Asian Social Science; Vol. 20, No. 5; 2024
ISSN 1911-2017 E-ISSN 1911-2025
Published by Canadian Center of Science and Education

Rethinking the Start of Using Textile Fibers

Xiyao Zhang[1], & Xiaoming Yang[2]

[1] College of Textiles, Donghua University, Shanghai, P. R. China

[2] College of Humanities, Donghua University, Shanghai, P. R. China

Correspondence: Xiaoming Yang, College of Humanities, Donghua University, Shanghai, 200051, P. R. China. E-mail: ynide@sina.com

Received: June 19, 2024 Accepted: July 26, 2024 Online Published: October 1, 2024

doi:10.5539/ass.v20n5p45 URL: https://doi.org/10.5539/ass.v20n5p45

Abstract

Textile historians tend to demonstrate the history of textiles from the start of using fibers yet rarely explain how people knew to use them. With an investigation of the early textile-related remains and a theoretical analysis of the difficulty in and the demand for using fiber materials, a hypothesis is raised that the know-how of using fibers came from the experience of making textiles with both fineness and strength, which was accumulated from the early technologies of interlacing and cord-making. The properties of fiber materials should have been discovered thanks to the frequent use of stripped or sliced materials taken from plants. Among all the main types of the earliest fiber materials used by humans, invisible plant fibers should have been the first to be used, cotton the second, wool synchronous with or a little later than cotton, and silk the last.

Keywords: fiber, textile, textile history, materials, archaeology

1. Introduction

A fiber is generally a matter having a length of 100 times its diameter (Sinclair, 2015). It is the basic element of textiles that we know today. Based on the sources, fiber materials nowadays utilized can be categorized into natural and chemical fibers, among which chemical fibers were not invented until the end of the 19th century being inspired by the process of silk production of the silkworm (Mauersberger, 1947, pp. 8-10) while natural fibers, obtainable directly from nature, have been utilized for tens of thousands of years (Hardy et al., 2020; Jørgensen et al., 2023; Kvavadze et al., 2009).

Textile historians tend to demonstrate the history of textiles from fiber utilization. When stating the origin of fibers, they usually point to folklore, mysteries, or limited archaeological finds (Barber, 1992; Chen, 1984; Cook, 1984; Geijer, 1979; McDonald, 2011; Wilson, 1979; Zhao, 2005). Rarely did they explain how people knew to make threads from fibers as if the first group of ancestors knew the process of dealing with fibers when they first saw them. Knowledgeable people in modern times, who have learned textile production, know how to make textiles from fibers well. However, human beings would not have known collecting and processing visible fibers such as cotton or wool when they first saw them, nor did they have the motivation to extract invisible fibers from plant stems, leaves, or silkworm cocoons.

Some scholars have pointed out that the discovery of bast fibers hidden within the plant stem might have arisen from the accidental rotting of baskets made of plants (Ryder, 1968; K. Liu, 2011). This possibility is supported by strips without separated fibers in the evidence of early mats, braids, basketry, and cordages (see below). However, the reason for using fibers is still unexplained. Based on archaeological finds of early textiles or textile-related products that reveal the early technologies for the start of using fibers, and theoretical analysis of the difficulty in and the demand for using fiber materials, this paper will explore the technical origin of using textile fibers.

2. Early Technologies of Interlacing

2.1 Extant Remains of Early InterLaced Objects

324 pieces of braids or fabrics were excavated from the Guitarrero Cave in Peru, in which one of the oldest is a fragment of braided basketry dating back to 10600-10000 BP (Lynch, 1980, pp. 264-289). This basket is braided with Z-twist cords measuring approximately 1.5 mm in the warp and 1 mm in the weft. And the cords are twisted with unspun fine strips. Among the remains unearthed from the Guitarrero Cave, the cordage, spiral braids, and

close-twined textiles are all made from Agavaceae or Bromeliaceae leaf fibers processed to varying degrees, and the open-twined mat fragment is woven from Cyperaceae rush stems (Jolie et al., 2011).

Figure 1. Fragment of a braided basket (10600-10000 BP) unearthed from Guitarrero Cave, Peru (Image from Lynch, 1980, p. 255)

A group of reed braids, mostly deteriorated, were unearthed from the first phase (7000-6500 BP) of the Hemudu site in Eastern China (Huang, 2000; Zhejiang Provincial Institute of Cultural Relics and Archaeology, 2003, pp. 153-154). One of the fragments measuring approximately 10 cm in both length and width is interlaced with 8 warps and 8 wefts, of which the reed strips are evenly split to some degree. Knowing its size, it can be estimated from Figure 2 that each reed strip of this mat has a width of approximately 1.5 mm.

In addition, 27 fragments of braided mats were unearthed from the Tianluoshan Site in Eastern China of the same culture (Sun et al., 2007). They are made of reeds [*Phragmites australis (Cav.)*] according to phytolith analysis and dated to 6775–6645 cal. yr. BP via AMS dating method applying to a fragment (Zhang et al., 2016). This fragment is interlaced with strands that have 4-6 evenly split reed strips arranged parallelly. Each strand is approximately 2 mm in width. By the way, a thread ball was unearthed from a fishbone pit at the same site. It seems to be twisted with plant fibers (Sun et al., 2007) but no detailed report with identification could be seen yet.

