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Holy Corn. Interdisciplinary Study of a Mexican 16th-Century Polychrome Maize Stem, Paper, and *Colorín* Wood Sculpture

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Abstract: Maize stem sculptures, produced during the 16th and 17th centuries in New Spain (today, Mexico) are a clear example of the convergence of the artistic traditions from the American indigenous populations and European influence. This typology of sculptures is not limited to the Americas, as the examples found in European countries have shown. Therefore, a detailed technological investigation is required to correctly classify them. This work presents the interdisciplinary and multianalytical investigation of a 16th-century sculpture made with a maize stem preserved in Guadalajara city, Mexico. We used a set of techniques, such as CT, SEM-EDX, μ-FTIR, and μ-Raman, to study, from a macro to a micro level, the structure, the polychromy, and the modification of the sculpture. The results showed the use of maize stems, paper, and wood in the construction of the sculpture and the use of the traditional polychromy, as well as the numerous modifications that changed its appearance considerably resulting in its misclassification. We were able to associate the statue with the Cortés workshop (Mexico City region), probably produced in the decade of 1580, and track its liturgical use and historical development through the centuries.

Keywords: maize stem; New Spain; computerized tomography; FTIR; Raman; SEM-EDX; Mexican sculpture; polychrome sculpture

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1. Introduction

The production of corn (*Zea mays* L.) stem light sculptures in New Spain (today Mexico) during the 16th and 17th centuries is a clear example of the convergence of two artistic traditions. On one hand, there are the Mesoamerican sculptural materials such as maize stems, agave inflorescence (*quiote*), and *colorín* wood (*Erythrina coralloides* DC.). On the other there are the European artistic traditions and iconographic models [1,2]. This technique is still used today in the Michoacán state (Western Mexico). Corn, the most characteristic material of this sculpture technique, was, and still is today, an important element in the Mexican culture. For example, according to the Mayan tradition, humankind was made of corn [3]. However, this type of sculpture was not exclusive to the New Spain viceroyalty. Bruquetas [4] reported examples of similar statues, made with glued fabrics and agave inflorescence, from the Andean region (previously the Peru viceroy). There are also historical records of the use of maize stem for sculpture production in the Kingdom of Guatemala [5].

It is possible to track the artistic tradition of American low weight sculptures through the Spanish *papelón* [6] until the Italian *cartapesta* [7] used at least since the 14th century as a profitable activity for artists thanks to an early serial production system of sculptures sold at lower prices due to the "poor" materials used. Because of the international trade routes of materials, such as gold, silver, and cochineal [8,9], as well as artwork during the Spanish Empire (16th–19th centuries) [10,11], some American light weight sculptures

arrived in European countries such as Spain [12–14] and Croatia (previously the Republic of Ragusa) [10].

The chronicles written by the friars in charge of the evangelization of the indigenous populations reported the technical procedures to use maize stem as sculpture material. According to the historical records, the production of maize stem sculptures started with the harvest of the adult maize plant after the production of the corn, followed by the cleaning of the stems, debarked or not according to their use, by boiling them. Finally, they were let to dry slowly. In some cases, the sculptors added poisonous plants to the boiling bath to increase the resistance to biological attack [14]. The debarked stems were ground and bound with a natural adhesive to prepare the paste for modeling the volumes. The historical references indicate the use of a polysaccharide gum named *tatzingueni* or *tzauhtli* extracted from orchid bulbs [15], but so far only animal glue has been identified in the sculptures analyzed [16].

Unfortunately, today, we know the name of very few artists that used maize stems and other local materials such as *colorín* wood. The Cerda family, Matías and his son, Luis, active during the 16th and 17th centuries in the Michoacán region (Western Mexico), are the most famous sculptors of which we have historical records [1,17,18]. Additionally, the sculpture of the *Virgen del Pueblito* (today in Querétaro state in central Mexico) is attributed to the friar Sebastián Gallegos (active during the first half of the 17th century), who probably learnt the technique in Michoacán [19]. There are also records about the use of maize stem by the friar Félix de Mata in Guatemala [5].

Despite the reduced records about artists, the technical and formal characteristics of the sculptures allow their classification into "workshops" linked to specific regions. Amador Marrero [13,20] proposed nine workshops associated with three geographical areas: the western area of Mexico, specifically, what is today the Michoacán state, the central area concentrated in Mexico City, which was the capital of the New Spain viceroyalty, and Oaxaca in the southwest region (Figure S1).

In addition to their formal characteristics, in general, the internal structure of the sculptures allows their classification; the examples from the Michoacán region have a core made of maize stem which is attached using natural fibers or light wood (e.g., *colorín*) covered with debarked maize stem and maize stem paste. On the other hand, the sculptures produced in the central area are hollowed. Artists used two-half casts to obtain the initial shape, made of paper (similar to the *papelón* or *cartapesta* techniques) and, in some cases, codices [14,21]. To facilitate the removal of the paper from the mold, the artist applied gypsum or diatomaceous earth [22]. This system allowed a semi-serial production of the sculpture [14]. The artists achieved the final volumes by modeling debarked or maize stem paste over the paper or wooden core.

The polychrome sculpture production was a collaborative work as dictated by the regulations of the guilds; after the sculptor finished the volumes, a polychromer (a specialized painter) prepared the polychromy [23–25]. Very few records report on the polychromy technique used in the maize stem sculptures. Bonavit identified the use of a preparation layer called *ticatlali* or *tízar* (most probably gypsum), which was also reported by Carrillo y Gariel [21]. Regarding the pigments, Bonavit suggested the painters used carbon black and cochineal lake mixed with a siccative oil as binder [26].

The scientific investigation of maize stem sculptures is paramount for their correct identification, classification, and correct conservation. The variety of materials and the complexity of the structure make it necessary to use a multianalytic approach to understand the technology of these sculptures. Radiography [12,27] and computerized tomography [10,28,29] are the preferred technique for the non-invasive investigation of the internal structure. Endoscopy also offers this kind of information, but it is applicable only to hollowed sculptures that, due to their condition, allow the insertion of the camera [30]. Microscopic and spectroscopic methods enable the study of the polychrome surface [27,31,32]. The research published so far indicates that the artists followed the European tradition: gypsum and animal glue for the ground layer and pigments (e.g.,

lead white, azurite, vermilion, minium) mixed with siccative oils, and in a very few cases, animal glue, as a binder. There are also reports of the use of metallic leaves applied over red bole to decorate the loincloth [13,19,22].

