# RESINS AND DRYING OILS OF PRECOLUMBIAN PAINTING: A STUDY FROM HISTORICAL WRITINGS. EQUIVALENCES TO THOSE OF EUROPEAN PAINTING

Mª Luisa Vázquez de Ágredos Pascual[1]; Mª Teresa Doménech Carbó[1] y Antonio Doménech Carbó[2]
Instituto Universitario de Restauración del Patrimonio de la Universidad Politécnica de Valencia.
[1] Laboratorio de análisis físico-químico y medioambiental de obras de arte
[2] Departamento de Química Analítica de la Universidad de Valencia

CORRESPONDING AUTHOR: Mª Luisa Vázquez de Ágredos Pascual, m.luisa.vazquez@uv.es

ABSTRACT: *The chemical characterisation of mural painting conserved on ancient palaces, temples and royal tombs of Mayan lowlands and its social and historical interpretations are research programmes promoted by the Instituto de Restauración del Patrimonio de la Universidad Politécnica de Valencia since 2003. The pigments used by Mayan painters when painting ancient architecture since very early times were mixed with several gums, mucilage, resins and drying oils that were described by Western Indian chroniclers of the sixteenth, seventeenth and eighteenth centuries. This paper covers binding measures, particularly resins and drying oils. A precise comparison was also made between these substances and those used in European paintings for the same purpose.*

KEYWORDS: Pre-Columbian painting, Maya art, Maya culture, binders, binding media, historical writings

## 1. INTRODUCTION. THE MAYAN MURAL PAINTING TRADITION.

Colour was a highly important form of expression in the monumental architecture of ancient American civilisations, including the Mayan culture, which was established and developed between the early Pre-Classic (c.1800 to 900 BC) and the Late Post-Classic (c.1300 to 1530 AD)[1] periods in vast territories, including the present-day nations of Guatemala, Honduras, Belize, El Salvador and, in Mexico, Yucatan Peninsula and southern Chiapas and Tabasco. Along with the study of sixteenth, seventeenth and eighteenth century writings, laboratory analyses by optical microscopy (LM), scanning electronic microscopy combined with energy dispersive X-ray (SEM/EDX), X-Ray diffraction (XRD), transmission electronic microscopy (TEM), Fourier transform infrared spectroscopy (FT-IR), voltammetry of microparticles and gas chromatography/mass spectrometry (GC/MS) have identified the materials and techniques of Mayan mural painting.

The walls of ancient Mayan palaces, temples and tombs were stuccoed with two renders: a thick mortar lining and a thin outer layer. The former was manufactured with a mixture of quicklime, calcite sand (*sascab*) or silica sand (*hí*) and water in which *chucum* (*Havardia albicans*), *holol* (*Heliocarpus spp.*), *pixoy* (*Guazuma ulmifolia*) or *ha'bin* (*Piscidia piscipula*) bark, among others, had been soaked to exude their respective gums which increased the solubility of calcium oxides and, thus, contributed to the formation of one homogeneous plastic lime paste with excellent hardening properties. Otherwise, the quicklime and calcite or silica sand of the thin outer layer were enriched by adding different types of clays, such as kaolin, attapulgite (palygorskite), sepiolite or montmorillonite, which helped obtain an ideal surface for brushing and painting (Vázquez de Ágredos et al., 2007:126). With this last purpose in mind, sixteenth, seventeenth and eighteenth century sources, ethno-historical research and our own laboratory studies indicate that the Mayan painter used different pigments (calcium carbonate, carbon black, red and yellow ochre, haematite, specular, haematite, cinnabar, malaquite and azurite), and pigment-lakes (Maya blue and green), and indigo-based pigments (Doménech, et al., 2006:6027-6039; Doménech, et al., 2007a:2812-2821; Doménech, et al., 2007b:4585-4595; Doménech, et al., 2007c:1335-1346) to paint political, social and ritual scenes of great symbolism, with palaces, temples and royal tombs, since very early times, particularly since the Middle Pre-Classic period (c.900 to 300/250 BC). To paint those scenes, the Mayan painter made use of the lime's binding properties and complemented them with the adhesive power of several plant gums, mucilage, resins and drying oils, which were frequently prepared in solutions of two or three to blend and extend the aforementioned pigments and pigments-lake. Based on the analytical results previously obtained (Magaloni, 1996; Magaloni, 1998:270-278), it is possible to affirm that some of those additive and plant substances were *chucum* (*Havardia albicans*), *ha´bin* (*Piscidia piscipula*), *pixoy* (*Guazuma ulmifolia*), *abal ak´* (*Spondias spp*), *kopo'* (*Ficus nitida*) and *holol* gums (*Heliocarpus spp.*), the mucilage of some types of orchids (*Catasetum maculatum kunth.* and *Cyrtopodium*

