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ANALYTICAL STUDY OF THE ARCHAEOLOGICAL LEATHER DOCUMENT PRESERVED IN EGYPTIAN MUSEUM AND NEW PROPOSAL FOR MUSEUM EXHIBITION

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By

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ABSTRACT

This study was done on an archaeological leather document preserved in Egyptian Museum storeroom under N°. JE90809 SR 5/13677, excavated in 1966. The leather document showed different aspects of deterioration types. Different analytical methods were used for identifying the components of the leather document to explain its mechanism of deterioration process. Analytical methods used were: visual assessment, documentation process by high resolution camera and scanner in multispectral imaging (MSI), diagnostic examinations using Multi Spectral Imaging (VIS-UV-IR), isolation and identification of different types of fungi, investigation of the surface morphology and animal type using digital light microscope (Dino light), stereo microscope (S.M.) and polarizing microscope (P.M.), identification of ink binder, amino acids degradation and tanning materials by Fourier transformation infrared spectrophotometry (FTIR). It is a qualitative analysis to give general information concerning collagen, identification of inks by X-ray diffraction (XRD), and measuring the thickness by micro meter. In addition to suggesting a new method for museum exhibition for the archaeological leather document as the preparation of a new method of exhibition is considered one of the most important goals of this study, because the current method of exhibition is regarded as a major reason for the deterioration of the studied document.

The results revealed that the microscopic examinations of samples clarify that the type of skin used was sheep in comparison with the standard samples. It also explained the deformation of the appearance, contaminations from stains and dusts, and damages caused by physical factors. X-ray diffraction results showed that the ink used was made of carbon black ink. In addition, the results showed that thickness measurement numbers were different which indicate somehow that the manufacturing process was not so perfect. The results of FTIR proved also the degradation of the collagen in the archaeological leather document, the binding agent was Arabic gum and the leather was tanned with vegetable tanning. Isolation and identification of micro-organisms clarified that the most dominant fungi isolated from the archaeological leather document were: *Aspergillus niger, Aspergillus sulphureus, Aspergillus versicolor, Aspergillus sydowii, Penicillium chrysogenum, Penicillium islandicum, Alternaria alternata, Aspergillus flavus,* and *Aspergillus terreus*. Finally, the storage of the leather document was very poor which led to different aspects of deterioration. That prompted the authors to suggest a new method for exhibition for the archaeological leather document**.**

KEYWORDS: Micro Organisms, Degradation, FTIR, Inks, Tanning, Fungi, Exhibition.

I. INTRODUCTION

Leather as a material represents complex composition. Leather tanned from raw hides and skins has been used to cover and protect the human body since early man. Animal skins have been used since pre-historical times for the preparation of different types of artifacts (bags, clothes, beds, shoes, shields, and chairs and have been used as a writing support in manuscript documents form (scrolls and charters) or manuscripts cover bindings as different types of cultural heritage which exist in public and private libraries, archives, and museums[1]). Leather had been already in use during the pre-historic period in Egypt[2]. The basic component of these leather artifacts is collagen. Collagen is an organic compound which is composed of carbon, oxygen, hydrogen, nitrogen, and also sulfur, but nitrogen is the most characteristic element. The proteins from chemical composition consist of a large group of complex substances of amino acids. There are three amino acids which are constituted mainly of protein (30% glycine, 10% of proline and 10% hydroxyproline). The triple-helix is the basic unit in which helices are arranged in fibrils at an upper hierarchical level, also fibrils are arranged into the final collagen fibers[3].

Leather is animal skin turned by the process of tanning to durable and resistant material against decay which entails chemically altering the composition of the skin. The main aim of tanning process is to stabilize the fiber structure of leather, give leather more resistance to surrounding environmental conditions compared to hide skin, and increase its hydrothermal stability. Leather artifacts are not stable but are in some inappropriate condition of decay under dry or wet conditions[4]. Degradation of leather is caused by a combination of exposure to elevated temperatures, light, humidity, atmospheric pollutants and microorganisms which affect the mechanical, physical and chemical properties of the collagen matrix. According to the inappropriate condition, some aspects of deterioration can be obtained such as brittleness, darkness, being very stiff, undulated, and darkened or relaxed and gelatinized[5]. Studying deterioration mechanisms in leather requires a systematic, multidisciplinary approach that is based on advanced chemical – physical techniques to collect all information from tiny samples[6]. Using analytical techniques has been developed to improve the procedures to authenticate patrimonial objects which are a composite of collagen as well as the

[1] LARSEN 2002: 89.

[2] FORBES 1957: 62; KATHAPALIA 1973: 39; LARSEN 2000: 85- 99; GANITI et AL. 2004 : 349-360; RICHARD 2019: 3.

[3] BAILEY & PAUL 1998: 104-106; ZVI 2007: 321-327.

[4] GUSTAFSON 1956; STAMBOLOV 1969.

[5] GUSTAVSON 1956; HIGHBERGER 1956: 103-167; MACGREGOR 1980: 142-147.

[6] BADEA et AL. 2008: 17– 27.

methods to study the effects of the environmental factors. It is noticed that the degree of degradation depends on some factors: presence of oxygen, pH, and irradiation wavelength. The methods of analysis used for investigating leather artifacts have been developed during the last decades[7]. So analytical and archeomaterial studies should be performed to the object of the study in order to provide the best documentation procedures, diagnoses deterioration factors, also dating to some extent of the archaeological leather document[8].

