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A multi-technical method for the taxonomic identification and production history of three medieval gilt leathers from the Palacio de Viana in Córdoba

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Abstract

Gilt leather was an artistic representation made on skin that became widely popular in the late 15th century and, especially, in the first half of the 16th century. It was a carved leather whose main decoration was gilding and painting, often with additional engravings and embossing. Its elitist character and the social recognition it acquired turned this object into a symbol of cultural identity. Nevertheless, understanding the complex production techniques requires an overview not limited to written sources, especially with regard to the nature of the hide. We applied Zooarchaeology by Mass Spectrometry (ZooMS) using matrix-assisted laser desorption/ionisation trapped ion mobility time-of-flight mass spectrometry (MALDI-timsTOF) to three gilt leathers from the Palacio de Viana leather collection (Córdoba, Spain). Using minimal amounts of sample, the three objects were established to derive from sheepskin. This technique also allowed us to estimate the peptide deamidation levels, found to be higher than those estimated in parchment. This likely reflects the aggressive chemical treatment of leather and its preservation history. The combination with a scanning electron microscope analysis fitted with an energy-dispersive spectroscopy (SEM-EDS) detector contributes to the reconstruction of their production history.

Introduction

It is beyond doubt that the study of historical material and its productive knowledge, underpinned by the applied sciences and technologies, is essential for answering questions which have not been resolved by traditional methodology[1,2]. Therefore, correlating historical and archaeological data is increasingly imperative, with the support of technological advances and new analytical methodologies[3]. The purpose is to provide a historical explanation of materiality, whose findings can be applied across the humanities and social sciences[4].

For this reason, the ZooMS method has been adopted for the taxonomic identification of three gilt leathers from the renowned leather collection held by the Palacio de Viana, a house-museum located in the historic centre of Córdoba (Spain). The “biological identity” of gilt leathers, called *guadamecíes* (Spain), *cuir doré* (France), *corami d’oro* (Italy) or *goudleer* (Netherlands), highlights the functional diversity of leather types and the socio-economic resources utilised during the transition from the Middle Ages to the Modern Era. Similarly, it is an incentive for heritage conservation and the enhancement of cultural assets[5–7].

Gilt leather designates embossed, painted, gilded or silvered leather. Its artistic connotation allowed for adaptation to different contexts –houses and noble palaces– or religious spaces with a strongly sumptuous character[8]. Indeed, certain leather subsectors acquired great relevance in the city of Córdoba, such as the manufacture of gilt leathers[9]. From the reign of the Catholic Monarchs, a gradual replacement of traditional tapestries with gilt leather coverings can be observed; more economical and suitable for upholstering walls, altarpieces, cushions, bedspreads, curtains and front doors[10].

Current scholarship traces gilt leather techniques back to the Iberian Peninsula in the 15th century, concurrently with the regulation of the craft in cities such as Córdoba, Seville and Valencia[11]. Its legacy survives today through the few collections preserved in the country, such as the aforementioned Palacio de Viana (Córdoba) and the Museu de l’Art de la Pell in Vic (Barcelona) Valencia[12]. From the first group, hardly any technical studies of the leatherwork and material have been carried out, emphasis has been rather placed on the works' artistic expressions[13]. Several aspects relating to gilt leather craftsmanship remain to be clarified, including the nature of the raw materials employed and the production methodology. Hence, the joint analysis of this study's pieces, together with the scarce documentary sources of normative character, is fundamental for evaluating the trustworthiness of transmitted information and the technical execution's accuracy.

Despite the historical background of the gilt leathers being very fragmented, the Obra Cultural de la Caja Provincial de Ahorros de Córdoba[14] accurately documented the purchase of the entire collection from the Palacio de Viana. From this, it can be inferred that part of the collection was in the Benacazón Palace (Toledo), and the remainder in a gallery of the Museo Nacional de Artes Industriales, now reformulated as the Museo Nacional de Artes Decorativas (Madrid). This

conundrum raises to a key question: Were Viana's gilt leathers made in Córdoba? The topic has a more complex backdrop than one might think at a glance; firstly, because gilt leather production is not exclusive to Córdoba, there were Castilian cities that also had a strong artistic tradition; and, secondly, recent studies have pointed to an Italian influence, albeit not connected with the Gallery's collection, in a gilt leather panel held at the Palace, whereby connections to Italy's Quattrocento cannot be ruled out[13].

In any case, it is evident that they are now part of Córdoba's cultural and historical legacy, justifying the recognition of a craft whose finest achievements refer to this territory. Indeed, it would not be far-fetched to assert Córdoba's originality of the gilt leathers, insofar as the leather sector meant a genuine hinterland tied to urban production[15]. During the Late Middle Ages transactions involving furs from Córdoba to many areas of the different peninsular kingdoms, including Portugal, are documented[16,17].

Attempts to trace the origin of species in objects made of leather date back to the 19th century. One of the first approaches involved the diagnostic assessment of hair –diameter, length, morphology, dimensions– through a comparative analysis using atlases and reference sets[18–22]; a highly complex task, as it required a deep understanding of the matter and, largely, depended on the greater or lesser deterioration of the dermis, the layer that is processed to form leather[23,24].

