

## Methods of Processing Animal raw Materials Ancient and Modern ( A Theoretical study)

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## **Abstract:**

This research delves into the essential methods and techniques employed by artists in ancient Egyptian civilization to process animal materials. It traces these methods from ancient times to contemporary approaches that integrate modern technology. The study defines animal materials as encompassing leather, bone, horn, and animal fibers such as wool.

Ancient Egyptians meticulously documented their techniques for processing animal materials on tomb walls. These methods varied based on the specific material. The research places particular emphasis on leather processing, both ancient and modern. Ancient Egyptians developed sophisticated techniques to meet diverse needs and ensure the durability of leather. They removed fats and blood to prevent rapid decay and employed plants for tanning and coloring. Modern techniques, including salting and air-drying, are also explored to highlight the evolution of leather processing.

The research further investigates the processing of animal fibers like wool, detailing the steps from shearing and washing to thread production. Additionally, it examines the processing of bone and horn, emphasizing their cultural significance and practical applications in ancient Egyptian art and daily life.

**Keywords:** Animal raw materials, Leather, Animal fibers, Bone, Horns.

## **Introduction:**

The ancient Egyptian found himself surrounded by a diverse array of animals, created by God to serve him and facilitate his life. In response, the ancient Egyptian sought to benefit from these animals in every possible way, especially the domesticated ones that he was able to tame and raise. Naturally, the ancient Egyptian raised livestock, sheep, and goats, making use of their meat, leather, wool for clothing, and bones for crafting jewelry.

There are numerous wall carvings that indicate his fondness for leather. "He was always fond of wearing fur, especially from animals he hunted himself in the desert. He used leather to make his sandals, work tunic, then braided it into fine strips to create a shield, quiver, and water skin"<sup>(1)</sup> "This is further evidenced by the discovery of leather in tombs from the Naqada period, the Badarian era, and the Pre-Dynastic period, where leather was used as clothing for the living and as shrouds for the dead to preserve the body and uphold the belief in immortality. The ancient Egyptians were well-versed in leather preparation, initially using it in its raw form, then softening and fully tanning it " <sup>(2)</sup> This is illustrated in a tomb drawing, where a worker is depicted placing a hide into a container, possibly filled with oil, while other artisans prepare the leather for use ( <sup>3)</sup>

The ancient Egyptian artist did not limit himself to leather alone but also processed a wide variety of animal materials such as wool, bones, teeth, ivory, and horns. For instance, ancient Egyptians used animal bones to craft tools, jewelry, combs, rings, beads, and amulets. Museums today display the artistic mastery of the ancient Egyptians in utilizing bone to create combs shaped like human and animal figures, Therefore, in order for animal materials to be suitable for human use, it is essential to eliminate the fats and blood adhering to the hides and bones, as well as the dirt and straw stuck to the wool and horns. The researcher will address both ancient and modern methods of processing animal materials (leather, wool, bone, and horn).

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<sup>1</sup> ) Hassan, *Selim*(1992), *Encyclopedia of Ancient Egypt: The City of Ancient Egypt and Its Culture in the Ahmose Era, Vol. 2, Cairo: Egyptian General Book Organization Press ,p. 105.*

<sup>2</sup> ) *Lucas, Alfreda*(1991) *Materials and Industries of the Ancient Egyptians, Translated by Zaki Iskander, 1st ed, Cairo: Madbouly Library ,p. 63.*

<sup>3</sup> ) *Kamal, Moharram* ( 1991) *History of Ancient Egyptian Art, 1st ed, Cairo, Madbouly Library ,p. 199.*

## **Research Objectives:**

The research aims to :

1. To identify the methods of processing animal materials both in ancient times and today, and to explore other treatment methods that have not yet been discussed.

## **Significance of the Research:**

The Significance of the research lies in the following points:

1. Tracing the historical roots of methods used to process animal materials.
2. Understanding animal materials and the modern techniques for their preparation.

## **Research Hypothesis:**

The methods of processing animal raw materials ancient and modern can be accessed through theoretical study.

## **Scope of the Research:**

This study is limited to examining the methods and techniques for processing animal materials, specifically focusing on leather, wool, bone, and horn in both ancient and modern times.

## **Methods of Processing Animal raw Materials:**

Consider combining the two sentences for a more concise and direct approach: "Before examining the processing of animal materials, it's essential to define the term: 'animal materials' refers to everything obtained from animals, including bones, hides, teeth, and all types of fibers.