This study aims to provide the best documentation and identification of the main structural aspects of leather by applying different analytical techniques and means of spectroscopic analysis for identifying the components of the archaeological leather document, and to explain its deterioration process. The authors used in the study visual assessment, documentation process by high resolution camera and scanner in multispectral imaging (MSI), and diagnostic examinations using ultra violet fluorescence imaging (UV/ IR). Also isolation and identification of fungi has an important role in the study, investigation of the surface morphology and animal type by using different typesof microscopes such as digital light microscope (Dino light), stereo microscope (S.M.) and polarizing microscope (P.M.), identification of pigment binder, explaining amino acids degradation and tanning materials used in leather by Fourier transformation infrared spectrophotometry (FTIR), and identification of inks by X-ray diffraction (XRD), measuring the thickness by micro meter (M.M.). In addition to suggesting a new method for museum displays for the archaeological leather document as the current method is to some extent the reason that caused the damage to the artifact. Therefore, the authors suggest 3D mounting display showcase for the archaeological leather document.

II. MATERIALS AND METHODS

The archaeological leather document (piece of leather) under study measures 32cm X 45cm, was excavated in 1966, and is preserved in the Egyptian Museum storeroom under N°. JE90809 SR 5/13677. It contains some unknown ancient writings which are written in black ink. The methodology of the study depends on identifying the material and characteristics of the leather document using nondestructive investigations. The analytical methods were more effective in explaining and somehow indicate deterioration aspects of the object. The authors selected the techniques used to obtain significant identification and to obtain the optimum amount of information concerning the materials used. The study applied different procedures using MSI, UV, IR, SM, PM FTIR, XRD, MM and isolation and identification of fungi analyses as follows:

[7] CHAHINE & ROTTIER 1996: 77-79.

[8] SIONKOWSKA 2004: 117 – 125.

1- Visual assessment, documentation process by high resolution camera, scanner in multispectral imaging (MSI) and multi spectral imaging (VIS-UV-IR)

Multispectral imaging is a set of images acquired through narrow band filters for consecutive wavebands of radiation. Multispectral imaging is the procedure used to observe an object, using selected ranges of wavelengths in the electromagnetic spectrum that include and extend the capabilities of the human eye. Each image shows the intensity of radiation from the scene in the corresponding waveband. Images are acquired at visible wave-lengths (nm 400-700) and may also include regions of the non-visible spectrum: ultraviolet (nm <400) and infrared (nm >700). MSI imaging can be used to guide the selection of areas for point based analytical examination, and they represent a valuable time saving tool that allows for a preliminary assessment[9]. This study will focus on the range of wavelength that can be observed using modified commercially available cameras, which typically employ silicon based sensors sensitive from approximately 350 nm to 1100 nm. The extent to which this radiation will penetrate the object under investigation will be dependent on its wavelength and on the absorbance of the materials which compose the object, with longer wavelengths of radiation generally penetrating further into the piece. The authors used high resolution Nikon Camera for documentation process, HP Deskjet model for scanner in multispectral imaging and the filter used in fluorescence imaging was IR90 filter.

2-Microscopic Examination

In order to exceed the abilities of the naked eye and detect previous restorations carried out on the object, and to understand quality extension the processes of manufacture, the authors used digital light microscope (Dino light) for visual examination. Some of the falling samples were also examined and photographed using the stereoscopic microscope (S.M.) to give a three-dimensional surface image that enables identifying the topography of its surface and its structure and the manifestations of invisible eye damage through its ability to zoom in and connect it to the computer and record the part to be studied. Investigation of the surface morphology and identification of the animal type was done by polarizing microscope (P.M.).

All samples were conditioned under the standard atmospheric conditions for 24 hours at temperature of 25°C and relative humidity 65% and examined by using an Inspect S50 (FEI Image size: 1000 x 1000Mag:128.686327077748xHV:5.0kV. The Zeiss Discovery V20 stereo was used by Axio Cam MRc5 camera and Fujitsu Siemens computer monitor.

[9] LIANG 2012: 309 – 323.

3. Fourier Transform Infrared Spectroscopy (FTIR)

Monitoring the chemical fingerprint of material is very important when dealing with material science. Identification of ink binder, and collagen degradation and tanning material was done by using Fourier transformation infrared spectrophotometry (FTIR). FTIR spectra of tested binder were recorded on a FTIR spectrophotometer (JASCO-FT/IR-6100 at (research Labs, Projects sector, Ministry of Tourism and Antiquities, Egypt) in the range of 4000–400 cm^{-1} using KBr pellets.

4. Identification of Inks by X-Ray Diffraction (XRD)

The ink sample (some fragments) was analyzed by X-ray diffraction using Compact X-ray Diffractometer System PW 1840 – Analytical Equipment – Philips– Eindhoven – the Netherlands (Cu Kα radiation with Ni-filter). The samples were analyzed at Cairo University labs.

5. Measuring the Thickness

According to the unique arrangement of complex natural fibers which give the variations on the types of leather types, leather is considered one of the most versatile materials known. The softness of leather is usually associated to its thickness. The thinner the leather, the softer it will be. Measuring the thickness of the archaeological leather document was done by micro meter. The thickness of each square of the leather piece was measured five times for accuracy in the results.

6. Isolation and Identification of Fungi (Collection of Sample Swabs)

The samples taken for the isolation and identification of fungi were in accordance with ᶜAbd ʾEl-Maksoud [10]. Sterile cotton swabs were wiped from different infected parts along the most damaged margins of the verso and recto of the archaeological piece of leather document to obtain samples for fungal culturing and identification. The samples were saved in dry, sterile, polypropylene bags, kept in ice during transportation, then stored in the refrigerator (4°C) till the isolation of microorganisms. Then the process was performed directly in the laboratory.

The fungi were isolated by rubbing the swabs gently on culture medium of potato-dextrose agar (PDA). Inoculated Petri dishes with fungi were incubated at 26 $\pm$2°C for 1–2 weeks. Isolated fungi were identified according to Barnett and Hunter, Domsch *et al*., and Stevens, Raper and Fennell [11].

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[10] ᶜABD ʾEl-MAKSOUD 2011: 180 - 189.