Figure 2. Reed braid (7000-6500 BP) unearthed from Hemudu Site, Zhejiang Province in Eastern China (Image from Zhejiang Provincial Institute of Cultural Relics and Archaeology, 2003)

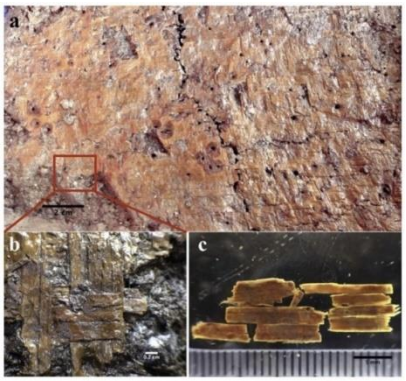

Figure 3. Reed braid (6775-6645 BP) unearthed from Tianluoshan Site, Zhejiang Province in Eastern China (a) shape of the braid (b) magnified image of the braid (c) dating sample (Images from Zhang et al., 2016)

2.2 Other Forms of Evidence for Early Interlacing

Some clay and bitumen with cloth impressions were excavated from the Jarmo site (9000-8000 BP) in northern

Iraq (Adovasio, 1975). Structures reflected in these impressions contain plain weave and basket weave, where both warp and weft threads can be identified as single yarns with unknown fiber materials. A twill weave made with split reed strands can also be identified from the imprints, with a visually inspected width of approximately 1 mm per strand.

Figure 4. Impression of reed braid (9000-8000 BP) unearthed from Jarmo Site, Iraq (Image from Adovasio, 1975)

Pottery fragments with interlacing impressions (12000-10000 BP) were unearthed from the Yuchanyan site in Southern China, displaying a clear woven structure with warp and weft (Liu, 1996). Numerous pottery bowls with fabric imprints at their bottom (7047-6287 BP) were unearthed from the Banpo site in Northwestern China, one of which has a bottom diameter of about 4 cm, showing a plain weave pattern with approximately 24-25 warps and wefts respectively (The Institute of Archaeology et al., 1963, pp. 106-107). Calculating from the width of and the number of threads included in the cloth impression, the diameter of the warp and weft threads in it can be estimated to be around 0.92-0.96 mm at maximum.

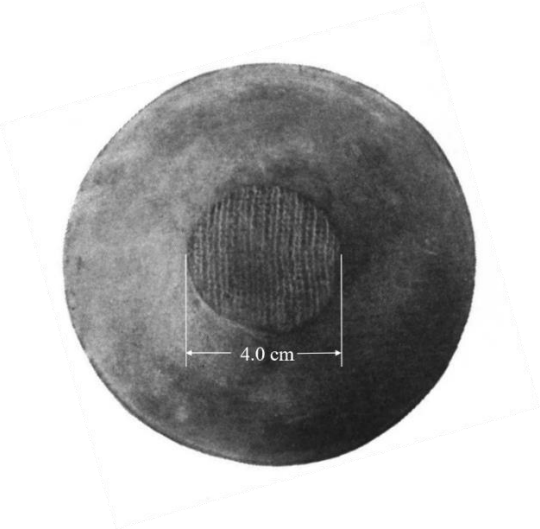

Figure 5. Pottery bowl with cloth impression at the bottom (7047-6287 BP) unearthed from Banpo Site in Northwestern China (Image from The Institute of Archaeology, Academia Sinica, and The Ban P'o Museum, Sian, 1963)

Within the site circle of Pavlov culture in Europe (28000-22000 BP), some batten fragments made from animal ribs or ivory with striations on their edges were unearthed (Soffer, 2015). One of them is a flat fragment unearthed from the Dolní Věstonice I site in the Czech Republic. It is made from mammoth ribs and has linear traces on its edge, of which the notches measure less than 1 mm in width. Intervals between two notches are between 1-2 mm, from which it can be suggested that this batten might be used as a beater for weaving.

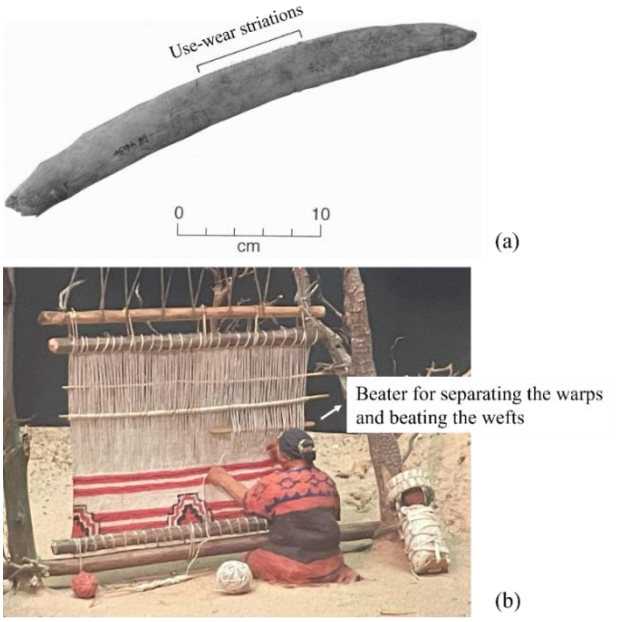

Figure 6. Beater for weaving (a) batten fragment with striations on the edge unearthed from Dolní Věstonice I (28000-22000 BP), Czech Republic (Image reproduced from Soffer, 2015) (b) a model of weaving on a vertical loom (Photographed by Xiyao Zhang, Harvard Peabody Museum)

2.3 From Braiding to Weaving

Braiding is a method of interlacing or arranging materials, whose product is called a braid. It can be inferred from the early interlaced objects that in primitive braiding, thick and stiff strips obtained directly from nature were overlapped or intertwined to form stable structures in the shape of sheets, bands, or containers. Since the raw materials are rigid, this process can be completed only by hand. Assuming other properties of the material remain the same, the thinner a strip is, the softer the strip will be. Archaeological evidence shows that early braids were mostly made from plant stems or barks (Jørgensen et al., 2023). These plant materials were obtained from nature, split into strips, and braided into different objects. As time went by, they were processed finer, and interlaced into thinner, softer, and more flexible products.

