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Κόμαρι: SOME HYPOTHESES ON AN ENIGMATIC DYESTUFF DESCRIBED IN CERTAIN RECIPES OF GREEK ALCHEMICAL PAPYRI

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Abstract

In his paper Teinture et Alchimie dans l'Orient Hellénistique (1935), Pfister wrote about κόμαρι, an enigmatic matter that Berthelot transcribed as Arbutus sp. and Lagercrantz associated to Comarus palustre L. In some recipes, the dissolution of κόμαρι is prescribed to obtain a vegetable purple dye described in the Leyden Papyrus X and the Papyrus Graecus Holmiensis as well as in another alchemy recipe, used for dyeing of fabrics, present in Genève 122 Papyrus. We can trace its use in later periods in Syrian alchemy recipes handed down from Antiquity to the Middle Ages. By studying classical sources to obtain knowledge regarding the chemical composition of substances, and by experimentation with recipes, we demonstrate that this enigmatic substance corresponds to the strawberry tree, Arbutus unedo L., its leaves or its bark, as postulated by Berthelot. We discard the hypothesis of association with Comarus palustre L. since it is endemic of the Northern European countries and possibly unknown by the craftsmen who made use of these recipes in 3rd-4th century A.D. Egypt.

1 Introduction

The colour of dress was one of the signals of wealth, hierarchy and identity in ancient cultures. Therefore, the multifaceted study of colour must be considered an indispensable element of the study and conservation of heritage, a legacy that we have the duty to protect.

Purple of marine origin was one of the most important status symbols of aristocracy in antiquity. Despite the fact that its use in Roman times was reserved to the emperor and his family and later to the highest grades of nobility, the taste for luxury goods also entered non-aristocratic Roman society. A rising middle class like *libertos*, some enriching traders and craftsmen, with high ambitions but a mediocre economic situation, liked to decorate their clothing in order to approach the ostentation of aristocracy.[1] It is known that an industry specializing in the manufacture of imitations of luxury items, such as purple dyed fabrics, and designed to meet the needs of the non-aristocratic social groups, developed in Egypt from the Hellenistic period.[2] Purple dyes used for these fabrics were produced from raw materials of low quality and diverse origins. The methods for obtaining some herbal purple dyes were simple and curious.

We normally associate the manufacture of purple colours made from herbal dyes with mixtures of blue and red producing raw materials such as woad (*Isatis tinctoria* L.) and true indigo (*Indigofera tinctoria* L.), and madder (*Rubia tinctorum* L.), respectively. However, the most important written sources on the dyeing industry in Roman Egypt during the 3rd and 4th centuries as the Leyden Papyrus X and the Papyrus *Graecus Holmiensis* do not corroborate this hypothesis.

A large number of recipes of the papyri describe the processes for obtaining purple dyes, covering hues that range from dark bluish red to violet and brown.[3] In-depth analysis of these recipes reveals that the highest quality

dyes such as true indigo or madder are the least prescribed. On the contrary, a large number of enigmatic dyeing substances such as κόμαρι or κομάρεως are mentioned in the recipes. To date, the exact nature of this substance is unclear. It could be the dye called κόμαρι, κομάρεως extracted from the shrub *Arbutus unedo* L. But it may be wondered if κόμαρι is the same as κομάρεως and in how far terminologies varied from one era to another.

In this paper we put forward the hypothesis that κόμαρι or κομάρεως are terms used indistinctly to designate an "enigmatic substance" in recipes of Papyrus *Graecus Holmiensis* and Leyden Papyrus X; that it is both a dye and and a fixative extracted from different parts of *Arbutus unedo* L. and perhaps also from its eastern variety *Arbutus andrachne* L., commonly called Greek strawberry tree. This hypothesis is in disagreement with the proposal of Lagercrantz that the dye was extracted from the root of the herbaceous plant *Comarum palustre* L.[4]

We will underpin our hypothesis with philological and archaeological arguments and by considering the chemical composition and the geographical distribution of plants concerned. Further support for our hypothesis will be sought from laboratory experiments based on the recipes of classical written sources and, later, from the analysis of their results.[I]

2 Historical Background: Classical Written Sources

The dissolution of the raw material known by the Greek term κόμαρι (lat. *comarum*) is prescribed in some ancient recipes. It was used in antiquity for different purposes: to obtain a purple, red or pinkish dyestuff with poor colour fastness; as an organic mordant and a fixative for other colouring raw materials such as anchusa or alkanet; as a mordant for colouring precious stones.

Lagercrantz thought that κόμαρι could refer to the species *Comarum palustre* L. (Fig. 1).[5] This assumption was followed by Lippmann.[6]

Berthelot, however, translates κόμαρι as the fruit of the strawberry tree, *Arbutus unedo* L. (Fig. 2).[7] Pfister calls κόμαρι: *une autre matière énigmatique*. He also comments on Bertehlot's translation of the term in Papyrus *Graecus Holmiensis* recipe I, for obtaining a purple dye from the fruit of the strawberry tree, with these words: *est loin d´être satisfaisante, mais le Comarum de Lagercrantz l'est encore moins*.[3]