[11] BARNETT & HUNTER 1972: 103-109; DOMSCH et AL. 1980: 118-200; STEVENS 1981: 123; RAPER & FENNELL 1995: 65.

III. RESULTS AND DISCUSSION

1- Visual Assessment, Documentation Process by High Resolution Camera, Scanner in Multispectral Imaging (MSI) and Multi Spectral Imaging (VIS-UV-IR)

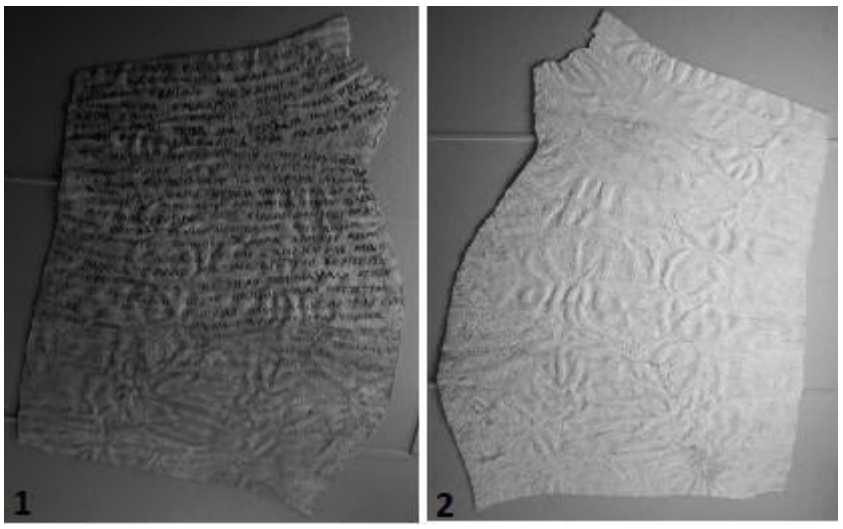
Documentation process (the condition survey) was done by using high resolution camera, scanner in multispectral imaging (MSI) and diagnostic examinations using ultra violet fluorescence imaging (UV) and Infra-Red (IR) as shown in [**FIGURES 1-3**].

A. Historical Background of the Studied Document

The archaeological leather document which measures 32 cm X 45 cm, had been excavated in 1966, and is currently preserved in the Egyptian Museum in Cairo storeroom under N°. JE90809 SR 5/ 13677. It has some unknown ancient writings which are written in black ink, and the document had not been studied before. The storage of the manuscript was very poor and led to advanced deterioration. The leather document suffered from different aspects of deterioration and dirt spread on the surface.

[FIGURE 1]: Documentation Process; 1- 2: diagnostic examinations by High Resolution Camera of the archaeological leather document (recto layer) beside the blank and color scale; 3: diagnostic examinations by High Resolution Camera of the archaeological leather document (verso layer).

[FIGURE 2]: Documentation Process; 1- 2: diagnostic examinations by Scanner in Multispectral Imaging (MSI) of the archaeological leather document (recto layers); 3- 4: diagnostic examinations by Scanner in Multispectral Imaging (MSI) of the archaeological leather document (verso layers) in different places.

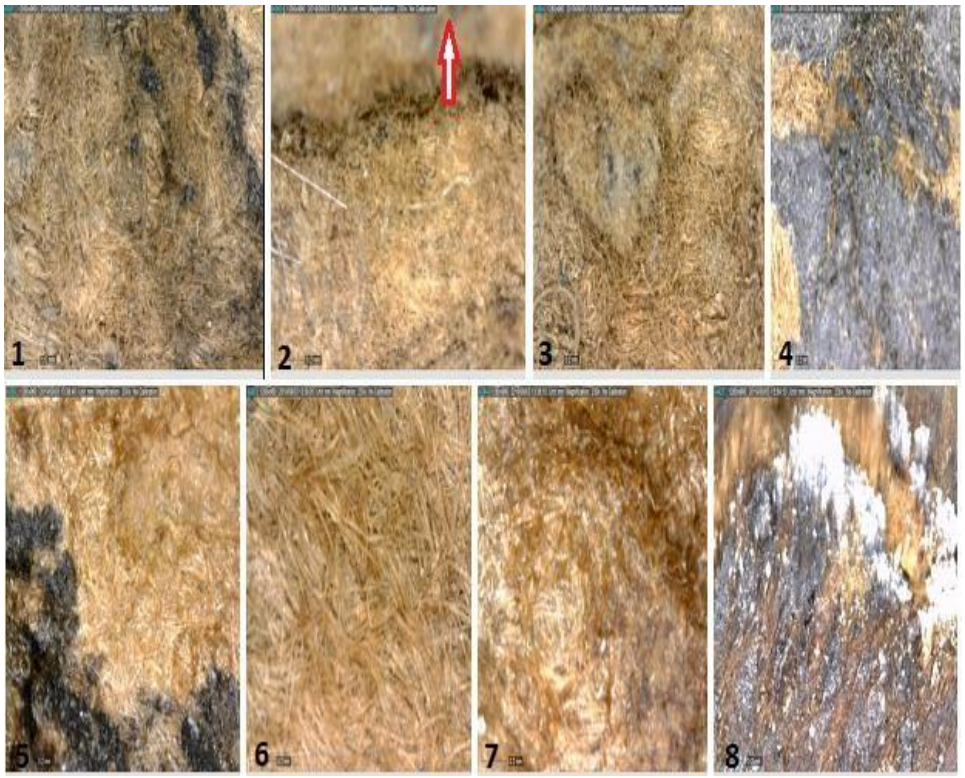


[FIGURE 3]: Documentation Process and diagnostic examinations; 1: using Ultra Violet Fluorescence Imaging (UV) of the archaeological leather document (recto layer); 2: using Ultra Violet Fluorescence Imaging (UV) of the archaeological leather document (verso layer).