Maha Hussein cites Rots (2008) stating that animal raw materials are "the primary materials obtained from animals that are used in various industries, most notably bones, hides, wool, horns, and

teeth"<sup>(4)</sup> Hides, horns, bones, and teeth are sourced from cattle and buffalo. Wool (animal fibers), teeth, and hides come from sheep. Hair and hides are obtained from goats, and wool and hides and bones from camels.

An operational definition of the methods for processing animal materials in this research refers to the various stages required to make these materials suitable for use. This process begins with the removal of fats and blood that could lead to rapid spoilage. Each type of animal material has a distinct processing method, which will be addressed separately in this research.

"The animal was the primary source for obtaining leather. The term 'leather' is used to refer to a wide range of animal skin products, and leather specifically refers to animal skins that have been rendered non-perishable in warm, humid conditions" <sup>(5)</sup>Looking back through history, we find that "in prehistoric times, the earliest examples of leather containers and garments were created. Rarely was leather processed or stripped of its fats during that era, as the tanning of leather was not yet known. The Ice Man has provided us with a living example of the importance of animal skin and fur as clothing in prehistoric times and even into the Middle Ages" <sup>(6)</sup>

This means that initially, no treatments were applied to the leather to prolong its durability. However, the situation was different in ancient Egyptian civilization "The ancient Egyptians made

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4 ) Hussein, Maha H. A. (2022) "The Convertibility of Sheep Wool in the Northern Region of Saudi Arabia into Textiles," Journal of Arts and Applied Sciences, Faculty of Applied Arts, Damietta University,N9, p.176

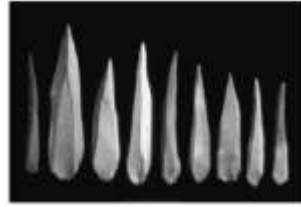
5) Harris, Susanna, and Andre' J. Veldmeijer (2014): Why Leather, Leiden: Sidestone Press, p.9

6) Kamal, Moharram.(1991) History of Ancient Egyptian Art, 1st ed, Cairo: Madbouly Library, p. 20

significant strides with leather; they used it in its raw form, then processed it to the point of softness and completed tanning."<sup>(7)</sup>

The leather industry began with the Pharaohs when they discovered that salt and sunlight helped preserve leather and made it suitable for use. Susanna Harris and Andre' J. Veldmeijer mention in their book *Why Leather* that "it is logical to conclude that if an animal skin is left untreated for several days, it will rapidly decompose. A simple intervention to remove the fatty layer beneath the skin and drying will reduce the effect of harmful bacteria and slow the rate of decay. Only through a lengthy process can animal hides be treated, tanned, or dressed to produce a stable product."<sup>(8)</sup>

"We do not know what materials were used in tanning or what processes were followed to prepare the hides, but it is very likely that they were soaked in water, scraped, pounded, and polished with stones." There is an illustration of discoveries of flint stones used for scraping hides, as shown in Figure ( 1).



**Figure (1)**

Erman describes the preparatory processes for making leather: "The workers first soften the leather in large vessels, then they stretch it and pull it by hand over a three-legged wooden device until it achieves the necessary softness" <sup>(9)</sup>. This is illustrated in a

<sup>7</sup> ) Abd al-Tawab, Zainab. (2014): "Animal Employment." *Studies in the Archaeology of the Arab World*, no18 ,p.145.156.

<sup>8</sup> ) Harris, Susanna, and Andre' J. Veldmeijer.( 2014): op.cit,p10

<sup>9</sup> )Erman, Adolf, and Hermann Ranke.(1937) : *Egypt and Egyptian Life in Ancient Times*. Translated by Abdel Monem Abu Bakr and Moharram Kama, Cairo: Egyptian Renaissance Library, p. 520.

wall painting depicting leather tanning in ancient Egypt, where the hides are first tanned. The wall painting, as shown in Figure (2), " depicts a worker placing the hide in a vessel filled with oil, surrounded by a group of other craftsmen preparing the leather for use" (<sup>10</sup>). They were well aware of how to prepare and tan the hides.



Figure (2).

Processing around the world is relatively well-documented in ancient Egypt. One of the most important sources of information is the scenes found in the tomb of Rekhmira, the minister of Thutmose III, and the tomb of Amenhotep II in the noble tombs on the West Bank of Luxor. In summary, the process is as follows: the fatty layer is removed after skinning the hide, and then the leather is completely cleaned of hair, undergoing a process of rejuvenation. The second step involves treating it with special oils, which is the method used by the ancient Egyptians" (<sup>11</sup>). The *Beni Hasan* tombs recorded "the operations for preparing hides" and leather manufacturing depicted on the walls of a tomb from the 26th dynasty in Thebes (<sup>12</sup>).

