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Review

The Story of *Elaeagia* Resin (*Mopa-Mopa*), So Far

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Abstract: The unusual resin from some species of *Elaeagia,* a genus now found in certain parts of Central America and South America, was probably first utilized by native peoples in Colombia more than a thousand years ago. It became a crucial part of often elaborately decorated objects made in the southwestern city of Pasto in the colonial period, and it has continued to be used there up to the present, in which it is at the core of a local craft tradition. The resin was also utilized for about 300 years by the Inka, mainly to decorate qeros (ceremonial drinking cups). The resin is often referred to as *mopa-mopa* and, specifically in Colombia, as *barniz de Pasto*. The botany, chemistry, properties, and analysis of *Elaeagia* resin are reviewed, along with a brief survey of the history of its use.

Keywords: *mopa-mopa*; *barniz de Pasto*; qero; Inka; *Elaeagia*

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1. Introduction

Elaeagia is a minor plant genus in the very large Rubiaceae family. Its different species are found from central America through parts of South America, most abundantly in the Western Andes of Colombia, Ecuador, and Peru. Resin from the trees, although insoluble, can be softened by mastication or heating in water, mixed with dyes or pigments by kneading, then stretched (while hot) into thin films that can be cut and applied as decoration on wood and other substrates, without the need for an adhesive.

Its historical use is restricted to two separate geographical regions and different cultures that may or may not have been aware of each other's knowledge of the resin. The resin has likely been continually used in the southern part of Colombia for a thousand years or more and is currently utilized by a small group of artisans in Pasto, Colombia. The best-known objects that were decorated with the resin (most of which are considered to have been made in Pasto) are relatively small wooden objects such as portable writing desks, created between the mid-16th century through the 18th century. The "traditional knowledge and techniques associated with Pasto Varnish *mopa-mopa* of Putumayo and Nariño" was inscribed in 2020 on UNESCO's List of Intangible Cultural Heritage in Need of Urgent Safeguarding (https://ich.unesco.org/en/USL/traditional-knowledge-and-techniques-associated-with-pasto-varnish-mopa-mopa-of-putumayo-and-nario-01599 (accessed on 15 March 2023)). Further south in Peru, the Inka utilized the resin over a period of approximately 300 years, throughout the colonial period. The Inka may have begun to use the resin before the arrival of the Spanish in 1532, but this is uncertain. Most of the Inka objects decorated with the resin are small wooden ceremonial cups (qeros). The resin does not seem to have been utilized in Peru since the end of the colonial era. In Colombia, scientists have recently explored its potential use in a biobased composite with fique fibers [1].

This paper reviews the botany, chemistry, and history of use of the resin, and discusses its identification in cultural artifacts. A Spanish translation of this paper is available in Supplementary Materials.

2. *Elaeagia* Species and Their Resin

In his 1849 book based on extensive travels in Peru, Bolivia, and Ecuador, Weddell [2] proposed a new genus, *Elaeagia*, an essential characteristic being the presence of round resin-rich bud scales (stipules) that are hard and protect the leaf buds as they form. Weddell noted that the tree previously named *Condaminea utilis* by Goudot [3] should be placed in this new genus. In 1977, Mora-Osejo [4] proposed a new species, *E. pastoensis*, named after the city of Pasto, Colombia. He indicated that the resin utilized by artisans in Pasto at that time belongs to this new species, not to *E. utilis*, as had previously been thought. (A corollary of this is that some specimens in botanical collections that were accessioned before 1977 could have been misclassified, or another species unless they have been re-examined in more recent years.) 19th-century scientists who studied the resin, some of its chemical properties, and reported about its use in Pasto include Humboldt [5] and Boussingault [6].

Of the *Elaeagia* species, *E. pastoensis* and *E. utilis* are among the most commonly collected and described in herbaria. Both grow in many of the same areas, as indicated by, for example, maps of preserved specimens and sightings in the Global Biodiversity Information Facility (GBIF) online database [7] (Figures 1 and 2).

Figure 1. Occurrences of *Elaeagia utilis*, from the Global Biodiversity Information Facility (GBIF). (Source: https://www.gbif.org [accessed on 22 November 2022]).

Figure 2. Occurrences of *Elaeagia pastoensis*, from the Global Biodiversity Information Facility (GBIF). (Source: https://www.gbif.org [accessed on 22 November 2022]).

In the GBIF database, *E. utilis* is by far the most reported species (over 90% of total compiled occurrences), with remaining occurrences mainly being catalogued as *E. mariae*, *E. karstenii*, *E. pastoensis*, and *E. myriantha*. There is no agreement on the number of species in the genus. While the GBIF database currently lists 28, far fewer are recognized by scientists most familiar with the genus. Steyermark [8] recognized 15. More recently, Maldonado [9] recognized nine. (In Maldonado's classification, *E. karstenii* is considered a variety of *E. mariae*.) Most of the less common species are restricted to specific countries or regions. In 2018, Mendoza-Cifuentes and Aguilar-Cano [10] described a new species from Colombia, one of five rare species the authors note are known to be found only in that country; the five major species noted above, which occur across a broad range of countries, all also occur in Colombia.

While all species produce resin, Taylor [11] noted that only two, *E. utilis* and *E. pastoensis*, produce large amounts. Both are slender trees, up to 30 or more meters tall. In the field, these two species are most readily distinguished from one another by their leaves (Figures 3 and 4). *E. utilis* leaves are on average larger and broader than those of *E. pastoensis* [9]. For the moment, it is assumed that resin utilized to decorate objects probably originated from one of the other of these two species, and only botanical specimens of resin from these species have undergone any scientific analysis to date.

Figure 3. Botanical specimen of *Elaeagia utilis*, from the Field Museum of Natural History. https://db.fieldmuseum.org/65ab1b9b-8653-4cc4-abe3-38b84afbf4eb, FMNH 2193647 (accessed on 16 March 2023).

Figure 4. Botanical specimen of *Elaeagia pastoensis*, from the Field Museum of Natural History. https://db.fieldmuseum.org/d702bd03-2c92-499b-b023-b35dfb6cd9c7, FMNH 2111075 (accessed on 16 March 2023).

The resinous stipules on both species, small rounded buds less than 1 cm in diameter (Figure 5), are very hard and virtually insoluble. Small solid pieces of the resin, as harvested from the trees during the growing seasons, are usually transparent and honey or amber-colored, sometimes tinted green.

Figure 5. Stipules on branch of *Elaeagia pastoensis.* (Photograph: J. Rodrigo Botina).

In the ancient Americas, as in other parts of the world, resins whose solid components are mainly or entirely diterpenoids or triterpenoids have been utilized for a wide range of purposes [12–18]. Specific examples range from the binders of paints on ceramics of the Paracas culture (Ica region, Peru; ca. 800–100 BCE) [16] to raw materials excavated at the Aztec site of Templo Mayor in present-day Mexico City (constructed beginning sometime after 1325, destroyed in 1521) [15]. Less widespread in occurrence than terpenoid resins are types primarily made up of phenolic compounds: by far the best-known resins of this type are the saps which are the raw materials of true Asian lacquers [12]. *Elaeagia* resin is a phenolic resin whose behavior is quite unusual. Softened by chewing or by heating in water, the resin can be formed into thin sheets or long strings without rupturing. Rather astonishingly, it has been reported that a 0.5 kg mass can be stretched into a 3–4 mm diameter string 100 m long [19] (p. 129). The resin hardens relatively rapidly as it cools, losing most of its malleability, but the malleability can be renewed by heating again, at least while it is still relatively fresh. On older objects with resin-containing decorations, the resin can be made at least somewhat malleable with a heated spatula.