In his edition of the Papyrus *Graecus Holmiensis*, Reinking assumes that κόμαρι may refer to the red fruit of the strawberry tree for this berry, like elderberries or blueberries, is capable of giving a red juice.[8] Halleux identifies κόμαρι with 'comaris' and he presents the interpretations of the Greek term by different authors in his lexicon.[6] In his study of the Leyden Papyrus X, Caffaro says: *la comaris é un colorante, forse da ricondurre alla specie arborea dell' Arbutus unedo* L.[9] We find this raw material again in the commentaries on the Geneva Papyrus III.[II] In this papyrus, we read that milk is used to dissolve a red dye similar to κόμαρι, which Schubert, like Lagercrantz and Lippmann, interprets as coming from the roots or flowers of *Comarum palustre* L.[10]

We also know of a rather unclear recipe with *comaris* (κομάρεως) that appears in the *Greek Alchemists Collection* at the Technical Treatise V, XII, a treatise of unknown origin and uncertain dating.[10]

> Πόσος ὁ τῶν βαπτομένον ἐρίων.
> [Aus Alchimist grecs. Traités techniques V. 12 (K. Reinking, 1938, p. 59)]
>
> Σταθμὸς ὠφειλέν, καὶ πόσος ὁ τῆς κομάρεως I), καὶ πόσος ὁ τῶν βεβαμμένων ὑδάτων. χρὴ μὲν τοὶ διπλάσιον εἶναι τὸν σταθμὸν τῶν ὑδάτων τοῦ σταθμμοῦ τῶν ἐρίων. ἡ δὲ μςᾶ τῶν βεβαμμένων ὑδάτων δέχεται κομάρεως (…)..
>
> Quelle est la proportion avantageuse des laines teintes?
> [Traités Techniques V. XII (K. Reinking, 1938, p. 59)]
>
> Quelle est celle de la comaris I), et celle des eaux tinctoriales? Il faut que la proportion des eaux soit double de celle des laines. Or la mine (poids) d'eaux tinctorials admet 32° partie de comaris I), pur que la matière teint soit en rapport convenable(...).

When accepting equivalence of the Greek term κόμαρι with κομάρεως, lat. *comaris*, as stated by Halleux, then for other texts of Greek Alchemy this issue gets complicated. In these texts, the term *comaris* can be interpreted as designating a liquor that is used for staining

Figure 1: Detail of the flower of the herbaceous plant *Comarum palustre* L.

Figure 2: Detail of the flower of *Arbutus unedo* L., strawberry tree (Photo: J. Martínez).

stones to imitate the colours of some red or purple precious stones.[6,11]

However, Maria the Jewess speaks about the dissolution of "*Comaris* (κομάρεως) and *chelidonium*" for producing divine water.[12] Sophe the Egyptian says:[13]

> Les teintures parfaites, comuniquen le vraie coleur du soleil, (...) et, l'unique qui transmeta la teinture, la comaris scythique, la teinture perfait (...) celle d'Isis, celle que proclame Heron (...).

When Democritus cites *comaris*, he makes the following statement:[14]

> Délayer ensemble l'afrosélinonIII et la comaris, mélanger, fixer, teindre et amollir.

Should we understand that the term *comaris* in these texts is used as a synonym of a fixing solution for dyes, in line with a prescription in P. Leid. X, recipe 89,[15] (Caley) as a drug for fixing the anchusa dyestuff:

> The Fixation of Alkanel
> [E. R. Caley, 1927, p. 1161]
>
> Urine of sheep, or arbute-berry, or henbane in the same manner.

From Technical Treatise V, XIV entitled: *Composition of comaris*,

> Τις η της κομαρευς σινθεσις
> [M. Berthelot (1967), Text Greek V, XIV, p. 374]
>
> 'Η χράσις τοῦ φαρμάχου σύνθεσιν ἔχει ἀτὸ στερεοῦ σώματος χαὶ
>
> ύγροῦ · τῆ γ° τοῦ στερεοῦ χομάρεως ὕδατος μιγνυμένης

Berthelot translates:[16]

> Le mélange de la préparation est composé avec un corps solide et un liquide; une once de comaris solide étant mélange avec l'eau.

In the alchemical recipes of the Treatises on Syriac Alchemy, XIII, we can read that, once prepared under certain conditions, *comaris* was similar to mercury. Berthelot's translation of recipe XIII, 2, mentions *comaris* as follows:

> Dissolution de la comaris qui est appelée perle (? m g i n i) et qui n'a étè connue (?) de personne...(préparation en partie effacée)[17]

Recipe XIII, 3, prescribes a way to dissolve *comaris*, which is almost identical to the processes described in Papyrus *Graecus Holmiensis*, recipe 97.

> Dissolution de la comaris:[18]
> [M. Berthelot, 1967, Alchemic recipe XIII, 3, p. 329]
>
> "Prends de la lie (?) et mets-la dans une vase, avec autant d'eau qu'il faut. Ensuite projette de la chaux, deux parties; et fais cuire jusqu'à ce que ces deux ingrédients se mêlent en se dissolvent..."
>
> Dilution de la comaris:[19]
> [R. Halleux, 1981, P. Holm. 97, p. 134]
>
> Diluer la comaris. Broyez de la lie dans l'eau, versez dans un petit pot, remuez. Transvasez alors dans un autre récipient l'eau qui s'est déposée et jetez-y la comaris broyée, agitez, filtrez immédiatement. Ensuite, laissez reposer jusqu'au lendemain et vous trouverez de la pourpre.