The method of processing, or understanding how animal hides transform during processing, allows for the creation of a specific material that differentiates the final product of leather. This is confirmed by (Susanna Harris and Andre' J. Veldmeijer) in their book *Why Leather*: "The final product heavily depends on the nature of the raw material and the method of processing. Leather

<sup>10</sup>)Kamal, Moharram(1991) :op.cit , P.199.

<sup>11</sup>)Veldmeijer, Andre J.( 2011): *Tutankhamun's Footwear: Studies of Ancient Egyptian Footwear*, Leiden, Sidestone Press, p.147:148.

<sup>12</sup>) Lucas, Alfreda (1991): *Materials and Industries of the Ancient Egyptians*, Translated by Zaki Iskander, Cairo: Madbouly Library,p. 63.



can be soft and flexible like textiles, or hard and stiff like baskets, or firm and water-resistant like pottery or gourds. The diverse characteristics of leather are partly due to the chemical and physical composition of the animal hides and the species or breed from which they originated, as well as the processing methods employed. For tanners, understanding how animal hides transform during processing enables them to create a specific material. For artisans, a particular material may be desirable due to its functionality, aesthetics, novelty, or availability" (13)

After completing the leather preparation process, the next phase is to transform the leather into a crafted item: "The craftsman sits on a seat surrounded by his tools, which include an awl, a chisel, and other tools with six teeth, along with a horn and a mallet, as well as a knife. He takes a single piece of leather to prepare the desired shape, puncturing it with his awl. He then creates the straps

that will be attached to it, and also makes sandals covered with leather on top to protect the foot from dust" (14). Evidence supporting this is found in the reliefs in the tomb of Hatum II, depicting the stages of leather manufacturing and the creation of chariots, among other items, as shown in Figure 3.

Although the findings of leather artifacts from the works of the Pharaohs indicate a clear proficiency in tanning processes, "the nature of the tanning materials used by the ancient Egyptians has never been thoroughly researched" (15).

Scholars believe that vegetable tanning was introduced by the Greeks or Romans (16). However, historical evidence indicates that vegetable tanning was practiced in ancient Egyptian

<sup>13</sup>) Harris, Susanna, & Andre' J. Veldmeijer. (2014) op.cit , p.10.

<sup>14</sup>) Kamal, Moharram.( 1991):op.cit, p.200.

<sup>15</sup>)Lucas, Alfreda.( 1991) : op.cit , p.64.

<sup>16</sup>)Veldmeijer, Andre J. (2011): op.cit p. 147. 148.

civilization, as evidenced by "the examination of remnants of tanned materials found in the town of Jabalin in Upper Egypt, which included raw tanned goat hides, tools, and tanning materials, dating back to the Pre-Dynastic era. The raw hides were goat skins, while the active ingredient in tanning was derived from acacia pods, extracted from the pods of the acacia tree, which grows in the deserts of Arabia and along the banks of the Nile" <sup>(17)</sup>.

It is also mentioned in the book about leather, its types, and tanning, "that the ancient Egyptians used acacia fruits or *Qard* in the tanning of leather. Fragments of it have been found from prehistoric times, and a depiction of acacia trees was discovered in the Beni Hasan tombs. *Qard* is still used today in Egypt for tanning sheep hides" <sup>(18)</sup>. Moreover, the use was not limited to acacia trees; there were other plant materials used in tanning. "Evidence from the mid-first millennium BCE reveals that the Kharga Oasis produced large quantities of castor oil, which were exported to the Nile Valley, despite the scarcity of archaeological and written evidence" <sup>(19)</sup>.

## Modern Methods of Leather Processing:

Modern methods of leather processing have evolved significantly from ancient times. Today, the process relies heavily on modern tanning chemicals. After initial treatments like salting to prevent decomposition, scaling, and soaking in a saline solution, the hide is soaked in a lime solution to remove hair. Various toxic chemicals are also used in this stage. Following trimming, the

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<sup>17</sup>) Lucas, Alfreda. (1991). Op.Cit, p: 64-65.

<sup>18</sup>) Zaghoul, Mohamed Abdullah. *Leather: Its Types, Preparation, Tanning, and Finishing*. Cairo: Anglo-Egyptian Library, n.d, p: 5

<sup>19</sup>) Miniaci, Gianluca, Juan Carlos, and Others (2018): *The Arts of Making in Ancient Egypt*, Leiden: Sidestone Press, p.161.

leather is treated with enzymes, salt, and sulfuric acid. It is then soaked in water and biocides before the tanning process. During tanning, the leather is stretched and soaked in a concentration of vegetable tannins, chrome sulfate, formaldehyde, or synthetic polymers for eight to twelve hours. This final stage transforms raw leather into finished leather <sup>(20)</sup>.

