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Historical recipes for preparatory layers for oil paintings in manuals, manuscripts and handbooks in North West Europe, 1550-1900: analysis and reconstructions

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Figure 11.1 Set-up for glue boiling

Chapter 11 Size layers for oil painting in Western European sources (1500-1900). Historical recipes and reconstructions

You push the canvas from the back in the areas where the knife passes to spread the glue more regularly and evenly and you leave as little as you can

Jombert & De Piles 1766¹

11.1 Introduction²

In historical recipe books, the size layer is discussed as an integral part of a sound layer build-up in the preparation of a support for easel painting. It is frequently recommended for panels, canvas and several other supports prior to the ground application not only in historical sources, but also in twentieth century painter's manuals, for instance Wehlte (1975) and Mayer (19871).³ Also in the investigation of cross-sections from paintings, size layers are encountered. However their exact composition is not regularly investigated due to problems encountered in sampling and analysing such thin layers. Knowledge about the presence and composition of the size layer is important, because the size layer co-determines the adhesion of preparatory layers to the support, it influences the reaction of the painting to changes in relative humidity and has an effect on the visual characteristics of the painting.

Historical recipe research is required in order to gain more knowledge about size layers. Not only do recipes reveal information about size layer composition, descriptions of application methods and discussions about the reasoning behind their use reveal important characteristics of this layer that cannot be investigated by any other means. In many cases the interpretation of individual recipes is less than straightforward. To overcome these difficulties, a wide range of recipes have been investigated and 'historically appropriate reconstructions' have been incorporated with the recipe research. Reconstructions help interpret historical recipes, besides allowing for an evaluation of the importance of size layers for the appearance and stability of paintings.

11.2 Animal glue as a historic size layer material

Chapters 5 and 6 discussed the materials and techniques advised in historical sources for the preparation and application of size layers. From these chapters it is evident that animal glue is the material mentioned with the highest frequency as a size layer material, both for canvas and for panel supports.

¹ Jombert and De Piles 1766: 126

² This chapter is an updated version of: Witlox 2008.

³ Wehlte 1975: 355, 367; Mayer 1981: 283-4.

Some authors describe the effect of animal glue size layers on the working properties, visual characteristics and long-term stability of paintings. However, how reliable are these descriptions? Do they have any relationship with what happens in actual paintings?

Reconstructions may help answer these questions, but only if care is taken to work with materials that are as historically accurate as possible, since without appropriate materials such reconstructions would lead to conclusions that are difficult to compare to observations from actual paintings.⁴

11.3 Reconstructions of glue size layers for canvas painting

11.3.1 Reconstruction details

Since modern glues are prepared using methods and materials with significant differences in relation to historical glue preparation,⁵ for these reconstructions glues are prepared with materials and techniques that bear a close resemblance to historical methods described in the sources and analysed in Chapters 5 and 6.

In order to decide which raw materials are appropriate for reconstruction, the occurrence of different types of skins and parchment in historical recipes has been studied. This analysis shows that the sizing glues mentioned with the highest frequency in historical recipes are made from parchment and glove clippings. Alum tawed goatskin is selected for the reconstructions because it is a type of leather that was used historically as glove leather. Reconstructions are also executed with sheep and calf parchment, because both are mentioned repeatedly in historical size layer recipes (Appendix 18, Table 11.2).⁶ Glues are prepared (Fig. 11.1) according to scaled-down historical methods. The skins are cut into small squares, heated in distilled water and filtered through cotton gauze or through a stainless steel sieve, if filtering through gauze is not possible due to remaining skin particles. Although boiling times are mentioned



Figure 11.2a Open-weave canvas with three layers of goatskin glue

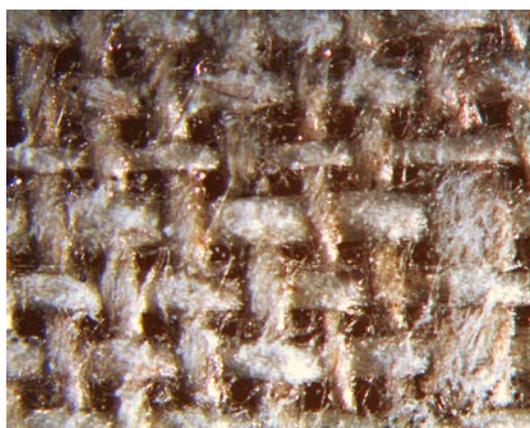


Figure 11.2b Open-weave canvas with three layers of sheep parchment glue

⁴ See Carlyle 2012a, Carlyle 2012b.

⁵ Alkaline or acidic hydrolysis is employed, depending on the skin type; glue extraction takes place at different intervals and temperatures, anti-foaming agents are added during extraction, often preservatives are added (except to food-grade gelatin), glues may be bleached with hydrogen peroxide. Oral communication, Frank Trommelen, Trobas Gelatine B.V. in Dongen.