Recipe XIII, 8 indicates that this substance *comaris* is called λάχχοζ, that is: "red hole or pit", because the colour of its solutions looks like the water contained in a cistern (Fig. 3). [20]

Figure 3: Extracts of *comaris* (*Arbutus unedo* L.) with tartrates: 1: Liquid from the filtrate of *comaris* fruit paste with tartrates after 24 h of deposition; 2: Liquid from the filtrate of *comaris* leaves, branches and bark mixture with tartrates after 24 h of deposition; 3: Solution 1 after two days of deposition; 4: Liquid from the filtrate of *comaris* leaves, branches and bark mixture with pig manure and children's urine (P. Holm. 149) after 24 h of deposition; 5: Solution 1 after three days of deposition; 6: Liquid from the filtrate of *comaris* leaf alone with tartrates after 24 h of deposition.

3 Philological and Botanical Observations

3.1 Philology

In the Greek-English Lexicon,[21] κόμαρι is defined as follows: *red dye obtained from the root of Comarum palustre* L. We question this definition. Indeed, a substance designated by the term κόμαρόν, τό is prescribed in Papyrus *Graecus Holmiensis* 25.15. and in recipe 9B of *Anonymous Alchemists*.[22] In Ancient Greek, the noun κόμαρόν -ου τό, is used for the fruit of the strawberry tree, *Arbutus unedo* L.[23] κόμαρόν then corresponds to the Latin form - *um* (*comarum*). Pliny states: *the Greeks give it (the fruit) the two names: comaron and memecylon*. [24]

> Aliud corpus est terrestribus fragis,
> Aliud congeneri eorum unedoni:
> (...)Pomum in honorum,
> ut cui nomen ex argument fit,
> unum tantum edendi.
> Duobus tamen hoc
> nominibus appellant Graeci,
> comaron et memecylon:
> quo apparet totidem esse genera.
> Et apud nos alio nomine arbutus vocatur.
> Juba auctor est,
> quinquagenum cubitorum
> altitudine in Arabia esse eas.

As a general rule, the ancient Greeks considered fruits as products, and for that reason they are designated by neutral nouns, e.g. κόμαρόν. Consequently, philologically speaking, the red colouring matter, which the papyri mention, could be a substance extracted from the fruit of the strawberry tree through dissolution.

The singular genitive has the ending *-ou*, in Latin *-i*. For example, Papyrus *Graecus Holmiensis*, recipe 149 is entitled Κομάρου ἄνεσις,

> Κομάρου ἄνεσις. |
> [P. Holm. 149 (R. Halleux, 1981, p.148]
>
> Λα[β]ὼν κόπρον χοιρείαν ἐχυδάρωσον […] | ἀφθόρου καὶ ἀνάζεσον καὶ ἀποσείρωσον | κατὰ […] κομάρου.

which could be translated as *Dissolving of Comarum*:

> Dissolving of Comarum:
> [E. R. Caley, 1927, p. 998]
>
> Take and soak pig manure with the urine of an uncomipted youth. Boil up these and pour it off on the comarum.[25]

Philologically, *comaris* may also refer to the strawberry tree itself for which the Greek language used the feminine noun κόμαροσ-ου. The Greek term κόμαρος is already found in Theophrastus I, 5, 2; III, 16, 4;[26] Ἡ δὲ κόμαρος ἡ τὸ μεμαίκυλον φέρουσα τὸ ἐδώδιμόν ἐστι μὲν οὐκ ἄγαν μέγα (...), in Dioscorides I, 122;[27] κόμαρος δένδρον ἐστὶ παρόμοιν κυδωνία, λεπτόφλοιον, καρπόν ἔχον ὡς κοκκυμήλου (...) and in Galeno, II XII, 38[28] *Omnibus hominibus mos est eas plantas vocare agrestes , quae fine ulla agricolae industria agro proveniunt. (...) Ex quo plantare genere est fagus, quercus, ilex cornus**, comarus**,(...)Apellatur autem is fructus en Italia unedo (...) &* μεμηκύλοις *(sic autem **comari** fructus apellatur)*. Papyrus *Graecus Holmiensis*, recipe 97 begins with Κόμμαρι ἀνιέναι (dilute *comari*).

> Κομμάρεως ἄνεσις
> [P. Holm. 97 (R. Halleux, 1981, p. 134)]
>
> Κόμμαρι ἀνιέναι. φαίκλαν τρίψας ὕ[δα]τι βάλε εἰς | βησσίον καὶ ἀνακίνει καὶ τὸ καθεσταμένον ὕδω[ρ] || 655
>
> μετέρασον εἰς ἕτερον ἀγγεῖον καὶ βὰλε εἰς αὐτὸ | τετριμμένον τὸ κόμμαρι καὶ ἀςακίνει καὶ | ἐξεράσει πάραυτα.[25]
>
> The Dissolving of Comarum:
> [E. R. Caley, 1927, p. 991]
>
> To dissolve comarum. Grind tartar with water, put it in a small dish and stir it. tour the clear water in another vessel, put ground comarum in it, stir it and it will give up its colour at once. Then let it clarify until the following day and you will find purple

In this case, one could think κόμαρι refers to the leaves or bark of the shrub. Indeed, the use of the Greek term κόμαρι in some recipes often proceed from loans of other languages, from Mediterranean origin words, or from local dialects of traditional use by the scribe. The archaic Greek ending in –i is common in nouns that designate plant or mineral matters or agents. Some parallels would be: πέπερι (pepper), κομμι (rubber) y κιννάβαρι (cinnabar).[29]