### **Natural Leather Tanning or Methods for Processing Leather:**

The purpose of the tanning process is to transform perishable leather (the raw material), "a term used to refer to the material in its natural state or when it undergoes slight changes due to processing" <sup>(21)</sup>, into manufactured leather.

**The tanning process involves three main stages: preparation, tanning, and finishing.**

#### **First Stage: Preparing the Leather:**

This stage includes a variety of technical processes that lead to the production of finished leather suitable for use. The leather preparation process consists of several steps:

1. **Sorting the Leather:** This involves categorizing the leather based on various defects such as size, thickness, burn marks, and skin diseases.
- **Storage:** This refers to the storage of raw hides after processing to keep them suitable for as long as possible,

<sup>20</sup>) Veldmeijer, Andre J ( 2011) : Op.ict ,p. 196.

<sup>21</sup>) Marai, Hassan (1975): *Dictionary of Textile Industry Terms: Arabic, English, French, German*, Cairo: Al-Ahram Foundation, p. 188.

whether through salting, drying, soaking in a saline solution, or air drying <sup>(22)</sup> until they are ready for the next stage.

- **Salting:** Hides are usually transported from the slaughterhouses to the factories, where they are spread out on the ground and the surface of the hide is saturated with salt. The hides are thoroughly rubbed with salt in all areas <sup>(23)</sup>. This method halts bacterial activity until the transformation processes begin, and the salt is applied to the flesh side of the hide to facilitate its dissolution and spread within the leather <sup>(24)</sup>.
- **Drying:** The hide is stretched on a wooden frame and exposed directly to air and sunlight for about four days to absorb the maximum amount of salt. The quicker the drying process, the better the condition of the hide .
- **Soaking in a saturated salt solution:** The salt solution provides rapid and complete penetration of the skin in a short time. Skins are soaked in a saturated salt solution for 4 hours for light skins and 8 hours for heavy skins, followed by draining for 30 minutes.
- **Air-dried skins:** This involves air-drying the skins, then sorting them based on weight. The skins are further air-dried by adding naphthalene to prevent deterioration during storage. <sup>(25)</sup>
- **Soaking stage (softening or rehydration):** This process involves washing the hides with water to restore the moisture

<sup>22</sup> ) Mukhtar, Salah Eddin Mohamed Ahmed (1999): "Removal of Hair from Heavy Hides Using Local Materials: *Al-Athron* and Lime," Master's thesis, Faculty of Agriculture, Omdurman Islamic University, Sudan, p.8-6.

<sup>23</sup> ) Zaghoul, Mohamed Abdullah:*Op.cit*, p. 6.

<sup>24</sup> ) Suleiman, Naima Ramadan.(2000) "The Environmental Impact of the Leather Tanning Industry in Egypt." Published paper, Fifth Annual Conference on Crisis and Disaster Management, Vol. 1, Issue 12, October 2000, Faculty of Commerce, Ain Shams University, Cairo, p. 305.306.

<sup>25</sup>) Zaghoul, Mohamed Abdullah:*op.cit*, p. 6.

lost during preservation, whether by salting or other preservation methods. It also removes impurities and other soluble substances. The duration of this process ranges from several hours to several days<sup>(26)</sup>, with salt-dried hides requiring up to 24 hours.

- **Hair removal and de-fleshing:** After a thorough water wash, hides undergo a chemical treatment involving sulfide and lime in an alkaline solution. This process serves a dual purpose: removing hair and epidermis, and loosening excess flesh and skin residues. By swelling the hide's structure, this treatment also prepares it for the tanning process, enabling deeper penetration of the tanning agents. This method yields soft leather with a smooth grain. The entire process usually takes one to two days. <sup>(27)</sup>

## Second Stage of Leather Processing

**Tanning process:** Tanning is the chemical reaction between the hide fibers and tanning agents, transforming the raw hide into a material capable of withstanding moisture, heat, bending, and stretching, while resisting mold growth. There are two types of tanning:

- **Vegetable tanning:** This method uses plants with tanning properties, such as *Acacia nilotica* (gum Arabic), *Acacia seyal*, tamarisk, mimosa, and others.

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<sup>26</sup>) Moussa, Ali Al-Naem.(1999) :Production of Light Leathers Using Local Tanning Materials." Master's thesis, Faculty of Agriculture, University of Omdurman, p. 11.20.

<sup>27</sup>)Mukhtar, Salahuddin Muhammad Ahmed.(1999) "Hair Removal from Heavy Hides Using Local Materials: Atron and Lime." Master's thesis, Faculty of Agriculture, Omdurman Islamic University, Sudan, p. 6:8.

