

Historical and Scientific Analysis on Sizing Materials Used in Iranian Manuscripts and Miniature Paintings

ABSTRACT

The present study aims to investigate historical and scientific analysis of sizing material used in Iranian manuscripts and miniature paintings. A large number of sizing materials has been introduced according to historical treatises from the Taimurid (fifteenth century), Safawid (sixteenth century), and Qajar (nineteenth century) periods. In order to investigate the presence of sizing materials mentioned in historical literary references, sample analysis was conducted on the sizing materials of eleven historical Persian and Indian miniature paintings and illuminated manuscripts from sixteenth to eighteenth century.

Out of the twelve sizing materials that were recommended by masters based on the historical survey, the mucilage of cucumber seeds was the most common sizing material on the paper samples as identified by the FT-IR (Fourier-transform infrared spectroscopy) method.

The present historical and scientific survey suggests a wide range of natural sizing materials that can be used as tools for conservation and restoration of paper documents where the sizing of paper is required.

INTRODUCTION

Sizing paper is the process of preparing the surface suitable for writing, illuminating, and painting. After the sheet is formed and dried, the cellulose fiber in paper can continue to absorb water unless it has been sized or impregnated with some substance such as starch, glue, or wax to prevent penetration (Bloom 2001). Different techniques have been applied for sizing paper depending on requirements, such as soaking or applying one or a number of layers of sizing material on the paper surface with the help of a soft brush.

Specimens from the third century indicate that paper-makers had a range of sizing techniques, from coating the surface with gypsum to treating with gum, glue, or starch, to prevent the ink from spreading (Bloom 2001). According to Dard Hunter one of the earliest methods of sizing paper consisted in covering the surface of the sheets with a thin coating of gypsum. The next improvement (Hunter 1957) was to render the body of the paper, as well as the surface, impermeable to ink by the use of lichen, starch, or rice flour. In Iran, according to Shiela Canby, once the paper was dried it was sized by soaking it in albumen or a starchy solution to fill in and even out the surface for painting (Canby 1993).

Some scientific investigation has also revealed valuable information on materials used in the sizing process. According to H. E. Wolf, based on chemical investigation, the Iranian papermakers at Samarqand have made an important contribution to paper technology by introducing sizing of paper to make it more suitable for writing with ink and a reed pen. According to him wheat starch and later gum tragacanth or the boiled bulbs of asphodel were used as the sizing substances.

There are a number of sizing materials, revealed by masters in Iranian treatises belonging to the Taimurid, Safawid, and Qajar periods, which have been overlooked by scientists and conservators. Studying these historical references not only gives a new chapter to identification of materials used in manuscripts and miniature paintings during the Safawid period, but also helps conservators and restorers to develop new methods and techniques for sizing processes based on traditional materials. Our analytical study on sizing material used in Persian manuscripts and miniature paintings was based on two phases: historical analysis and scientific analysis.

In the first phase we collected information and studied Persian historical treatises from the Taimurid and Safawid to Qajar period (fifteenth to nineteenth century). In the second phase sizing materials of original samples from the Iran Bastan Museum collection as well as from some pri-

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vate collections were identified based on the information from the historical analysis.

HISTORICAL ANALYSIS

During the Sassanian period (fifth to sixth centuries CE), before the Islamic era, Iranians used sizing materials on cloth to prepare the surface for writing and painting (Heravi 1993). After learning the process of papermaking from the Chinese, Iranians continued the sizing process tradition on paper to prepare a suitable surface for writing and painting. The chief contribution of Iranian paper makers working under Arab rule was the perfection of rag paper through improved techniques for beating the fibers and by preparing the surface for writing by sizing it with starch (Bloom 2001).

Referring to Persian historical treatises, use of a sizing layer has been recommended by Iranian masters many times. Soltan Ahmad Majnoon Ra fiqi Heravi advises in his book "Adab al-Mashq" to use soft, smooth, and even paper to write or to draw. Also in the book "Favayed al-Khotoot" is the recommendation to apply sizing materials to make fragile papers strong enough and to reduce the fluffiness of paper fibers as well as to make them smooth for writing.