Most recently, studies have focused on gaining a better understanding of the degradation mechanisms of maize stem as a sculpture material, particularly its physical properties linked to their preparation, by studying the mechanical properties and the resistance to biological damage according to the part of the stem used and the method of preparation [33].

This work presents an interdisciplinary investigation that covers the historical research, the stylistic analysis, and the technological study of a 16th-century maize stem sculpture, *el Señor del Santo Entierro* (Lord of the Holy Sepulcher). Before our study, scholars misclassified the sculpture and suggested it was a substitution of the original. We completed historical research together with a multianalytic examination, combining non-invasive and micro-invasive methods, using computerized tomography (CT) to understand the internal structure, optical and scanning electron microscopy (SEM-EDX), micro attenuated total reflection-Fourier transform Infrared (μ-ATR-FTIR) and micro-Raman (μ-Raman) spectroscopies for the study of the original polychrome surface and its modifications. We aimed to recover the statue history and study its technology to classify it correctly and help in its conservation.

2. Materials and Methods

2.1. The Sculpture of Señor del Santo Entierro

We studied the sculpture entitled *Señor del Santo Entierro* (Figure 1) currently at the *Nuestra Señora de la Soledad* church in Guadalajara city, in Jalisco state (Western Mexico).



Figure 1. Sculpture of *Señor del Santo Entierro*, ca. 1580, Cortés workshop, Mexico.

2.2. Computerized Tomography

The computerized tomography (CT) was performed using a two-slide Siemens Emotion Duo 1 scanner with a standard protocol for lung tissue diagnosis (113 mA and 130 kV). The tomograms were acquired in slices of 3 mm with a separation between every measure of 0.5 mm and processed in the transverse, sagittal, and coronal planes.

2.3. Sample Preparation

Table 1 summarizes the samples analyzed and the analyses performed. The sampling areas are reported in Figure S2. Cross-section samples were imbibed in Nic Tone® transparent acrylic resin and polished until the sample surface was exposed. One of the cross-sections from the polychromy was imbibed initially with KBr and then in Implex® polyester resin. It was polished until the sample surface was exposed [34].

The fibers from the paper samples were partially separated under the stereomicroscope and then introduced into a test tube with distilled water and completely separated. A drop of the fibers sample was put over a glass slide and covered for observation.

The maize stem sample was boiled and cut using a razor blade to obtain a transverse view of the cellular structures. The slides were added to a sample holder with carbon adhesive tape.

Table 1. List of samples analyzed and a summary of the analysis performed.

Sample ID	Type	Analysis
SSE-1	Cross-section	Optical microscopy, SEM-EDX, μ-FTIR, μ-Raman
SSE-2	Cross-section	Optical microscopy, SEM-EDX, μ-Raman
SSE-5	Cross-section	Optical microscopy, SEM-EDX
SSE-6	Maize stem paste	SEM
SSE-8	Paper	Optical microscopy

2.4. Stereo and Optical Microscopy

The samples were observed and documented with a stereomicroscope Leica model EZ4HD and an optical microscope Leica model DM 4000 M with a Leica digital camera model DFC 450 C using 20× and 50× magnifications. We processed the images with the Leica Application Suite 4.0 software.

2.5. Scanning Electron Microscopy

The cross-section samples imbibed in polyester resin were completely covered with graphite adhesive tape leaving the sample uncovered. We applied two strips of aluminum adhesive tape on both sides of the sample to increase its conductivity.

Sample images were captured with a SEM Jeol model JSM-6390LV under low vacuum using 20 kV. Small areas according to the size of each layer were analyzed using EDX, the time of analysis was 100 s. Maps of the cross-section samples were obtained with 3 million counts. The data was processed with the INCA Suite 4.08 software.

2.6. Attenuated Total Reflection-Fourier Transformed Infrared Spectroscopy

Micro-ATR-FTIR (μ-ATR-FTIR) analyses were performed using a Thermo Scientific Nicolet iN10MX spectrometer in attenuated total reflection (ATR) mode with a Ge crystal. The spectra were recorded in the range between 4000 to 675 cm^{-1} with an optical aperture of 200 × 200 μm, corresponding to an effective investigated area of 50 × 50 μm, and a spectral resolution of 4 cm^{-1} and 64 scans. Maps were recorded with an optical aperture of 40 × 40 μm (effective investigated area of 10 × 10 μm) and a step size of 8 μm. The data was processed with OmnicPicta and Omic32 software.

2.7. Micro Raman Spectroscopy

μ-Raman analyses were performed with a Bruker Senterra Raman Microscope coupled to an Olympus BX 40 microscope equipped with a CCD camera. The spectra were recorded in the 100–3200 cm^{-1} range using a 785 nm He–Ne laser source and with excitation powers of 9 mW and 1 mW and a spectral resolution of 3–5 cm^{-1}. Acquisition time was 5–10 s and 5–10 accumulations to maximize the signal-to-noise ratio. Spectra were processed with OPUS and Origin Pro software.

3. Results

3.1. Historical Research

Unfortunately, little historical documentation about the sculpture has survived. Therefore, a partial history has been reconstructed by us using the documentation regarding where the sculpture has been located and examining the constant changes through the centuries.

The *Nuestra Señora de la Soledad y el Santo Entierro de Cristo* confraternity—constituted only by Spaniards—was founded in 1590 in the capital of the Kingdom of New Galicia

(an autonomous kingdom that was part of the New Spain viceroyalty and today is the Guadalajara city in the Jalisco state) in the San Miguel Royal Hospital; its principal function was to organize the representations and processions for the Holy Friday that, according to historical documentation, was done for the first time in 1595 [35]. The confraternity commissioned the sculpture of the *Señor del Santo Entierro*, together with the sculpture of the *Señora de la Soledad*, for the liturgical representations of the Holy Friday.

A historical description of the confraternity procession indicates that the *Señor del Santo Entierro* sculpture was descended from the cross—the reason why the arms of the sculpture were articulated—and placed in a richly decorated urn, which was followed by angel statues holding the *Arma Christi* [35], which were also a visual didactic element for the evangelization. The last procession performed by the confraternity was in 1866 [35]. These religious performances were very popular and useful from a didactic and evangelical perspective in the early years of the Spanish colonization [36]. The processional uses of the images are directly linked to their materiality; the maize stem sculptures were famous because of their low weight. The mural paintings of Huejotzingo (Puebla state) and Teitipac (Oaxaca state) monasteries depict similar examples of the Holy Friday processions done in New Spain [36], which are still performed nowadays in Tzintzuntzan (Michoacan state) where another maize stem statue, *Señor del Rescate*, is used to represent the descendant of dead Christ's body, followed by a procession [37].

