	Balm stuck to the linen of the shroud. Black balm smeared over the shroud to ensure adhesion	XXIIe	945–715 BCE	Thebes	Tomb excavation near surface
2680	Balm in the mouth. Red balm filling the mouth, pressed against the tongue,	XXIIe	945–715 BCE	Thebes	Tomb excavation near surface
2681	retracted into the back of the mouth				
2681	Balm from the thoracic cavity. The bottom of the left chest cavity is lined with a black balm, poured hot when embalming and forming a horizontal surface	XXIIe	945–715 BCE	Thebes	tomb excavation near surface
2770	Balm from human mummy originating from the excerebration hole in the skull	XXIIe	945–715 BCE	Thebes	Tomb excavation
2771	Balm in the skull (sag in the skull that runs from front to back)	XXIIe	945–715 BCE	Thebes	Tomb excavation
2774	Balm collected deep inside the pharynx, which is completely obstructed by the black material	XXIIe	945–715 BCE	Thebes	Tomb excavation
2702	Balm from a mummified shrew	XXXe	380–342 BCE	Giza	Necropolis excavation
2703	Balm from a mummified shrew	XXXe	380–342 BCE	Giza	Necropolis excavation
2704	Balm on linens from a shrew	XXXe	380–342 BCE	Giza	Necropolis excavation
1811	Deposit in a stone vase discovered in a pit	Old Kingdom	2686–2181 BCE	Saqqarah	Pit excavation
2785	Yellow powder with mineral grains	New Kingdom	1552–1069 BCE	Thebes	Temple storehouse
2795	Deposit scraped from a potsherd	New Kingdom	1552–1069 BCE	Thebes	Temple storehouse
2775	Reddish amorphous material scraped from a potsherd	XIX–XXe (Ramesid period)	1296–1069 BCE	Thebes	Temple storehouse
2776	Amorphous material scraped from a potsherd	XIX–XXe (Ramesid period)	1296–1069 BCE	Thebes	Temple storehouse
2779	Amorphous material on a jar handle	XIX–XXe (Ramesid period)	1296–1069 BCE	Thebes	Temple storehouse
2783	Gray flakes scraped from a potsherd	XIX–XXe (Ramesid period)	1296–1069 BCE	Thebes	Temple storehouse
2786	Yellow/Orange amorphous material scraped from a potsherd	Copto-Byzantine period	395–645 AD	Thebes	Temple storehouse
2790	Deposit scraped from the bottom of an amphora	Copto-Byzantine period	395–645 AD	Thebes	Temple storehouse
2794	Deposit scraped from the bottom of an amphora	Copto-Byzantine period	395–645 AD	Thebes	Temple storehouse

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