Motivated by the demand for products with both softness and stability, humans split and refined materials for braiding and contrived to mass-produce fine cords with both fineness and strength. As strip materials became thinner and softer, it was harder to control them by hand. Therefore, simple tools such as needles, bars, and weights started to be used to assist the work, giving birth to weaving. From braiding to weaving, the principle of interlacing remained the same, while the processing technique evolved from pure handwork to tool-assisting, and the product quality turned from coarse and thick to fine and thin.

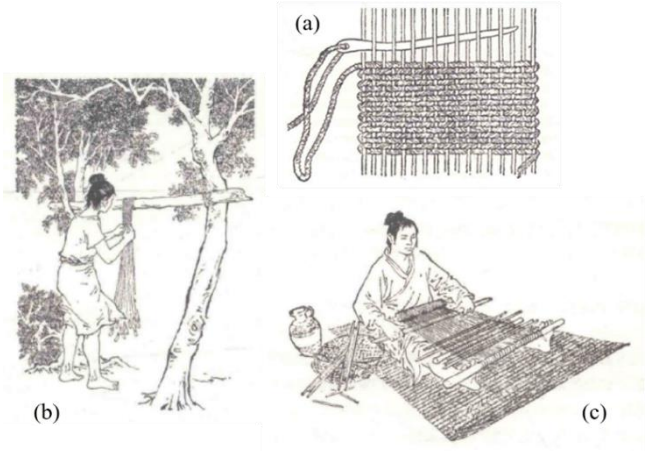

Figure 7. Making textiles with tools (a) making fabric with a bone needle (b) straightening warps with loom weights (c) weaving with a primitive loom (Images from Zhou et al., 2018, pp. 26–28)

3. Early Technologies of Cord-making

3.1 Extant Remains of Early Cordages

A cordage fragment adhering to a flake (52000±2000-41000±2000 BP) was unearthed from Abri du Maras in France. It is 6.2 mm long and 0.5 mm wide, Z twisted 3-ply thread with an S-twist in each ply. Fourier Transform Raman spectroscopy (FT-Raman) analysis suggested that the fiber materials used to make this cord were probably from the inner bark of conifers (Hardy et al., 2020).

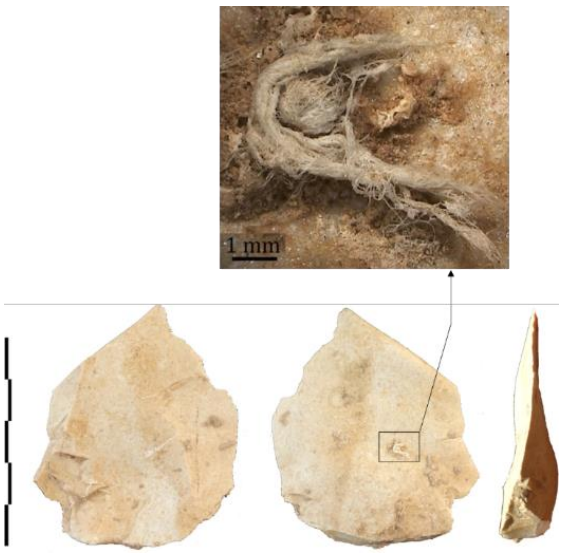

Figure 8. Flake with a cord fragment adhered (52000±2000-41000±2000 BP) unearthed from Abri du Maras, France (Image from Hardy et al., 2020)

Three fragments of charred twisted fibers interpreted as cord remains were found in waterlogged sediments at Ohalo II (23000 cal. BP) during the sorting of charcoal material (Nadel, 2017; Nadel et al., 1994), one of which was examined under SEM and identified that the "fibers" are vascular bundles probably derived from the stem or leaf of a monocotyledonous plant. The cord is Z-twisted with a twist angle varying from ca. 20-80 ˚.

A fragment of three-strand braided rope was unearthed from the Paisley Cave in Oregon, USA, dating back to 12000-10300 BP (*GREAT BASIN BASKETRY*, 2020). It was crafted by splitting the sagebrush bark into fine strips and then combining and braiding them, measuring approximately 10 cm in length and 1 cm in width. This braid resembles the braided bamboo rope (4630±140 BP) unearthed from the Qianshanyang site in Southeastern China (J. Wang & Mou, 1980; Zhejiang Provincial Cultural Relics Management Commission, 1960). The latter, with a diameter of 3 cm and a length of up to 16.3 m, was twisted from three strands of bamboo strips.

Figure 9. Three-strand braided rope (12000-10300 BP) unearthed from Paisley Cave, Oregon, the United States (Image from https://mnch.uoregon.edu/collections-galleries/great-basin-basketry, accessed on 20 Mar 2020)

A thread twinning around sticks of a wooden comb (11500 BP) was unearthed from Wadi Murabba'at (Bar-Yosef, 2020; Schick, 1995). It is originally reported to be Z-spun, S-plied, and made from cultivated flax identified through microscopic fiber longitudinal and cross sections. However, the observation of archaeologists in recent years indicates that this thread is not made by spinning fibers but by splicing strips (Gleba & Harris, 2019; Shamir & Rast-Eicher, 2020). The newest SEM examination has revealed that its raw material includes not only flax but also unidentified tree bast (Shamir & Rast-Eicher, 2020).