The *Nuestra Señora de la Soledad y el Santo Entierro de Cristo* confraternity was associated with the Archbasilica of Saint John Lateran in Rome in 1598 [38], the same year in which the sculptures were moved from the hospital and placed in the Shrine chapel inside the cathedral. Because of the great devotion towards the two sculptures, in 1599, a specific chapel was built for them, and by 1658, their own church was built in a park next to the cathedral [39,40].

Because of the "law of tolerance of sects" enacted in 1926 and the subsequent Cristero War [41], the church gradually reduced its activity and finally closed on 2 October 1933 by presidential decree [42], passing to the administration of the Federal Finance offices, and in 1935, it became an archive. Finally, in 1949, was destroyed as part of an urban modification program planed by Ignacio Díaz Morales and promoted by governor Jesús González Gallo [43]. After the closure of the church, the sculptures were placed initially in the cathedral and later in different private houses until the construction of the current church of Our Lady of Solitude, designed by Pedro Castellanos de Lambley. Its construction started in 1950, but today it remains unfinished [44].

3.2. Stylistic Analysis and Workshop Adscription

To ascribe the sculpture to a specific workshop, we performed a stylistic analysis of the sculpture. It is of natural size (170 cm) and the representation is anatomically correct. Two main elements allow the adscription of the sculpture to a specific workshop: the loincloth and the head. The loincloth is simple and short; it represents a single white cloth wrapped around the loin from right to left. The Spanish sculptor Alonso Berruguete (1490–1561) used this type of loincloth in his wooden sculptures [45]. Amador Marrero [14] identified similar loincloth designs in the early maize stem sculptures (around 1570) ascribed to the Cortés workshop. However, in the *Señor del Santo Entierro* sculpture, the loincloth is simpler; we suppose it is an intermediate stage between the early sculptures from the 1570s and the sculptures made in 1580s that have a simpler loincloth design (Figure 2). Regarding the facial representation, the beard is the only element we can consider, since the hair is a modification: it is short and forked and the mustache surrounds the mouth.

Based on these elements, we proposed the ascription of this sculpture to the Cortés workshop, associated with the central region, particularly Mexico City. It is probably closer to the production of the 1580s, in agreement with the historical documentation of the confraternity.

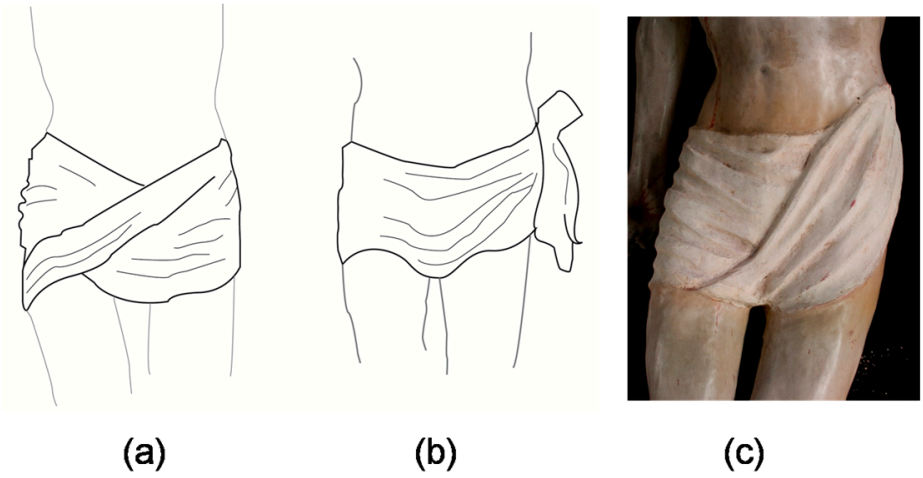


Figure 2. Comparison between different loincloth designs. (**a**) Loincloth general design identified in the Cortés workshop sculptures from the 1570s; (**b**) loincloth found in the Cortés workshop sculptures from the 1580s; (**c**) detail of the loincloth from the *Señor del Santo Entierro* sculpture.

3.3. Computerized Tomography

The tomographic images showed the original structure of the sculpture and some modifications (Figure 3). The body is hollowed and was constructed initially with a two-half cast (Figure 3c) to obtain a general shape. The artist modeled the volumes over the paper silhouette, first with debarked maize stems and later with maize stem paste.