Figure1 Mural painting in Subestructure A-3, A-5 and A-6 of Calakmul (Campeche, Mexico). Early Classic (ca. 450 A.D).

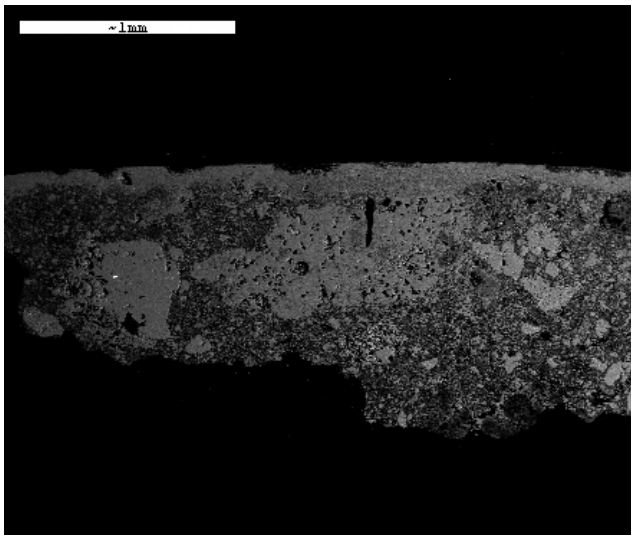


Figure 2 (SEM/EDX). The two renders of Maya mural painting (Río Bec, Campeche, Mexico). Late Classic (ca.700 A.D).

*macrobulbum*), several resins such as of *chaká* (*Bursera simaruba*), cedar (*Cedrela spp.*) and copal (different species of *Bursera copallifera*), among others, and drying oils of *chía* (*Salvia hispánica*), *chicalote* (*Argemone mexicana L.*) and pumpkin.

The Mayan painter obtained a good part of the binders of several plants, flowers and trees that grew in the exuberant and different environments where Mayan cities were built in Pre-Columbian times. In this sense, two main geographical zones; the Lowlands (hot climate) and the Highlands (temperate or cold climate); exist in the Mayan area. Here there are three main types of forest: pine-oak, situated in the temperate, cool mountainous areas of Guatemala and Chiapas, areas with poor soils or deficient drainage in the Mayan Lowlands; deciduous forests of oak and sweet gum in the lower mountainous zones between the high tropical and the temperate zones; and the tropical forest situated in the most humid region (Gómez-Pompa, 2001:39-51). In this last zone, lots of natural species exist which are rich in different types of binders, such as *holol* (*Heliocarpus spp*), *ha'bin* (*Piscidia piscipula*), *kopo'* (*Ficus nitida*), *chaká* (*Bursera simaruba*), cedar (*Cedrela spp*) or several varieties of orchids living on the branches of numerous trees. However, the most important resin in ancient Mayan and Pre-Columbian art, the copal, was common in pine-oak forest zones and was dominated by different pine species (*Pinus strobus, Pinus pseudostrobus, Pinus tenuifolia, Pinus ayacahuite, Pinus teocote*), oaks (*Quercus insignis, Quercus peduncularis*) and sweet gum (*Liquidambar styraciflua*) (Gómez-Pompa, 2001:39-51).

