Diversity and distinction of the fibers in two historical papers known as Doulatabadi and Termeh in the manuscripts dated to the 5th century AH/ 11th AD

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Presented by
Kambiz Pourtahmasi
Outline:

- Brief history about Iranian papermaking
- Brief history about plants used in Iranian papermaking such as Flax, Hemp, Kenaf, Rami/Nettle and Cotton
- Introducing two manuscripts known as Doulatabadi and Termeh
- Methods and materials for fiber identification
- Discussion about Diversity and distinction of the fibers
- Conclusion
Brief history about Iranian papermaking:

- Based on Renker map, the history of paper making in Iran began in 134 AH/751 AD that mainly includes Manavi works with Parthian Pahlavi languages and the papers are Samarqandi.

- But the real example of paper emerged during the 4th century AH/10th century AD in Iran.

- The main basic compounds of the papers were plant fibers. Even the papers before the emergence of Islam, such as papers of paintings of Mani’s religion during the Sassanid era were also made of hemp and cotton fibers.

- Flax and hemp were two main fibers used to produce Islamic papers that grew in large amounts in the middle east.

- Samarqandi papers were considered as the best eastern papers until the 12th century AH/18th century AD and were a huge step toward the production of pulp and innovation of Persians and middle east over China.
Linum usitatissimum L. / Flax / Family: Linaceae

-One of the oldest fibrous products in the world (Kanaani Noutash et al. 2017)

-A part of the bark fibers and among the flexible fibers in the same group

-Diameter of fibers, variable Lumen cavity, with Dislocations (nodes) that are sometimes weak and sometimes regular and with no crystals (Haugan, 2014)
According to Zakhoder, flax harvesting was common in the Saudi Arabia and southwest of Iran and flax oil was mainly extracted in Reyshahr and Siniz in the Fars area.
Brief history about plants used in Iranian papermaking:

* Cannabis sativa L./ Hemp/ Family: Moraceae *

- This plant also known as bang is one of the oldest herbal plants (Avicenna, 1987, 310) in Bondhash in the group of shrub plants

- The features of hemp include long fibers with thick walls, frequent cross markings, frequent and prominent Dislocations (nodes), prominent longitudinal lines, thick alternate bulky Lumen cavity between 1.2 to 1.3 cells and fibers with round ends and with calcium oxalate crystals

-As the main material of paper making, before the 15th century AD
Brief history about plants used in Iranian papermaking:

Cannabis harvesting was common in ancient Iran and existed throughout the middle ages. The main regions where this plant was harvested were in Lorestan, Kazeroun and Shiraz.
Brief history about plants used in Iranian papermaking:

*Hibiscus cannabinus* L. / Kenaf / Family: Malvaceae

- It is the native species in the south of Asia, India, Bangladesh, Thailand and a part of Africa

- The name of the plant in Bondhesh is "Shan" used in the definition of Jameh ("Shan and cotton and any other species were called Jameh) (Bahar, 2001)
Brief history about plants used in Iranian papermaking:

In past, the plant was harvested in Gorgan and its fibers were used.
Brief history about plants used in Iranian papermaking:

*Boehmeria nivea* (L.) Gaud. / Ramie, China grass / Family: Urticaceae

- Ramie fibers, stripped from bast, are smooth and long, approaching lengths of 30 cm, with excellent tensile strength.

- Ramie fiber has been in use since pre-historic times at least in China, India and Indonesia.

- It is one of the oldest plant fibers known to have been cultivated in the orient and its use as a textile fiber in the east is of great antiquity. It is known to have grown in China for many centuries before even cotton entered in that country in 1300 AD.
Brief history about plants used in Iranian papermaking:

**Gossypium sp./ Cotton / Family: Malvaceae**

- *Gossypium herbaceum* species is specific to Asia and maybe it is the first species of cotton used in cloth. This plant grows in India, Iran, China, Egypt, Turkey, Cyprus and other parts of Asia.

- Cotton fibers are in two groups:

  A. long fibers known as Lint that are produced from cotton stalk and are flat, strip-shaped and somewhat twisted

  B. shorter fibers (Linter) that are the fibers around the seed.
Brief history about plants used in Iranian papermaking:

According to Patroshefski, cotton was harvested in Iraq, Iran, Khozestan, Fars, Shabangar, Kerman, Ghahestan, Khorasan, Gorgan, Mazandaran, Ghomes and Gilan.
Doulatabadi paper-(345)

- papers of manuscripts in Malek national museum with the property no. 345 with the title "Divan-ol-Adab" and "Mizan e Kalam-ol-Arab" in Arabic language and with the script "Moarab Naskh" written in 419 AH (5th century AH) are of this type.

- Mir Emad in Adab-ol-Mashgh has stated the other name of the paper as "Sultani Paper".

- It is a paper smoother than Sialkouti with a lower thickness and similar to Bukhara cashmere and was known as a high quality paper among.
Introducing the two manuscripts known as *Doulatabadi* and *Termeh*:

**Termeh paper – (5922)**

- Manuscript with the property no. 5922 available in Malek national museum and library with the title "Permission of Abu Ali ibn Maskouyeh to Zia-e-din Abu Mansour Yahya ibn Hossein ibn Ali" written in Arabic with a Kufi-Naskh script (410 AH) with a transcription history before the time interval (the late Ghaznavi era).