As with many materials used in cultural heritage, the earliest history of the use of this resin will probably never be known. One can imagine that people noticed small balls looking almost like berries growing from the ends of branches on certain slender trees during the growing seasons. Chewing the berries would have quickly demonstrated that they were not food, but the chewing would have turned the "berries" into a rubbery substance that likely was rather unique among plant materials available to these people. If many of the small balls were combined and chewed or heated together, and bits of plant material were removed during this simple processing, a large enough mass of the malleable resin could be accumulated that would be useful for shaping into small items. If the rather extreme stretching properties were appreciated, other uses may also have been visualized. The fact that a thin layer of the resin is impervious to water was also probably noted during early experimentation with the resin.

3. Terminology

"*Mopa-mopa*" is a term of unknown origin. The earliest publication using this term (to the best of the authors' knowledge) is by Juan and Ulloa in 1748 [20] in a brief description of objects made in Pasto, Colombia. Jijón y Caamaño and Larrea [21] may be the first publication (1918) to link mopa-mopa with Inka qeros. *Mopa-mopa* is currently a common name for *Elaeagia* resin in both of the cultural contexts in which it has been (or still is) used.

"*Barniz de Pasto*" is a term that first appeared during the colonial period to refer to objects made in Pasto that were decorated (at least in part) with *Elaeagia* resin [22]. The term now refers to the resin itself and to the objects that are currently made in Pasto and decorated there by local craftspeople. The term is also used to refer to objects made in the Pasto region throughout known history that include the resin. The Spanish word "barniz" means varnish, defined in the dictionary as a sticky liquid applied as a coating on a surface, or a glaze. Early Spanish writers who saw objects decorated with the resin did not know how the raw material was harvested or how it was applied. A surface covered with a thin layer of the resin can appear glossy and could be mistaken for a surface coated with a liquid layer of varnish, thus the understandable early confusion and use of the term "barniz". In 2011, the Superintendencia de Industria y Comercio de Colombia established "*Mopa Mopa Barniz de Pasto*" as a protected name indicating the authentic material utilized in Pasto [23].

In the study of Inka qeros, those decorated with *Elaeagia* resin have sometimes been referred to as "painted", more often as "lacquered". As in the case of "barniz", these are not accurate uses of the words as currently defined. However, Tom Cummins (personal communication 2022) has reasonably argued that in the past "painted" was utilized in a broader sense to indicate different forms of applying color to a surface. In 16th–18th century documents, colonial period Inka qeros were often termed "llimpi" ('llimpi' is a Quechua term that can refer to the colored materials applied to decorate qeros or to the process of applying such colored materials).

4. Composition of *Elaeagia* Resins

The biosynthetic routes by which phenolic resins are produced are complex and not thoroughly understood, but in a simplified view, as outlined by Langenheim [12], two are noted as particularly important: the shikimic acid/phenylpropanoid pathways [24,25] and the malonic acid pathway [26] (Figure 6). The former leads to phenylpropanoids, which represent the basic "monomeric" structural components of the resin. The latter contributes to the production of flavonoids that are responsible for at least part of the color of the raw resin but which would be present as isolated molecules that do not contribute to the structure and behavior of the resin itself.

Biftu and Stevenson [27] carried out exhaustive solvent extracts on a sample of *Elaeagia* resin (identified as *E. utilis* purchased in the commercial market in Pasto, Colombia, but probably *E. pastoensis*) and from those extracts specifically identified several triterpenoids as well as the flavone apigenin, all of which, however, are only minor components of the raw material.

Elaeagia pastoensis resin is virtually inelastic and only slightly malleable at room temperature, with a low tensile strength (7.2 MPa at RH 47%) [28]. The resin absorbs little water, virtually none at 47% RH, 1.5–2.0% at 97% RH. X-ray diffraction indicates that the minimally processed material is semicrystalline. Thermogravimetric analysis (TGA) indicates some loss at 99C (probably residual solvents from the processing in water and alcohol that was carried out on the sample which was tested), then a gradual continual decrease in mass beginning at 200C, with small plateaus at 312C and 378C, culminating in a complete loss at 450C. These observations suggest that the chemistry of the phenolic resin is complex and involves at least somewhat discrete components that degrade at different temperatures. However, these observations have no direct bearing on the degradation of the material through normal processing for use as a decorative material (which is carried out at relatively low temperatures) or to natural aging at ambient temperatures.

The resins from only *E. pastoensis* and *E. utilis* have been subjects of scientific study to date. Newman et al. [29] discussed analyses of resin from botanical specimens of these species by Fourier transform infrared microspectroscopy (FTIR), pyrolysis gas chromatography/mass spectrometry (pyGC/MS), and liquid chromatography/diode-array spectrometry/mass spectrometry (LC/DAD/MS). To date, the physical properties of *E. utilis* have not been addressed, so no comparison can be made to the limited data from *E. pastoensis*.

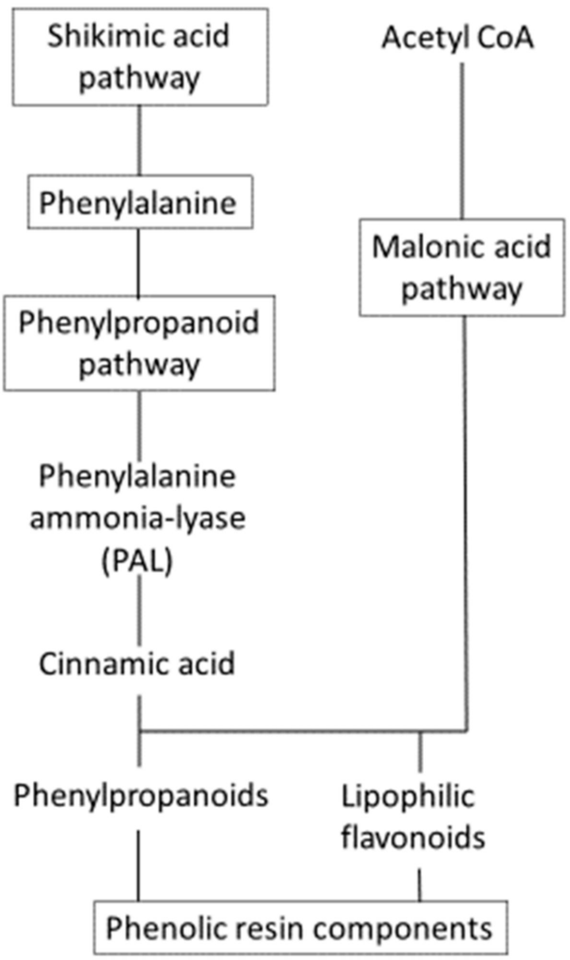

Figure 6. Outline of biosynthetic pathways for production of phenolic resins in plants (Redrawn after Langenheim [12]).

5. Analytical Identification of *Elaeagia* Resins

Elaeagia resin (of the two species studied to date) can be distinguished from other natural resins by FTIR spectrometry (Figure 7); reference spectra of a few *Elaeagia* specimens of these two species are available in the Infrared and Raman Users Group (IRUG) database (www.irug.org (accessed on 27 March 2023)).

In order to compare spectra of resin from *E. utilis* and *E. pastoensis*, an FTIR spectral reference library of 18 specimens of the former and 6 of the latter (Appendix A, Table A1) was prepared and evaluated by principal components analysis (PCA). Although there are subtle differences between the spectra of resin from some samples of the two species, PCA indicates that they cannot be reliably distinguished by this technique.

The two species can be best distinguished in the C=O stretching vibration range (1750–1690 cm^{-1}; Figure 8), but there is an overlap. *E. utilis* specimens often exhibit two overlapping broad peaks, one exhibiting the greatest absorbance at ca. 1705–1715 cm^{-1}, and one exhibiting less absorbance at ca. 1725–1735 cm^{-1}. *E. pastoensis* samples often also exhibit two overlapping peaks in the same general ranges, but the latter frequently shows a greater absorbance than that of the former (Figure 9). The higher wavenumber absorption is due to esters in the resins.