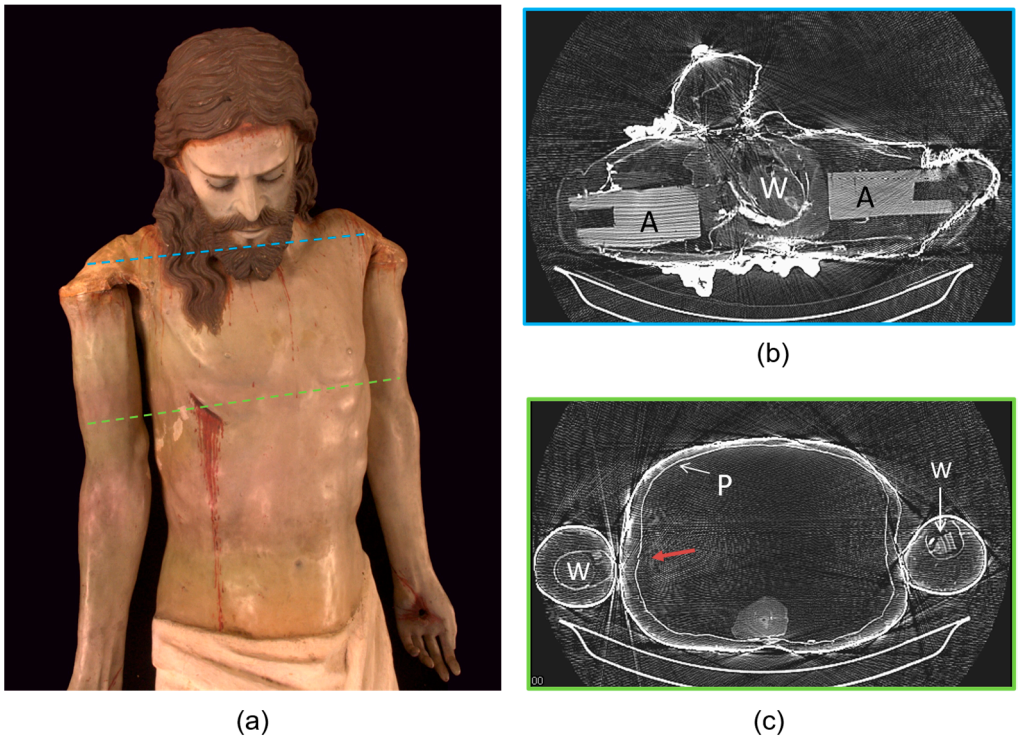


Figure 3. (**a**) Detail of the sculpture, the dashed lines in color indicate the different areas of the tomograms; (**b**) Axial tomogram of the shoulder areas, the image shows the articulation system (A) and the wooden elements used to insert the head of the sculpture (W); (**c**) Axial tomogram shows the hollowed structure, the paper layer (P) obtained using a two-half mold; the red arrow shows the union between the two halves obtained from the mold. The wooden elements used to reinforce the arms and insert the wooden hands are marked with W.

The upper head part (i.e., the cranial vault) was modified by adding three wooden fragments pasted together (Figure S3b,c). Additionally, the space between the head and hair (which was modeled using gypsum as suggested by SEM-EDX analysis, data not showed) suggests it is a modification. Small metallic nails (approximately 60) fixed it to the sculpture head (Figure S3a).

The tomographic study also allowed us to understand the shoulders articulation system (Figure 3b), it is a "*galleta*" or "*gozne de paleta*" system (similar to a hinge), done using a woodblock cut in the external extremity to create a space; another wooden element from the inside of the arm was inserted in the middle of the woodblock and fixed with a linchpin (Figure S3a). This particular articulation system was already used in Spanish sculptures in the 16th century [46]; however, previous studies on New Spain sculptures suggest that the "*galleta*" system was used after the 18th century, while the most common articulation system during the 16th century was spherical [47]. In light of this, the articulation system was probably substituted, which is reasonable considering the possible damage produced by the constant use.

Particularly in the loincloth area, we observed a hidden perforation on the left side (Figure 4b) that was probably used to insert a ribbon (today lost) when the sculpture was placed on the cross, as several paintings show, for example, *El Señor de Santa Teresa* (1760) by Francisco Antonio Vallejo (1722–1785) or the *El Señor de Chalma* (1719) by José de Mora (1642–1724), both today at the Museo Nacional de Arte in Mexico City.

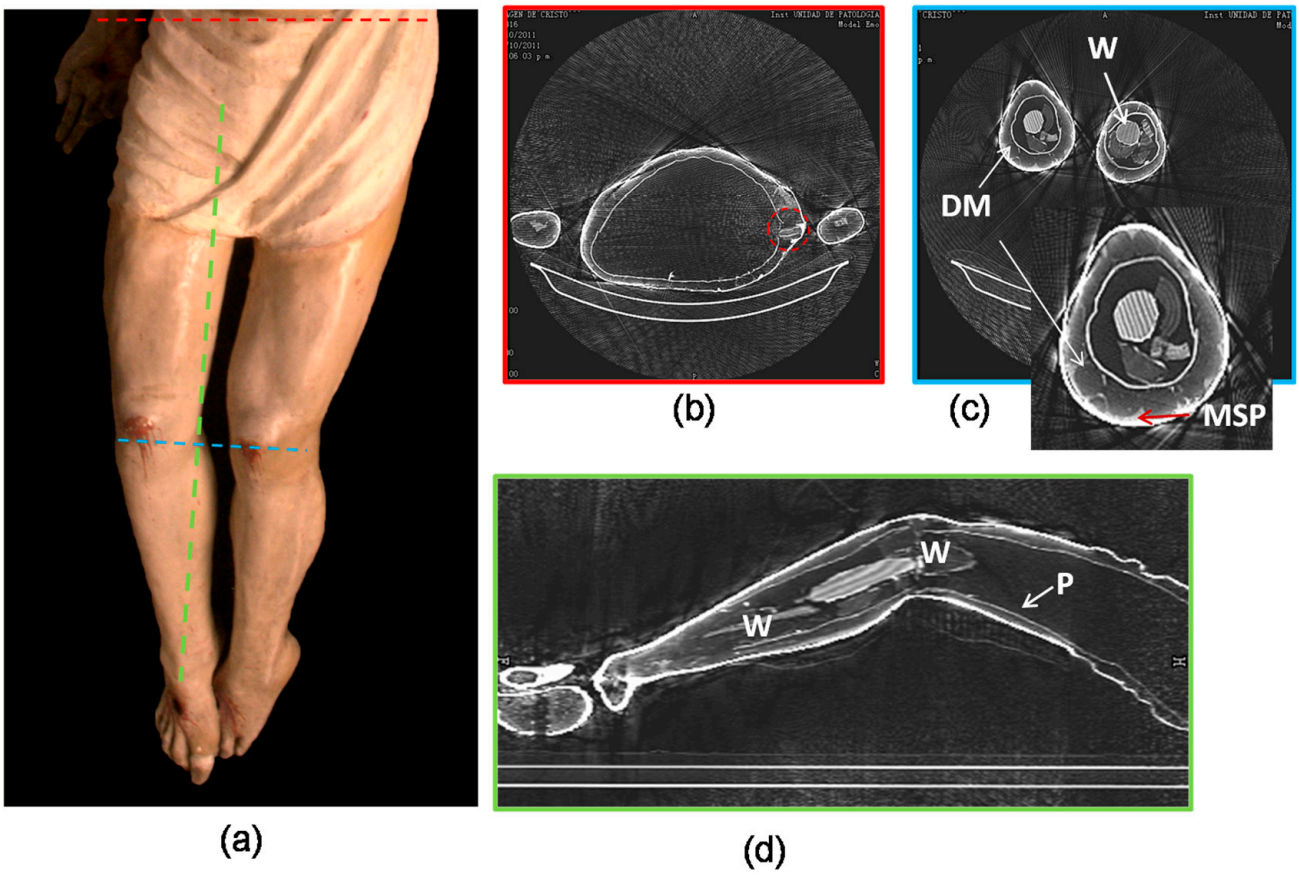


Figure 4. (**a**) Detail of the lower part of the sculpture, the dashed lines in color indicate the different areas of the tomograms; (**b**) Axial tomogram of the loincloth, the image shows a possible hold to insert a removable ribbon (marked with a red dashed circle), in the same region the separation of the two halves of the paper layer is shown; (**c**) The axial tomogram shows the wooden elements that reinforce the knees, the inset shows the circumference of the debarked maize (DM) stems and the maize stem paste (MSP) used to obtain the volumes; (**d**) Sagittal tomogram that shows the hollowed structure, the paper layer (P), and the wooden elements (W) used to reinforce the knees and to insert the feet.