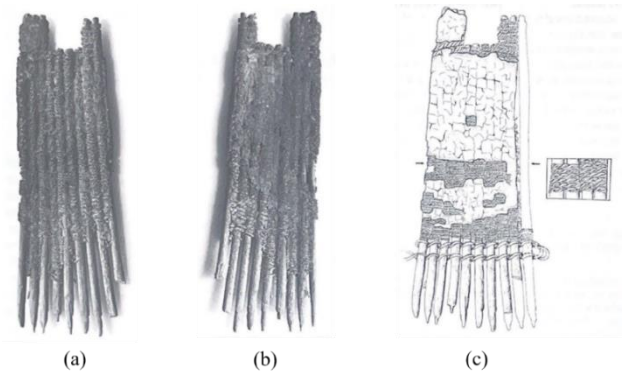

Figure 10. Comb (11500 BP) twined with flax threads unearthed from Wadi Murabba'at in the Judean Desert (a) (b) General view of the comb (photos by T. Sagiv) (c) details of threads twining around paired sticks (drawing by C. Hersch)

233 specimens of cordage were unearthed from the Guitarrero Cave in Peru, among which the earliest were 22 fragments dating back to 10600-10000 BP (Lynch, 1980, pp. 253-264). 5 of the 22 cordages were knotted and 17 unknotted. They are all S-twist, Z-ply, two plied yarns, with lengths ranging from 2.2-21 cm, diameters 0.5-2 mm, and twists of 2.5-14 twists/cm. Fibers used to make these cordages are from Agavaceae and Bromeliaceae leaves identified by their cross sections (Jolie et al., 2011; Lynch, 1980, pp. 87-94), that is, they might be sisal and pineapple fibers.

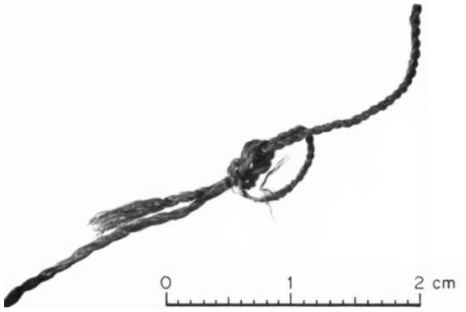

Figure 11. Cordage (10600-10000 BP) unearthed from Guitarrero Cave, Peru (Image from Lynch, 1980, pp. 255)

Quite a few ropes varying in thickness were excavated from the 4th cultural layer (7000-6500 BP) at the Hemudu Site in Eastern China (Zhejiang Provincial Institute of Cultural Relics and Archaeology, 2003, pp. 153-154). When discovered, some of them remained in the square holes of bone tools, some were strung through handles of pottery pitchers, and others were inside cooking vessels such as pottery kettles (Archaeological Team at Hemudu Site, 1980). Under a microscope, both of the thick and thin ropes are too compact for the light to pass through, from which it was inferred that these ropes were twisted with bast strips split from plants without degumming. Strips used to make ropes vary in width and thickness but they are all above 10 μm. Cross sections of the thick bast strips have cavities similar to bast fibers, while the thin ones have no characteristics like that (Gao, 2003). The identification report stated that these ropes were twisted together with 2-3 strands and each strand was twisted with long and fine fibers, which should more accurately be ropes twisted with 2-3 single ropes twisted from fiber bundles stripped from plants. No identification of the specific plants has been seen yet.

Figure 12. Rope (7000-6500 BP) unearthed from Hemudu Site, in Eastern China (a) one of the thick ropes (Image reproduced from Zhejiang Provincial Institute of Cultural Relics and Archaeology, 2003) (b) 30× image of the rope's cross section (Image from Gao, 2003)

3.2 Other Forms of Evidence for Cordages

At the Denisova Cave in southern Siberia, Russia, bone needles from the Paleolithic period were discovered. Among them, a fragment of a perforated bone needle was unearthed from the upper parts of layers 11.1 and 11.2 of the East Chamber (50000-41000 BP), measuring 52.6 mm in length, 2.0-2.5 mm in width, and 1.1-2.2 mm in thickness (Shunkov et al., 2020). The cross section of the needle head is flat, of the middle section is slightly rounded. The diameter of the remaining hole on the needle is approximately 0.8 mm (Shunkov et al., 2020), from which it can be extrapolated that cords with a diameter of less than 0.8 mm were in use at that time.

From layer 11 of the Main Chamber at the Denisova Cave (48300-36000 BP) (Shunkov et al., 2020), 6 needles and a fragment were unearthed. One of the intact bone needles measures 74.9 mm in length, 0.9-2.5 mm in width, and 0.8-1.7 mm in thickness (Деревянко et al., 2016). It can be estimated from the scale in Figure 13 that the eye on the needle is approximately 1 mm in width, suggesting the use of cords finer than 1 mm were used at that time. Apart from sewing, such needles might also be used as tools for weaving.

(a) (b)

Figure 13. Eyed bone needles unearthed from Denisova Cave, southern Siberia, Russia (a) fragment of an eyed needle (50000-41000 BP) from the East Chamber (Image from Shunkov et al., 2020) (b) three dimensions of an eyed needle (48300-36000 BP) from the Main Chamber (Image from Деревянко et al., 2016)

Over 90 pottery fragments (20000-19000 BP) and 7 bone needles were unearthed from the Xianrendong Cave Culture I in southern China (Li, 1963; Wu et al., 2012). All the pottery fragments have cord impressions on them. These cord impressions vary in diameter, among which the thicker ones measure approximately 2.5 mm and thinner ones around 1 mm, indicating that people at that time were capable of making cords at the millimeter scale.