Comarum palustre L. or *Potentilla palustris* L, commonly known as purple marshlocks, purple cinquefoil or swamp *potentilla*, is native to Northern and Central Europe. It is an erect herbaceous plant, which reaches a meter in height. Its leaves have 3 to 5 toothed leaflets and its flowers are red. There are "Potentillas" or "cinquefoils" native to Mediterranean countries, like, for example, *Potentilla reptans* L. These are rosaceous plants like *Comarum palustre* L. They were known by the ancients and alluded to by classic authors with the Greek term πεντάφυλλον.[30] Terms such as κόμαρι, κόμαρον (Lat. *comarum*), κόμαρου, κομάρεως, κόμμαρις or κόμαρος have never been found in this context.

> 42 RV: πεντάφυλλον·οἱ δὲ πενταπετές, οἱ δὲ πεντάτομον, οἱ δὲ πενταδάκτυλον, οἱ δὲ ψευδοσέλινον, οἱ δὲ καλλιπέταλον (…).
>
> Dioscurides IV, 42.
>
> 42 RV: Some call it "five petal" (*pentéphyllon*), other *pentátomon*; other "five fingers"(*pentadáctylon*); other "pseudo-parsley" (*pseudoselínon*); other "beautiful petal" (*kallypétalon*)(...).

3.2 Botany

If we examine the archaeological records and plant iconography of Roman times, taking into account the geographical distribution of *Arbutus unedo* L. and *Comarum palustre* L. then we can explain the confusion existing with both plants species.

The strawberry tree, *Arbutus unedo* L., is an evergreen shrub. It is native to the Mediterranean countries and prefers littoral zones. Its preferred habitat is the low forest. Under appropriate conditions, it can grow into a tree. Pliny XV, 28 tells us King Juba wrote that there were strawberry trees of *quinquagenum cubitorum altitudine* in Arabia. Hence, this shrub was well known in the Kingdom of Juba (*Mauritania Caesarea*),[IV] and it must have grown along the caravan routes that arrived in Egypt from Arabia or from India through the Arabian Peninsula. Three species of *Arbutus* occur still nowedays in the Southern Mediterranean region from North Africa to the Middle East: *A. unedo, A. andrachne,* and *A. andrachnoides*.[31]

Botanical records from archaeological sites allow us to identify trees, shrubs and herbs that would have been part of the ancient Mediterranean forests. The species *Arbutus unedo* L. has been identified in the records of Ancient Pompeii and the areas surrounding Mount Vesuvius circa 79 AD.[32] This species has also been identified in archaeological records of littoral Mediterranean areas of the Iberian Peninsula. Wood and pollen have been found in such important sites of the Iron Age as El Puig de la Nao, Los Villares and Kelin, in the region of Valencia, and also at Mas Castellar and Olerdola, in areas corresponding to the Roman province of Tarraconensis.[33] We wish to emphasize that one of the zones excavated at the Olerdola site has been interpreted as a craft room dedicated to the production of dyes.

Ample iconographic evidence exists that *Arbutus unedo* L. was a highly prized ornamental tree in Roman gardens since it is represented in numerous frescoes that adorned the Roman *domus* such as the Villa of Livia near Rome (Fig. 4a)[34] or the House of the Fruit Orchard (Casa del Frutteto)[35] and Casa del Bracciale d'oro in Pompeii.[36]

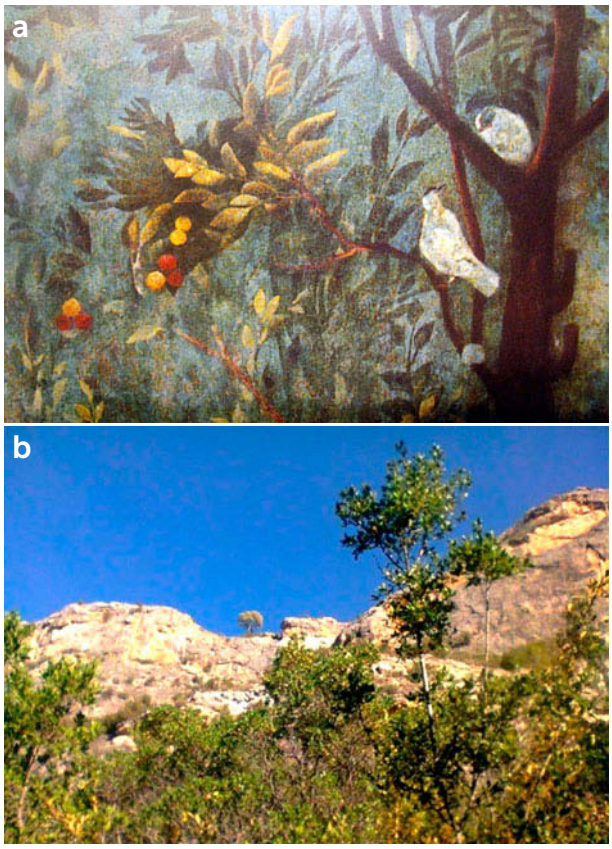

Figure 4: (a) Fresco at the *Villa* of Livia, Roma, Museo Nazionale (Credit: J. Martínez). (b) *Arbutus unedo* L., Mediterranean forest of the National Park "Hoces del Cabriel", Spain. (Credit: J. Martínez).