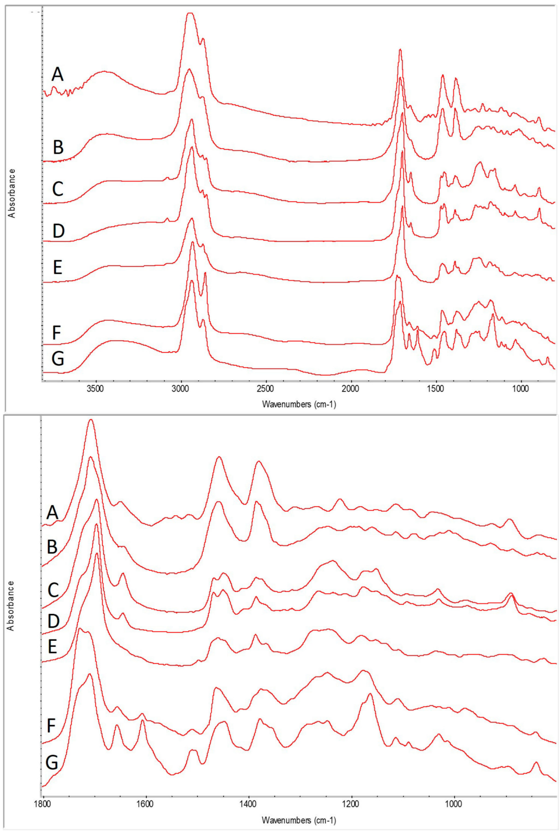

Figure 7. FTIR absorbance spectra of several diterpenoid and triterpenoid resins (A–E, spectra from irug.org database, spectral identification numbers indicated) and reference samples of *Elaeagia pastoensis* (F, Field Museum 2226159) and *Elaeagia utilis* (G, Field Museum 999470) resins. A, dammar (INR00082). B, mastic (INR00067). C, Manila copal (INR00092). D, sandarac (INR00091). E, rosin (pine resin, INR00114). Full spectra in the top panel; spectra between 1800–800 wavenumbers in the bottom panel. Y-axes arbitrarily adjusted for ease of comparison. IRUG spectra source: Price, Beth A., Boris Pretzel and Suzanne Quillen Lomax, eds. Infrared and Raman Users Group Spectral Database. 2007 ed. Vol. 1 & 2. Philadelphia: IRUG, 2009. Infrared and Raman Users Group Spectral Database. Web. 20 June 2014. www.irug.org (spectra C–E, courtesy of the Philadelphia Museum of Art; spectrum A, courtesy of the National Gallery of Art; spectrum B courtesy of the British Museum).

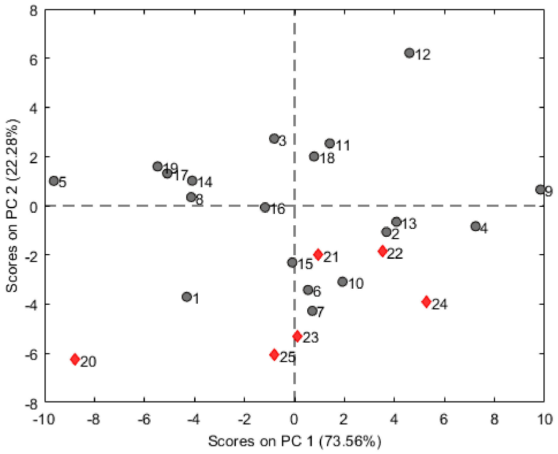

Figure 8. Plot of principal component 1 versus principal component 2 from FTIR spectra of reference resin specimens from *Elaeagia utilis* (18 samples; black dots) and *Elaeagia pastoensis* (6 samples; red triangles). Spectra were evaluated in the 1750–1690 cm^{-1} range.

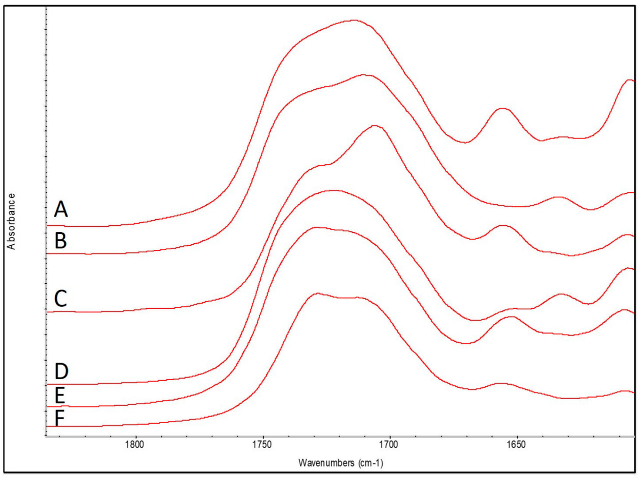

Figure 9. Details of FTIR absorbance spectra from three reference samples of *Elaeagia utilis* resin (A–C) and three of *Elaeagia pastoensis* resin (D–F). A, Smithsonian National Museum of Natural History 2165540. B, Smithsonian National Museum of Natural History 2166582. C, Field Museum 2184875. D, Missouri Botanical Garden 5834698. E, Missouri Botanical Garden 4571036. F, Field Museum 2226159. Y-axes arbitrarily adjusted for ease of comparison.

Py GC/MS analyses of resin from the two species have been undertaken to date by derivatization by a transmethylation reagent, tetramethyl ammonium hydroxide (TMAH), a commonly-utilized reagent for pyrolysis of samples from cultural heritage and other fields [30,31]. Pyrolysis of the resin with this reagent can be expected to give chromatograms that include small, volatile compounds which do not decompose at the pyrolysis temperature, fragments of molecules that did decompose during pyrolysis, and methylated derivatives of some pyrolyzed or derivatized fragments, depending on their structures and compositions. Pyrolysis is a logical methodology to characterize what might be considered "monomers" of the polymeric matrix of the largely-insoluble *Elaeagia* resins, although it provides no information on the structure of the original polymer(s).

Some typical identifiable components in pyrograms of all botanical specimens include glycerol derivatives, fatty acids, and derivatives of flavonoids (particularly trimethyl apigenin). These compounds or their relative amounts cannot be considered diagnostic for these resins [29]. Of most diagnostic value for the presence of *Elaeagia* resins, at first glance, is the presence of p-methoxycinnamic acid and 3,4-dimethoxycinnamic acid. The former is consistently more abundant in *E. utilis* than in *E. pastoensis* (Figure 10). It seems likely that these two compounds are present in the resins in esters, but the compositions of the esters in the two species must differ in certain details (Figure 10). Since the derivatization reagent used for pyrolysis can methylate active hydroxyl groups, it is not certain that the original substituted cinnamic acid components of the resin were in the specific methoxylated forms detected by py GC/MS.

Appendix B compares pyrograms of reference *E. pastoensis* samples by two laboratories utilizing different pyrolyzers.

Little is known regarding chemical or physical changes the resin may undergo in thin decorative layers applied to the surfaces of objects. On qeros that are hundreds of years old, *Elaeagia*-containing layers often exhibit craquelure, perhaps indicating that aging has reduced the original (if slight) malleability of the room-temperature resin [32]. Craquelure is typically not observed on Pasto objects of similar (or somewhat younger) age, however. This may be due to differences in processing and applying the resin, environmental factors in aging processes, or even the original resin source(s). Discoloration of the resin over time has been suggested, but the extent to which this occurs is not known at the moment. FTIR spectra of samples from objects that are hundreds of years old may closely resemble those of herbaria samples, suggesting that chemical changes due to aging may have been relatively minor, and characterization by chromatographic techniques also implies no very extreme alterations. That there are differences in properties of resin harvested from trees of varying age, and that chewing may produce effects not identical to those obtained by boiling resin in water were remarked on by Humboldt [5], but such differences have yet to be addressed by scientific research.