Optical microscopy has had a greater influence on the distribution of species-specific grain patterns –hair follicles–, across the skin's surface[25]. Currently, databases of leather microscopic images (LeaData) have been created to facilitate automatic species identification; although to date, most of the results on archaeological pieces have been partial[26–28]. A superficial reading is more problematic than might be inferred, as the tanning stage can lead to follicle destruction. In the case of gilt leather, the paint and gilding make recognition even more difficult[29]. Despite its widespread application, biological discrepancies have been found in microscopic analyses, a factor which implies the necessary validation with other alternative approaches[30,31].

DNA-based strategies, by contrast, have been successfully applied to ancient parchment, bookbindings and leather garments, but their efficacy depends on conservation quality and, in archaeological leather, on diagenetic conditions[32–34]. Several studies have found that nuclear DNA degrades significantly during chemical treatments[35–37]. Among biomolecular methods (archaeogenetics and palaeoproteomics), mass spectrometry yields the best indicators[38–40]. The reason is that proteins, particularly collagen, are less affected by the physicochemical interventions in leather, which translates into increased stability in environments where it is not possible to amplify DNA[26,41,42]. While proteins are less genetically informative than DNA, they still carry enough taxonomic specificity.

Consequently, this study centres on the taxonomic identification of gilt leather targeting type I collagen (COL1), the most abundant protein in skin[43–47]. Its robust structure and long-term stability, renders it a good target for the palaeoproteomic characterisation of archaeological artefacts[48]. It is a slowly evolving protein composed of three intertwined chains arranged in a triple helix – two identical COL1α1 chains and one COL1α2 chain–. Minor sequence changes introduce differences in peptide mass that enable taxonomic discrimination[49,50] using ZooMS (Zooarchaeology by Mass Spectrometry), a collagen peptide mass fingerprinting (PMF) technique underpinned by MALDI-TOF MS (matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry).

The main advantage of ZooMS is that it generally requires smaller sample sizes than other techniques, and even minimally invasive techniques, like eraser sampling[51] have been developed. Hence, it is a relevant technique for the examination of hides in general and medieval gilt leathers in particular, whose dimensions are still to be determined[52,53].

The intrinsic features of these organic artefacts make them more vulnerable to deterioration over the centuries. The contribution of Zhang et al.[54] has revealed that vegetable-tanned leather, that is, the traditional technique used by the Viana gilt leathers, maintains around 67% collagen. Due to the phenolic groups that comprise vegetable tannins, hydrogen bonds

are generated which can cross-link the collagen macromolecular chains[55]. To obtain a clearer view of the fibres, a scanning electron microscope (SEM) has been employed, which permits magnification of large depth of field; and, at the same time, the energy-dispersive X-ray spectroscopy (EDS), in which elements distribution, mostly those related to dyeing and decorating, suggests the optimisation of the obtained results. SEM has performed satisfactorily in the identification of fibres in parchment[55] and leather[57–59].

Materials and methods

Samples

Of the roughly thirty pieces that constitute the so-called “Leather Gallery”, three framed gilt leathers hanging on the wall have been selected (see Fig. 1 and Table 1):

Table 1
Signature, approximate historical period, and dimensions of the gilt leathers analysed.
Thickness was measured using a micrometer by conservation personnel.

ID	Time Period	Culture	Dimension (cm)	Thickness (mm)
35-G-010	16th century	Renaissance	24 x 178	0.75
35-G-015	15th-16th centuries	Renaissance	105 x 128	1.2
35-G-016	15th-16th centuries	Renaissance	78 x 88	1.15–1.5

The samples, dating from the late fifteenth century to the first half of the sixteenth century, were taken in the Conservation Department of the Palacio de Viana. Priority was given to “self-sampled” material, partially detached or hidden fragments to avoid visible damage in the objects[60]. Although the samples were not weighed, it is estimated that they did not exceed 10–15 mg, with an average size of 10–17 mm (Fig. 2). As a general rule, a small portion that can be manipulated with forceps is sufficient to obtain reliable PMF results[61]. For this reason, the method described by Cucina et al.[62] was followed, based on the use of subsamples for proteomic analysis, whilst most of the record has been preserved for future studies. Furthermore, electrostatic molecular extraction using a PVC polymer has recently been demonstrated to be unsuitable for leather, as it can harm the surface during sampling[63,64].

Appropriate measures were taken to minimize contamination, such as the proteinaceous material in the environment. Samples of the pieces were collected using a sharp scalpel and placed in 1.5 mL Eppendorf tubes. They were stored at room temperature until their transport and preparation at the Globe Institute ancient protein laboratory (University of Copenhagen, Denmark).

Sample preparation

The samples were prepared in accordance with previously published protocols for parchment[51] and leather[30]. During the protein extraction process, the PPE used included a lab coat, nitrile gloves (to prevent contamination from human skin keratin), sterile sleeves, hairnets and shoe covers. To reduce laboratory contamination, the samples were handled in a fume hood. For each sample, decontamination of sampling equipment was performed with bleach and ethanol.