In the sizing process three basic elements are involved. Size (*ahar*), burnishing tools (*mohreh*), and a base surface (*takhteh*). Several sizing materials have been used according to the historical treatises, which is the particular concern of this paper. According to these sources the materials can

generally be categorized as proteinaceous materials, including: animal glue; starches from rice or wheat; vegetable gums; mucilage of plants and seeds; and fruits and sugar. A number of burnishing materials also have been used such as agate stone (*aqiq*), jade (*yashm*), ivory (*aaaj*), glass (*zejjaj*), crystal (*bolloor*), and shell (*jis*). Sometimes hands alone also have been used to smooth the surface. A hard and smooth surface made of flint stone (*chaqmaq*) and a wooden board was also used as the base for burnishing and sizing the paper (Heravi 1993).

SIZING MATERIALS

Our historical analysis was based on nine treatises from the fifteenth to the eighteenth century. Some of these historical treatises are by known authors and some are anonymous. In table 1 the titles of the treatises along with the date and the name of the author have been listed. Twelve sizing materials in six general categories have been identified in the historical analysis and are listed in table 2. These sizing materials have been described in historical treatises basically from the Taimurid (fifteenth century), Safawid (sixteenth century), to Qajar (nineteenth century) periods as follows:

Starch (*neshasteh*)

A general term for starch (*neshasteh*) has been mentioned in five treatises; we believe that when the nature of starch has not been specified it refers to rice starch. In these

No.	Title of the Treatises	Author	Date
1	Dar Bayani Khaghaz, Morakah Va Hali Alvan	Anonymous	9th AH (c.15th CE)
2	Serat-al Sotour	Soltan Ali Mashhadi	920 AH/1542 CE
3	Golzari Safa	Ali Syrafi	950 AH/1572 CE
4	Favayed al-Khotoot	Mohamad Ibn Doust Mohamad Bokhari	995 AH/1617 CE
5	Adab al-Mashq	Baba Shahi Isfahani	10th AH (c. 17th CE)
6	Khat Va Morakab	Hossein Aqili Rostamdari	930–984 AH/1552–1606 CE
7	Resaleh Dar Bayani Tariqeh Sakhtani Morakabi Alvan Va Kaghazhayi Alvan	Anonymous	10th AH (c. 17th CE)
8	Dar Bayani Khat, Morakab Va Kaghaz Va Sakhtani Rangha	Anonymous	10th–11th A.H (c.17th–18th CE)
9	Haliat al-Ketab	Anonymous	10th–11th AH (c.17th–18th CE)

Table 1. Historical analysis of Persian treatises

sources (1, 2, 4, 8, and 9) the process of sizing by starch (*neshasteh*) has been discussed in detail. For example the eminent calligrapher Soltan Ali Mashhadi devoted several couplets of his treatise “Serat al-Sotour” on calligraphy to sizing and glazing paper by hand (Bloom 2001). The process of sizing has been described as follows:

Prepare the size (ahar) from starch
Learn these words from an old man,
First make a paste, then pour in water,
Then boil this for a moment on a hot fire;
Then add to thin starch some glue (*serish*);
Strain [so that it is] neither too thin nor too thick,
Spread it on paper and see
That the paper should not move from its place;
When you are applying size to your paper
Moisten the paper slightly with water, carefully

It is worth mentioning that in sources nos. 2 and 4 it has been specifically advised to mix *serish* gum with the starch paste.

Wheat Starch

Wheat starch (*neshasteh-e gandom*) has been specified in two sources, “Golzari Safa” by Seyrafi and “Khat va Morakab” by Hossein Aqili Rostamdari, as follows:

For sizing paper make some wheat starch paste, filter it followed by cooking. Then take a wooden board and cover it with felt (*namad*) or a muslin cloth. Take two bowls; pour the starch in one and some water in the other.

Moisten a cotton ball with starch and rub it over the paper. Finally take another piece of clean cotton ball, moisten it with water and rub it over the starched paper. This way the paper can be sized.

Rice Starch

Rice has been specified in one source, “Haliat al-Ketab” by an anonymous author. In this source the process of making starch paste for sizing material out of rice has been explained as follows:

Take the best quality of white rice, rub it with salt, wash it until it becomes clean and the taste of salt disappears. Then add some water and keep it for one full day till it becomes soft and it dissolves by rubbing. Place it in a mortar (*havan*) and bray it with water till it becomes very soft. Boil it on a slow fire; stir it with a wooden stick until it becomes pasty. Let it get cold. Spread a piece of cloth in the sun and put the paper over it till it dries up. Finally burnish the paper till it becomes very smooth. Dyes can be added to the paste to get colored paper. By this method nobody can distinguish this paper from *Baghdadi* paper.