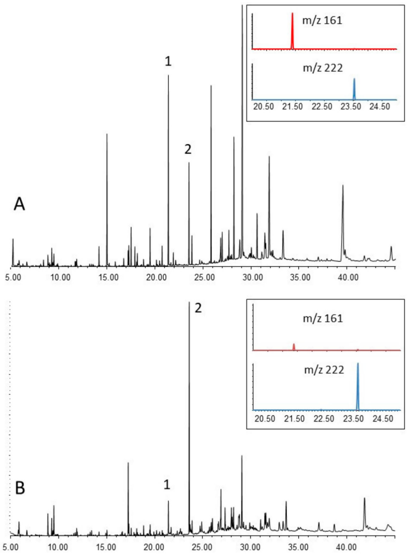

Figure 10. Pyrograms from py GC/MS analyses of *Elaeagia* samples. (**A**). *E. utilis* (Smithsonian National Museum of Natural History 1770637). (**B**). *E. pastoensis* (Missouri Botanical Garden 3012033). Insets: selected ion chromatograms, indicating positions of peaks for methyl esters of p-methoxycinnamic acid (m/z 161, top) and 3,4-dimethoxycinnamic acid (m/z 222, bottom), which are labeled 1 and 2 respectively in the pyrograms.

LC/DAD/MS applied to heated methanol/water extracts from botanical specimens has primarily been useful for identification of the flavonoids. The major one in both species is apigenin (this is the same flavonoid that can be identified, in derivatized form, in pyrograms). A simple distinction between the two species can be made from these chromatograms: luteolin is a minor component of *E. pastoensis* but virtually absent from *E. utilis*, and the monomethyl ether of apigenin (possibly 7-methylapigenin, genkwanin) is a significant component of *E. utilis* but is absent in *E. pastoensis*. The flavonoid content can be considered diagnostic, but it should be kept in mind that flavonoid-containing yellow plant dyes may have been used as colorants in resin applied to certain artifacts, and many of these plant dyes [33] contain some of the same flavonoids that are present in the resin itself.

Although it might be assumed that the flavonoids of the freshly harvested resin were removed, or at least severely depleted, by the extensive processing undergone by the resin before being employed for decorative purposes, analyses of samples of applied decorations on various objects readily detect flavonoids of the same types and relative amounts detected in botanical samples [29].

6. *Elaeagia* Resin in Pre-Colonial Colombia

The earliest known utilization of *Elaeagia* resin is probably in beads made by indigenous people in the southwestern part of present-day Colombia. In excavations completed in 1974–1975 at Alto de Lavapatas within the present-day San Agustín archaeological park, archaeologists reported finding several hundred necklace beads in graves [34,35]. Stated to have "possibly been made with *mopa-mopa*", the beads were described as "made up of hundreds of pieces placed on strings around the necks of dead bodies, harmonious set of bands in gray, brown, and cream, some of them tubular and others round" [28]. The San Agustín site (about 130 km northeast of Pasto) contains burial mounds with megalithic statues, among many other artifacts, dating to the Regional Classic Period (1–900 AD), although the site was continually inhabited until about 1350 AD [36]. Similar beads were reportedly found in graves dating to the 9th–13th century in Miraflores, a region about 55 km south of Pasto [37]. The current locations of beads from these two excavations are unfortunately not known.

About 250 beads were found in a primary burial and a secondary burial during 1992 excavations at Tajumbina [38], a site approximately midway between Pasto and San Agustín. *Elaeagia* has been tentatively identified in samples from these beads, which are currently housed at the Instituto Colombiano de Antropologia e Historia (ICANH).

Most of the resin beads are tubular, typically from 0.5–2 cm in length (Figure 11). They show a narrow range of colors, from black to brown to pale beige or white. The very few that have been studied in some detail come from private collections and have no provenience. Radiocarbon analysis of one such bead indicated a date of 899–1001 AD [39].

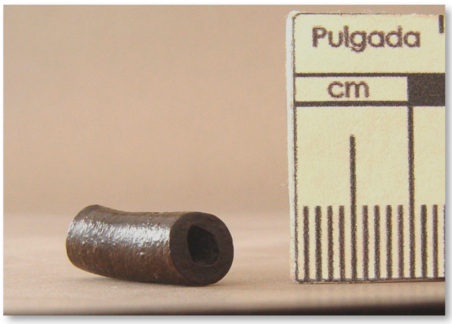

Figure 11. *Elaeagia* resin bead from Colombia, provenance unknown (Sample and photograph: Maria Cecilia Álvarez-White).

The ages of these *Elaeagia* beads could well vary, but if on the order of a thousand years or more, their appearance in graves located as far as 200 km apart (the approximate direct distance between Miraflores, northeastward to San Agustín) could indicate considerable early trade of *Elaeagia* beads, or perhaps widespread early knowledge about the harvesting, processing, and utilization of the resin.

While some beads are uniformly colored (probably simply the brownish color of the resin itself), others show one or two other colors (white and black) in oblique bands. These presumably were made by forming thin sheets of resin (of different colors), placing sheets side by side and adhering cut edges together with heat and pressure, then rolling the multicolored material around a thin cylindrical core to form a tube of resin. After the removal of the core, individual beads could be cut from the long cylinder. The causes of the colors in these beads are uncertain at the moment.

7. *Elaeagia* in Colombia during the Colonial Period

Pasto was established as a town by the Spanish in 1537. Fray Geronimo de Escobar passed through Pasto in 1582. He made a somewhat-confused mention of what is almost certainly *Elaeagia* resin in chronicling the Timaná region, which is several km east of San Agustín, one of the sites from which *Elaeagia* beads have been excavated. He wrote:

> " . . . with scant indigenous population and no mines nearby, the main farming activity here is making preserves, as there is much honey in the trees of that land and with the fruits they make preserves; also from some seeds that grow there in that land called peanuts, using them as a sort of almonds, they make nougat loaves and with these preserves and some staves the Indians there paint with an elegant varnish of many colors and send all to be sold at the mines of Almaguer and other areas where there is gold . . . " [40].

Geronimo made no mention of the resin being used in Pasto itself. Castellvi [41] stated that Indians familiar with the use of barniz for decorative purposes were brought to Pasto shortly after the founding of the town in 1537, but this does not appear to be verifiable.

Humboldt [5] stated that it was said a particular woman who owned parcels of land in the Timaná had "invented the way of varnishing as it is done today [in Pasto]" from the beginning of the conquest.

In 1827, Hamilton [42] briefly noted wooden bowls, "adorned in the most tasteful manner with flowers of very brilliant colors" that were made in the small town of Timaná. He wrote that "a high varnish is laid over the whole, which the Indians of the province of Timaná extract from a plant ... [These bowls] may be used with hot water without injury". Although it is not certain, he was probably referring to bowls decorated with tinted *Elaeagia* resin. If so, there would seem to have been a centuries-long tradition of using the resin in that region. Most surviving decorated objects from Colombia, nearly all of which are considered to have been made in Pasto, have wood substrates. The best-known objects made from wood and decorated with *Elaeagia* resin include portable writing desks, miniature sideboards, trunks, lecterns, and trays, examples of which have been the subject of several recent studies [43–48]. Most surviving objects do not have firm dates but are usually considered to have been made in the mid-17th century or later. On many, resin decorations cover virtually the entire surface.

Gourds were also a common substrate. A recent study of such an object from the Hispanic Society Museum & Library collection included radiocarbon dating, which placed the object in the 1522–1638 range, with 95% probability [33]. Thus this would suggest that the gourd may have been made in the 16th century. As far as is known at the moment, although based on comparatively few analyses, *E. pastoensis* was the specific resin used to decorate colonial-era objects produced in Pasto [29], including the gourd just noted.

In a book published in 1627, Fray Pedro Simón noted that the resin was used in Quito, Ecuador [49]; the book did not mention Pasto. It is thought that some colonial-era objects decorated with *mopa-mopa* may have been made in this city, which is about 200 km directly southwest of Pasto. The history of the use of the resin beyond Pasto during the colonial period is currently unknown.