Firstly, an alkali washing solution was applied to remove humic acid compounds that may interfere in extraction: 200 µL of 0.1 M NaOH was added to the sample tube and vortexed for 5 seconds. They were centrifuged for 1 minute at 13,000 revolutions/minute (rpm). The 200 µL of NaOH was drawn up with a pipette, taking care that no pieces of leather transferred it. Afterwards, 200 µL of 50 mM AmBic (Ammonium Bicarbonate) was added to the sample tube and vortexed for 5 seconds, and centrifuged for 1 minute at 13,000 rpm. The 200 µL of 50 mM AmBic was drawn up and this step was

repeated twice more (three times in total). Thereafter, the samples were gelatinised at 65°C in 50 µL of AmBic on a heating block, following the established procedure for historical leathers[2].

To digest proteins, 5 µL of trypsin (0.4 µg/µL solution) was added to the tube with the protein solution. Digestion was performed overnight (17.5 hours) at 37 ºC with 300 rpm agitation on a heating block.

After digestion, the samples were centrifuged for 1 minute at 13,000 revolutions/minute (rpm). Subsequently, the supernatant was recovered using a pipette (set to 55 µL), ensuring that no solids were removed, and deposited into a new 1.5 mL Eppendorf tube to prevent unnecessary transfer of residues. 10 µL of 5% TFA (trifluoroacetic acid) was added to inactivate the trypsin. Digested peptides were desalted using ZipTips[44] as follows:

First, the tip was rinsed twice with 100 µL of conditioning solution (0.1% TFA in 50:50 acetonitrile and UHQ water). Next, the tip was rinsed twice with 100 µL of washing solution (0.1% TFA and UHQ water). Afterwards, the sample was resuspended by pipetting back and forth through the tip ten to fifteen times, taking care that no air entered the pipette. Finally, the sample was eluted with 50 µL of conditioning solution into a new Eppendorf tube by pipetting ten to fifteen times.

Spotting and MALDI-TOF mass spectrometry

For mass spectrometry, 1 µL of each eluted sample was spotted in triplicate onto a reusable stainless-steel 384 spot MALDI plate. Then, 1 µL of matrix (α-cyano-4-hydroxycinnamic acid [CHCA]) was added on top for co-crystallisation. Mass spectrometry was carried out at the University of Southern Denmark (SDU) in Odense, Denmark, where the samples were analysed with a timsTOF fleX MALDI-2 instrument (Bruker Daltonics).

Among the main limitations of palaeoproteomics, biases in the databases persist, preventing a more comprehensive taxonomic record. Protein sequence repositories are dominated by reference organisms and cover only a minority of the protein diversity of all species. Although initiatives have emerged in recent decades to identify specific peptide markers for certain mammals[65], restrictions still apply to wild species. And despite the predicted results being consistent with the domestic character of the identified species, protein sequences from other animals cannot be completely excluded. Accordingly, the biomarkers of the samples were cross-checked against York University's publicly available list, which is updated online (https://www.york.ac.uk/archaeology/research/research-centres/bioarch/research-themes/palaeoproteomics/, accessed 25.09.2026).

Resulting spectra were processed using the open-source, multi-platform software mMass[66]. The mean of the three spectra replicates associated with each sample was calculated, and the mean spectrum was inspected manually to detect peptide marker presence. In parallel, it was compared with a laboratory blank and was evaluated in the same manner as the samples throughout the entire extraction process. Given the possible variability in manual readings, these were complemented with an automated PAMPA tool[67], confirming an absolute correlation between the proteotypic peptides. The marker names were listed according to the nomenclature proposed by Brown et al.[43]. Low-intensity peaks or peaks below 3 signal-to-noise ratio (SNR), or with overlapping peaks, are labelled with question marks “?”. While poor-quality markers or without distinctive peaks were designated as “–” (Table 2).

Deamidation was estimated using the maldiMDS package (Yang et al., 2025) for the sheep markers COL1α1 781–789 (m/z 898.51), COL1α1 508–519 (m/z 1105.58), COL1α2 978–990 (m/z 1180.64), COL1α2 757–789’ (m/z 3033.47). Default parameters were used, but the mass tolerance was reduced to 0.05 Da.

SEM-EDS characterization

Simultaneously, to obtain a more detailed view of samples' fibrillar surfaces, a scanning electron microscope coupled with an energy-dispersive X-ray spectrometer (SEM-EDS), model JEOL JSM 6300, was used. The instrument is equipped with a

secondary electron (SE) detector, which provides detailed topographical images, and a backscattered electron detector (BSE), which aids in the identifying of elements within the internal layers. The images and EDS spectra were captured at an acceleration voltage of 15 kV, a working distance of 10–13 mm and a probe current of 3×10^{-10}. Since the samples had to be kept under vacuum conditions, they were placed on sample holders applying pressure with tweezers until the samples were stably secured. Only the surfaces of the flower were analysed to verify the condition of the supports that had been treated. The tests were undertaken at the Servicio Central de Apoyo a la Investigación (SCAI), of the University of Córdoba.