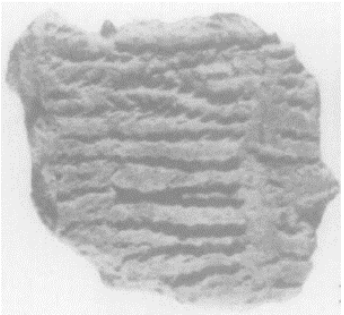

Figure 14. A pottery fragment with cord impression (20000-19000 BP) unearthed from Xianrendong Cave Culture I in southern China (Image from Li, 1963)

From location 29 of the Shizitan site in northern China, a U-shaped object (26000-23000 BP) was excavated. This object was initially classified as a perforated decorative artifact yet eventually identified as a fragment of a

bone needle upon closer observation and experimental verification (Song et al., 2016). It measures 6.08 mm at its widest part, 2.04 mm in thickness, and 1.86 mm in diameter at the remaining eye. Aside from this object regarding an eyed needle, 15 ornaments made with ostrich eggshells were also unearthed from the lower part of the seventh cultural layer (24271-23541 BP) at the same site. On these eggshell artifacts, traces of stringing and tying cords were identified (Song & Shi, 2013).

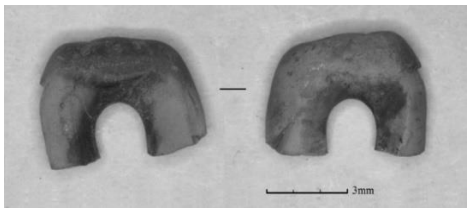

Figure 15. Two sides of the fragment of an eyed bone needle (26000-23000 BP) unearthed from Shizitan 29 in northern China (Image from Song et al., 2016)

3.3 From Cord-making to Thread-making

A cordage, or rope, is a slender and long flexible object used for binding, twinning, hanging, etc. Conjectured from the nature of the evidence above, the use of cordage should have started by using raw materials gathered from nature, such as plant stems, branches, barks, as well as animal tendons. Natural cordage is limited in length, strength, and flexibility so humans started to make strong and flexible cords that could be extended as needed after the technique of splitting and splicing developed. The earliest cords, which were relatively thick and stiff, were braided, twisted, or knotted by hand (Wang, 2016; Rao, 2019, pp. 18-28) with strip-like materials obtained directly from nature. They were used for hunting, gathering, marking, recording, and making other tools such as pottery with cordage impressions. As the production activity progressed, finer cords, or threads, were needed for sewing, stringing, and even weaving.

Archaeological cords found in Europe, the Middle East, and East Asia indicate that the earliest threads in the world were most probably made by splicing plant materials (Barber, 1992, pp. 44-51; Granger-Taylor, 1998; Antoinette, 2005; Gleba & Harris, 2019; Jørgensen et al., 2021; Rast-Eicher et al., 2021; Jørgensen et al., 2023; Loudon et al., 2023; Gao, 2003). Both splicing and twisting threads could be done manually or with the assistance of simple tools, such as tiles or sticks. It remains unclear when and how spinning appeared but can be known that spinning yarns runs more efficiently than splicing threads. The cord-making technique involving only hand or simple tools could not serve the demand for mass production. Therefore, a new tool was invented to increase productivity. According to archaeological finds and experimental archaeology, this new tool was a spindle with a weighted object added to a stick originally used for winding and fixing well-made threads (Barber, 1992, pp. 41-51, 1995, pp. 29-70; Rao, 2019, pp. 48-91). The weighted object is called a flywheel or spindle whorl, whose function is to reduce wobble and to prolong the spin while spinning (Barber, 1995, pp. 37-38). From cord-making to thread-making, the principle of extending remained unchanged, while the products became finer and the productivity increased.

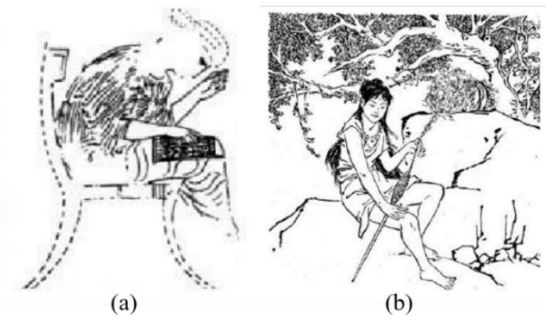

Figure 16 Making cords with simple tools (a) twisting cord on the leg with a tile (b) winding and fixing cords with a stick (Images from Rao, 2019)

4. The Early Use of Fibers

4.1 Difficulty in Obtaining Natural Fibers

Based on the sources, natural fibers can be categorized into plant fibers and animal fibers. The main types of plant fibers used by human ancestors include seed fibers (cotton, etc.), bast fibers (hemp, flax, ramie, etc.), and leaf fibers (sisal, pineapple, etc.), while animal fibers include mainly wool and silk. Cotton and wool fibers are exposed to the air, which are visible and can be easily collected once seen by humans. Bast fibers, leaf fibers, and silk filaments are hidden inside plant stems, leaves, and silkworm cocoon shells respectively, which are invisible and require specific extraction methods if needed. It should be easier to obtain the visible cotton and wool fibers than the rest. And given that wool fibers grow on mobile animals while cotton ones grow on immobile plants, it would be easier to collect cotton than wool materials.

4.2 Human Demand for Fiber Materials

Humans did not initially have a demand for fine fibers but for supple tools in the form of ropes, strings, braids, mats, and fabrics, with utilitarian functions of tying, stringing, blocking, wrapping, or hunting. These supple tools were made from split plant strips gathered from nature. With the growing need for finer, softer, and more flexible artifacts, humans were motivated to refine raw materials. To ensure the strength and stability of the products, interlacing and twisting were applied. In this process, human beings gradually accumulated experience in making soft and durable textiles with fine fiber materials, and were prompted to continue seeking, selecting, and utilizing fibers with better obtainability and higher performance.