There is a possible gap of centuries between the *Elaeagia* beads and objects noted by European writers that were made in the Timaná region (of which there are no currently known specimens). Several surveys of historical documents related (or possibly related) to the use of *Elaeagia* resin in Colombia have been published [50–55].

8. Some Characteristics of the Use of *Elaeagia* in the Colonial Period in Pasto

Two broad application techniques have been recognized in colonial-era objects from Pasto: "barniz brillante" and "matte barniz" [43,56]. The former is characterized by a glittering surface, a result of the abundant use of silver leaf with very thin tinted overlaid layers of resin. In the latter technique, silver leaf was not used. Thin layers of unpigmented *Elaeagia* resin are transparent and generally honey-colored (probably, but not necessarily entirely, from small amounts of flavonoids). The addition of colored organic compounds that are transparent or have very fine particle sizes (such as indigo, cochineal, or yellow dyestuffs) creates a tinted but still highly transparent layer, which can be applied over silver, acting much like a glaze applied over metal leaf in an oil painting would. In a study of a gourd from the Hispanic Society Museum & Library collection, Pozzi et al. [33] showed that the layer structures in some areas were quite complex, presumably due to the partial covering of some decorative elements with others as the final design was developed, or perhaps even design modifications in places. Thin transparent red layers (10–20 µm) overlaid silver leaf in two samples, a thicker transparent green layer (100 µm) overlaid silver leaf in another, and a thin transparent blue layer (10–20 µm) overlaid silver leaf in another. In the more complete cross sections, it seems that a thick underlying resin layer (perhaps untinted) served as substrate a the metal leaf.

A portable writing desk from the Hispanic Society Museum & Library is shown in Figure 12. The object is dated (from an inscription) to ca. 1684. Visual examination reveals the basic manner of application of the decorations, although cross sections have not been taken from the object. On the inside of the lid of the desk (Figure 13), the lowest visible layer is opaque beige (containing lead white pigment). All decorations overlie this. The very dark features are a layer containing indigo, which if concentrated enough in the resin, has a nearly black color. The glittering red, green and blue elements all seem to consist of three-layer structures, beginning with an untinted resin layer, adhered to the opaque ground layer. On top of this is silver leaf with an upper transparent tinted layer: an organic red for the red, a fairly large amount of indigo for the blue, and a small amount of indigo for the green. The latter may have a green tint from the resin itself, or perhaps a yellow dyestuff was added to it. These decorations stand somewhat above the background, the slight relief apparently intended: it was made possible by the fairly thick untinted resin layer. The lower layer extends out beyond the upper two, so it would appear that thin sandwiches of silver leaf overlain by a tinted transparent resin layer were cut out and applied to a thick untinted underlayer, which gave relief to the overall decorative elements. Note a tiny sliver of errant silver leaf overlain by the red glaze, attached to the ground layer near one of the decorations. On surviving objects, silver leaf usually remains untarnished if it has been protected by a layer of *Elaeagia* resin.

Figure 12. Portable writing desk, ca. 1684. Height 19 cm. Hispanic Society Museum & Library, LS2000. View of inside of lid below, with blue outline (near feet of bird at right) showing area included in Figure 13. (Photographs: courtesy of Monica Katz).

Figure 13. Detail of decoration on inside of lid of Hispanic Society Museum & Library LS2000 (Figure 12). Detail includes some of bird's green and red feathers, as well as part of one leg. Width of field: 2.5 cm. (Photograph: Richard Newman).

There are a few examples of other types of artifacts in which *Elaeagia* resin was utilized or suggested to have been utilized. The "barniz brillante" technique was utilized to decorate low-relief carved floral patterns on a series of picture frames, probably made in Colombia near the end of the 17th century or shortly thereafter [57]. The technique was used on parts of a small (about 35 cm height) wooden sculpture Wise Man Caspar, probably from the 18th century, in a collection in Bogotá, Colombia. The flesh tones of the figure were executed in oil paint, and all decoration of the clothing and jewelry was done in the "barniz brillante" technique [58].

Stuckart [19] provided a summary of the use of the resin in the early 20th century. A humble example are some very small (ca. 3 cm height) bowls purchased in Pasto in 1929 which contain simple *Elaeagia* decorations, in addition to other materials (Figure 14). These date to just a few years before a revival of the *barniz de Pasto* technique, according to Stuckart's review.

Figure 14. Bowl, collected in Pasto, Colombia in 1929. Decorations are made from tinted *Elaeagia* resin, applied on top of paint or varnish (which is of different composition). Diameter of saucer: 4.5 cm. Smithsonian National Museum of the American Indian 18/2849 (cup) and 18/2848 (saucer). (Photograph: Emily Kaplan).

9. *Elaeagia* Resin in Peru: Qeros and Other Inka Artifacts

Qeros are wooden ceremonial drinking vessels produced and used in pairs for centuries before the arrival of the Spanish in the central and southern Andes [59]. The ritual toasting and drinking of chicha (fermented maize and fruit beer) in matched pairs of qeros served important cultural functions in the establishment and maintenance of reciprocal relations within communities. Under the Inka state the ceremonial drinking of chicha defined and reinforced reciprocal, hierarchical state relations with constituent populations. Qeros produced by specialist artisans (qerocamayoc) were distributed to political elites who cooperated with the Inka Empire. Following the Spanish conquest, qero decorations incorporated European aesthetics, including a wide color palette, depictions of human and animal figures, and European vessel forms.

The earliest decorations on wooden qeros were shallow carved (or incised) geometric designs. It appears, based on a few excavated examples, that close to or soon after the colonial period began, the Inka started to use *Elaeagia* resin in decorations on qeros. In the most typical examples, shallow flat areas carved into the surface were inlaid with resin [60]. The inlays were usually flush with the surrounding wood surface. While the thicknesses of these inlays varied, those used to make the larger fields of color are up to a few hundred microns.

Presumably, the object and resin were heated to aid in the attachment of the decoration to the wood. While sometimes accretions or possibly coatings have been observed over *Elaeagia* layers on qeros, to date there has been no definitive indication that the original decorative layers were ever covered with other materials of any kind. Surviving inlays sometimes exhibit unusual textural features that are currently unexplained [32].

A single recently excavated fragmentary qero from Moqi, a site on the border between Peru and Bolivia, is considered to have been a part of a ritual feasting event [61]. Radiocarbon dating (at 95.4% confidence level) gave a calibrated range of 1407–1443 for the wood and 1473–1600 for the resin. The dating of the decoration falls on the border between the late Imperial period and the arrival of the Spanish in 1532. Qeros not including *Elaeagia* resin were also found at this site. The earlier date for the wood in this qero may be due to the parts of the tree used in the object (and sampled for analysis), and may not indicate the date of carving. There is also the possibility that an older piece of harvested wood could have been used.

A pair of qeros excavated at a grave in the Inka site Ollantaytambo, a site considered to date to 1537–1539, are other early examples of the use of *Elaeagia* resin [62]. The diminutive felines, six on each of the qeros, are expertly executed, suggesting considerable experience with the material on the part of the artisans who carried out the decoration (Figure 15). It would seem there was an earlier period of use of this resin by the Inka, so far unknown, that presumably dates to before the arrival of the Spanish.

Most inlays on qeros are opaque, but some were translucent or even transparent, particularly those tinted with cochineal dye. Inlays tinted only with cochineal tend to appear deep purplish red in situ, the dark color of the wood significantly affecting the inlay color. Details were applied to fields of uniform color by pressing small much thinner tinted pieces of resin into the underlying resin (Figures 16 and 17). Rarely, very thin layers of resin tinted with cochineal have been found attached to surfaces of wood surrounding inlaid decorations on qeros [63]. The layers seem to serve no direct decorative purpose, although they would have created a smooth somewhat glossy surface over the wood, perhaps a desired aesthetic effect.