Results and discussion

Biomarker validation

Taxonomic identification was performed by applying the parsimony principle (family, genus and species), based on unequivocal markers. ZooMS analysis confirmed domestic sheep (*Ovis aries*) in the three samples (Table 2). The absence of any unexpected animals and the reliable rejection of other taxa mean that gilt leathers have had a 100% overall success rate for a single species. The peptide mass for marker COL1α2 757–789 is 3033.4, a peak that distinguishes *Ovis aries* and *Bos taurus* from *Capra hircus* (3093.4) and equids (2999.4). In turn, the 2883.4 mass of the marker was positioned at COL1α1 586–618 cattle (*Bos taurus*) (Fig. 3a). Additionally, the presence and absence of other masses from markers COL1α2 978–990, COL1α1 688–704, COL1α2 793–816 support the identification as *Ovis aries* and further discard *Bos taurus, Capra hircus* or equids (Fig. 3b, c, d).

Table 2
m/z values of collagen peptide markers obtained on mMass platform.

Peptide Marker m/z										
ID	**COL1α1 508–519 (P1)**	**COL1α2 978–990 (A)**	**COL1α2 484–498 (B)**	**COL1α1 502–519 (C)**	**COL1α2 292–309 (P2)**	**COL1α2 793–816 (D)**	**COL1α2 454–483 (E)**	**COL1α1 586–618 (F)**	**COL1α2 757–789 (G')**	**Identif.**
35-G-010	1105.6	1180.6	1427.7	1580.8?	1648.8	2131.1	–	2883.4/ 2899.4	3017.4/ 3033.4	Domestic sheep
35-G-015	1105.6	1180.6	1427.7	1580.8?	1648.8	2131.1	–	2883.4/ 2899.4	3017.4/ 3033.4	Domestic sheep
35-G-016	1105.6	1180.6	1427.7	1580.8?	1648.8	2131.1	–	2883.4/ 2899.4	3017.4/ 3033.4	Domestic sheep

The deamidation levels ranged between 0.4 and 0.75 for markers COL1α1 781–789 (m/z 898.51), COL1α1 508–519 (m/z 1105.58) and COL1α2 978–990 (m/z 1180.64), while for COL1α2 757–789' (m/z 3033.47), the minimum value was 0.15. Sample 35-G-015 shows the lowest deamidation for all 4 peptides compared to the other two samples. These values overall are higher than those observed in parchment by Nair et al.[68] and near the highest ones observed by Yang et al.[69]. The high deamidation estimate also matches the observed sheep peak isotopic envelope for COL1α2 978–990 (Fig. 3c) and COL1α1 508–519 (Fig. 4 bottom), in which the second peak is the highest. Nair et al.[68] established COL1α1 508–519 as the slowest deamidating peptide in parchment, and it is not usual to observe the second peak higher than the second for this peptide in any kind of sample, bone or skin.

Generally, it tends to be regarded as an accumulated indicator of protein damage over time, but also suggests a connection with object production and usage history[44,68]. It is worth remembering that leather undergoes chemical and mechanical treatments that could modify deamidation patterns. The high pH in the liming, acid tanning and dyeing processes, together with temperature fluctuations during the maceration, may have affected deamidation rates[68,70]. Furthermore, there is no

record of any restoration work on the gilt leathers, although it is very likely that they have received conservation and maintenance treatments at some point. For example, the Palace's own workshop uses mineral turpentine cream diluted with a small proportion of beeswax for stiff leather.

A relevant detail is that the animal species identification has been limited exclusively to the surface where the samples were taken (see Fig. 1). Gilt leathers were composed by an indeterminate number of sewn pieces, whose size depended on their intended purpose[9]. Nevertheless, the central hypothesis is that, irrespective of the surface layer selected, all the pieces must have belonged to the same biological species, *Ovis aries*. The justification lies in their morphological similarity and, above all, in the medieval Castilian regulations which stipulated that gilt leathers ought to be made from the same animal[71]. There was, then, an advanced knowledge of material properties, avoiding mixing leathers with different physical characteristics[72].

The fact that gilt leather samples all come from sheep might indicate that hides were obtained from the immediate vicinity. The sheep farming sector was heavily dependent on tanning, more than any other industry[73]. In the kingdom of Córdoba, it reached a very wide range, partly due to the favourable biotic conditions, which sustained the grazing of large flocks of merino and castilian sheep[15]. So, it is not surprising that locally available raw materials were used in the manufacture of luxury goods. And when compared with the historical context the data acquire added value, in that medieval craft provisions are consistent with production techniques of the three Viana gilt leathers. The municipal ordinances of cities such as Córdoba and Seville are very explicit on this matter, ordering gilt leathers to be made from sheepskin[74].

Surface evaluation

Leather quality greatly depends on the production method, the type of tanning agents, when it was tanned, and the tanner’s technical ability[29,75]. From this perspective, scanning electron microscopy images have helped to identify the typical diagnostic signs of sheepskin: a soft, uniform and supple skin, making it the ideal organic material for covering sumptuous artefacts[30].

The collagen fibres in gilt leathers are lengthy and relatively slender, with a diameter ranging between 5 and 20 μm. They appear twisted into well-defined bundles and are very densely concentrated, an intrinsic quality of greasy sheepskin[76]. At higher magnifications, the fibrillar surface exhibits rough granules which are probably related to the transformation process into a non-putrescible product and the unavoidable temporary degradation (Fig. 5). The frayed aspect would appear from a progressive loss of interstitial water[77], due to a decreased hydration that unifies the peptides through hydrogen bonds[78].