4 Phytochemistry

Finally we will consider the chemical composition of the species cited, particularly the components with properties potentially suitable for different uses in dyeing. The high quality and resistance to fire of *Arbutus unedo* L. (Fig. 4b) wood have been known since ancient times and that explains industrial uses.[37] But this shrub could have also been used for other purposes, such as for dyeing, due to the chemical properties of its bark, leaves and fruits. The strawberry tree bark, leaves and young stems contains 36% of tannic matters. Leaves and young stems also contain a glycoside called unedoside, and a hydroquinone.[38] Phytochemical studies on the fruit of *Arbutus unedo* L. revealed the presence of sugars (sucrose, glucose, fructose and maltose), vitamins A (especially *β*-carotene in mature fruit), C and E, organic acids (malic acid and fumaric acid, the latter in greater amounts in the green fruit) and phenolic compounds, especially flavonoids. Carotenoids are the natural pigments of the fruits and are responsible for the yellow-orange colour of their flesh.[39] 80% of a methanol extract of the fruits were identified as pro-anthocyanidins, the most important being cyanidin-3-O-galactoglucoside, cyanidin-3-O-galactoside, cyanidin-3-O-arabinoside, cyanidin-3-O-glucoside and delphinidin-3-O-galactoglucoside.[40] Fruits also contain phenolic acids, the most important being gallic acid and its derivatives such as 5-O-galoylquinic acid andgallic acid 4-O-*β*-D-glucopyranoside.[41]

Another study on the characterization of all the metabolites isolated from *Arbutus unedo* L. revealed eight flavonoids, among which myricetin, quercetin, kaempferol, catechin and gallocatechin, as well as arbutin (an esterified phenolic acid; Fig. 5) and two of its derivatives.[42] High-Performance Liquid Chromatography with UV detection (HPLC-UV)

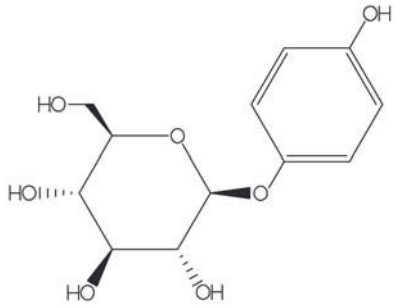

Figure 5: Chemical structure of arbutin (Credit: Marta E. Martínez).

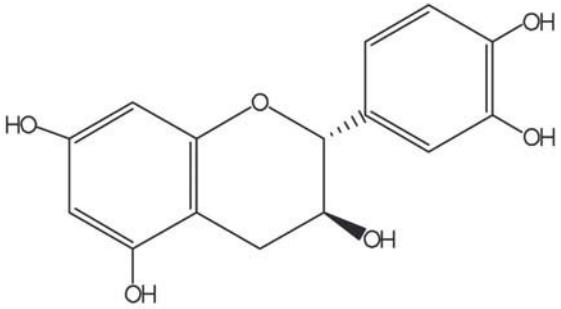

Figure 6: chemical structure of catechin (Credit: Marta E. Martínez).

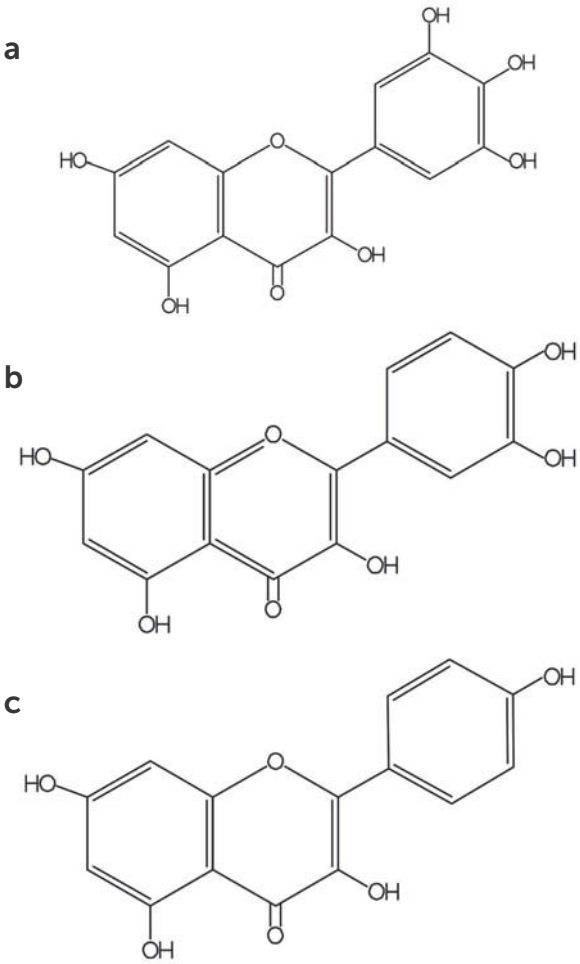

Figure 7: Chemical structures of (a) myricetin, (b) quercetin, (c) kaempferol (Credit: Marta E. Martínez).

showed that the most abundant component in the plant matrix of *Arbutus unedo* L. is catechin (Fig. 6).