Figure 15. One of a pair of qeros excavated at Ollantaytambo, Peru, in 1936. Height 15 cm. Museo Inka (Cusco, Peru) 229. Each qero is decorated with small felines (about 3.0 cm in length in this case) made from red, yellow, and black-tinted *Elaeagia* resin. (Photograph: Emily Kaplan).

Figure 16. Qero. Height 20 cm. Top: overall view. Bottom: rollout showing entire design. Smithsonian National Museum of the American Indian 6/5837. (Photographs: Ernest Amoroso).

Figure 17. Detail of decoration on qero shown in Figure 16. Width of field: 6.2 cm. Width of exposed areas of wood surface 1.5–3.0 mm. (Photograph: Emily Kaplan).

The general processing, preparation, and handling of the resin were no doubt similar in their broad strokes to what was carried out in Pasto, as the same steps would have been necessary to collect, initially process, mix in colors, and spread the resin into relatively thin sheets. But the applied decorations were usually considerably thicker and opaque. There are no known contemporary documents that note, let alone discuss, the use of *Elaeagia* by the Inka, although many qeros extensively decorated with *Elaeagi*a inlays were created by the Inka during the colonial period. Although the dating of qeros is mainly provisional, as few have been archaeologically excavated, it is thought that the use of *Elaeagia* inlays on individual qeros became more extensive as time passed, and the surfaces of later colonial objects are often nearly entirely covered with inlaid decorations. This more extensive applied decoration coincides with a shift to a narrative style that was influenced by examples of Spanish art with which the Inka artisans became familiar. The provisional dating of qeros described by Rowe [64] remains relevant.

In addition to shallow-carved recesses in qeros, *Elaeagia* resin was also applied directly on top of flat or carved surfaces of three-dimensional objects, a particularly striking example being a tiana in the Field Museum collection [65]. Some qeros also included high-relief carving on which the resin was applied.

Recent research has shown several changes in pigments utilized by the Inca from the early to late colonial periods [66,67]. As far as is known, however, based on a limited number of analyses [68], there were no changes in the resin (binding material) with which they were mixed over the approximately 300-year period in which the decorated qeros were made, although one qero has appeared to be decorated with another (non-*Elaeagia*) medium. Early analyses led to speculation that vegetable oil was intentionally mixed with *Elaeagia* resin during the making of the material to be used as inlays, but this is no longer believed to be the case, and in any event, would be difficult to establish as raw *Elaeagia* resin contains some native oil.

10. A Conundrum: The Relationship between the Inka and Colombia

At first glance, it seems possible that the Inka became aware of *Elaeagia* resin through contact with natives of southern Colombia who were familiar with its collection, preparation, and application to wooden objects. This seems possible given what is known regarding late excursions of the Inka into Colombia and the first appearances of *Elaeagia* resin on qeros.

Inka excursions into the southwestern part of Colombia occurred during the last few years of the empire [69]. The nature of Inka interactions with native peoples in Colombia may have been quite limited [70], and it is possible that there was no opportunity to become aware of *Elaeagia* resin, which, as discussed briefly above, may have been utilized during those years only to the north, somewhat beyond the area with which the Inka were in direct contact.

If the Inka learned about the unusual resin through such contact, a possibility is that the raw material and craftsmen who were well-versed in its manipulation were brought south to the Inka centers in Peru, where their material was repurposed to decorate qeros. Although the dating of the earliest uses of the resin on qeros is not firmly established, some recent radiocarbon dates summarized above suggest that the resin may have been used before the Inka excursions into Colombia took place.

Newman et al. [29] concluded, based on a very limited number of detailed analyses, that the resin used in qero decorations closely resembles botanical specimens of *E. utilis*, a finding that further complicates possible direct connections between the use of the resin by the two widely-separated cultures. This conclusion was based on two types of chromatographic techniques, which have been briefly noted above. Figure 18 shows the ratio of two significant components in *Elaeagia* resins that distinguish between the two species (from py GC/MS analyses); also plotted are ratios from some samples from objects of Colombian origin and Inkan qeros.

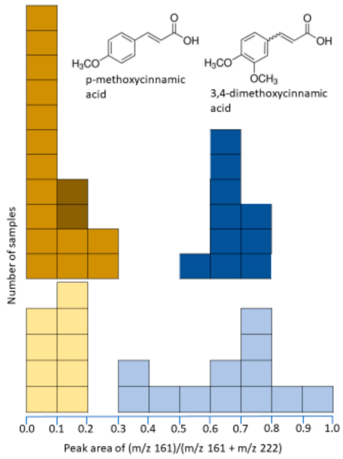

Figure 18. Plot of ratios of intensities of m/z 161/(m/z 161 + m/z 222) from pyrograms of *Elaeagia* botanical and *Elaeagia*-containing samples from artifacts. m/z 161 is a major fragment of p-methoxycinnamic acid methyl ester, m/z 222 of 3,4-dimethoxycinnamic acid methyl ester. Light yellow boxes: botanical specimens of *E. pastoensis* resin. Light blue boxes: botanical specimens of *E. utilis* resin. Dark mustard boxes: samples from colonial era objects made in Pasto, Colombia. Brown boxes: samples from pre-colonial resin beads from Colombia. Dark blue boxes: samples from Inka qeros. (Data source: Newman et al. [24]).

The Colombian botanist J. Rodrigo Botina (unpublished correspondence, 2022) has argued that *E. utilis* resin cannot be successfully manipulated in the same manner as *E. pastoensis* resin and thus could not have been used by the Inka. An intriguing note in Stuckart [19] suggests that *E. utilis* is known to the people who currently collect the resin used in Pasto, but that it was recognized that the resin from this species could not be used for decorating objects. This appears to be the only published statement addressing potentially crucial differences in the behavior of the two resins, assuming that the unsuitable resin did originate from *E. utilis*.

A recent experiment with very small (2–3 mm) pieces of resin from the two species have suggested that it is generally no more difficult to manipulate *E. utilis* than *E. pastoensis*. Repeated heating in boiling water and pressing on the hot resin with a flat steel tool reduced the *E. utilis* lump to a thin sheet about 0.5 mm thick, a simple exercise that was as easy to accomplish as with a similarly-sized piece of *E. pastoensis*. However, there may be differences in the extent to which the two species can be stretched into thin layers, which in effect would have been a limiting factor in how the resin could be utilized on objects, but this remains to be determined. As noted above, inlays on qeros tend to be thicker than the very thin layers featured on "barniz brillante" colonial period objects from Pasto, and at the moment there is no reason to question the hypothesis from analyses that *E. utilis* was utilized by the makers of qeros, who did not need to manipulate the resin into the paper-thin layers that artisans in Colombia needed to at times.

While the types of objects, how the resin was manipulated to create designs, and the roles of the objects which used were quite different in the colonial era Colombia and in Peru, there is one intriguing object, unique to the best of the authors' knowledge. This is a chest, made in Bolivia, dated to the 17th century (Museo "Casa de Murillo", La Paz, Bolivia) [71]. While illustrating an event of Inka history, the object itself is similar to ones being made in Pasto around the same time, and the coverage of the entire outer surfaces with (apparently) *Elaeagia*-based decorations is also similar to that of Pasto objects. The materials used in the decoration of this object have not been studied in detail as yet.