EDS mapping showed that the fibres are composed predominantly of carbon (C) and oxygen (O). Such evidence reaffirms what is already self-evident, which is the organic origin of the gilt leathers[79]. The distribution of the elements corresponds to the fibres’ morphology. The coherence of the remaining elements strengthens the hypothesis that the gilt leathers followed similar or, at least, analogous production techniques. The presence of calcium (Ca), specifically the 0.97% detected in 35-G-010 sample, could be related to hide liming, a pre-tanning operation that helped to remove the hair[80]. As for sulphur (S), reduced to 0.20% and 0.79% respectively, it is of great interest given its possible involvement in silver degradation, the quintessential precious metal of the gilt leathers[81]. Silver sheets subjected to an anthropogenic environment may have undergone contaminating sulfurisation upon reacting with atmospheric hydrogen sulphide[80]. Likewise, condensed tannins, characterised by a brown colour (see Fig. 1), can absorb atmospheric contaminants such as sulphur dioxide, which would explain their detection[82].

Ultimately, SEM-EDS has provided information on the metallic elements that would have been employed as mordants and pigments in the dyeing phase. In this sense, scientific literature has demonstrated that metal compounds may have an antimicrobial effect upon contact with organic materials[83,84]. That raises a clear point of inquiry: Did the artistic decoration

of the gilt leathers enhance collagen preservation? Solazzo et al.[85,86] work offers a positive response to the issue, as the increased surface mineralisation appears to be correlated with a reduction in deamidation levels.

On the one hand, the aluminium (Al) and potassium (K) found in one sample could decipher the mordant used to set the colours: either alum (aluminium potassium bisulphate) or, alternatively, tartar, rich in potassium[77]. On the other hand, the low presence of copper (Cu) and iron (Fe) is possibly associated with the pigments applied during dyeing. The Cu points to a greenish colour, probably verdigris[80]; in the gilt leather sample 35-G-016 (Fig. 2), green pigmentation is noticeable in some spots with macroscopic observation. Instead, Fe may be bound to a brown or ochre dye derived from iron oxides[87].

Conclusion

The scientific analyses of gilt leathers presented here have enabled the partial reconstruction of the production processes for gilt leather, one of the most representative leathers in Hispanic material culture. Its manufacture relied on available animal resources. In this regard, the taxonomic identification has helped clarify the crafting practices of an exclusive object attributed to the medieval elite. Through ZooMS, we have for the first time identified sheepskin as the primary surface of historical gilt leather wall panels. This had until now only been suggested by the scant evidence of a few late medieval ordinances.

The micrographs obtained by scanning electron microscopy were an auxiliary tool for assessing the integrity of collagen fibres. Together with the distribution map of the elements, they revealed very valuable information about leather processing techniques. And, finally, it can be concluded, at least from the examples described, that by the transition from the Middle Ages to the Early Modern period there must already have been a thorough knowledge of the technique, developed within a well-established system of craft rules.

Declarations

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Author contributions

D.F.S.: conceptualization, methodology, investigation, resources, data curation, writing–original draft, visualization and funding acquisition; I.R.P.: software, validation, data curation, writing–review & editing; Z.F.: resources, writing–review & editing; D.C.H.: resources, writing–review & editing; J.R.R.A.: writing–review & editing; M.J.C.: funding acquisition, writing–review & editing.

Competing interests

The authors declare no competing interests.

Additional information

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Data Availability

Data availabilityThe dataset with the MALDI-TOF spectra has been deposited on Zenodo (https://doi.org/10.5281/zenodo.20815626).