Plant Mucilage (*loab*)

Mucilage is a gummy or gelatinous substance produced in certain plants by the action of water or the cell wall. In four sources (1, 3, 6, and 7) a number of sizing materials out of plant mucilage are named. However, the descriptions are not as detailed as the descriptions on starch.

Historical treatises reference no.	Starch			Plant Mucilage					Fruit		Animal Glue	Vegetable Glue		Sugar
	Starch	Rice	Wheat	Rice	Fleawort Seed	Cucumber Seed	Marshmallow	Myrtle	Melon Juice	Grape Syrup	Fish	Gum arabic	Serish	Egyptian Rock Sugar
1	X			X	X	X	X		X	X	X	X		
2	X												X	
3			X	X	X	X			X	X	X	X		
4	X												X	
5	X													
6			X	X	X	X			X	X	X	X		
7							X	X			X	X		X
8	X												X	
9	X													

Table 2. Identification of sizing materials based on historical analysis

Mucilage of Rice (loabi berenj).

Rice mucilage is named in three historical treatises (1, 3, and 6) as follows: "Cook rice on fire until its mucilage is obtained. Make sure the rice and vessels used are free of oil. Then size the paper with it."

Fleawort Seed (ispaghol, esfazeh, quitona)

In all three sources (1, 3, and 6) the techniques explained are the same; however the duration of dipping the paper in mucilage is different.

In sources nos. 3 and 6 the term *quitona* has been used for fleawort seed and the process explained as follows: "Pour some fleawort seed until you get its mucilage. Leave the paper in the mucilage for one hour and then take it out."

In source no. 1 the advised duration for dipping the paper in fleawort seed is shorter. The description is as follows: "Size the paper sheet with mucilage of fleawort (*esfazeh, spaghol*) at one time. Then let it dry."

Cucumber Seeds (tokhmi khiar)

Another sizing material is cucumber seed, which is cited in the same three sources (1, 3, and 6). The description on preparing mucilage from cucumber seed is quite brief. "Keep cucumber seeds in water until its mucilage is obtained. Dip the paper into it for some time and then take it out."

Mucilage of Marshmallow (loabi khatmi)

Mucilage out of marsh mallow is mentioned in only two sources (1 and 7) as follows: "Keep marshmallow in some water for one night and one day. Heat it over fire until you get the mucilage. Dip the paper into it for some time and then take it out."

Fruit Juice/Syrup

It is very interesting to know that in the historical treatises two types of fruits, melon and grape, have been introduced for use as sizing materials.

Grape Syrup (shireh-e-angoor)

Grape syrup is mentioned as a sizing material in three sources (1, 3, and 6). Seyrafi in *Golzari safā*, in part of his couplets on sizing materials, names grape syrup as the fourth material for sizing. In source no. 1 the technique is explained as follows: "Filter grape syrup. Apply it on paper for sizing. Grape should be seedless."

Juice of Sweet Melon (Kharboozeh)

Juice of the sweet melon known as *kharboozeh* is mentioned as a good sizing material in the same three sources (1, 3, and 6) as mentioned above. Seyrafi in "Golzari Safa," in part of his couplets on sizing material, lists melon juice as the second material for sizing. In source no. 6, Hossin Aqili Rostamdari in his book "Khat va Morakab" mentions

that: "... and furthermore they take juice of sweet melon (*kharboozeh*) and dip the paper in it for sizing."

Animal Glue

The next category that can be identified in the historical sources is animal glue.

Fish glue (sirishumi mahi)

Fish glue as one of the sizing materials used by the masters is mentioned in four sources (1, 3, 6, and 7) in a quite similar way as follows:

Soak a small amount of white fish glue (*sirishum*) in water. Change the water and refill fresh water for three days until it clears thoroughly. Heat the *sirishum* until it melts, then filter it with a piece of muslin cloth. Apply the fish glue on paper as a sizing material. Let it dry in the sun carefully.

Vegetable Glue

The next category that has been identified as sizing material in the historical treatises is vegetable glue.

Gum arabic (Samqi arabi)

Gum arabic is named in four sources (1, 3, 6, and 7). According to the above-mentioned historical reference gum arabic is a very good sizing material and it is suitable for writing. The description (6) reads: "... and furthermore melt gum arabic and size the paper with it."