11. Conclusions

Elaeagia resin(s) are unusual natural materials that with some manipulations can be mixed with pigments or dyes, stretched into thin sheets, and applied to surfaces of various materials, wood apparently being the most common historically. While still utilized by artisans in Pasto, Colombia, it has long been out of use in the only other region of South America in which it seems it was ever employed as a decorative material. Objects decorated with *Elaeagia* resin continue to be subjects of study, from cultural, art historical, material, and conservation or preservation points of view. While the story of the resin is known in broad (and some finer) strokes, there are numerous details about material and utilization yet to be researched, and archaeological excavations in the future may reveal more about its history of use. The differences, physical and chemical, between *Elaeagia* from various species warrant further exploration. To date, it appears from limited analyses that the species utilized in Colombia, perhaps throughout history in that region, is *E. pastoensis*. In contrast, the Inka appear to have utilized a different species, whose chemical properties closely resemble those of *E. utilis* (although there are other Elaeagia species that have yet to be studied). This finding may have important implications for how the use of *mopa-mopa* was developed by the Inka, a topic on which future archaeological research will hopefully also shed light.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/heritage6050229/s1, Supplementary material file: Spanish translation of this paper.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Twenty-four reference samples of *E. utilis* and *E. pastoensis* (Table A1) from three herbaria (Field Museum, Chicago, IL, USA, FM; Missouri Botanical Garden, St. Louis, MO, USA; MO; Smithsonian National Museum of Natural History, NMNH) have been analyzed by FTIR microspectroscopy. Samples that could be taken from herbaria ranged from very small bits of finely powdered resin to larger (one-mm-sized) fragments. Herbaria samples were not necessarily collected at the times optimal for resin production by the trees, nor were samples intended to necessarily include substantial resin. Herbaria samples have not been processed in any way, although some had probably been treated with pesticides. Many were collected decades ago and all are stored attached to branches which were usually taped or sometimes attached with adhesive to paper (as in Figures 3 and 4). Since collection, most of the specimens have been stored in the dark and probably only occasionally examined by researchers.

Two spectra each of a single small sample from each specimen were acquired by transmission analysis on a Thermo iS10 FTIR spectrometer with an attached Thermo Continuμm IR microscope. The analysis area was ca. 50 μm × 50 μm. 100 scans were acquired at 4 cm^{-1} resolution between 4000–650 cm^{-1}. Spectra were acquired and processed with Thermo OMNIC version 9 software. After conversion to absorbance, straight-line corrections were applied to eliminate residual CO_2 bands from the air, and "Autobaseline" was applied. In addition, each spectrum was smoothed to eliminate some background noise and normalized.

The processed absorbance spectra (one from each specimen) were then evaluated by principal components analysis (PCA) in Solo version 9.1.0.0 software (Eigenvector Research Incorporated, Manson, WA, USA). The 18 *E. utilis* specimens served as the model group, and the six *E. pastoensis* specimens were then evaluated against this group. Full spectra (4000–650 cm^{-1}), spectra between 1800–650 cm^{-1}, absorbances at 12 major peaks, and spectra in the 1750–1690 cm^{-1} range were submitted separately to PCA analysis, with the best separation of the two species being achieved in the spectra in the 1750–1690 cm^{-1} range (see Figure 9).

Table A1. Herbaria samples. Species: u, *Elaeagia utilis*; p, *Elaeagia pastoensis*.

Collection	Specimen No.	Species	Collection Date	Country of Collection
FM	1926966	u	1967	Peru
FM	899023	u	1936	Colombia
FM	2110369	p	1988	Colombia
FM	1283354	u	1946	Colombia
FM	2184875	u	1997	Peru
FM	2046939	u	1985	Ecuador
FM	2011061	u	1963	Peru
FM	2260045	u	2002	Peru
FM	2226159	p	1999	Peru
FM	1753291	u	1968	Peru
FM	1142196	u	1943	Ecuador
FM	999470	u	1939	Colombia
MO	3381352	u	1967	Peru
MO	4228268	u	1990	Ecuador
MO	3656206	u	1987	Ecuador
MO	3012033	p	1959	Colombia
MO	5834698	p	1959	Colombia
MO	4571046	p	1993	Colombia
NMNH	1770637	u	1939	Colombia
NMNH	1901587	u	1944	Colombia
NMNH	2165540	u	1943	Colombia
NMNH	2166582	u	1944	Colombia
NMNH	2843435	u	1957	Colombia
NMNH	1661583	p	1935	Colombia

Appendix B

In this appendix, chromatograms from py GC/MS analyses of *E. pastoensis* samples by two laboratories (Museum of Fine Arts, Boston [MFA] and Metropolitan Museum of Art [MMA]) utilizing different analytical equipment are compared. In both laboratories, 25% TMAH in methanol was added to a solid sample prior to pyrolysis. The MMA instrument [33] utilized a Frontier Lab pyrolyzer, while MFA analyses [29] utilized a CDS pyroprobe. Pyrolysis at the MMA was carried out at 550C, at the MFA at 480C.

The MFA samples are "raw" resin from the market in Pasto, Colombia (2010) and a herbarium sample (see Table A1, NMNH 1661583; collected in 1935 in Mocoa, Putumayo Department, Colombia). The MMA samples are "raw" resin collected in 2012 in Pasto and a "processed" sample, prepared at MMA by boiling "raw" material (which had been collected in the market in 2002) in water. All four samples were likely collected from trees growing in the same region near Mocoa in Colombia.

The pyrograms contain many of the same compounds, although relative amounts of these can be quite variable. Figures A1 and A2 show the pyrograms, with some common peaks labeled. Major m/z fragments for these peaks are given in Table A2. Some peaks could be identified through searching the Wiley Registry 10th edition/NIST 2012 Mass Spectral Library; others could not.

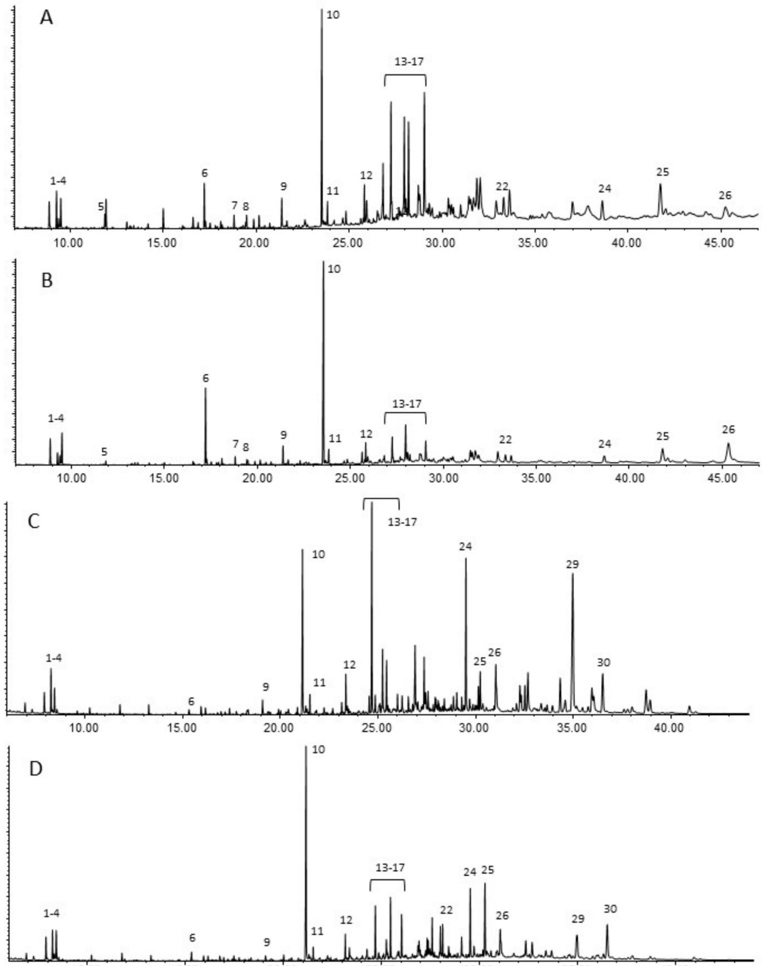

Figure A1. Pyrograms from analyses of *Elaeagia pastoensis* samples. (**A**) and (**B**) from analyses at MFA, (**C**) and (**D**) from analyses at Metropolitan Museum of Art. (**A**): herbarium sample, NMNH 1661583. (**B**): raw resin from Pasto market. (**C**): raw resin from Pasto market. (**D**): "processed" resin from Pasto market. Labels refer to information in Table A2.