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Figures

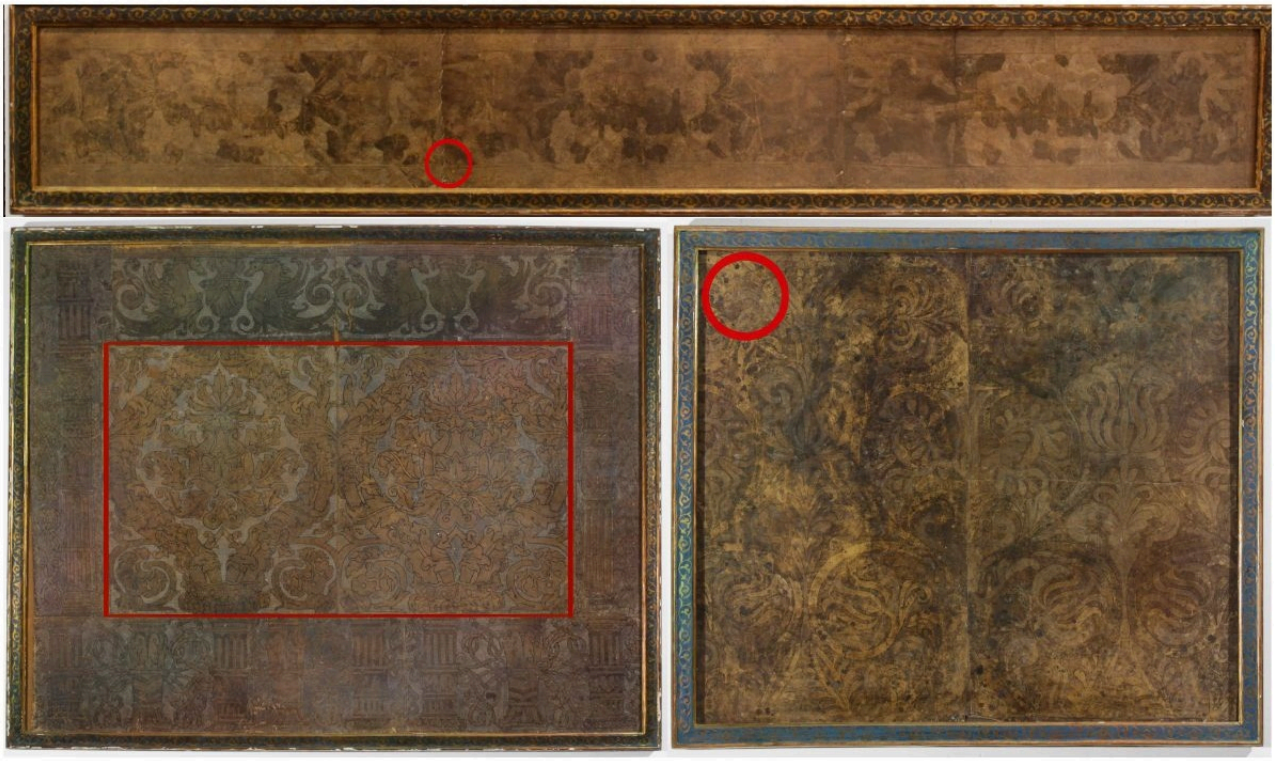


Figure 1

Front view of gilded leather at Palacio de Viana, Córdoba. The one above (35-G-010) is a gilt leather frieze with Renaissance decoration based on floral garlands and cherubs; those below (left: 35-G-015 and right: 35-G-016) are large square-shaped with Renaissance decoration in stripes and vegetable motifs. Red marks the area where samples were taken. Images from Palacio's Restoration Department.



Figure 2

A complete overview of the three samples from the gilt leathers. The images were taken at the Biological Analysis Laboratory, Research and Transfer Department of the Instituto Andaluz del Patrimonio Histórico (IAPH), through a Leica Emspira 3 digital microscope.