- **Mineral tanning:** This method uses chromium, aluminum, formaldehyde, or a combination of these, and is the most commonly used method in modern tanneries. <sup>(28)</sup>

### Third Stage of Leather Processing

- **Finishing stage:** This is the final stage that the leather undergoes to achieve the final product. In this stage, the leather is treated to protect it from damage and exposure to harmful factors such as moisture and other environmental elements. It also enhances the desired appearance and sheen of the leather, giving it a specific texture and color, or leaving it uncolored. <sup>(29)</sup>The coloring of the leather helps conceal some imperfections while providing an aesthetically pleasing appearance.

### Wool Processing in Ancient Times

Archaeological discoveries have shown that early humans were familiar with the processes of spinning and weaving wool. The oldest known piece of wool fabric, dating back to around 4000 BC, was found in Egypt. Wool spinning was also a significant industry among the Sumerians.

Wool is composed of a protein called keratin, a key component of hair, nails, and fur. [1] Furthermore, as stated in *The History of Wool and Woolcombing*, the textile industry is much older. Abel was a shepherd, and Noah, a skilled craftsman, built the ark. It's unlikely that they were ignorant of spinning and weaving processes. [2]

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<sup>28)</sup> Moussa, Ali Al-Naeem.(1999) "Production of Light Leathers Using Local Tanning Materials." Master's thesis, Faculty of Agriculture, University of Omdurman, , p. 11–20.

<sup>29)</sup> Mukhtar, Salahuddin Muhammad Ahmed(1999),Op.cit, p. 6–8.

In ancient times, the wool industry, transforming nature's gift into fabric, demonstrates human creativity inspired by the natural world. The spider, the oldest spinner and weaver, likely inspired the original idea of woven fabric..<sup>(30)</sup>

The stages of spinning and weaving were depicted in the inscriptions on the walls of temples. "The ancient Egyptians referred to it as *sti*," a term associated with spinning and weaving scenes. This practice was known since the Old Kingdom and continued to be used until the Ptolemaic period. We see a woman engaged in this process, with two vessels before her: the first is conical in shape, and the second has a different form.

This container supplies the spinner with the threads she needs to twist them into yarn, as illustrated, In another scene at Beni Hassan, in the tomb of Khnumhotep II, the term *sti* is shown alongside an image depicting two spinners standing on what resembles inverted baskets, with one of them lifting her left leg to wrap the spindle with it<sup>(31)</sup>, as shown in Figure (4 )



figure (4 ).

### Stages of Processing Animal Fibers (Wool)

Textile fibers are hairs that can be spun into threads and woven into fabrics. These fibers must possess specific characteristics, such as elasticity, length, and strength, to be suitable for textile production. These qualities enable the transformation of raw

<sup>30</sup> ) Burnley, James.(1989): *The History of Wool and Woolcombing: The Romance of Modern Industry*, London: 1989, p. 34

<sup>31</sup> ) Noor, Abdel Halim (2009):"Clothing and Fashion in Ancient Egypt." *Journal of History, Antiquities, and Heritage of Egypt*, Cairo: Al-Hadara Publishing, no. 4, May 2009, p: 6.

materials into yarns, which can then be woven into various fabrics. (32)

Experts classify fiber sources for spinning and weaving into two main categories:

**Natural Fibers:** These fibers originate from plants and are primarily composed of cellulose. Common examples include flax, cotton, hemp, and jute.

**Animal Fibers:** Derived from animals, these fibers are primarily composed of protein. Examples include wool, goat hair, camel hair, and silk, which is obtained from silkworms. [1] While the term "wool" specifically refers to sheep's hair, it's often used more broadly to encompass hair from various animals, such as goats, camels, and rabbits. (33).

The Egyptians were familiar with wool and engaged in sheep farming since the Neolithic period. However, only a limited amount of wool has been discovered in tombs up to later periods. Notably, brown and white wool fabrics have been found, along with fragments of red and blue wool dating back to the Twelfth Dynasty. This scarcity of suitable wool for spinning can be attributed to the inferior quality of the sheep's wool available at the time, as well as their belief in its impurity. Consequently, they would weave it into their outer garments, which they removed upon entering the sacred areas of their temples(34).

### Modern Wool Processing Stages:

<sup>32)</sup>Kamel, Abdel-Raouf.(1992) :*Introduction to Textile Technology and Tapestry*,2nd ed. Cairo: Dar Al-Maaref, p. 13.

<sup>33)</sup> Nasr, Ansaf, and Kawthar Al-Zoghbi (1993):*Studies in Textiles*,4th e, Cairo: Dar Al-Fikr Al-Arabi, p. 68.