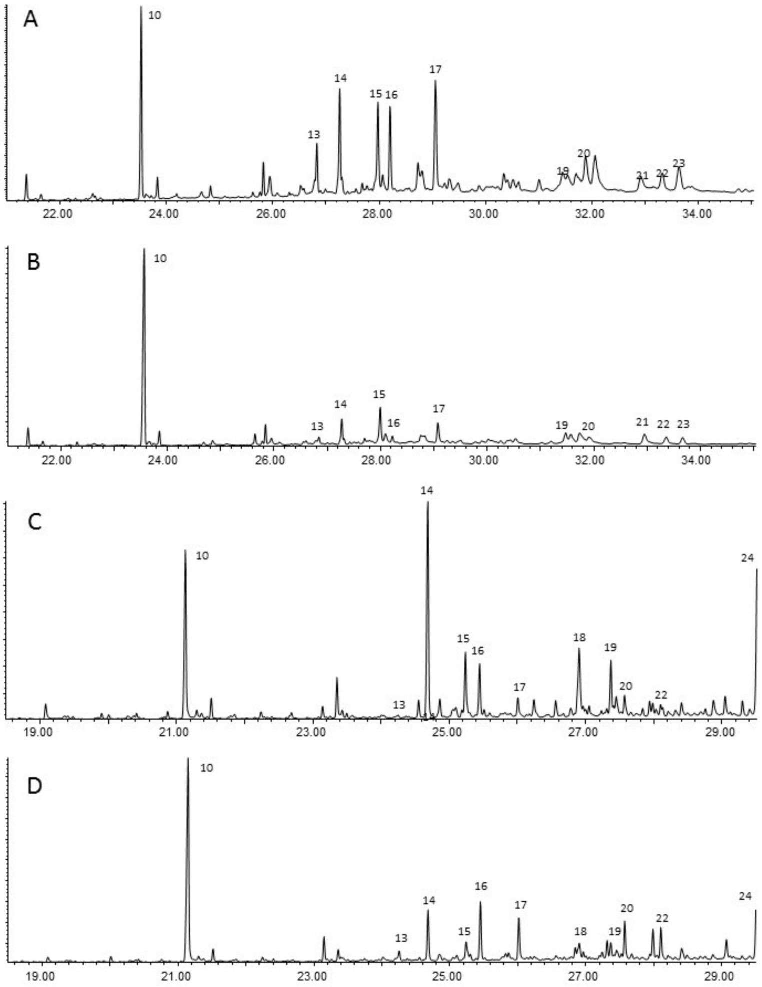

Figure A2. Details of pyrograms shown in Figure A1. (**A**) and (**B**) from analyses at MFA, (**C**) and (**D**) from analyses at Metropolitan Museum of Art. (**A**): herbarium sample, NMNH 1661583. (**B**): raw resin from Pasto market. (**C**): raw resin from Pasto market. (**D**): "processed" resin from Pasto market. Labels refer to information in Table A2.

Differences between the pyrograms could in part reflect real differences in the chemistry of the samples. Instrumentation could lead to differences in results. In particular, the GC/MS temperature program for the MMA samples ended at a higher temperature than the MFA program, and some of the later eluting compounds in the MMA samples were not seen in the MFA pyrograms. These later-eluting compounds include derivatives of flavonoids and triterpenoids. These classes of compounds make up a small proportion of the resin itself but the triterpenoids themselves may be characteristic of *E. pastoensis*. A series of unidentified peaks, probably pyrolytic fragments, in the middle of the pyrograms (peaks 13–25) seem to be characteristic of the resin, although apparent proportions are not the same and not all peaks may be present. If the result of pyrolysis of the insoluble matrix of the resin, these peaks could be expected in processed resin samples (such as the MMA "boiled" sample) as well as "raw" samples, although how processing affects the chemistry of the resin has yet to be addressed in any detail. Pyrolysis temperature differed between the two labs, although this variation was probably not great enough to result in significant differences in the pyrolysis fragments that were generated from the resin samples.

Table A2. Selected peaks in pyrograms of *Elaeagia pastoensis.* Retention times (RT, minutes) for MFA sample NMNH 1661583 and MMA sample "raw resin". Identifications from mass spectral databases are given when possible.

Peak no.	RT (MFA)	RT (MMA)	Mass Spectra Peaks, m/z (Intensity)	Identification
1	8.86	7.90	45 (100), 43 (32), 75 (28)	2-propanol, 1-3-dimethoxy
2	9.25	8.24	59 (100), 89 (85), 45 (57), 102 (43)	propane, 1-2-3-trimethoxy
3	9.36	8.31	45 (100), 43 (48), 75 (43), 61 (25)	1,2-propanediol, 3-methoxy
4	9.48	8.42	45 (100), 58 (89), 75 (67), 43 (55)	2,3-dimethoxypropan-1-ol
5	11.85		122 (100), 91 (51), 77 (33), 79 (28)	benzene, 1-methoxy-3-methyl
6	17.20	15.32	164 (100), 149 (37), 91 (35), 77 (31)	benzene, 4-ethenyl-1,2-dimethoxy
7	18.82		166 (100), 95 (30), 77 (23), 51 (15)	benzaldehdye, 3,4-dimethoxy
8	19.49		152 (100), 55 (92), 74 (81), 83 (70)	nonanedioic acid, methyl ester
9	21.38	19.10	161 (100), 192 (67), 133 (38), 89 (19)	methyl p-methoxycinnamate, cis
10	23.53	21.13	222 (100), 191 (47), 207 (17), 147 (12)	methyl 3,4-dimethoxycinnamate
11	23.84	21.51	74 (100), 87 (85), 270 (22), 143 (19)	hexadecanoic acid, methyl ester
12	25.83	23.36	74 (100), 87 (63), 43 (28), 55 (24)	octadecanoic acid, methyl ester
13	26.84	24.26	248 (100), 55 (96), 98 (78), 81 (72), 67 (69)	
14	27.26	24.68	215 (100), 159 (82), 95 (58), 71 (54), 45 (27)	
15	27.98	25.24	169 (100), 145 (73), 95 (62), 87 (44), 55 (44)	
16	28.21	25.45	215 (100), 173 (67), 141 (58), 81 (48), 187 (44)	
17	29.07	26.01	169 (100), 87 (99), 127 (93), 159 (71), 155 (53)	
18		26.91	215 (100), 71 (81), 135 (59), 201 (52), 67 (49)	
19	31.46	27.37	215 (100), 167 (57), 71 (45), 135 (41), 55 (32)	
20	31.88	27.57	201 (100), 169 (32), 137 (32), 71 (25)	
21	32.93		153 (100), 55 (66), 169 (65), 81 (63), 113 (59)	
22	33.32	28.10	187 (100), 201 (87), 155 (81), 137 (44), 71 (36)	
23	33.64		119 (100), 299 (87), 85 (87), 342 (85), 189 (75)	
24	38.61	29.51	299 (100), 191 (72), 43 (67), 95 (67), 331 (62)	
25	41.75	30.25	299 (100), 43 (84), 95 (74), 207 (72), 317 (70)	
26		31.04	312 (100), 311 (50), 266 (25), 283 (25), 313 (20)	tri-o-methylapigenin
27		32.27	189 (100), 69 (98), 109 (93), 191 (73), 95 (68)	(highest m/z 440)
28		32.69	342 (100), 341 (68), 296 (31), 313 (27), 343 (20)	methylated luteolin derivative?
29		34.97	109 (100), 69 (56), 189 (53), 95 (43), 191 (36)	(highest m/z 440)
30		36.52	109 (100), 69 (60), 95 (46), 189 (38), 207 (35)	lupeol? (highest m/z 426)

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