4.3 The Theoretical Chronology of Using Natural Fibers

As early fiber materials used by humans, visible cotton and wool are easier to obtain compared to invisible bast, leaf, and silk fibers. However, humans did not initially have a demand for fine fibers. Therefore, cotton and wool would not be the earliest fiber materials used. The properties of fiber materials should have been discovered thanks to the frequent use of stripped or sliced materials taken from plants. They were originally used for making supple artifacts with both fineness and strength and used for tying, stringing, blocking, wrapping, or hunting. This activity led to the discovery that certain plants contain fibers hidden inside their stems or leaves, that is, bast or leaf fibers. After discovering and learning the know-how of using invisible bast or leaf fibers, a demand for fiber materials was developed and led to the exploration and exploitation of other fibers. Considering that it is more difficult to discover and obtain silk filaments than cotton and wool, and more challenging to collect wool from mobile animals than cotton from fixed plants, assuming that all types of natural fibers simultaneously existed in the same geographical region, invisible plant fibers would have been the first to be used among all the types, cotton the second, wool synchronous with cotton or a little later and silk the last.

4.4 Chronology of Archaeological Fibers

It is very difficult to find a region where all main types of natural fibers were accessible at the time of knowing fiber materials. The earliest fibers with artificially processed traces that have been known today are those unearthed from the unit D (34500-32200 BP) at the Dzudzuana Cave (Bar-Yosef et al., 2011), located at the southern foothills of the Caucasus mountains in present Georgia. Some of these fibers were twisted and colored, including bast fibers and a few tur hairs (Kvavadze et al., 2009, 2010; Bergfjord et al., 2010), indicating that they might have been used to process into textiles. Tur hairs found at this site are unusual fiber materials and they are just a few, that might be used occasionally or be the remains of using the animal furs.

As for other natural fibers, the earliest archaeological evidence of utilized cotton was mineralized fibers inside a copper bead found at the Mehrgarh site (8000 BP) in present Pakistan (Moulherat et al., 2002), of wool was charred wool fabric discovered from the level VI of Çatalhöyük (8000 BP) in southern Anatolia, present Turkey (Burnham, 1965), of silk was two pieces of charred silk fabric unearthed from the Qingtai site (5500 BP) in central China (Institute of Relics and Archaeology of Zhengzhou City, 1999; S. Zhang & Gao, 1999). The fibers in both warp and weft of the silk fabric fragments are parallel without twist, indicating that they were silk filaments extracted from silkworm cocoon shells.

4.5 Problems in the Time Sequence

Based on the extant remains of fiber materials discovered so far, the chronological order of their dating is generally consistent with the theoretical chronology of using natural fibers. However, the time sequence of using fibers based on archaeological evidence depends on the lifespan of fiber artifacts and the opportunities for archaeological discoveries. The nature of fiber artifacts' being perishable and the inexhaustibility of archaeological activities make it hard to explore the actual chronology of starting using fibers. Our knowledge of the origin of using fibers will continuously be updated with the progress in archaeology. For perishable fiber

materials that did exist in early human history but whose existence cannot be corroborated through extant remains, an integrated approach of analysis that deploys the extant remains together with ethnographic data, experimental data and other forms of evidence needs to be adopted (Hurcombe, 2014, pp. 1-15). Conclusions drawn from such analysis, if correct, would be further proved by archaeological discoveries in the future.

4. Conclusion

With an investigation of the early textile-related remains and a theoretical analysis of the difficulty in and the demand for using fiber materials, a hypothesis is raised that the know-how of using fibers came from the experience of making textiles with both fineness and strength, which was accumulated from the early technologies of interlacing and cord-making. The properties of fiber materials should have been discovered thanks to the frequent use of stripped or sliced materials taken from plants. They were originally used for making supple artifacts with both fineness and strength and used for tying, stringing, blocking, wrapping, or hunting. This activity led to the discovery that certain plants contain fibers hidden inside their stems or leaves, that is, bast or leaf fibers. After discovering and learning the know-how of using invisible bast or leaf fibers, a demand for fiber materials was developed, leading to the exploration and exploitation of other fibers. Among all the main types of natural fibers that are the earliest fiber materials used by humans, invisible plant fibers should have been the first to be used, cotton the second, wool synchronous with or a little later than cotton, and silk the last.

References

Adovasio, J. M. (1975). THE TEXTILE AND BASKETRY IMPRESSIONS FROM JARMO. *Paléorient*, 223-230.

Antoinette, R.-E. (2005). Bast before wool: The first textiles. Hallstatt Textiles: Technical Analysis, Scientific Investigation and Experiment on Iron Age Textiles, 117-135.

Archaeological Team at Hemudu Site. (1980). The main discoveries of the second excavation of the Hemudu site in Zhejiang Province. *Cultural Relics*, *5*, 1-15, 98-99.

Barber, E. J. W. (1992). *Prehistoric textiles: The development of cloth in the neolithic and bronze ages : with special reference to the Aegean* (3rd ed.). Princeton University Press.

Barber, E. J. W. (1995). *Women's Work: The First 20000 Years-Women, Cloth. and Society in Early Times.* W. W. Norton & Company.

Bar-Yosef, O. (2020). The Neolithic Revolution in the Fertile Crescent and the origins of fibre technology. In *The Competition of Fibres* (pp. 5-16). Oxbow Books.

Bar-Yosef, O., Belfer-Cohen, A., Mesheviliani, T., Jakeli, N., Bar-Oz, G., Boaretto, E., Goldberg, P., Kvavadze, E., & Matskevich, Z. (2011). Dzudzuana: An Upper Palaeolithic cave site in the Caucasus foothills (Georgia). *Antiquity*, *85* (328), 331-349. https://doi.org/10.1017/S0003598X0006779X

Bergfjord, C., Karg, S., Rast-Eicher, A., Nosch, M.-L., Mannering, U., Allaby, R. G., Murphy, B. M., & Holst, B. (2010). Comment on "30,000-year-old wild flax fibers." *Science (American Association for the Advancement of Science)*, *328* (5986), 1634; author reply 1634-1634. https://doi.org/10.1126/science.1186345

Burnham, H. B. (1965). Çatal Hüyük—The Textiles and Twined Fabrics. *Anatolian Studies*, *15*, 169-174.