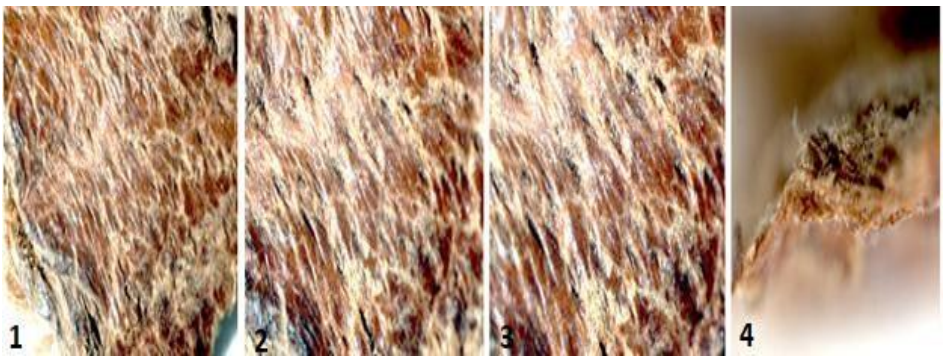
B. Microscopic Examination

Investigation of the surface morphology and animal type was done by using different types of microscopes; digital light microscope (Dino light), stereo microscope (S.M.) and polarizing microscope (P.M.). The leather surface was so deteriorated that one could hardly observe the hair holes' arrangement. By close examination the deformation of the surface morphology was clear **[FIGURES 4- 7]**. The microscopic examination of samples of the archaeological leather document indicated that the type of skin used was sheep in comparison with the standard samples. The coarse follicles were found in the form of bundles. There was a wide and smooth surface between these groups. Also the leather document was manufactured using a long, strong and flexible leather piece which was used as written manuscript.

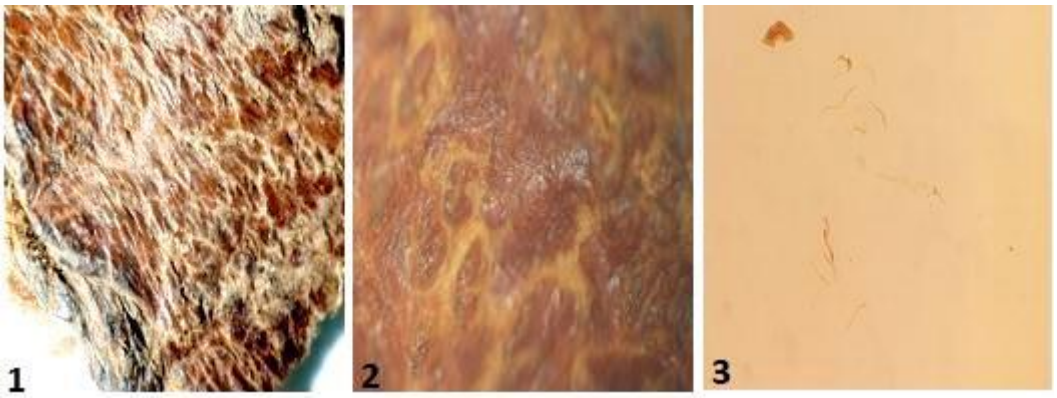
The leather surface was smoothed and glazed. In addition, from the microscopic examination it was clear that there was deformation of the appearance, contaminations from stains and dust, random distribution of the fiber structures, damage caused by physical factors appeared in the erosion of the fibers and many bores.



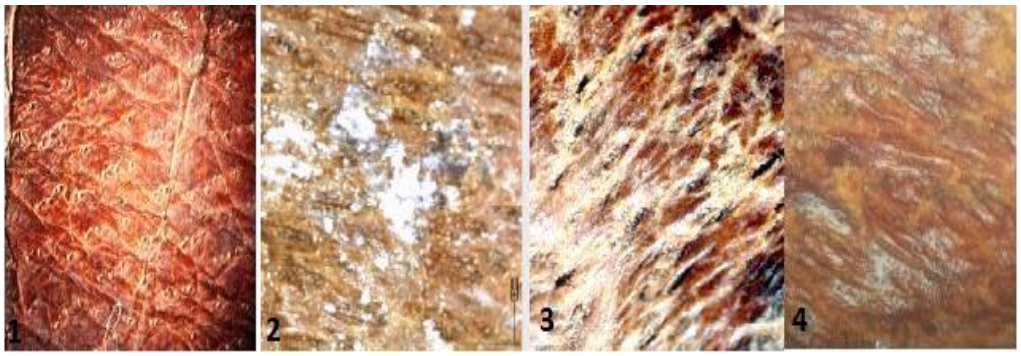
[FIGURE 4]: Examination of the archaeological leather document sample with magnification 230x, 1280x960 no calibration as the arrow indicates the image; 1-8: using digital light microscope (Dino light) for examination which explain deformation of the surface morphology in different places.



[FIGURE 5]: Examination of the archaeological leather document sample, 1-4: using stereo microscope (S.M.) for examining the coarse follicles in different places of the samples arranged with magnification 1-50x; 2, 3-35x; and 4-94x.



[FIGURE 6]: Examination of the archaeological leather document sample; 1-3: using polarizing microscope (P.M.) for examining the surface morphology with magnification 1-50x; 2-100x; 3-25x.