Serish

Serish is a very well-known vegetable glue, which traditionally is used for binding books in Iran. As mentioned before, two sources (2 and 4) advise mixing serish with starch to thin the paste: "... then add some glue (*serish*), to thin starch."

Mixed Sizes

In one source, "Resaleh dar Bayani Tariqrh Sakhtani Morakabi Alvan va Kaghazhayi Alvan" (7), myrtle extract and sugar syrup are introduced as the materials to be added to a plant mucilage for sizing paper as follows:

If a paper has deep turquoise color and it is difficult to write on, the advice is to apply either sweet melon juice (*abi karboozeh*), or syrup of Egyptian rock sugar (*abi nabati mesri*) or myrtle extract (*abi mord*) with mucilage of fleawort seed (*ispaghol*) and mucilage of oil-free cooked rice (*loabi berenj*). All these materials make paper strong and if the paper is then burnished it becomes smooth like a mirror.

SCIENTIFIC ANALYSIS

In order to investigate the presence of sizing materials mentioned in historical literary references, sample analyses

Origin	Owner	Object	Date	Check List No.	Sta	Fis	Gum	Fle	Mel	Ric	Gra	Cuc	Sug	Myr	Tra
IRAN	Iran Bastan Museum	M	16th c.	4555	sf										
"	Atiqi	I.M.	16th c.	11								f			f
"	"	I.M.	17th c.	12								f			
"	"	I.M.	17th c.	13								f			
"	"	I.M.	17th c.	14								f			
"	"	M	16th c.	15								f			
"	"	M	16th c.	16								f			
"	"	M	16th c.	18								f			
"	"	M	16th c.	19								f			
INDIA	Iran Bastan Museum	M	17th c.	4535	sf										
"	Atiqi	M	18th c.	17	sf										

Key to sizings:
Sta = Starch
Fis = Fish glue
Gum = Gum arabic
Fle = Fleawort
Mel = Sweet melon
Ric = Rice mucilage
Gra = Grape syrup
Cuc = Cucumber seeds
Sug = Sugar syrup
Myr = Myrtle Juice
Tra = Tragacanth

Key to object:
I.M. = Illuminated manuscript
M = Miniature

Key to identification methods:
s = determination of starch by staining the paper with iodine-potassium iodide solution
f = identification of sizing materials in the sample is obtained by comparing the infrared spectrum with reference spectra or by reorganizing specific bands.

Table 3. Sizing materials on selected paintings collected from Iran Bastan Museum collection and traditional artists

were conducted on the sizing materials of eleven historical Persian and Indian miniature paintings and illuminated manuscripts belonging to the Iran Bastan Museum and private collections dating from the sixteenth (Safawid period) to eighteenth century (Qajar period). The analysis of sizing materials used in the original samples was carried out at the Research Centre for Conservation of Cultural Relics (RCCCR) in Iran. Sizing materials were identified by a staining method and FT-IR (Fourier-transform infrared spectroscopy) analysis.

Starch was detected on paper by formation of the characteristic blue color when a dilute aqueous solution of iodine-potassium iodide was added.