- A very delicate thin and firm paper with smooth regular fibers made in Isfahan.

- Some manuscripts related to Safavid and Qajar eras are from these papers.
Spot test (Chemical Reagent(-Herzberg stain)

- Separation of fibers with a non-wooden source from wooden fibers
- Fibers without lignin produced from rotten cloths (such as hemp, ramie and cotton) with wine red color
- When the level of lignin increases, the color changes from wine red (without lignin) to blue-gray, gray-yellow and to yellow-brown

- Finally it becomes yellow for fibers with a high level of lignin (such as bamboo)
Optical Microscopy and Dino lite / Doulatabadi paper fibers

- The presence of fibers with different thicknesses (A)
- Longitudinal striations lines along the fiber (B)
- Gap or slit along the fiber (B)
- Fibers with clear and sometimes unclear dislocations (nodes) with cross-markings weak along the fibers (A)

Methods and materials for fiber identification:

- A-345
- B-345

A-345 \(\times 200 \text{ mag}\)

B-345 \(\times 200 \text{ mag}\)
Methods and materials for fiber identification:

Optical Microscopy and Dino lite / Termeh paper fibers- 5922

- Smooth fibers with regular and sometimes clear and prominent dislocations (nodes) with similar thickness along the fiber (A)
- With a swelling or inflation along the fiber (B)
- Change in the thickness of the length of the fiber (C)
- Round end in fibers (C)
In the polarized light, due to the polarization of the light incident on the surface of fibers:

- Dislocations (nodes), cross markings, longitudinal striations and slits are more evident (A)

- Clarity and presence of calcium oxalate crystals ($\text{CaC}_2\text{O}_4$, $\text{CaO}_x$) (B) torsion of fibers with light refraction in the strips in the polarized light and different from cotton fibers (C)
In the polarized light, due to the polarization of the light incident on the surface of fibers:

- Dislocations (nodes), cross markings, longitudinal striations and slits are more evident (A)

- Clarity and presence of calcium oxalate crystals (CaC$_2$O$_4$, CaO$_x$) (B)

- Twisted fibers with light refraction in the dislocations (nodes) in the polarized light and different from cotton fibers (C)
Method and material for fiber identification:

**Scanning Electron Microscope (SEM) / Doulatabadi paper fibers- 345**
- Study of the surface and size of fibers in magnification (A-X820 mag)

- Study of beating, starching and sealing of fibers (arrow in fig. B)

- Study of the form and size of calcium oxalate crystals (B-X400 mag)
Methods and materials for fiber identification:

Scanning Electron Microscope (SEM) / Termeh paper fibers- 5922

- Study of the surface and change in the thickness and size of fibers in magnification (A-5.00KX mag)

- Study of the form and size of calcium oxalate crystals (B-10.0 KX mag)
Elemental analysis of papers of manuscripts:

- The presence of calcium, an index of the presence of calcium oxalate in the structure of the fibers of the papers

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Elemental analysis of papers of manuscripts:

- The presence of calcium, an index of the presence of calcium oxalate in the structure of the fibers of the papers

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Discussion about Diversity and distinction of the fibers:

**Problems Identifying Fibers in Historical Papers:**

- Physical signs has been changed and sometimes they are mistaken and become similar to some other fibers of the bark group such as similarity to the transparent layer of mulberry fibers or similarity to cotton fibers (Fig. A)

- The presence of the fibers in a paper together and due to the physical similarity of the fibers of the bark group that makes identification hard and disturbing (Fig. B)
Discussion about Diversity and distinction of the fibers:

- passing of time and acidification of papers during the chemical processes, and these events have changed the structure of the papers and also affect the physical features of the fibers.

- The presence of swellings or inflation in the flax fibers, the prominent feature of the plant, although the thickness of the fibers has changed along the fiber and is much larger than the standard level for flax fibers

- That is observed in the fibers of Termeh and Dolatabadi papers
Discussion about Diversity and distinction of the fibers:

- Fibers with a twisted form and a thickness as the width of the ramie fibers beside long flax fibers (Fig. A- Ramie (arrow) and Flax (arrowhead))

- Twisted of ramie fibers in the polarized light (Fig.B)

- Longitudinal striations along flax and ramie fibers (Fig.C)
Discussion about Diversity and distinction of the fibers:

- Physical similarity of flax fibers in the Termeh manuscript no. 5922 to hemp fibers in the Dolatabadi manuscript no. 345 under a polarizing microscope (Fig. A- Non Safranin and Fig. B -with safranin)
The results showed that:

- The fibers used in the papers of Dolatabadi manuscripts with the property no. 345 are flax and hemp fibers that are confirmed by microscopic and instrumental analyses.

- Also, the fibers used in the papers of the manuscript 5922 are flax, hemp, and ramie fibers.
Thanks for your attention