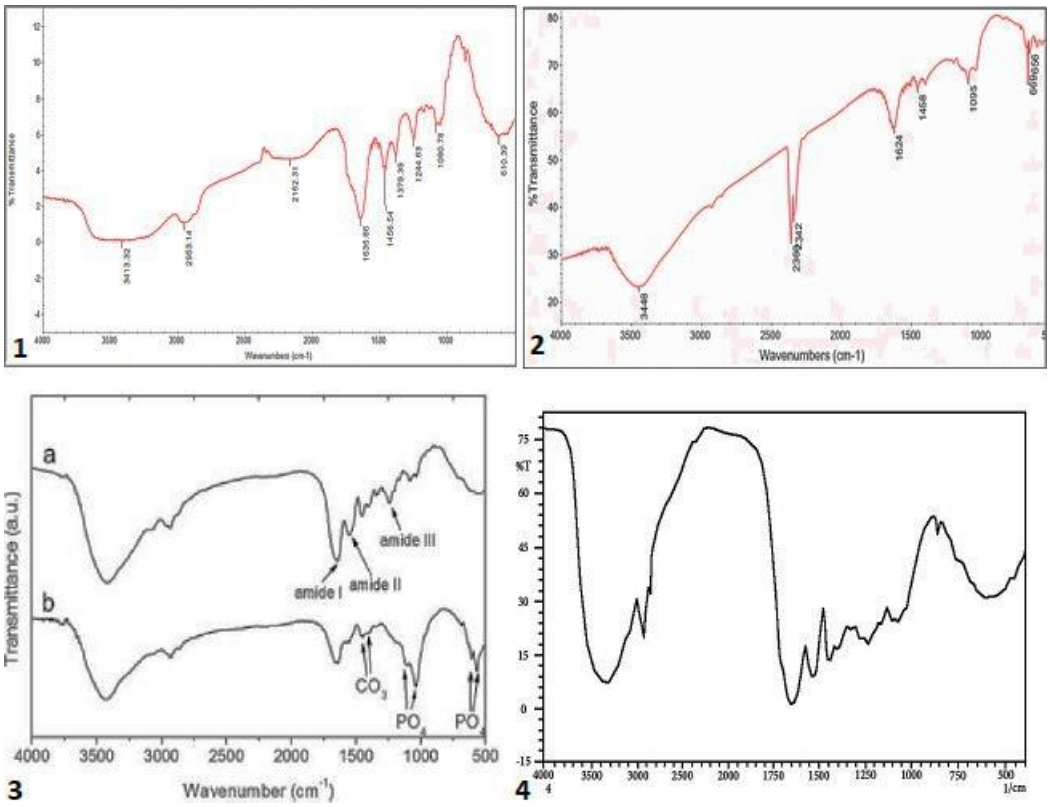
[FIGURE 7]: Identification of the animal type by comparison with the standard sample of sheep leather: 1- the standard sample of sheep leather examining by Digital light microscope showed coarse follicles were found in the form of bundles, 2-examination of the archaeological leather document sample by digital light microscope (Dino light), 3- examination of the archaeological leather document sample by stereo microscope (S.M.), 4- examination of the archaeological leather document sample by polarizing microscope (P.M.).

C. Fourier Transform Infrared Spectroscopy (FTIR)

The binder used with the black ink was identified as gum Arabic. After comparison with the blank sample of pure gum Arabic (which is a natural polysaccharide) the O-H bending band at 1650 cm^{-1} which indicates the characteristics of polysaccharides appeared [**FIGURE 8**].

In comparison with the control sample the analysis proved that the archaeological leather document was tanned with vegetable tanning as the 3414 cm^{-1} for the oak tannin extract was found in the sample [**FIGURE 8**]. Also, this explained the degradation in the archaeological sample that had occurred in the collagen. It is clear that the band at 3429.78 cm^{-1} assigned to a broad band represents (OH) hydroxyl stretching due to intermolecular hydrogen bonding of the hydroxyl group. This band includes multiple bands made up of multiple N-H groups, both in the solid state and in the presence of hydrogen bonding. The C-H stretching vibrations occur in the region 2924.52-2926.45

cm^{-1} stretching of aliphatic groups. The bands between 3422.06 cm^{-1} and 2924.52 cm^{-1} are protein characteristics, and the increase or decrease of these bands may give an indication of the expansion or contraction of the protein areas. Collagen exhibits a series of absorption bands from 1656.55 cm^{-1} to 1241.93 cm^{-1}. The band at 1641.13 cm^{-1} (C=O stretching) is assigned to amide I. In the solid state, the frequency of the vibration slightly decreased. The presence of hydrogen bonding is an important contributing factor to this decrease in frequency[12]. The bands at 1562.06 cm^{-1} (NH bending, CN stretching) are assigned to amide II. The band at 1243.86 cm^{-1} is assigned to amide III which involves C-N stretching and N-H bending. The wavenumber of these peaks depends on the secondary structure of the protein.



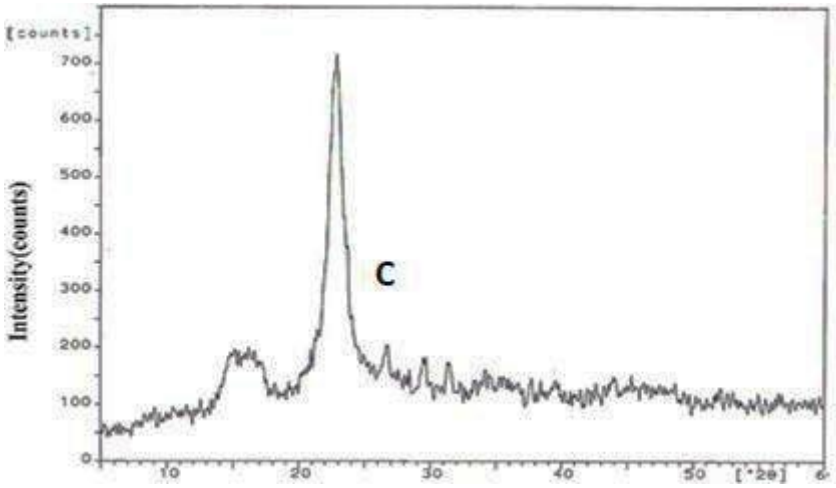
[FIGURE 8]: Fourier Transform Infrared Spectroscopy (FTIR) of the archaeological leather document; 1- standard FTIR of the gum Arabic; 2- standard FTIR of vegetable tanning; 3- standard FTIR of amino acids (Michele, *et Al.*, 1999; Nicoletam *et Al.*, 2006); 4- FTIR of the archaeological leather document.