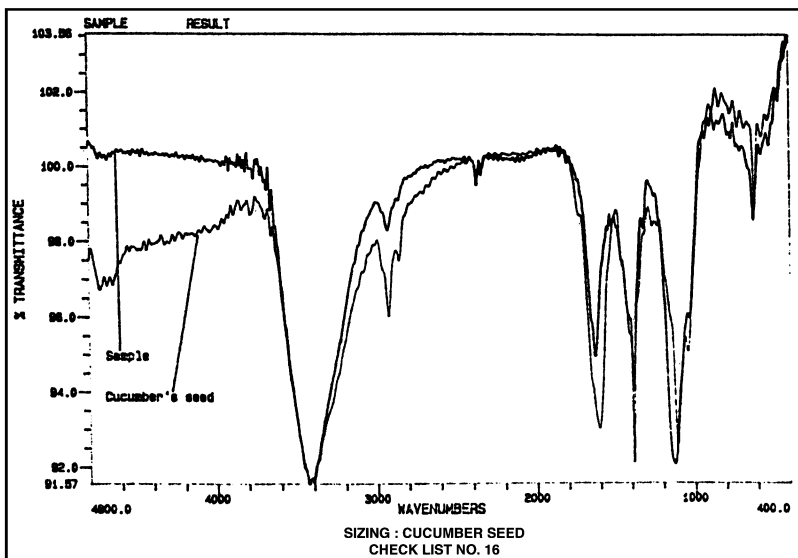
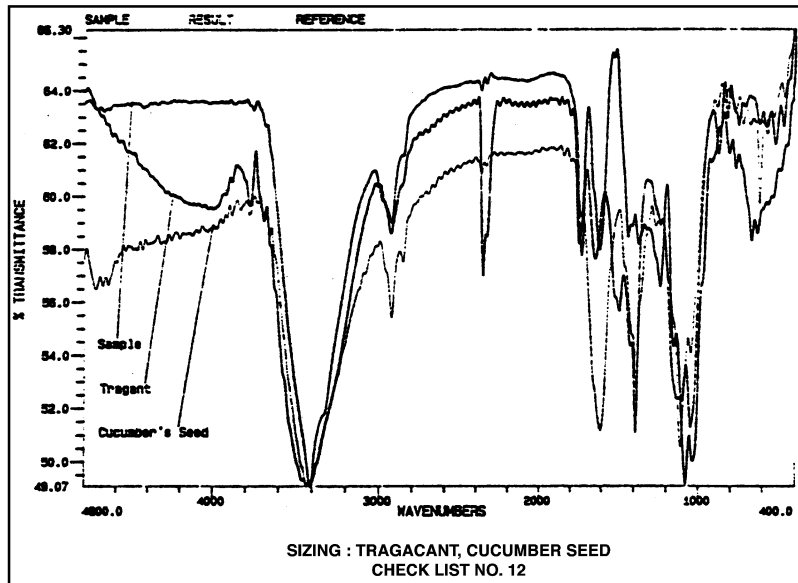
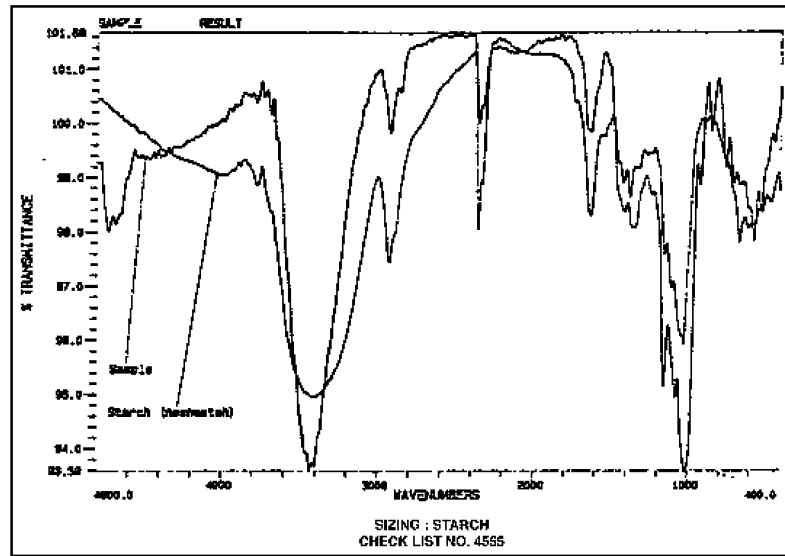
A large collection of sizing materials was prepared based on historical recipes for comparison with the spectra of the original samples. FT-IR spectroscopy was carried out with a Nicolet, Model 510 P, instrument provided with a microscopic attachment. Sample preparation was done by mixing potassium bromide (KBr) and the unprepared sample 100:1 (Broekman-Bokstijin et al. 1970). Identification of the materials in the samples was obtained by comparing the infrared spectrum with the reference spectra via recognition of specific bands. Table 3 provides a complete record of the sizing materials found and indicates the identification methods used in each case.

Out of the six categories of sizing materials recommended by masters in the historical survey, the mucilage of cucumber seeds was the most common sizing material on the paper samples identified by FT-IR. Out of nine Persian miniature paintings and illuminated manuscripts, one was starch, seven were cucumber seed mucilage, and one was a mixture of tragacanth and cucumber seed.

Figures 1–5 show some of the spectra of the sizing materials found in the sample. It can be noticed clearly that in the samples belonging to check list numbers 16, 13, and 18 (figs. 3–5) the spectra exactly match the fingerprints of cucumber seed spectra which were used as reference.