The multi-toothed configuration catechin polyphenols allows them to fix firmly onto proteinaceous and cellulosic fibres. This feature makes them useful as mordants and dyes for natural textiles.[43] The richness in tannins of the strawberry tree bark and leaves justifies their use as a fixative for colouring matters in antiquity, as prescribed in Leyden Papyrus X, recipe 89 and Papyrus *Graecus Holmiensis*, recipe 147.

In Technical Treatises V, VII, 14 for staining stones, Maria the Jewess and Zosimus conclude in their discussions:[44]

> It is possible to dye and fasten at in the same time by using a mordant for the colouring matter and operating in a way that one single liquor plays the role of mordant and dye, because this way it imbibes, dyes and fasten at the same time.

Thanks to its chemical composition, rich in tannins, and yellow colouring substances like myricetin, quercetin and kaempferol (Fig. 7), with defined dyeing properties,[45] the dissolutions of the bark or leaves of the strawberry tree, theoretically, could mordant and dye at the same time.

This is suggested indeed in recipe 97 of Papyrus *Graecus Holmiensis*, a recipe for dyeing purple: dyeing and mordanting is performed in a unique dissolution of *comaris* with either tartrate[IV] or alum to dye, without wool being previously mordanted with alum. In southern Europe, both the leaves and the fruit in infusion have been traditionally used for the tanning and dyeing of skins.

Some species of the genus *Potentilla*, to which *Comarum palustre* L. belongs, contain 14% of tannic matters in their roots, particularly catechu tannic acid. This characteristic allows root extracts of these rosaceous plants to be used to mordant. The problem is that the rhizome should be used as fresh as possible, since the tannin content decreases when it dries.[46] In Finland, *Comarum palustre* L. is known as *kurkjenjalka*[V] and its root is used for dyeing wool and leather a reddish brown colour in this country. As already introduced in section 1, the plant has a circumboreal distribution, but curiously it also grows in the wild in the north of the Iberian Peninsula (Cantabria, Asturias etc).

4 Results and Discussion

We have carried out experimental tests of some of the recipes that prescribe the use of κόμαρι. There are quite a few recipes in ancient technical recipe books that explain how to dissolve κόμαρι. Other recipes recommend it for fastening different colouring matters. This is always with the purpose of imitating the colour purple and getting more solid dyeings. The oldest recipes correspond to the Leiden Papyrus X and the Papyrus *Graecus Holmiensis*. Five recipes in Papyrus *Graecus Holmiensis*, numbers 85 (Κόμμαρεως), 88 (κόμαριν), 147 (κόμαρι), 149 (κόμαρον) and 150 (κόμμαρι) prescribe the dissolution of *comaris*[47] and in recipe 89 *comaris* (κόμμαρι) is mentioned to fasten alkanet.[48] Recipes 85 and 88 describe how to imitate precious stones; recipes 147, 149 and 150 are included in the processes of dyeing textile fibers. Other Egyptian technical treaties pertaining to the period called Late Antiquity have also left us some recipes. Treatise V, XII gives the proportions of wool, water, and *comaris* (κομάρεως) that should be used to get a good dye. Treatise V, XIV titled "*Quelle est la composition de la comaris*" tells what the composition of *comaris* is: "*le mélange de la préparation est composé avec un corps solide et un liquide; une once de comaris solide étant mélangée avec l'eau*".[49] *Syriac Alchemical Treatise* XIII,3 repeats a recipe similar to Papyrus *Graecus Holmiensis*, recipe 97, but incomplete. This latter also mentions φαίκλε (*faecula* lat.), tartrates, to dissolve *comaris*.[50] Besides these, we have six recipes more in *Syriac Alchemical Teatrise* XIII that prescribe the dissolution of *comaris*. One of them explains how to fix it with milk of mulberry or fig trees. The milk of fig trees has vinegar-like properties.[51]

We have reproduced Papyrus *Graecus Holmiensis* recipe 97, following the quantitative proportions of water and raw materials indicated in Technical Treatise V, XII. The experience has been done with different parts of the strawberry tree *Arbutus unedo* L.: on the one hand leaves, branches and bark, and fruit on the other. Tartaric acid mono potassium salt was dissolved in distilled water at 65-85 °C until saturation and the filtrate was mixed with the fruit paste. This mixture was agitated and filtered. The filtrate was left overnight at ambient temperature (20-25 ºC), covered. The next day the filtrate had a pink-orange colour. It was used to dye 5g of alum mordanted wool. The dyeing liquor was heated at 80-85 °C, the wool was added and dyeing continued for 1 h at 65-80 °C. The dye bath was then cooled down, the wool rinsed and dried in the open air avoiding sunlight. The wool was dyed a soft pink colour (Fig. 8). Dyeing with the leaves-branches-bark mixture occurred following the same procedure and the resulting dyed wool had a yellow-brown colour (Fig. 9).

Figure 8: Dyeing wool with tartrates and fruit paste of *Arbutus unedo* L.; (1) Fruit paste; (2) Filtrate, ready for dyeing; (3) Dyed alum mordanted wool (Credit: J. Martínez).

Figure 9: Dyeing wool with tartrates and leaves-bark-branches mixture of *Arbutus unedo* L.; (1) Leaves-bark-branches mixture; (2) Filtrate, ready for dyeing; (3) Dyed alum mordanted wool (Credit: J. Martínez).