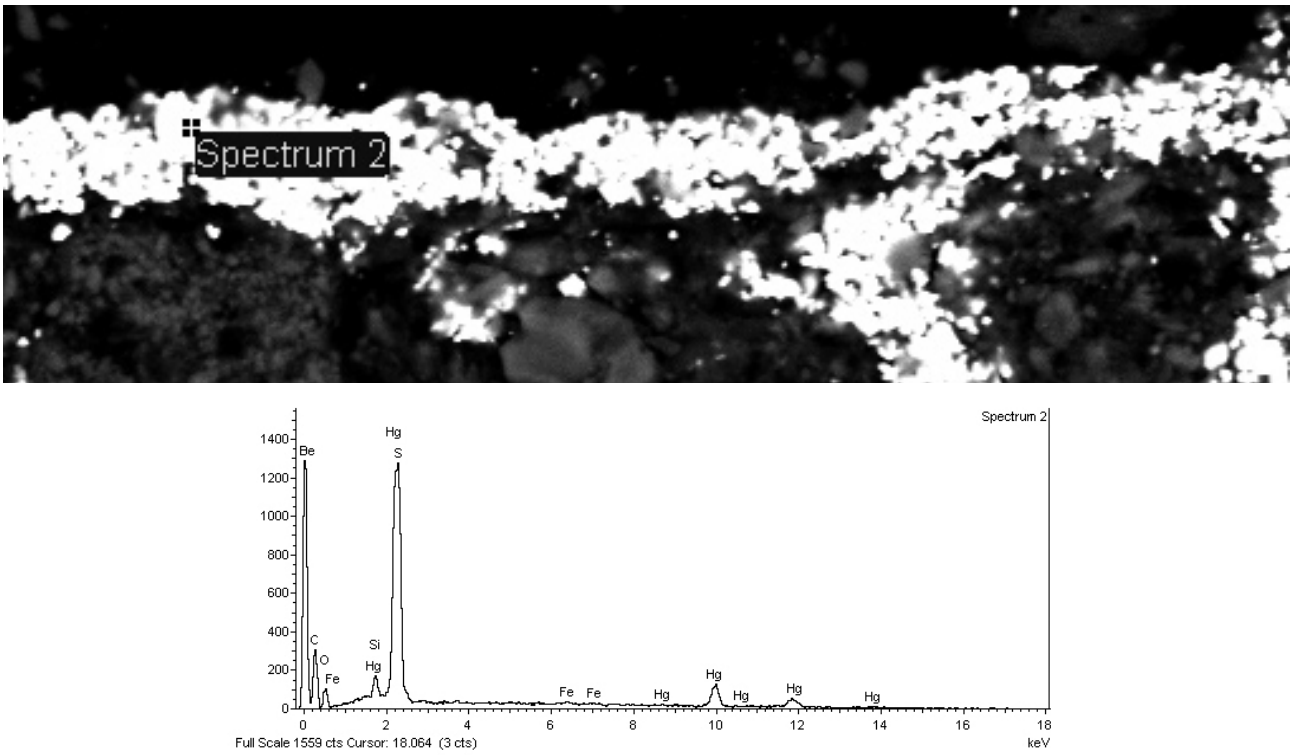
## 2. SOME NOTES ABOUT THE RESINS AND DRYING OILS CITED IN ETHNO-HISTORICAL WRITINGS.

The most important resin in ancient Mesoamerica was copal [Fig.6] whose diterpenic[2] nature places it with many other resins, including sandarac and colophony which have been used as pictorial binders since antiquity. Known as *copal-quahuitl* or *tecopalquahuitl* by the Nahua and as *pom* by the Maya, this exudation was obtained by making an incision in the trunk of any of the forty copal-producing leguminous plant species in Mexico (Martínez, 1970:41). But the best quality copal came from *Bursera copallifera sessé & moc.*[3] However, this resin, which was used for different purposes, especially ceremonies, was dispersed throughout Mesoamerica, the above-mentioned tree varieties did not grow equally in all the regions of the vast Mesoamerican geographical area. The copal-producing species were more abundant in colder climates. Therefore, the resin was principally produced in the Central High Plateau of Mexico.