In addition, the CT images showed the technical knowledge of the artist who used resistant materials in the areas where mechanical stress concentrates. The hands and feet were carved in wood (probably *colorín* to avoid increasing the weight) and some wooden elements to reinforce the neck, the arms (Figure 3b,d), and the legs (Figure 4d), as well as for fixing the hands and feet were inserted (Figure 4d). Several wooden elements reinforced the knees (Figure 4c,d).

3.4. Maize Stem and Paper Identification

Sample SSE-6, obtained from a fracture in the beard of the sculpture, confirmed the use of maize stem paste for modeling the volumes. The SEM images showed the characteristic cellular structures of the maize (*Zea mays* L.) vascular bundle (Figure 5a,b) [48]. The internal structure of the sculpture (sample SSE-8) was made with a thick cardboard-like paper made of long, yellowish fibers. Under the microscope, we identified cotton (*Gossypium hirsutum* L.) fibers (Figure 5c), which was the most common textile fiber used by the indigenous populations [49].

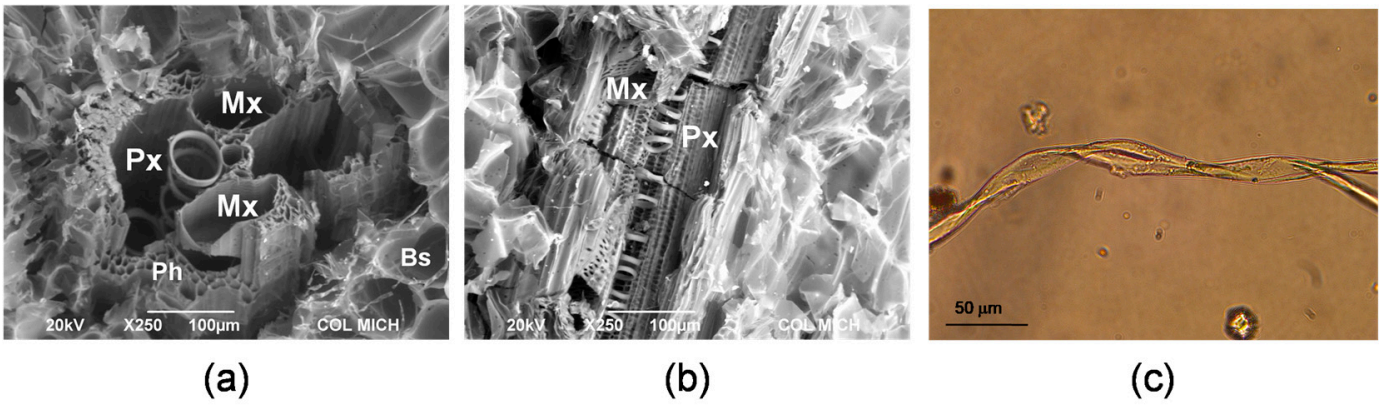


Figure 5. (**a**) SEM backscattering image of the maize stem sample (SSE-6) shows the maize vascular bundle, Px: protoxylem, Mx: metaxylem vessels, Ph: phloem, Bs: bundle sheath; (**b**) Longitudinal view of some structures of the maize vascular bundle, Px: protoxylem, Mx: metaxylem vessel; (**c**) Cotton fiber from the paper layer (sample SSE-8) under the optical microscope (50×), average diameter 10 µm.

3.5. Polychromy Analysis

3.5.1. Original Polychromy

The polychromy was done following the European artistic tradition. Over the final layer of maize stem paste, the artist applied a preparation layer made of *gesso grosso*, containing mainly anhydrite ($CaSO_4$), identified thanks to the 1095 cm^{-1} band from the νS=O in the µ-FTIR spectra (Figure 6f). Anhydrite, obtained by roasting gypsum, was traditionally used for ground layers in Southern Europe until the 16th century [50]. A particular characteristic of the ground layer of this sculpture is the presence of a cellulosic material (probably maize stem fragments) used as a filler (Figure 6a,d). These fragments are present in the different cross-section samples. The weak bands at 1656 cm^{-1} and 1548 cm^{-1} (data not showed) arising from ν(C=O) and NH, respectively [50], suggest the used of animal glue as a binder for the ground layer.