D. Identification of Inks by X-Ray Diffraction (XRD)

The results showed that the black ink was made of carbon ink which was commonly made from lampblack or soot and a binding agent such as gum Arabic. The binding agent keeps the carbon particles in suspension and adheres to the document.

[12] MICHELE et AL. 1999: 108- 128; ANDREAS 2007: 1073–1101; AMERTANINGTYAS et AL. 2012: 939 - 942.

Carbon ink was the first writing ink in history that ancient Egyptians used to write. The ink was formed in the process of burning organic materials (oil, or wood). The ink material is formed by mixing pure carbon with adhesive, which is often gum Arabic. Carbon ink is characterized by extreme stability, and this stability is due to the fact that carbon is chemically inert under normal conditions. Among its disadvantages is the possibility of its separation in the form of scales or flaking off from the document and is affected by humidity which occurred in the archaeological leather document.

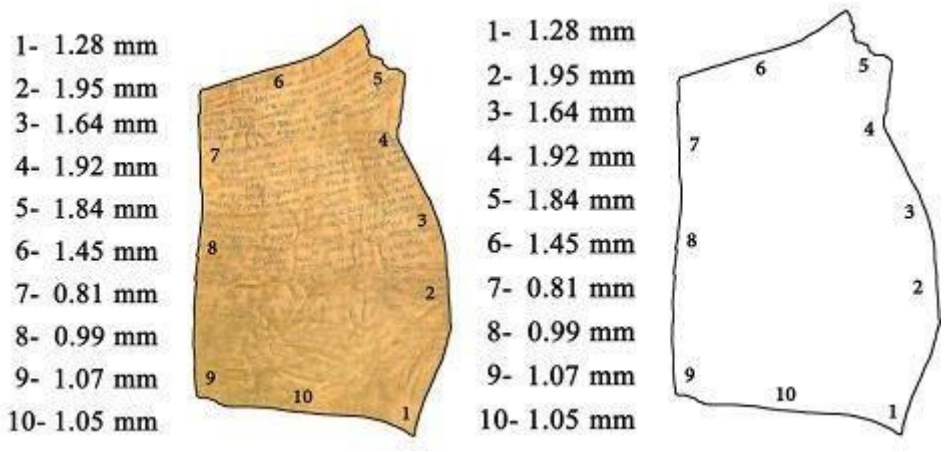


[FIGURE 9]: Identification of carbon ink by X-ray diffraction (XRD) of the archaeological leather document.

E. Measuring the Thickness

One of the most important characteristics during exploitation of leather documents is leather softness. One of the best ways to evaluate this parameter is the measurements performed of the thickness and softness to give indications of the manufacturing process of leather. The evaluation was processed by using the micro meter. Unfortunately, the authors found that the leather document suffered from wrinkles, creases. So, different points were chosen for measuring as shown in [**FIGURE 9**].

The results showed that the skin thickness measurement displayed a high number in some areas and low numbers in other areas which indicates that the manufacturing process was not so perfect. The skin was thicker always near the areas of the tail along the back of the animal, used though the manufacture process, in the oldest animal, also towards the neck. But the area of uniform skin thickness was in the middle of the back, on either side of or parallel to the vertebral column. It was clear that the thickness of leather is too high. It was normal of written leather in the nineteenth century to be thick.



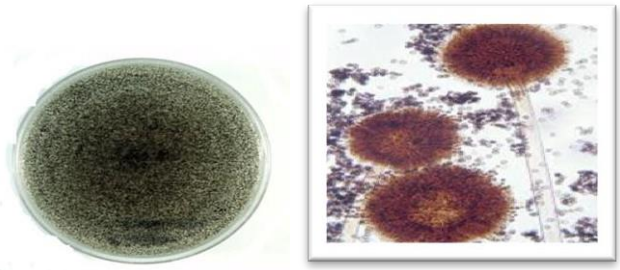
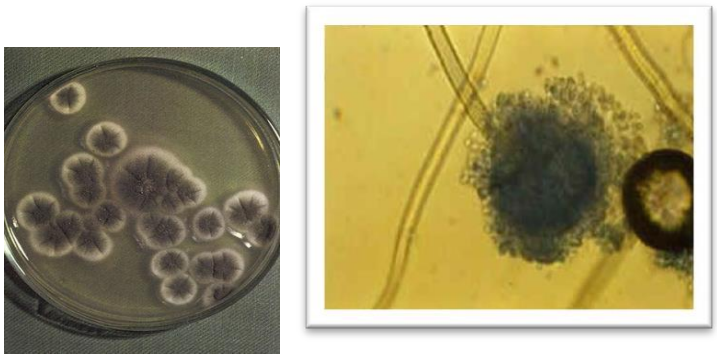
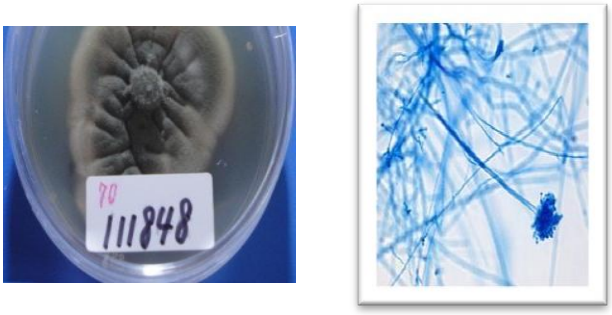
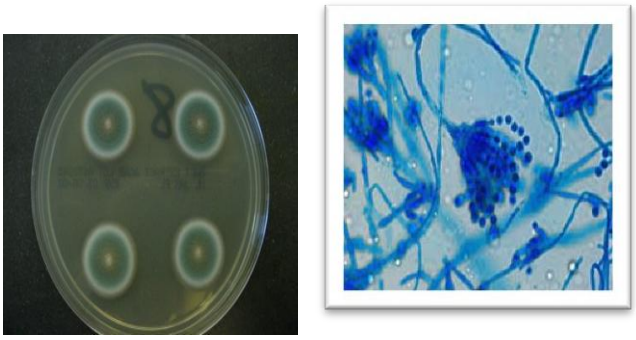
[FIGURE 10]: Topographic sections of archaeological leather document and points of thickness measurements.