Mesoamerican cultures that developed in warmer climates tended to be less fruitful in terms of the growth of copal-producing species, not because these species did not grow in those regions, but because they grew less than other species and, most importantly, the trees that offered the best quality copal, including the aforementioned *Bursera copallifera sessé & moc.*, were not among the most abundant species. In the Mayan area, although all the regions produced some variety of copal, there were certain regions whose climates greatly favoured the growth of species offering high quality copal than others. The climate of Chiapas, for example, supported the growth of not only trees that exuded copal with excellent properties, but also other species which were very important for painting, such as conifers *Pinus oocarpa schiede ex schlechtendal* and sedges (Villamar et al., 1994:1060).

The resin obtained from *Pinus oocarpa schiede ex schlechtendal*, which was known as *nabá* by the Maya living in Chiapas, as *iztah-te* by the Maya of Yucatan, and as *ocotzotl* or *óxitl* by the Nahua of the Central High Plateau, is the same as the diverse plant secretions from conifers in Mexico which were commonly known as turpentine. All these species have oleo-resinous properties (Calvo, 1997:225). The irregularity with which these two terms appear in ethno-historical sources does not favour a consensus being reached as to whether they both refer to the same resin or if each refers to a different compound. In the 1960s, some authors began to suggest that both *ocotzotl* and *óxitl* referred to the resin and not to the oil obtained through distilling the resin (Garibay, 1964:373). In recent research, students have considered the possibility of the word *ocotzotl* actually referring to the resin turpentine in Nahuatl, and of *óxitl* being used to define the essential oil that was obtained by processing turpentine (Cervera & López, 2000:174). In addition, descriptions of these substances in chroniclers' ethno-historical writings have caused considerable confusion, which has led to many chemical analyses and posterior studies to confirm the true nature of each one. Similarly in old texts, it was common to describe the oleo-resin turpentine not as a resin or oil that resulted from distilling a resin, but as a balsam or gum: "The women often anointed themselves, as their husbands did, with a certain coloured ointment, and when they had the possibility to do so, they covered themselves with a certain confection of strong-smelling and very sticky gum that I believe to be liquidambar, which in their language is known as iztah-te" (Landa 1985:64).

Very few resins escaped being confused which meant that many of the organic substances employed in Pre-Columbian painting as binding media of numerous Mayan and Pre-Hispanic paintings were not correct identified. The three substances which proved to be luckier were amber, natural rubber and, in particular, copal.




Figsure 3 & 4 (SEM/EDX). The cinnabar of Mayan area in the mural painting sited in the tomb 4 of Calakmul (Campeche, Mexico) Late Classic (ca. 795 A.D).

Copal was likely to be found in Pre-Columbian markets in any of the three textures and tonalities in which it could be obtained from a tree. Whether a resin was the result of the first, the second or the third exudation of the species in question could be determined by the rough texture and dark colour that characterised the first of these, which was gradually substituted by a more refined and light-coloured quality and progressed to the almost translucent third variety. Despite there being no references in ethno-historical sources about these distinct qualities of copal, they must have been perfectly well-known not only during the colonial period, but also throughout the preceding Pre-Columbian times when differences among exudations would have conditioned the whether a material was selected to be used for a given purpose. Nonetheless, all three varieties of copal had good adhesive properties which must have made them all excellent binding media for several artistic expressions requiring the use of these additive substances, such as sculpture or lapidary work (Martínez, 1970:40).[4] Painting the colour of each of the aforementioned exudations must have completely dictated its use. Therefore, while the dark copal that the tree initially secreted could have been used as smoke black, the lightness of the subsequent two secretions rendered them more suitable as pictorial binding media, especially the last of the three.[5]

The double use for painting that characterised copal, providing colour and acting as binding media, was also common for other resins which were employed in the Pre-Columbian period for painting purposes. This was the case of turpentine which could also be used as an oily diluting agent after being correctly distilled. Another example is the black resin of natural rubber (*Castilloa elastica cerv.*) which, through the application of heat, was transformed into a liquid that was useful to painters and scribes alike as pigment and ink, respectively [Fig.7]. The same can be said of amber, which was used as a binding medium that came in two tonalities, green and white, a difference which was also registered in some indigenous languages such as Nahuatl in which the green variety received the name *tlalapozonalli* and the whitish variety was identified as i*ztacapozonalli* (Molina, 1997:7*)*. In addition, some tree varieties from which resins were extracted also served double purposes since painters knew how to make use of more parts of the tree than just its gelatinous sap. One such example is the black charcoal obtained by burning the wood of pines that also provided the aforementioned resins and turpentine spirit.[6]