Chen, W. (1984). *History of Chinese Textile Science and Technology*. China Science Publishing & Media Ltd.

Cook, J. G. (1984). *Handbook of Textile Fibres* (Vol. 1). Woodhead Publishing Limited.

Gao, H. (2003). Identification of ropes from Hemudu Site. In *Hemudu: A Neolithic Site and Its Archaeological Excavations* (p. 455). Cultural Relics Publishing House.

Geijer, A. (1979). *A History of Textile Art*. Palsold Research Fund in association with Sotheby Parke Bernet Publication.

Gleba, M., & Harris, S. (2019). The first plant bast fibre technology: Identifying splicing in archaeological textiles. *Archaeological and Anthropological Sciences*, *11*, 2329–2346. https://doi.org/10.1007/s12520-018-0677-8

Granger-Taylor, H. (1998). *Evidence for linen yarn preparation in Ancient Egypt. In Lahun Studies.* SIA Publishing.

GREAT BASIN BASKETRY. (2020). [dataset]. https://mnch.uoregon.edu/collections-galleries/great-basin-basketry

Hardy, B. L., Moncel, M.-H., Kerfant, C., Lebon, M., Bellot-Gurlet, L., & Mélard, N. (2020). Direct evidence of Neanderthal fibre technology and its cognitive and behavioral implications. *Scientific Reports*, *10* (1), Article 1. https://doi.org/10.1038/s41598-020-61839-w

Huang, W. (2000). Discussion on the age of each cultural layer of the Hemudu site. *Prehistory*, 372-384.

Hurcombe, L. M. (2014). *Perishable Material Culture in Prehistory: Investigating the Missing Majority* (1st ed.). Routledge. https://doi.org/10.4324/9781315817729

Institute of Relics and Archaeology of Zhengzhou City. (1999). Report on Textiles Unearthed from the Qingtai Site in Xingyang. *Cultural Relics of Central China*, *3*, 4-9.

Jolie, E. A., Lynch, T. F., Geib, P. R., & Adovasio, J. M. (2011). Cordage, Textiles, and the Late Pleistocene Peopling of the Andes. *Current Anthropology, 52* (2), 285-296. https://doi.org/10.1086/659336

Jørgensen, L. B., Rast-Eicher, A., & Wendrich, W. (2021). Textiles, cordage and basketry from Catalhöyük. In *The matter of Çatalhöyük: Reports from the 2009-2017 seasons* (Vol. 14). British Institute at Ankara.

Jørgensen, L. B., Rast-Eicher, A., & Wendrich, W. (2023). Earliest Evidence for Textile Technologies. *Paléorient. Revue Pluridisciplinaire de Préhistoire et de Protohistoire de l'Asie Du Sud-Ouest et de l'Asie Centrale, 49-1*, Article 49-1. https://doi.org/10.4000/paleorient.2479

Kvavadze, E., Bar-Yosef, O., Belfer-Cohen, A., Boaretto, E., Jakeli, N., Matskevich, Z., & Meshveliani, T. (2009). 30,000-Year-Old Wild Flax Fibers. *Science*, *325* (5946), 1359-1359. https://doi.org/10.1126/science.1175404

Kvavadze, E., Bar-Yosef, O., Belfer-Cohen, A., Boaretto, E., Jakeli, N., Matskevich, Z., & Meshveliani, T. (2010). Response to Comment on "30,000-Year-Old Wild Flax Fibers." *Science (American Association for the Advancement of Science)*, *328* (5986), 1634-1634. https://doi.org/10.1126/science.1187161

Li, Y. (1963). Preliminary excavation of the Xianrendong Cave at Wannian, Jiangxi Province in China. *Acta Archaeologica Sinica*, *1*, 1-16, 140-147.

Liu, K. (2011). *A brief History of Cotton and Flax Textile in China*. Social Sciences Academic Press (China).

Liu, Z. (1996). The Great Historical Significance of the Excavation of the Yuchanyan Site. *Agricultural Archaeology*, *3*, 95-38.

Loudon, N. N., Wollstonecroft, M., & Fuller, D. Q. (2023). Plants to textiles: Local bast fiber textiles at Pre-Pottery Neolithic Çatalhöyük. *Journal of Archaeological Science: Reports*, *49*, 103940. https://doi.org/10.1016/j.jasrep.2023.103940

Lynch, T. F. (1980). *Guitarrero Cave: Early man in the Andes.* Academic Press.

Mauersberger H., R. (1947). *Matthews' Textile Fibers*. John Wiley and Sons.

McDonald, F. (2011). *Textiles: A History*. Remember When.

Moulherat, C., Tengberg, M., Haquet, J.-F., & Mille, B. (2002). First Evidence of Cotton at Neolithic Mehrgarh, Pakistan: Analysis of Mineralized Fibres from a Copper Bead. *Journal of Archaeological Science, 29* (12), 1393-1401. https://doi.org/10.1006/jasc.2001.0779

Nadel, D. (2017). Ohalo II: A 23,000-Year-Old Fisher-Hunter-Gatherer's Camp on the Shore of Fluctuating Lake Kinneret (Sea of Galilee). In *Quaternary of the Levant: Environments, Climate Change, and Humans* (pp. 291-294). Cambridge University Press. https://doi.org/10.1017/9781316106754.033

Nadel, D., Danin, A., Werker, E., Schick, T., Kislev, M. E., & Stewart, K. (1994). 19,000-Year-Old Twisted Fibers From Ohalo II. *Current Anthropology, 35* (4), 451-458. https://www.jstor.org/stable/2744002

Rao, J. (2019). *Study on the Birth, Evolution of Spinning Wheel and Its Relationship to the Development of Spinning Technology——Taking the Spinning Wheels Excavated from the Typical Site of the Neolithic Age in China As Example* [Doctoral Dissertation]. Donghua Univeristy.