<sup>34)</sup> Al-Nemr, Ahmed Abdel Hamid.(2022): *Coptic Textiles in the Islamic Era in Light of the Collections of the National Museum of Egyptian Civilization*,1st ed, International Book Foundation, p. 90.



The process of preparing animal fibers, such as wool, hair, and fur, involves several stages to obtain raw material suitable for use. This preparation includes removing impurities and dirt from the animal fibers and dyeing them in various colors.

**Stage 1: Shearing Animal Fibers** Wool, hair, and fur are sheared from live animals like sheep, cattle, and camels. The weight of a single fleece ranges from 6 to 20 pounds.<sup>(35)</sup> The shearing process can be performed using either manual hand shears or specialized machines known as shearing tools. However, livestock owners often prefer manual shears due to the mistaken belief that machines cause harm to animals by not leaving a sufficient gap between the blade and the skin <sup>(36)</sup>.

Samim Al-Dabbagh emphasizes three important points to consider when starting the shearing process to obtain wool " Careful handling of sheep during shearing to avoid injury, Shearing the wool as close to the skin surface as possible, Ensuring that the fleece remains intact Usually, sheep are restrained during manual shearing with hand shears, but this is rarely necessary with mechanical shearing. The best shearing method involves holding the animal in a way that minimizes resistance and does not interfere with the process "<sup>(37)</sup>.

Maha Hussein also notes, "The shearing of livestock is done by laying the animal on the ground, and the shearing is carried out from the bottom up, with each session lasting around 10

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<sup>35</sup> )Mar'i, Hassan.( 1975): Glossary of Textile Industry Terms: Arabic, English, French, German,Cairo: Al-Ahram Foundation, p.131.

<sup>36</sup> ) Al-Masoudi, Maha Hussein Eid.(2022) "The Feasibility of Converting Sheep Wool from the Northern Region of Saudi Arabia into Textiles." *Journal of Applied Arts and Sciences*, Faculty of Applied Arts, Damietta University, vol. 9, no. 4 (October 2022),p: 180.

<sup>37</sup> ) Al-Dabbagh, Samim Fakhri.(2021) *Production and Technology of Wool*. 1st ed. Cairo: Noon Publishing and Distribution House,p: 92.

minutes"<sup>(38)</sup> ,She emphasizes that shearing should be done in a clean, dry environment, with thick fabric sheets spread on the ground for the animal to be sheared on.

Samim Al-Dabbagh, in his book Production and Technology of Leather (2021), mentions that sheep" should only be shorn when their wool is completely dry, as wet wool can rot and deteriorate during pressing and storage, becoming matted. Additionally"<sup>(39)</sup>, any foreign matter or dirt must be removed from the wool, especially around the tail area, as it can stain the wool yellow.

**Stage 2: Sorting the Wool** Once the raw wool reaches the factory, it undergoes a sorting process, where the fleece is divided into different grades based on length and growth characteristics.

### **Stage 3: Dust Removal and Wool Opening**

Special machines are used in this stage to remove impurities such as dust, manure, and food remnants. The purpose of this process is to eliminate sand and dust trapped in the wool to facilitate the washing process.

### **Stage 4: Washing**

This process is carried out to remove all natural impurities (a mixture of fats and sweat). There are two primary methods for washing wool: the first involves using soap, while the second employs solvents or detergents like Tebbol<sup>(40)</sup>.

Raw wool is initially washed to remove dirt and impurities. Subsequently, the wool is sorted by length. Shorter fibers from the belly and legs, as well as darker-colored fibers and any remaining impurities, are manually removed. [1]

<sup>38</sup> ) Al-Masoudi, Maha Hussein Eid.(2022) Op.cit , p.180.

<sup>39</sup> ) ) Al-Dabbagh, Samim Fakhri.(2021) Op.cit , p. 92

<sup>40</sup> ) Al-Dabbagh, Samim Fakhri.(2021): Ibid. p. 98.

Before the next washing stage, the wool fibers are manually detangled in a process known as unraveling.

The wool undergoes a mechanical washing process using hot water at a temperature of 60 degrees Celsius. Sodium carbonate and soap are added to the water to aid in cleaning.

After washing, the wool is transferred to steam ovens for drying. Care is taken to avoid excessive heat, which could weaken the wool fibers.

### **Stage 6: Bleaching**

During the bleaching stage, any remaining plant material, foreign fibers, straw, or hay that were not removed in previous processes are eliminated. The impurities are removed using one of two methods: either by mechanically capturing the impurities or by bleaching with chemicals (<sup>41</sup>).