Regardless of those characterised by a dark colour being used as binding media or as black smoke, the resins in Pre-Columbian painting required an oily medium in order to become soluble (Calvo, 1997:192). This meant that even if it was true that the oil painting technique was not used, it was also true that on those occasions when resins were selected for paint binding media, it would have been necessary to use oils in order to dissolve them, which resulted in an oleo-resinous mixture in which the colour was blended and applied through a mixed technique.

For some of the aforementioned resins, it would have been necessary to melt them before being able to use any drying oil to dilute them. While this process was not absolutely necessary for the *chaká* resin, it would have been absolutely essential for natural rubber, copal or cedar [Fig.8].[7] The oils that could have been of use in the Mayan region to agglutinate the resins of copal, amber, natural rubber and the abundant *chaká*, to name but a few, were quite scarce. Although there were various seeds, fruits and flowers from which oils could be extracted, in most cases such oil was not the drying oil required for painting. In other words, as either an adhesive for use with an oil technique or a transporter of other binding media, the latter situation was important when resins were being used in Pre-Columbian painting. The scarcity of drying oils was not exclusive to this ancient civilisation; it was quite common with other cultures in the rest of the world since only very rarely does the composition of these oils include the minimum 65% of polyunsaturated fatty acids required to count them as drying agents (Masschelein-Kleiner, 1978:52). What is also very important is the proportion in which linolenic and linoleic acids occur in the oil as they improve the oil's drying ability and ageing quality, respectively (Masschelein-Kleiner, 1978:52). In this sense, linseed (*Linum usitatissimum*), poppy (*Papaver somniferum*) and walnut (*Juglans regia*) oils were widely used in European painting, especially from the fourteenth century

Figure 5 (ML) The ancient Maya city of Ek' Balam (Yucatan, Mexico).

Figure 6. The sacred resin of copal.

onwards, while soy and safflower oils have been used for painting in the Far East since antiquity. However, Mexico added oils which were extractable from chia (*Salvia hispanica L.*), *chicalote* (*Argemone mexicana L.*), gourd, *jangua* or avocado and mammee plants.

Of the plants mentioned from Mexico, chia was the first to stand out for its excellent properties from the rest, and it was exalted by all the chroniclers that referred to it in their writing: "Chia is the fruit or small seed of a plant, the stalk of which is straight and quadrangular and its branches are in the form of a cross; its flower is blue, very small and similar to that of the mallow. There are two species, one small and black, from which excellent oil can be extracted for painters, and the other white and larger, from which they made and make a refreshing drink" (Clavijero, 1991:14-15). The two species mentioned by Francisco Javier Clavijero were known in the Nahuatl language as *chiantzotzolli* and *tlilticchien*, the latter was dark in colour from which an optimal quality drying oil was extracted by painters. The high quality of *tlilticchien* explains why the majority of the chroniclers often mentioned this Mexican oil along with the linseed plant's quality, and they sometimes suggested the superiority of the former: "Among oils, that of chia was used more by painters than by medics, for being, as we have already mentioned, very superior to that of linseed" (Clavijero, 1991:262).[8]

The good quality of this drying oil, which was confirmed by the first scientific analyses of the substance (Lenz, 1973),[9] made it one of the most common seeds used as a tribute to Mexico Tenochtitlan (Castillo & Sepúlveda, 1991), as well as one of the goods that was most frequently exchanged along the trade routes of Mesoamerica in Pre-Columbian times. This is the only way the substance could have reached the many regions of Mesoamerica where it was used by painters as a binding media, a resin transporter and a varnish.