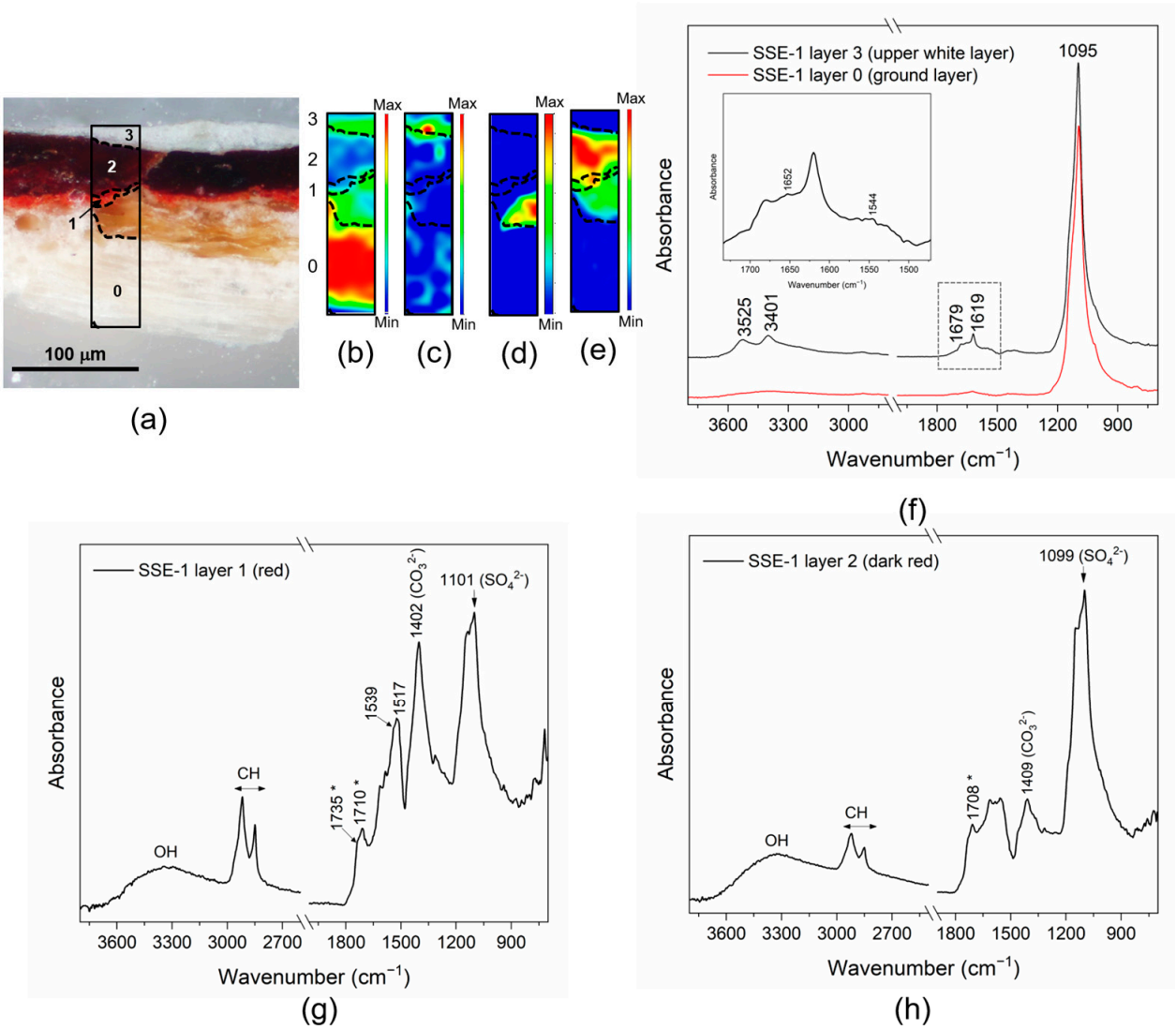


Figure 6. (**a**) SSE-1 cross-section, 20x; (**b**) Map of the band 1095 cm^{-1} from the SO_4^{2-}; (**c**) Map of the band at 3526 cm^{-1} from OH of gypsum; (**d**) Map obtained integrating the area of the band at 1029 cm^{-1} from the νCO at C_6 [51] of cellulosic material used as filler; (**e**) Map of the band at 1735 cm^{-1} from the C=O of the oil binder; (**f**) FTIR spectra from layers 0 (anhydrite) and 3 (gypsum) of sample SSE-1. The inset shows the bands attributed to animal glue as a binder; (**g**) FTIR spectrum obtained from layer 1, the bands associated with the binder marked with *; (**h**) FTIR spectrum of the dark red layer (layer 2) where the band at 1409 cm^{-1} indicates the addition of lead white and the band at 1099 cm^{-1} suggests the presence of sulfates (probably calcium sulfate).

The cross-section analysis suggested that the original loincloth decoration was simple as the artist used the white color of the ground layer. Additionally, we identified the remains of the painted blood in the samples SSE-1 and SSE-2. The SEM-EDX (Table 2) and µ-Raman (Figure 7b) results suggested that the artist used two different red pigments applied in two layers; the first one contains vermilion (HgS), which has an intense red color, while the second was made using a red lake, most probably a cochineal lake, to achieve a darker hue to represent coagulated blood. The SEM-EDX results (Table 2) indicated the presence of Al, K, and Si in the dark red layer, probably associated with the lake substrate (alum [$KAl(SO_4)_2 \cdot 12H_2O$]) and traces of Cu, previously related to the use of insects for the lake preparation [52]. Lead white was also added to the mixture, as suggested by the SEM-EDX (Table 2) and µ-FTIR results (Figure 6g,h), probably as a drier [53].

Table 2. SEM-EDX and spectroscopic results of the three cross-section samples analyzed.

Sample	No.	Layer	Main Elements	Trace Elements	μ-Raman/μ-FTIR
SSE-1	3	White layer	Ca, S	-	Gypsum ($CaSO_4 \cdot 2H_2O$), animal glue
	2	Dark red layer (blood)	Ca, S, Si, K, Pb, Al	Cu	Drying oil, Pb carboxylates
	1	Red layer (blood)	Hg, S, Ca	Si	Vermilion (HgS)
	0	Ground layer	Ca, S	-	Anhydrite ($CaSO_4$), cellulosic material, animal glue
SSE-2	6	White layer (flesh-tones)	Zn, Ba, S, Pb	Fe, Ca, Cr, Si	-
	5	White layer (flesh-tones)	Pb	-	-
	4	Yellowish layer (flesh-tones)	Pb, Ca,	Cl	-
	3	Layer dark red (blood)	Ca, Si, Al, K, Pb, S	Cu	-
	2	Layer red (blood)	Hg, S, Pb	Cu, Ca	Vermilion (HgS)
	1	Original flesh-tones	Ca, Pb	-	Cerussite ($PbCO_3$)
SSE-5	6	White layer (flesh-tones)	Zn, Ba, S, Pb	Fe, Ca, Cr, Si	-
	5	White layer (flesh-tones)	Pb	Ca, Cl	-
	4	Yellowish layer (flesh-tones)	Pb	Ca, Si, Cl	-
	0	Ground layer	Ca, S	-	-