### **Stage 7: Topping**

This stage, known as the topping or "tops" stage, occurs after the washing and drying of the wool. It involves drawing, carding, and combing the wool fibers to achieve the topping stage, also called "tops." Hossam Al-Din (2017) indicates that the drawing stage is crucial for shaping the final yarn and improving tensile strength and consistency (<sup>42</sup>).

### **Stage 8: Wool Carding**

This process helps remove foreign materials embedded in the wool and disentangles wool fibers that are stuck together. It

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<sup>41</sup> ) Al-Masoudi, Maha Hussein Eid.(2022) "The Feasibility of Converting Sheep Wool from the Northern Region of Saudi Arabia into Textiles." *Journal of Applied Arts and Sciences*, Faculty of Applied Arts, Damietta University, vol. 9, no. 4 (October 2022): p:179.

<sup>42</sup> ) Mahmoud, Hossam Al-Din Sayyed. "The Impact of Developing the Drawing Process on the Properties of Cotton Yarns Produced from Different Types." *Journal of Applied Arts and Sciences*, Arab Republic of Egypt, vol. 4, no. 3 p:

transforms them into a thin, uniform layer. The machines used in this stage consist of cylinders covered with fine metal teeth, which rotate in opposite directions.<sup>(43)</sup>

### **Stage 9: Wool Combing**

This process is exclusive to spinning factories, where machines vary based on the length of the wool fibers.

### **Stage 10: Spinning**

Spinning is the process by which wool fibers are twisted to produce spun wool. There are two methods for spinning wool: the first produces finely spun yarn, while the second creates long, thick strands of spun wool.<sup>(44)</sup>

### **Final Stage: Dyeing**

Dyeing was a crucial technique that contributed to the fame of Egyptian textiles. Until the late 19th century, natural dyes derived from plants and animals were the primary coloring agents. These natural dyes were among the most significant organic materials used by the ancient Egyptians to color their garments, coverings, and rugs. The ancient Egyptians were remarkably skilled in extracting a wide range of colors from nature.

"It is worth noting here that the ancient Egyptians reached a high level of expertise in the manufacture of dyes and colors. Evidence of this can be seen in the inscriptions and paintings that adorn the walls of tombs and in artifacts discovered at various sites, which are preserved in both local and international museums. Regarding dye manufacturing, the ancient Egyptians practiced dyeing in vats,

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<sup>43</sup> ) Ahmed, Salim Muhammad. (1997). "The Aesthetic and Formative Potentials of Environmental Materials as an Approach to Innovating Artistic Works." PhD diss., Faculty of Art Education, Helwan University ,p. 100

<sup>44</sup> ) Ahmed, Salim Muhammad (1997):Ibid ,p. 101.

where threads were immersed in a dye bath, and after the dye penetrated the fibers, they were exposed to air." (45)

## **Bone Processing Methods:**

Bones serve as the internal framework upon which the external structure of the body is built. They can be defined as "a different form of structural connective tissue that exists in a solid state." Bones constitute most of the skeleton in higher vertebrates. Bone tissue includes bone cells and the intercellular matrix, which is characterized by the presence of collagenous fibers. These fibers represent the organic component of the bone structure, comprising approximately 35% of the bone's weight. In contrast, the inorganic component constitutes about 65% of the weight of bones, depositing in the intercellular material, providing strength and rigidity to the bones. The inorganic salts in bones include calcium phosphate, accounting for around 85% of the inorganic material weight, as well as calcium carbonate and trace amounts of calcium fluoride and magnesium fluori(46).

The wall carvings do not mention any steps for processing bones; however, the steps followed by artisans and artists in preparing and cleaning bone material will be outlined.

First, bones are obtained after the animal is slaughtered from various parts of its body. Long bones, particularly those of the legs, are extracted, and surrounding excesses, such as veins and muscle tissue attached to the bones, are removed as much as possible(47)

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45 ) Al-Nimr, Ahmed Abdel Hamid.( 2022). *Coptic Furnishings in the Islamic Era in Light of the Collections of the National Museum of Egyptian Civilization*. 1st ed. International Book Foundation, p.103.104.

46 )Ismail, Muhammad, and others ( 2002). *Fundamentals of Animal Science*. Cairo: Dar Al-Fikr Al-Arabi Publishing, p: 97.

47)Ahmed, Salim Muhammad (1997):Op.Cit ,p: 101

Second, a vertical cut is made on the joint bone (the spongy bone) using a blacksmith's saw to maintain the length of the bone for maximum utilization.