When chia drying oil was not available, the alternative for Pre-Columbian painters was to experiment with drying oils obtained from local seeds, including those of the *chicalote* whose principal production in the Mayan area centred in the regions of Quintana Roo and Yucatan (Villamar et al., 1994:339). In fact, just as chia oil can be compared with linseed oil, the drying oil of the *chicalote* has some very similar properties to that of the poppy as both types of oil come from species belonging to the *Papaveraceae* family. Furthermore, the proportion of gum, albumin, gluten and casein that *chicalote* oil contains (Cervera & López, 2000:187) would have served the painters of the regions where the species was cultivated as not only a medium in which to dissolve resins, but also an excellent binding medium. The properties of the *chicalote* oil must have been greatly appreciated in ancient America since, in addition to being useful for painters and doctors, it could have also been of widespread use in ceremonies that required its participants to reach a state of trance, or communion, due to its hallucinogenic and narcotic effects (Evans & Hoffmann, 2000).

Another option for Pre-Hispanic painters was presented with gourd seeds from which a drying oil could be produced that acted as a resin transporter, a varnish, and a binding medium all at the same time. Gourd seed oil, as well as mammee and *jangua* or avocado oils, possessed a high amount of linolenic acid, a trait which seems common to all drying oils that come from fruits. This explains why the composition and properties of the three aforementioned oils used in Pre-Columbian painting are more similar to the characteristics of walnut oil than to those of linseed and poppy oils. Finally, another common trait to gourd, mammee, and avocado oils was the lesser amount of oil that could be obtained from their seeds in comparison with the larger quantities extracted from chia, *chicalote*, linseed and poppy, and sunflower seeds. For example, only a maximum of 32% oil could be extracted from gourd (Solana, 1953:34). This fact, together with the excellent properties that characterised the chia and *chicalote* oils, would have been another reason for ancient American painters to give preference to these oils, although without them completely excluding the use of the aforementioned oils.

Finally, what is particularly interesting is the fact that those oils used in Pre-Columbian cultures shared, along with other plant and additive substances such as gums and mucilage, the capacity of being equally useful to painters and doctors alike, the latter of whom, among the many other functions described and acknowledged in Maya and Nahuatl medical summaries, principally valued these glutens for treating gastrointestinal ailments.

## 3. CONCLUSIONS

According to the study of sixteenth, seventeenth and eighteenth century's ethno historical writings, the binders used in Maya and Pre-Columbian painting between Pre-Classic and Post-Classic times were plant additives that the Mayan painter obtained from several local trees. Some of these binders were the sacred resins of copal, natural rubber or chaká, among others, which were mixed with drying oil to dilute them before use as a binding measure of different pigments and pigments-lake. The composition and properties of Pre-Hispanic drying oils that have been described in this paper, especially those of the chía and chicalote, show similarities with those contained in linseed, poppy and walnut drying oils, all of which have been widely used in European painting since the Renaissance.


Figure 7. The Maya ts'ib (scribe-painter) in one pottery polychrome of Late Classic period. Kerr (Inv. nº K1185).

Figure 8. The resin of ceder.

Currently, one of the lines of research that has recently been introduced into the Instituto de Restauración del Patrimonio de la Universidad Politécnica de Valencia consists in analytical chemistry research of the Pre-Columbian drying oils, resins, gums and mucilage that were cited in ethno-historical sources to confirm their respective uses in the ancient Maya mural painting.

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**NOTES**

[1] Maya history is divided into three main phases: the Preclassic period, during which civilisation emerged in the area (ca.1800 B.C-A.C 250/300), the Classic period or golden age of Maya culture (ca. A.C 250/300-900/950) and the Post-classic period, when this ancient civilisation collapsed between A.C 900/950 and the conquest of the Maya area in 1541.

[2] Isoprene is the basis of all resins, and the amount in which this substance is found in each resin type determines the principal differences among resins. When we call copal a diterpenic resin, we refer o the fact that it is composed of four isorenes which distinguish it from other resins used by the Maya, such as turpentine, which is monoterpenic or sesquiterpenic, that is, its structure includes two or three isoprenes, in: Masschelein-Kleiner L. (1978): Aglutinantes, barnices y adhesivos antiguos, IRPA, Brussels.

[3] The most important copal production derives from the many Aruacariaceae and Caesalpinioideae species which are members of the conifer and leguminous families, respectively. Although the word copal is of Mexican origin, the production and use of this resin is dispersed over many parts of the world, especially in Central and South America, East and West Africa, the East Indies, New Zealand and Manila, in: Masschelein-Kleiner L. (1978): *Aglutinantes, barnices y adhesivos antiguos*, IRPA, Brussels.