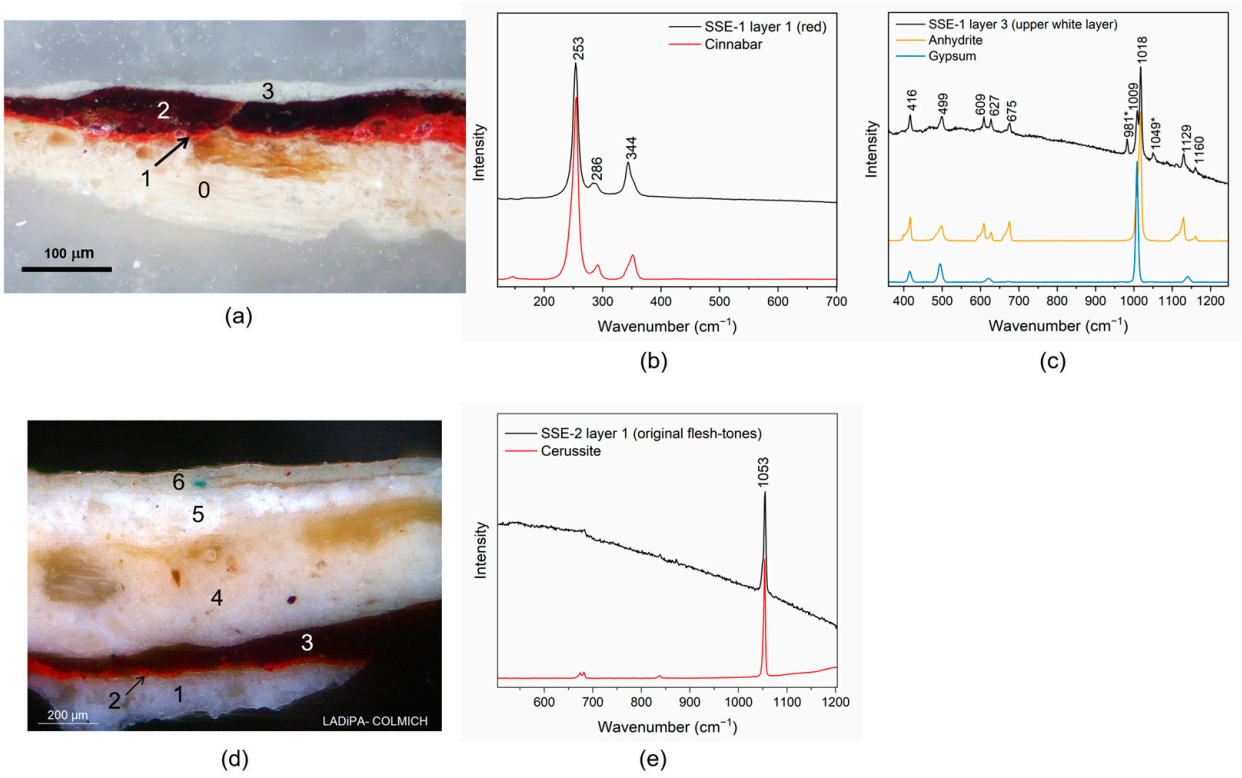


Figure 7. (**a**) SSE-1 cross-section, 20×; (**b**) Raman spectrum of the red layer (layer 1) of sample SSE-1, compared to that of cinnabar; (**c**) Raman spectrum obtained from the upper white layer (layer 3) of SSE-1 compared to the spectra of anhydrite and gypsum; (**d**) SEE-2 cross-section, polarized light, 50×; (**e**) Raman spectrum of the original flesh-tones (layer 1) compared to that of cerussite.

The original flesh-tones were rendered using lead pigments, as suggested by the SEM-EDX results (Table 2) of sample SSE-2. In the μ-Rama spectrum (Figure 7e), the band at 1053 cm^{-1}, arising from the $\nu_1(a'_1)$ CO_3^{2-}, suggested the presence of lead white [54], mainly constitute by cerussite ($PbCO_3$), which indicates an "inversed" proportion between cerussite (generally the minor component in the mixture) and hydrocerussite ($2\ Pb_3(CO_3)_2(OH)_2$) produced by acidic processing of lead white pigment by washing or grinding with vinegar as suggested by Gonzalez [55].

The μ-FTIR analysis of sample SSE-1 (Figure 6e,g,h) suggests that the artist used a drying oil as a binder due to the band at 1735 cm^{-1} from the ν(C=O) of the esters of the oil. Additionally, the spectra showed the characteristic bands of degradation products from the binder, such as free fatty acids (suggested by the band at 1710 cm^{-1} [56]) and Pb carboxylates (associated with the band at 1517 cm^{-1} and a shoulder at 1539 cm^{-1} [56,57]).

3.5.2. Polychromy Modifications

The cross-section analyses allowed us to identify the modification to the original polychromy. The loincloth was covered with gypsum ($CaSO_4{\cdot}2H_2O$), identified by the two bands at 3528 cm^{-1} and 3398 cm^{-1} from the νO-H, and the band at 1095 cm^{-1} from the νS=O [50] identified in the μ-FTIR spectra (Figure 6f). Furthermore, the μ-Raman analysis suggested that a small amount of anhydrite is also present (Figure 7c). Additionally, the bands at 1651 cm^{-1} and 1544 cm^{-1} indicate the use of animal glue as a binder (inset of Figure 6f).

Regarding the flesh-tones, we identified two over paintings; the first composed of a double layer made of Pb-based pigments, mainly lead white, as suggested by the μ-Raman and SEM-EDX results (Table 2 and Figure S4). In these two layers, the SEM-EDX detected Cl, which can be associated with the presence of laurionite ($PbCl_2OH^-$) as a contaminant from the Pb ore deposits [58] or by the use of the Dutch method—developed mainly after the 16th century in the Netherlands—for the synthesis of lead white as suggested by Noun and colleagues [55,59].

We supposed that the second over painting of flesh-tones was performed using lithopone (ZnS, $BaSO_4$, and traces of ZnO), as suggested by the presence of Zn, Ba, and S. To obtain the required hue, other pigments containing Fe and Cr were added. The presence of lithopone in this layer allowed us to date this modification to after 1874 [60].

4. Discussion

Before our study, some scholars, particularly Orozco [44], who was also involved in the construction of the current *Nuestra Señora de la Soledad* church, suggested that the sculpture was probably a substitution of the original because its characteristics, mainly the polychromy and the hair, were atypical for the 16th-century maize stem images.

The multianalytical analysis allowed us to understand the complex structure of the sculpture and confirm that it is the original (Figure 8). The artist considered the function of the sculpture during the Holy Friday and the need for reinforcement in the areas subjected to higher mechanical stress, such as the hands, feet, knees, arms, and the neck. In particular, the wooden elements used to reinforce the neck and the modification of the hair, and the upper part of the head may suggest that, originally, the head could move for the representation of Christ and that, probably, a wig and metallic crown were applied, as was usual for these kind of sculptures during the liturgical representations. However, a more detailed investigation is required to confirm this hypothesis.