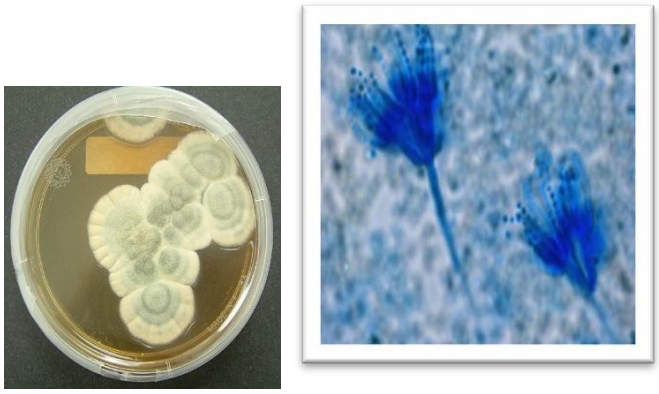
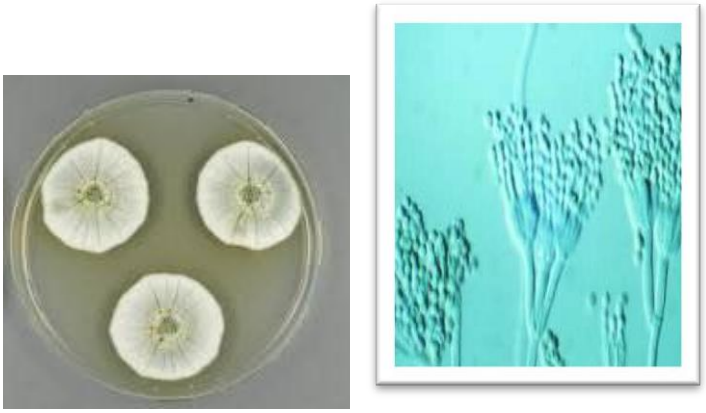
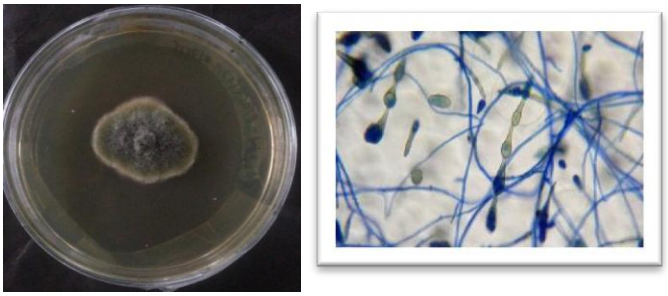
F. Fungi Identification of Archaeological Leather Piece

The results of this study revealed that the most dominant fungi on the leather document are the fungal species which were identified and characterized based on their morphological characters and microscopic analysis by using taxonomic guides[13]. The most dominant fungi isolated from the historical leather document of the study were identified: ***Aspergillus niger, Aspergillus sulphureus, Aspergillus versicolor, Aspergillus sydowii, Penicillium chrysogenum, Penicillium islandicum, Alternaria alternata, Aspergillus flavus, Aspergillus terreus***. Leather artifacts are organic materials that are susceptible to numerous microbial deterioration processes, especially fungi. Fungi that attack tanned leather often belong to lipolytic species and utilize the fats present in leather as a source of carbon. Effects of microbial deterioration on protein materials are due to the presence of different stained spots, the loss in tensile strength and, the hydrolysis of leather[14].

Isolation and identification of micro-organisms are very important for the restoration and conservation treatments of the archaeological manuscripts; they give an idea of the microbiological deterioration which helps to determine the most appropriate methods for prevention, inhibition and removal of these micro-organisms[15]. Valentin [16] stated that among the types of fungi found in museums, archives and libraries are *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigates, Penicillium chrysogenum, Rhizopus nigricans*. David [17] mentioned that fungi of various types are often seen in ancient leather artifacts as a result of poor storage.

[13] APINIS 1963: 57- 78; ROHILLA & SALAR 2012: 297- 303.
[14] RABEE 2015: 369- 382.
[15] ᶜAbd El-MAKSOUD 2011: 180- 189.
[16] VALENTIN 2001: 5- 7.
[17] DAVID 2008: 77- 79.

Fungi Identification	
Aspergillus niger	 ***Aspergillus niger;*** **Colonial characters on PDA medium and Morphological characters (X-400).**
Aspergillus sulphureus	 ***Aspergillus sulphureus;*** **Morphological characters (X-400) and Colonial characters on PDA medium.**
Aspergillus versicolor	 ***Aspergillus versicolor;*** **Colonial characters on PDA medium and Morphological characters (X-400).**
Aspergillus sydowii	 ***Aspergillus sydowii;*** **Colonial characters on PDA medium and Morphological characters (X-400).**

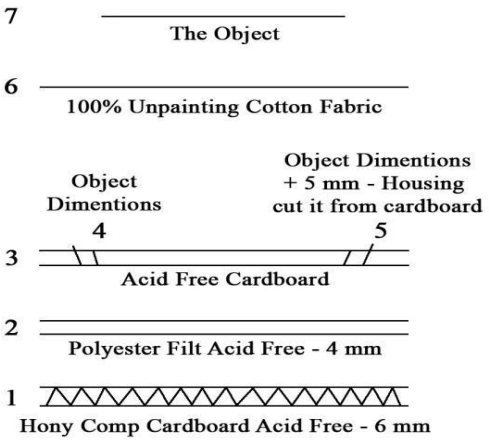
Penicillium chrysogenum	 ***Penicillium chrysogenum*; Colonial characters on PDA medium and Morphological characters (X-400).**
Penicillium islandicum	 ***Penicillium islandicum*; Colonial characters on PDA medium and Morphological characters (X-400).**
Alternaria alternata	 ***Alternaria alternata*; Colonial characters on PDA medium and Morphological characters (X-400).**

[TABLE 1]: The results of this study revealed the most dominant fungi isolated from the leather document and their identification.