CONCLUSION

Unlike many nations that used limited sizing materials to improve the mechanical strength and to smooth paper surfaces, Iranians have used various materials for the sizing process. A large number of sizing materials have been introduced according to historical treatises belonging to Taimurid (fifteenth century), Safawid (sixteenth century), and Qajar (nineteenth century) periods, such as starch (rice and wheat), plant mucilage (fleawort, cucumber seeds, marshmallow), animal glue (fish glue), vegetable glue (*serish*, gum arabic), fruit juice, and syrup (melon and grape).



Above: Figs. 1a-b. Sizing: starch

Right: Fig. 2. Sizing: tragacanth, cucumber seed

Below: Fig. 3. Sizing: cucumber seed

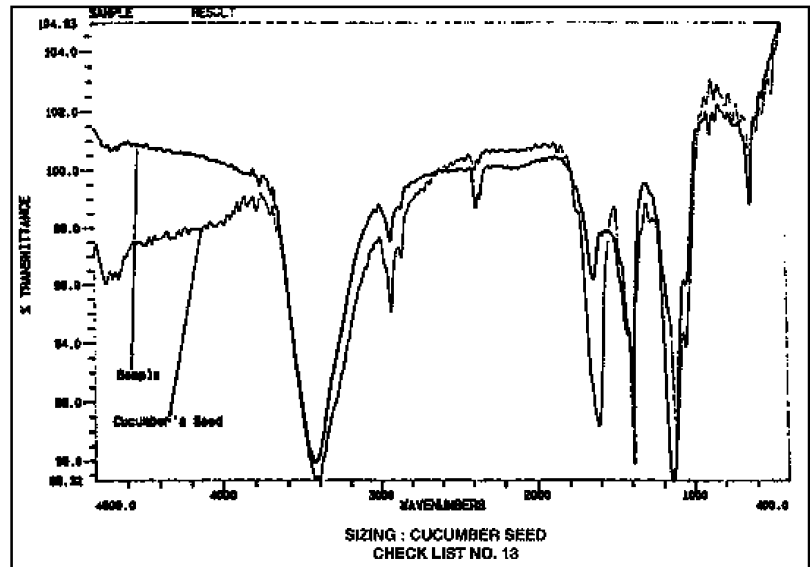
Scientific analysis was conducted to identify the nature of the sizing material used in Persian miniature paintings and manuscripts using a stain method and FT-IR analysis.

The findings of the present investigation revealed that cucumber seeds were used extensively in comparison to the other sizing materials under study. Of course further investigation is needed to conclude whether these materials have been used in pure or in mixture form.

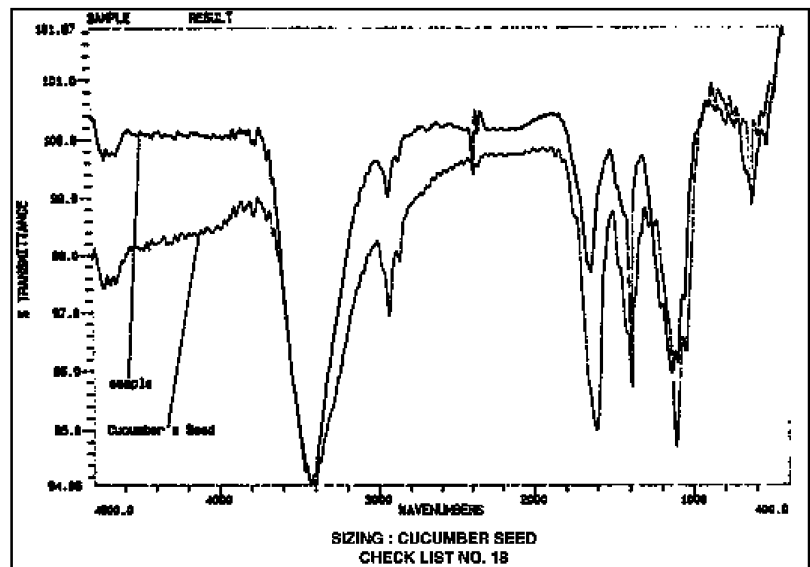
The present historical and scientific survey suggests the use of a wide range of natural sizing materials, which can be used as tools for conservation and restoration of paper documents when the sizing of paper is required. The present research is still under investigation. We need to collect more data to conclude which sizing materials were common during specific periods, and which sizing materials were used for specific papers and even for specific requirements.

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Figs. 4a–b. Sizing: cucumber seed



Figs. 5a–b. Sizing: cucumber seed

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