In addition to understanding the sculptural technology, based on the formal and technical examination, we were able to associate the sculpture to the Cortés workshop, particularly to the production in the 1580s decade, and identify the changes it has suffered over time. Indeed, the hollowed structure obtained using a two-half mold is similar to the structure of other previously studied sculptures attributed the Cortés workshop and can be associated to artists with a stronger influence of the Eu-

ropean traditions (*papelón* or *cartapesta*) concentrated in the capital of the New Spain viceroyalty [2,10,12].

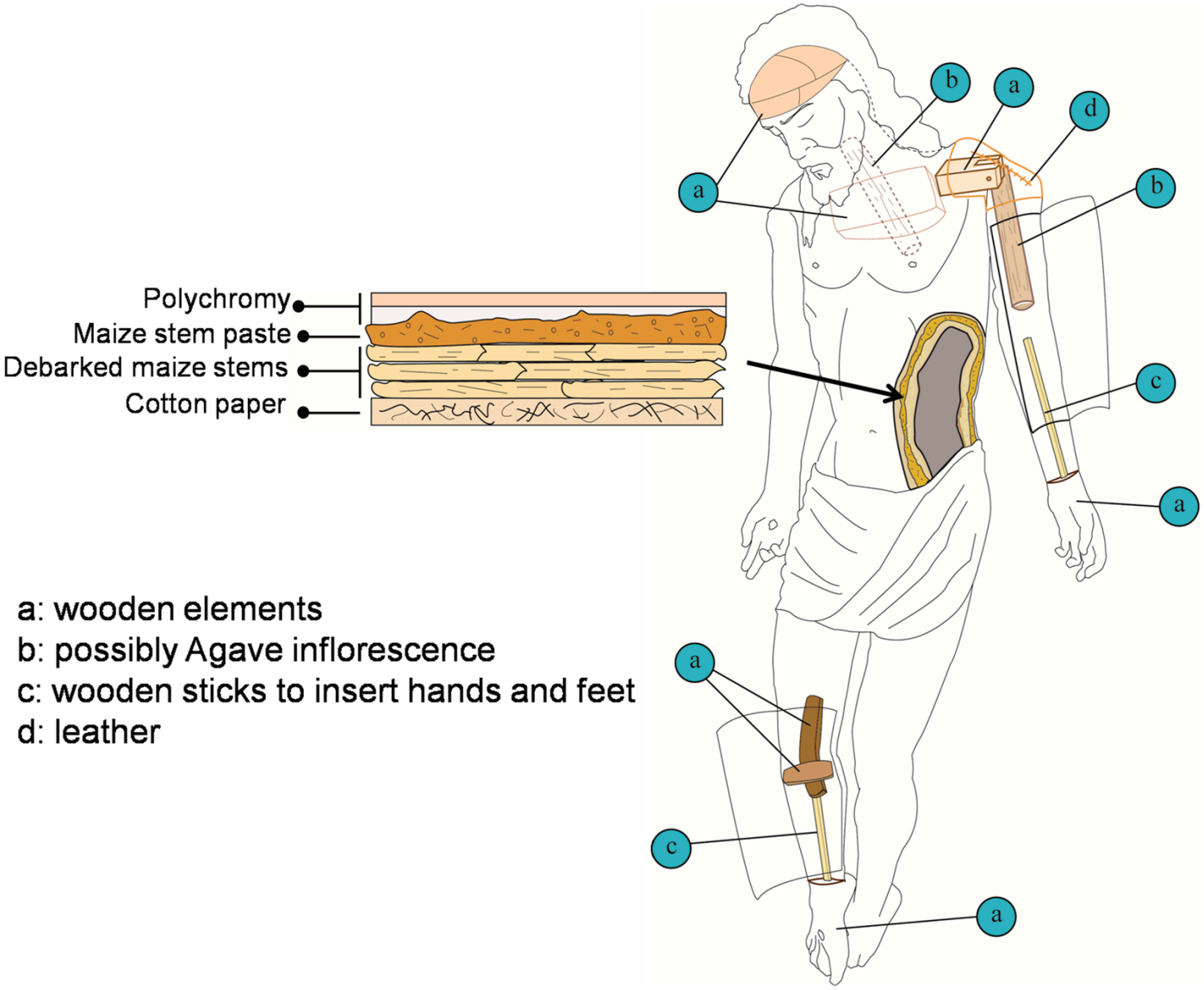


Figure 8. General scheme of the *Señor del Santo Entierro* sculpture.

The polychromy modifications can be associated with changes in preference and taste, particularly the flesh-tones. As the cross-section samples show, the profuse blooding represented in the original polychromy, which is a characteristic of the Christ images of the 16th and 17th centuries, was covered and substituted with more decorous polychromy for the tastes of the 19th century. Indeed, the Guadalajara cathedral, where the sculpture was placed for several years, suffered a complete renovation during the 19th century to adapt it to the neoclassical taste [61].

Finally, the presence in Guadalajara city of a sculpture made close to Mexico City despite the vicinity of the Michoacán region, suggests a particular link between the confraternity and the capital of New Spain. The acquisition of a statue produced in a specific region can be linked to a particular interest on certain workshops. Further studies are required to understand the trade routes of this typology of sculptures.

5. Conclusions

Our study allowed us to recover the history, understand the technical characteristic of both the structure and the polychromy, and correctly classify the *Señor del Santo Entierro* sculpture, as well as to understand its changes through the centuries. We were able to ascribe the sculpture to the Cortés workshop made around 1580. The analytical techniques showed that the statue suffered several modifications related to the damage produced by the constant use during the liturgical representations of the Holy Friday and to adapt it to the modern aesthetic taste.

As this study has shown, the technological complexity of the low weight maize stem sculptures requires a multianalytical approach, combining non-invasive and micro-invasive methods, to understand the structure and the nature of the materials. These sculpture techniques, which are not confined to Mexico, still require recognition around the world for their correct classification and the understanding of the technical variations according to the regions of productions. The historical investigations shed light on possible trade routes, which required further studies both inside the Mexican territory and in other parts of the Americas and Europe.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/heritage4030085/s1, Figure S1: Location of some maize stem sculptures register in Mexico; Figure S2: Sampling scheme; Figure S3: Topogram and tomograms of the upper part of the sculpture; Figure S4: SEM-EDX mapping of sample SSE-1, SSE-2, and SSE-5.

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