G. New Proposal for Museum Exhibition

Old preservation method and the current method of exhibition may lead to chemical, physical and biological deterioration. The state of conservation must be especially considered with deteriorated leather; in such cases the authors suggested a new method for preservation and displaying to stabilize the archaeological leather document condition. The authors used a method that has been developed at the GEM for such treatments called 3D mounting. This procedure offered two advantages: first it could be established whether there was text or the remains of text on the verso under the backing document, and second it enabled the leather document fibers to be examined and

preserved or displayed safely. It should be noticed that the leather document must be displayed in 45º degree in the new 3D mounting showcase. The details are explained in the following illustration [**FIGURE 11**].



[FIGURE 11]: New 3D mounting showcase for the leather document

IV. CONCLUSION

Archaeological leather document preserved at the Egyptian museum showed different aspects of deterioration. The authors applied different analytical methods. Visual assessment and documentation process had been done. The results revealed that the microscopic examinations of samples clarify the type of skin. X-ray diffraction results showed also that the ink used was made of carbon black ink. FTIR proved the degradation of the collagen in the archaeological leather document, the binding agent was Gum Arabic and the leather was tanned with vegetable tanning. In addition, the results showed that thickness measurement numbers were different which indicates that the manufacturing process was not so perfect. Isolation and identification of micro-organisms clarified that the most dominant fungi isolated from the historical leather document were: *Aspergillus niger*, *Aspergillus sulphureus*, *Aspergillus versicolor*, *Aspergillus sydowii*, *Penicillium chrysogenum*, *Penicillium islandicum*, *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus terreus*. Finally, the authors suggested a new method for exhibition of thearchaeological leather document which is explained in details in diagram.

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دراسة تحليلية لقطعة جلد اثرية محفوظة بالمتحف المصرى

ومقترح جديد للعرض المتحفى

السيدة نفيسة الشامى ومؤمن عثمان

مدرس فى كلية الآثار والإرشاد السياحى / جامعة مصر للعلوم والتكنولوجيا

رئيس قطاع المتاحف بوزارة السياحة والآثار بمصر.

الملخص

قطعة من الجلد الأثرى محفوظة فى مخزن المتحف المصرى برقم JE90809 ١٣٦٧٧/٥، تم اكتشافها عام ١٩٦٦، وتعانى الوثيقة الجلدية مظاهر التلف المختلفة. تركز هذه الدراسة على استخدام التقنيات التحليلية الحديثة لتحديد مكونات المخطوطة لشرح عمليات التلف. استخدمت فى الدراسة التقييم البصرى، وعملية التوثيق بواسطة كاميرا عالية الدقة والماسح الضوئى فى التصوير متعدد الأطياف (MSI) والفحوص التشخيصية باستخدام التصوير متعدد الأطياف (VIS-UV-IR)، وعزل وتحديد الفطريات، والتحقيق فى الشكل السطحي ونوع الحيوان باستخدام أنواع مختلفة من المجاهر: المجهر الضوئى الرقمى، المجهر الاستريو (SM)، المجهر الاستقطابى (PM) ايضا تم تحديد نوع الحبر، ومواد الدباغة بواسطة التحليل الطيفى بالأشعة تحت الحمراء (FTIR)، وتم تحديدنوع الحبر بواسطة حيود الأشعة السينية (XRD)، وتم قياس السمك للقطعة. بالإضافة إلى اقتراح طريقة جديدة للعرض المتحفى للوثيقة حيث أن طريقة العرض الحالية هى إلى حد ما السبب الذى تسبب في تلف القطعة.

نتائج حيود الأشعة وقد أوضحت نتائج الفحوصات للعينات أن نوع الجلد المستخدم هو الأغنام مقارنة بالعينات القياسية. كما أظهرت السينية أن الحبر الأسود المستخدم هو الحبر الكربونى. بالإضافة إلى ذلك، أظهرت النتائج اختلافًا فى أرقام نتائج قياس السمك للقطعة مما يدل بطريقة أو بأخرى على أن عملية التصنيع لم تكن مثالية. كما أثبتت نتائج FTIR تلف وتدهور الكولاجين فى الوثيقة الجلدية، وكان الوسيط الصمغ العربى والجلد المدبوغ تم دباغته بالتانين (الدباغة النباتية). أوضح عزل الكائنات الحية الدقيقة أن الفطريات المعزولة من هي: *Aspergillus niger* و *Aspergillus sulphureus* و *Aspergillus versicolor* و *Aspergillus sydowii* و *Penicillium chrysogenum* و *Penicillium islandicum* و *Alternaria Alternus* و *Aspergillgillus flavus*. وأخيرًا كان تخزين المخطوطة رديئًا للغاية مما أدى إلى جوانب مختلفة من التدهور. ودفع ذلك المؤلفين إلى اقتراح طريقة جديدة للعرض المتحفى للوثيقة الجلدية الأثرية.

الكلمات الدالة: كائنات حية دقيقة، تلف، احبار، دباغة ، فطريات، عرض متحفى.