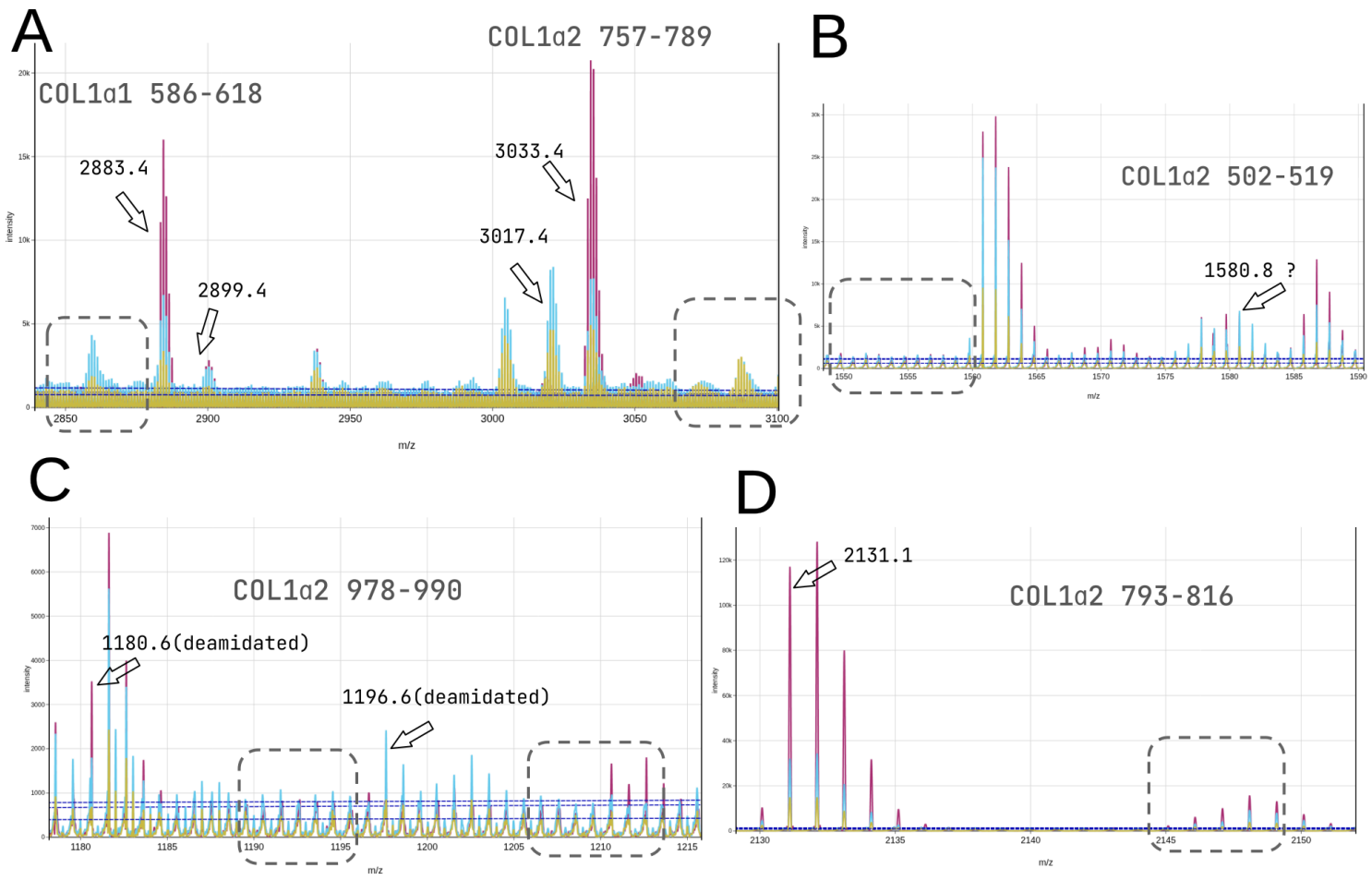


Figure 3

MALDI-TOF spectra sections of the relevant ZooMS markers. Replicates are combined. 35-G-010 in cyan, 35-G-015 in magenta and 35-G-016 in yellow. Key peak masses from table 2 are indicated, while regions with missing peaks from alternative organisms (*Bos taurus*, *Equus caballus*, *Capra hircus*, *Cervus elaphus*) are indicated with dashed boxes.

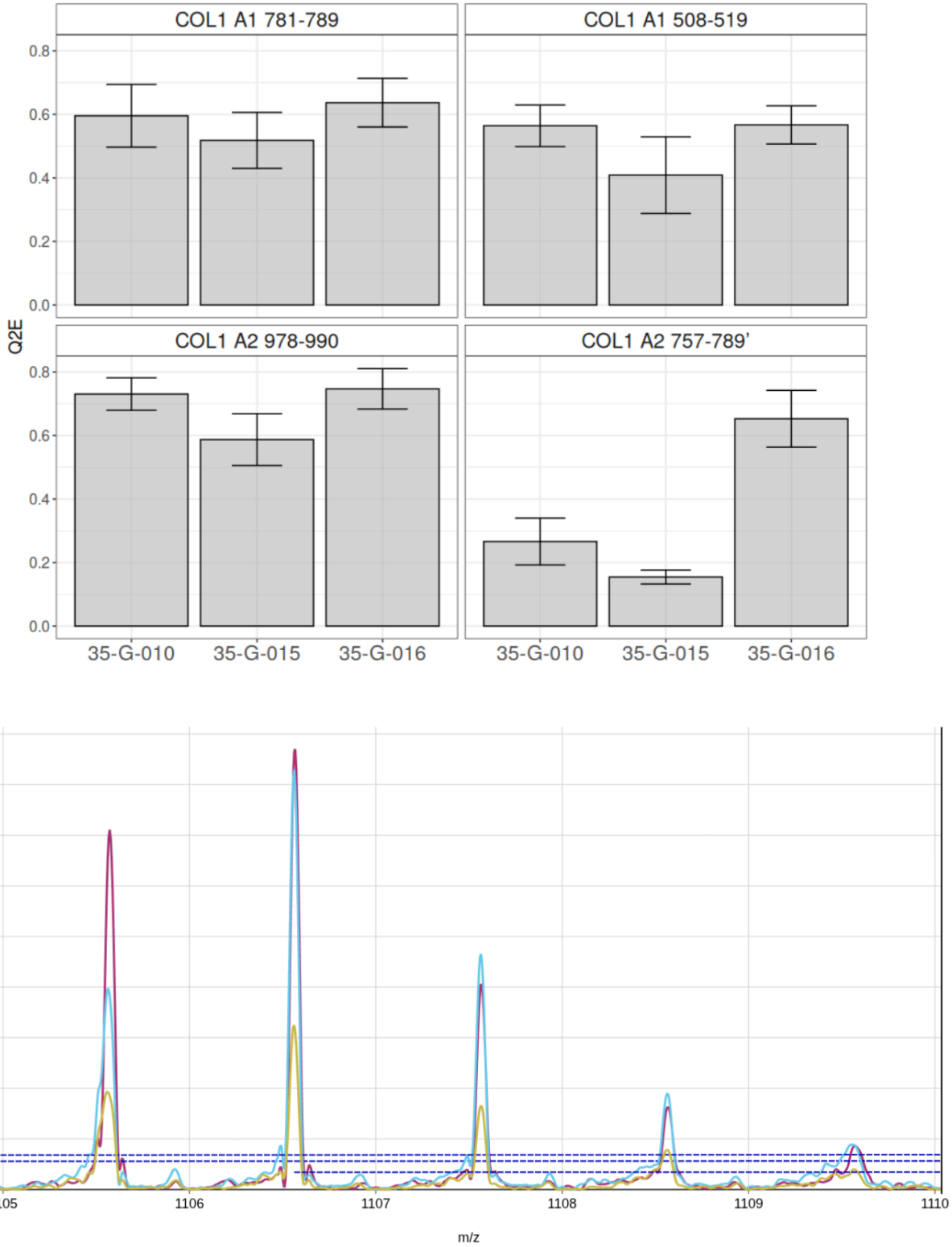


Figure 4

In the top, deamidation (Q2E) values for the COL1α1 781-789 (m/z 898.51), COL1α1 508-519 (m/z 1105.58), COL1α2 978-990 (m/z 1180.64) and COL1α2 757-789' (m/z 3033.47). The bottom shows the isotopic envelope of marker COL1α1 508-519 (m/z 1105.58), with the second peak as the highest. 35-G-010 in cyan, 35-G-015 in magenta and 35-G-016 in yellow.