[4] For information about the binding media used in this art, see: Anaya E. (1992): *La química del México Prehispánico*, Tesis de Licenciatura, Facultad de Química, Universidad Nacional Autónoma de México, México D.F.

[5] It is important to remember that one of the principal problems of using copal as a painting binding medium is the facility with which it oxidizes, which causes it to change colour rapidly. To see: Doerner, M. (1991): *Los materiales de la pintura y su empleo en el arte* (5ª ed.), Ediciones Reverté, Barcelona.

[6] Today's Lacandons still make black pigment which results from combining charcoal from burned pine wood with turpentine resin from the same tree, and enriched with honey, in: Odile, M. & Singer M. (1986): *Los hombres de la selva. Un estudio de tecnología cultural y medio selvático*, Colección Regiones de México, México D.F..

[7] The melting point of copal is 320ºC. At this temperature, copal has lost 20% of its weight and becomes soluble in oils, in: Masschelein-Kleiner L. (1978): *Aglutinantes, barnices y adhesivos antiguos*, IRPA, Brussels.

[8] We know that the excellent quality of chia oil inspired Francisco Javier Clavijero to take a few seeds to Italy as he intented to cultivate the plant there and to obtain a useful drying oil for Italian painters, who, nevertheless, did not benefit from this substance because the species was not able to survive the freezing temperatures that the country suffered in the winter of 1777, in: Carrillo & Gariel, A. (1983): *Técnica de la pintura mural en la Nueva España,* Universidad Nacional Autónoma de México, México D.F.

[9] According to the analyses carried out by this author, the use of chia oil strengthened the colours with which it was combined. In fact, this mixture of oil and colour was used to manufacture of some ancient lakes, as well as those that were made by the Pre-Columbian cultures of Central Mexico.

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**AUTHORS**

**Mª Luisa Vázquez de Ágredos Pascual:** Doctor in Geography and History at the University of Valencia, and "European" Doctor in History of Art at the Polytechnic University of Valencia.
Researcher at the Heritage Conservation Institute of the Polytechnic University of Valencia.
Professor in the Official Master's Degree in Science and Restoration at the Department of Conservation and Restoration of Cultural Heritage of the Polytechnic University of Valencia.

**Mª Teresa Doménech Carbó:** Doctor in Chemistry at the University of Valencia. Professor at the Polytechnic University of Valencia.
Professor at the Department of Conservation and Restoration of Cultural Heritage, specialist in chemical and physical analyses of works of art.
Director of the Heritage Conservation Institute of the Polytechnic University of Valencia.

**Antonio Doménech Carbó:** Doctor in Chemistry at the University of Valencia. Senior Lecturer at the Department of Analytical Chemistry of the University of Valencia, specialist in chemical analysis of materials by electrochemical techniques, particularly the analysis of works of art by solid-state electrochemistry

*Versión española*

TITULO: ***Resinas y aceites secantes de la pintura Precolombina: un estudio histórico de los escritos. Equivalentes a los de la pintura europea.***

RESUMEN: *La caracterización química de las pinturas murales conservadas en los antiguos palacios, templos, y tumbas reales de las Tierras Bajas Mayas y su correcta interpretación histórico-social es una de las lineas de investigación que han sido promovidas por el Instituto de Restauración del Patrimonio de la Universidad Politécnica de Valencia desde el año 2003. Los pigmentos que los pintores mayas utilizaron desde tiempos muy antiguos para decorar esas antiguas arquitecturas fueron mezclados con varios tipos de gomas, mucílagos, resinas y aceites secantes que los cronistas de las Indias occidentales describieron entre los siglos XVI y XVIII. Este trabajo se centra en la descripción de esos aglutinantes, en especial en la de algunas resinas y aceites secantes, y proporciona una comparación precisa entre estas sustancias y las que fueron empleadas en la pintura europea con la misma finalidad.*

PALABRAS CLAVES: *pintura precolombina, arte maya, cultura maya, aglutinantes, fuentes históricas*