Rast-Eicher, A., Karg, S., & Jørgensen, L. B. (2021). The use of local fibres for textiles at Neolithic Çatalhöyük. *Antiquity, 95* (383), 1129-1144. https://doi.org/10.15184/aqy.2021.89

Ryder, M. L. (1968). The Origin of Spinning. *Textile History*. https://doi.org/10.1179/004049668793692746

Schick, T. (1995). A 10000 Year Old Comb from Wadi Murabba'at in the Judean Desert. *Atiqot Xxvii*, 199-202.

Shamir, O., & Rast-Eicher, A. (2020). Continuity and discontinuity in Neolithic and Chalcolithic linen textile production in the southern Levant. In W. Schier & S. Pollock (Eds.), *The Competition of Fibres* (Vol. 36, pp.

27–38). Oxbow Books. https://doi.org/10.2307/j.ctv13pk7d6.10

Shunkov, M. V., Fedorchenko, A. Yu., Kozlikin, M. B., & Derevianko, A. P. (2020). Initial Upper Palaeolithic ornaments and formal bone tools from the East Chamber of Denisova Cave in the Russian Altai. *Quaternary International, 559,* 47-67. https://doi.org/10.1016/j.quaint.2020.07.027

Sinclair, R. (2015). Understanding Textile Fibres and Their Properties: What is a Textile Fibre? In *Textiles and Fashion: Materials, Design and Technology* (pp. 3-27). Woodhead Publishing.

Soffer, O. (2015). Recovering Perishable Technologies through Use Wear on Tools: Preliminary Evidence for Upper Paleolithic Weaving and Net Making. *Current Anthropology*, *45* (3), 407-413. https://doi.org/10.1086/420907

Song, Y., Li, X., Wu, X., Kvavadze, E., Goldberg, P., & Bar-Yosef, O. (2016). Bone needle fragment in LGM from the Shizitan site (China): Archaeological evidence and experimental study. *Quaternary International*, *400*, 140-148. https://doi.org/10.1016/j.quaint.2015.06.051

Song, Y., & Shi, J. (2013). On the Stringing and Tying Fashions of Perforated Ornaments Found at Shizitan Site. *Cultural Relics of Central China, 1*, 17-22.

Sun, G., Huang, W., Zheng, Y., Liu, Z., Xu, Z., Qu, K., Zhang, H., Li, Y., & Xu, C. (2007). Brief Report of the Excavation on a Neolithic Site at Tianluoshan Hill in Yuyao City, Zhejiang. *Cultural Relics*, *11*, 4-24+73+1.

The Institute of Archaeology, Academia Sinica, & The Ban P'o Museum, Sian. (1963). *The Neolithic Village at Ban P'o, Sian*. The Wen Wu Press.

Wang, H. (2016). *On the Origin of Twisting-formed Matter and Its Synchronous Civilization with Stone Implement* [Master's Thesis]. Donghua Univeristy.

Wang, J., & Mou, Y. (1980). About the Excavation of the Qianshanyang Site in Wuxing. *Archaeology*, *4*, 353-358+360.

Wilson, K. (1979). *A History of Textiles*. Westview Press.

Wu, X., Zhang, C., Goldberg, P., Cohen, D., Pan, Y., Arpin, T., & Bar-Yosef, O. (2012). Early Pottery at 20,000 Years Ago in Xianrendong Cave, China. *Cultural Relics in Southern China*, *3*, 1-6.

Zhang, J., Lu, H., Sun, G., Flad, R., Wu, N., Huan, X., He, K., & Wang, Y. (2016). Phytoliths reveal the earliest fine reedy textile in China at the Tianluoshan site. *Scientific Reports*, *6* (1), Article 1. https://doi.org/10.1038/srep18664

Zhang, S., & Gao, H. (1999). Observation and Research of Silk and Hemp Fabrics Unearthed from the Qingtai site in Xingyang. *Cultural Relics of Central China*, *3*, 10-16.

Zhao, F. (2005). *A History of Chinese Silk Art*. Cultural Relics Press.

Zhejiang Provincial Cultural Relics Management Commission. (1960). Report on the First and Second Excavations at the Qianshanyang Site in Wuxing. *The Chinese Journal of Archaeology*, *2*, 73-91+149-158.

Zhejiang Provincial Institute of Cultural Relics and Archaeology. (2003). *Hemudu: A Neolithic Site and Its Archaeological Excavations*. Cultural Relics Publishing House.

Zhou, Q., Zhao, F., & Bao, M. (2018). *General History of Chinese Textile*. Donghua University Press.

Derevyanko, A. P., Shunkov, M. V., & Kozlikin, M. B. (2016). Bone needle of the early Upper Paleolithic from the central hall of Denisova Cave (based on the materials of excavations in 2016). *Problems of archaeology, ethnography, anthropology of Siberia and adjacent territories*, *22*, 72-75.

Acknowledgments

We greatly appreciate the valuable contributions of our community advisory committee members. We would also like to thank Yanping Li, a PhD candidate at the Princeton University, who helped with some language problems in this article.

Authors contributions

Doctoral student Xiyao Zhang and Prof. Xiaoming Yang were responsible for study design, revising, and data collection. Xiyao Zhang drafted the manuscript and Prof. Xiaoming Yang revised it. All authors read and approved the final manuscript.

Funding

Not applicable.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.