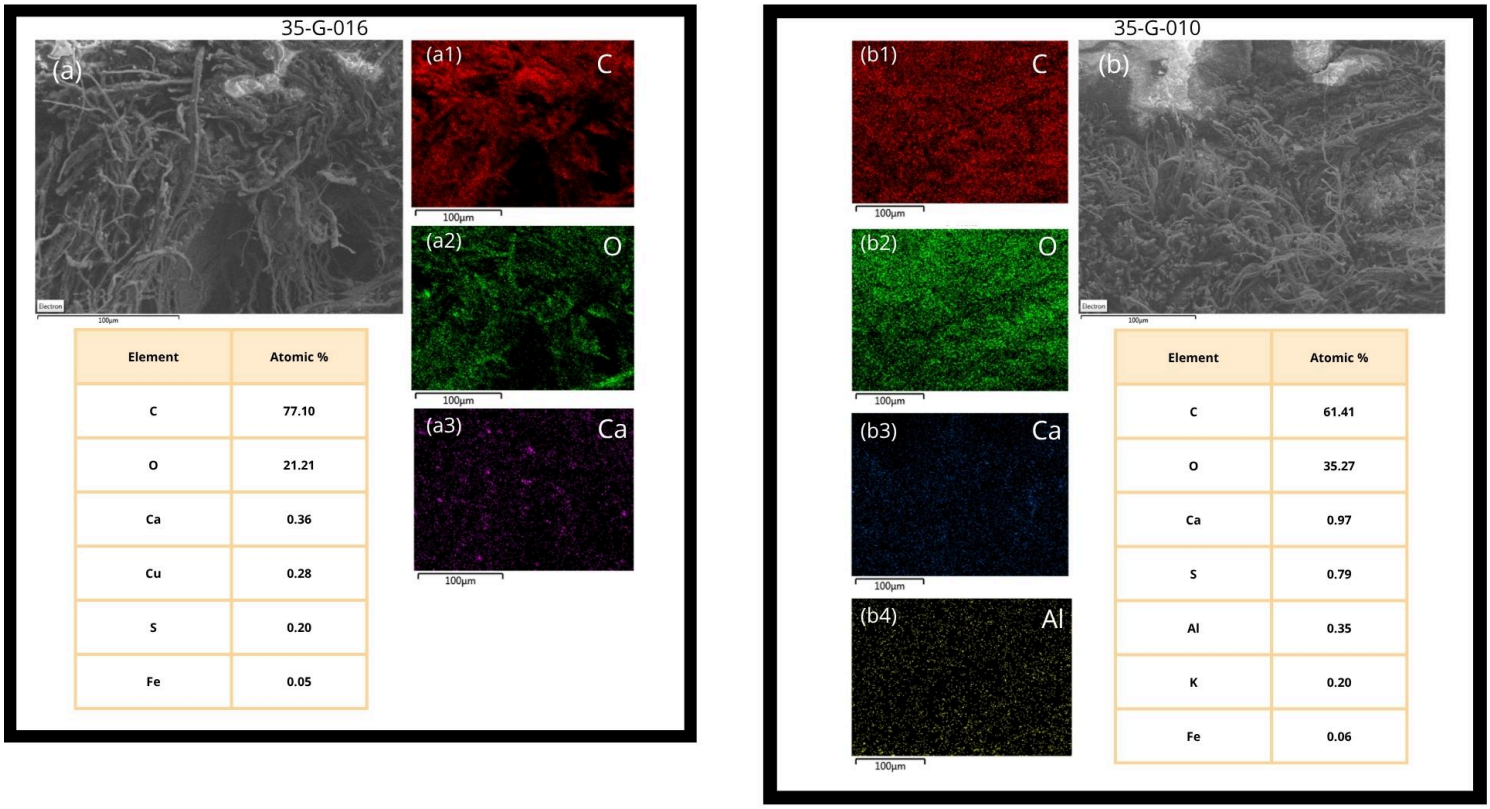


Figure 5

SEM-EDS of collagen fibres and a table with the atomic percentage of the analysed surface. (a) elemental distribution of 35-G-016 gilt leather: (a1) carbon, (a2) oxygen and (a3) calcium; lower concentrations of (S) sulphur, (Cu) copper and (Fe) iron are also detected. (b) elemental distribution of 35-G-010 gilt leather: (b1) carbon, (b2) oxygen, (b3) calcium and (b4) aluminium; a significant concentration of (S) sulphur is also detected, along with lower (K) potassium and (Fe) iron occupancy. The remaining gilt leather (35-G-015) is not included in the image since the fibril mapping yielded very little data.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.xlsx
- Table2.xlsx
- giltleatherzooms.mzml