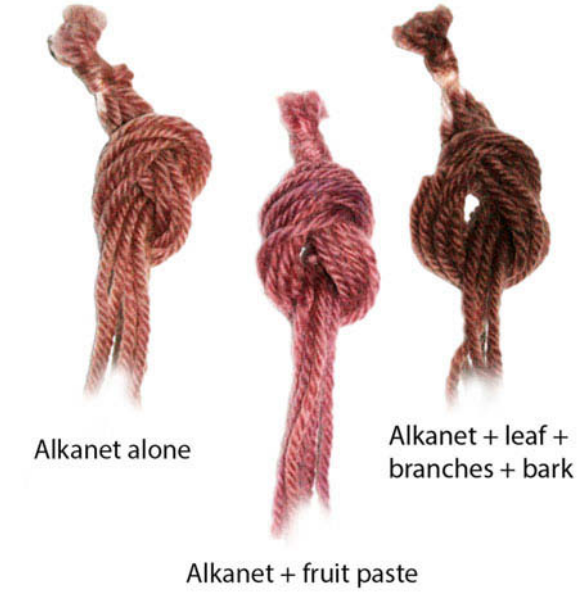

Figure 10: Experimental reproduction of recipe P. Leid. X, 89, involving treatment of alkanet dyed wool with either a fruit paste or a leaves-branches-bark extract of *Arbutus unedo* L. (κόμαρι) (Credit: J. Martínez).

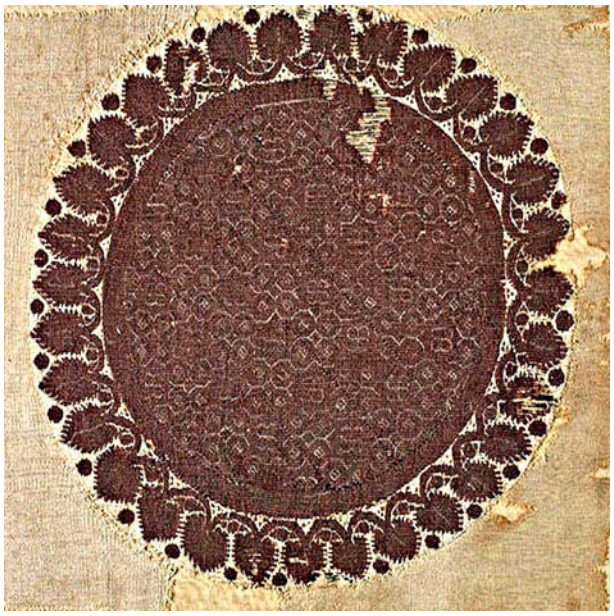

Fig 11: Purple Coptic medallion in wool and linen (33.5 x 42 cm) 4th century AD, object number 654-16, Collection Fundation Katoen Natie, Antwerp (Belgium), (Credit: C. Verhecken - Lammens).

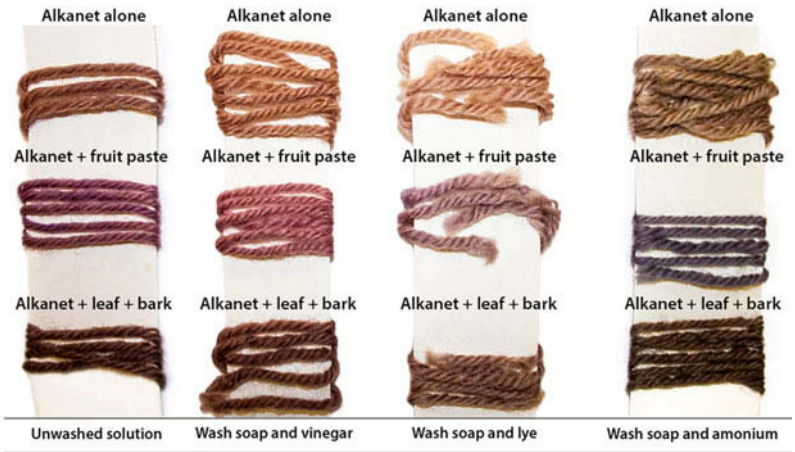

Figure 12: Colour shifts of wool samples as a function of dyeing conditions and chemical reatments (Credit: J. Martínez).

The different colours of fruit paste and leaves-bark-branches extracts developed after standing may be explained by the development of brown colour through the oxidation of tannins present in the latter liquor. [45]

Recipe P. Leid. X, 89 was reproduced to investigate how to fix alkanet with *comaris*. A reference alkanet dyed wool was prepared as follows. 100 g of alkanet root was macerated in 100 mL 96% ethyl alcohol (denatured) overnight in a covered container. In the morning, 1000 mL water was added and the mixture heated to 65-85 °C for 1 h. 5 g of alum mordanted wool was added and dyeing continued for one hour at this temperature range. The resulting colour was light red-brown.

The alkanet dyebath was then divided in two parts, one to be treated with the extract of the fruit paste of *Arbutus unedo* L. and one with the extract of the leaves-branches-bark mixture of the same plant. Each of these dye baths was heated to 65-85 °C; 5 g of wool was added to each bath and dyeing continued for one hour at this temperature range. The wool dyed in the fruit paste bath took a nice purple; that in the leaves-branches-bark mixture a brown colour, like coagulated blood. Such a colour is typical in Coptic medallions of 4th to 6th centuries AD (Figs. 10-11).