Third, the inner marrow located within the medullary cavity is removed. Boiling water mixed with cleaning powder is prepared, and the bone piece is placed in it to boil several times until the remnants of fat are removed. The skin remnants are cleaned through scraping, and this process is repeated multiple times until the color changes to white.

Fourth, the bone is air-dried for approximately one day, then its surface is sanded thoroughly using coarse sandpaper followed by fine sandpaper<sup>(48)</sup>.

It is noted that when cleaning camel bones, some bones do not require the addition of caustic substances; instead, they need a small amount of oxygen to assist in their cleaning. This is because the addition of caustic soda alters the nature of the bone material, making its surface less cohesive.

The process of treating animal horns is complex due to the lengthy duration required for processing. This complexity is reflected in the precision of the details executed on the surfaces of the crafted items made from horn material. Before discussing the methods of horn processing, it is essential to understand what horns are. As noted by Huda Ibrahim in 2015, "animal horns, in the context of physiology, are defined as bony structures derived from the head, extending from one of the skull bones. They are found on the heads of many mammals and ungulates. Horns grow in two ways: one involves an increase in diameter, while the other involves the growth of the bony rings that compose them, which occurs as the animal matures throughout its life. Horns remain on the animal's head for its entire life. Most animals possess a pair of horns, such as cattle, bulls, sheep, and goats. Both males and females typically

<sup>48</sup>) Ahmed, Salim Muhammad. (1997):Ibid .p. 193.

develop horns, although in some horned species, female horns may be smaller than those of males”<sup>(49)</sup>.

Historical inscriptions from ancient civilizations do not mention methods for preparing and processing horns; however, modern processing techniques for horns will be discussed. In ancient civilizations, such as ancient Egyptian civilization, horns were utilized either attached to the skull or separated from it, often decorated with colors, and held various ideological significances that justified their use in their original forms. This is particularly noteworthy given the scarcity of information on this subject.

### **Modern Horn Processing Methods:**

First, horns are obtained from slaughtered animals (such as cattle, buffalo, and sheep), where the horns are connected to the skull. Separating the horns from their natural position in the skull is a necessary step, which involves cutting them with a metal saw. This cutting requires specific procedures or a series of consecutive tasks to acquire an appropriate piece of raw material that allows for suitable preparation in subsequent stages.<sup>(50)</sup>

The method of separating certain horns indicates that cross-cutting them near the junction of the horn with the skull is customary, as the circular part fused to the head is excluded. This might be due to its spongy nature and irregular shape.

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<sup>49</sup> ) Mahmoud, Huda Ibrahim. (2015): “Animal Horns: Their Uses and Secular and Religious Significance in Ancient Egypt.” Master’s thesis, Faculty of Archaeology, Cairo University.P.2.

<sup>50</sup> ) Astuarokh, Azloubith Badia. 2003. “Andalusian Boxes of Bone and Ibex Horns (12th–13th Century CE): Workshop of the Castle of Tazugue de Xijona.” Translated by Abdullah bin Ibrahim Al-Omair, Published research, *Adomato Journal*, Saudi Arabia, no. 8 (July), p.107.

**Secondly**, salt is placed inside the cavity of the horn and left in the sun for no less than a year, allowing the bone (the spongy bone) to separate easily from the horn. Prolonged exposure to sunlight dries the binding materials between the horn and the spongy tissue. The horn is unsuitable for use without drying, as it remains pliable like nails.

**Thirdly**, the piece of bone (the spongy bone) located in the hollow part of the horn is removed, making the horn hollow inside. Thin excess material at the base of the horn is cut off with a saw. In some cases, the horn is left intact while its surface is well-sanded, preserving its distinctive conical shape. The subsequent processing steps are not addressed here, as they pertain to preparing the horn for sculpted forms, and the choice of part of the horn largely dictates the artistic shape desired.

**Fourthly**, the solid part at the top of the horn is removed, and the horn is cut lengthwise on one side only, leaving the other side intact.

**Fifthly**, to flatten the surface of the horn, it is coated with oil and placed over a fire for a brief period, ranging from one to two minutes. Then, it is pressed down with weight until the surface becomes flat. This process is repeated several times until the desired result is achieved. Afterward, the horn is immediately submerged in water to maintain this shape.

**Sixthly**, the outer surfaces of the horn are scraped and polished with coarse sandpaper followed by fine sandpaper until they become smooth and even. At this stage, scraping is continuously employed during the execution of the artistic piece.

**Seventhly**, after completing the artwork, the horn is polished and buffed using a polishing machine equipped with a circular cloth



brush, to which a polishing substance called "Jamatta" is added. This process is repeated to achieve a proper finish. <sup>(51)</sup>

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