All wool samples were washed in an aqueous neutral soap bath. All washed wool samples were tested for fastness against acid, alkali and oxidation. To that end, wool samples were treated with 25 mL each of 8% (w/v) domestic vinegar, 3.3% (w/v) aqueous ammonia and domestic bleaching agent (active chlorine 3.5% (w/v)) respectively, for 2 h at ambient temperature. All treated wool samples were air dried and exposed to sunlight for 24 hours. The most obvious change concerns the colour shift from purple red to purple blue of wool dyed with alkanet and fruit paste, and treated with ammonia. This may reflect the colour shift to be expected of anthocyanins contained within the fruit paste in an alkaline medium. All samples loose colour through the bleaching agent treatment and this is to be expected due to oxidative fading of colourants (Fig. 12).[VI]

So far, no analytical evidence has been found in our laboratory for the presence of κόμαρι in ancient textiles remains. Possibly due to the lack of fastness of these dyes. Most commonly, herbal purple in Coptic fabrics is composed of madder and indigo. However, faded remains have been found. Some of them give negative results for the most common dyestuffs, but inorganic elements such as salts of Fe, Cu and Al are detected. These might have their origin in the mordanting of fibers that were dyed with a fugitive dye, such as saffron, red algae, κόμαρι, κομάρεως, or alkanet. These stains disappear and change with the passage of time, by being exposed to the sun or to certain taphonomic substances. Positive tests for tannins in pieces with remains of purple might come from mixtures similar to which we have analysed in these recipes with κόμαρι: a raw material of low quality as alkanet dissolved in a bath of substances rich in tannins as χόμαρι, whose function was either to fix the dye or to help its dissolution.

5 Conclusion

Our study has clearly demonstrated that κόμαρι or κομάρεως, a matter prescribed in the recipes of the Papyrus *Graecus Holmiensis* and Leiden Papyrus X, as well as in the Syriac Alchemical Treatises, is extracted from the fruit, leaves, bark and branches of the strawberry tree, *Arbutus unedo* L.

According to the collected information, our study reveals that the proposal made by some authors as Lagercranz about the extraction of the dye called κόμαρι/κομάρεως from the root of *Comarum palustre* L. is not accurate. Indeed, we pointed out that the ancients knew the plants of the Potentilia genus by the name of πεντάφυλλον. The name *comarum* dates rather from the modern era. Chemically, the *Comarum palustre* L. rhizome could have dyeing and fixing properties, but the tannins of its root degrade easily. The geographical distribution of this plant indicates that it is not native to Mediterranean littoral areas. Possibly, the Northern and Central European researchers who provided early translations of the Greek papyri (Lagercrantz and Lippmann, respectively) knew a Northern European herbaceous plant called *Comarum.* Moreover, in Finland, the roots of *Comarum palustre* L. have been used traditionally to dye wool. Possibly early translators didn't know any plant called *comarum* or *comaris*, because *Arbutus unedo* L. is a typical tree of the Mediterranean forest. They postulated the most logical assumption for them: κόμαρι was the colouring raw material of *Comarum palustre* L.

However, philologically, ancient authors gave the name of *comarum* to the fruit of *Arbutus unedo* L. and *comaros* to the tree. Most of the recipes refer to the fruit of the strawberry tree, *comaron*. The spelling of the term varies in some of the recipes. In the papyri and treatises, we can see it written as κόμαρι, κόμμαρι, κομμάρεως, κόμαριν and κόμαρου, interchangeably/indistintinctly. In other Greek papyri we can also find analogies of this type to designate some colours. For example, the use of the Greek term καλλαινου/καλαινου, καλαίνου to refer to a colour between green and blue.[52] This may be due to the use of some kind of dialect writing, or any particular terminology used by the writers of these recipes.

Regarding the question about whether the Greek word κόμαρι/κομάρεως changed its meaning from one era to another, some analogy may be hypothesized between a changed meaning of the term *comaris* from the treatisies of Democritus onwards where it referred to the fruit of the *Arbutus unedo* L., and changing terms of other red colourants.

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8 Endnotes

I. We are awaiting the analytical results of samples from the experimental reproductions of prescriptions that we present in this paper. These results will allow knowledge of the dye potential of the raw material called κόμαρι. These analyses are being conducted by Mrs. I. Vanden Berghe (IRPA/KIK), Belgium.

II. It has been thought that this papyrus contains a set of alchemical recipes analogous to those present in the P. Leid. and P. Holm., which show some parallelism with some others of the Syriac alchemical treatises as well.

III. Refers to natural saltpeter, potassium nitrate.

IV. According to R. Halleux 1981 (see note 2 above) the 'lie' refers as well to the sediment of wine barrels, tartrate, as to the 'allume', alum.

V. This information about *Comarum palustre* L. was given to the author by Krista Vajanto (University of Helsinki, Finland). In Finnish 'kurkjenjalka' (name of *C. palustre* L.) is a compound word that combines 'Kurki= *Grus grus* L. and 'Jalka'= foot.

VI. Every wool sample was photographed at the same time under the same lighting conditions with a Canon EOS 400D camera.

VII. This paper reflects the view of the authors, and the European Commission cannot be held responsible for any use which may be made of the information contained therein.