⁶ The alum tawed leather has been prepared using a traditional recipe, with egg substitute. It was beyond the scope of the present study to investigate the exact preparation methods for the sheep and calf parchments.

infrequently in recipes, exact boiling times are used to enable a direct comparison between glues boiled from different raw materials. Glues are heated for 105 or 210 minutes. 105 minutes is the time needed to fully dissolve one of the skin types; 210 minutes is based on boiling times in recipes for small-scale glue preparation (See Appendix 18, Table 11.1).

A comparison is made between pre-soaked and non-soaked skin, since both non-soaked and soaked skins are mentioned in historical recipes. In order to investigate the influence of heating temperature, glue boiled at 100°C is compared to glue heated to 60°C.⁷ Glues are dried in a climate chamber at room temperature (20°C) with a low relative humidity (25%) to speed up the drying and thus prevent glue degradation and the formation of fungi.⁸

The resulting glues are redissolved at a moderate temperature (45 °C) and are applied to three types of canvas,⁹ both liquid (with a hogshair brush) and as a gel (with a stainless-steel spatula). They are applied as one, two or three layers (Fig. 11.2a and b). Parallel sets are executed of pumiced and non-pumiced glue layers. When the size layers are fully dry, two types of ground are applied on top, a chalk/glue ground and a lead white/linseed-oil ground.¹⁰ The chalk-glue ground is applied in one and two layers.

Several physical properties of the reconstruction glues are determined by Trobas Gelatine B.V. Dongen (viscosity, Bloom value or gel strength, pH).¹¹

11.3.2 *The chemistry of animal glue preparation*

What happens chemically during glue extraction? Animal glue consists of amino-acids. i.e. proteins. Inside the skin, these are bound in polypeptide chains. Three polypeptide chains build a triple helix, held together by hydrogen bonding and other intermolecular forces. During glue extraction (thermal hydrolysis), the triple helix is disarranged, protein chains are separated (denaturation) and when the covalent bonds within these chains are broken, shorter molecules with different chain lengths and composition are formed. The resulting gelatine is a very heterogeneous material with crystalline and amorphous

⁷ This temperature is used at the factory of Trobas Gelatine B.V. Dongen for the first gelatine extraction. Oral communication from Frank Trommelen, Trobas Gelatine B.V. Dongen.

⁸ Historical procedures describe drying in the open air, in the shade. See Greber 1950

⁹ The types of canvas chosen are: a closed-weave linen canvas, an open weave linen canvas and a jute canvas. Prior to use, the canvases were rinsed repeatedly, first in hot tapwater, then in demineralized water. Rinsing was continued until the water no longer becomes coloured and until it has no more odour from water soluble components in the canvases.

¹⁰ Chalk/glue ground was prepared with goatskin glue, boiled for 105 minutes without prior soaking, re-dissolved as a 7% solution, with unprocessed Omya chalk in a 1:1 ratio. The lead white/linseed oil was prepared with cold-pressed oil and stack-process lead white (6.5 % (w/w) linseed oil). The chalk employed has not undergone processing after it was mined.

¹¹ Viscosity was determined with a certified American pipette at 60.0 °C (6.67 % concentration by mass). The gel strength was measured with a Stevens Texture analyser type LFRA, with plunger TA.5, diameter of 12.7 mm and edge radius of 0.35 – 0.43 mm, according to BS757. The plunger was pressed 4 mm into a gel of 6.67 % concentration by mass, cooled for 16 to 18 hours at 10.0°C. The pH of a standard 12.5 % solution was determined by means of a calibrated pH meter with a temperature pre-set at about 50°C. The Bloom value (expressed in Bloom grams) is the strength or pressure needed to press a plunger 4 mm deep into a standard concentration gel.

areas.¹² The higher the degree of hydrolysis, the lower are the crystallinity and the gelling capacity of the glue. The degree of hydrolysis depends on boiling time, heating temperature, the presence of impurities,¹³ as well as the pH during glue extraction. The age of the skin also plays a role, since older skin is more highly cross-linked and therefore more difficult to dissolve.¹⁴

Bearing in mind the multitude of factors influencing glue preparation, it is easy to understand why authors of historical recipes rely on glue consistency instead of boiling time. They are interested in obtaining a reliable and workable glue, and this means checking and adapting the boiling time for different batches of skin. Gel consistency is also temperature dependent and will therefore show seasonal differences and variations due to climate. A 'trembling jelly', as was described in Paragraph 6.1.2, will have a higher concentration in summer than a similar jelly in winter.

11.3.3 Reconstruction results: influence of raw material

The results confirm repeated comments in historical recipes about the higher strength of parchment glue, as opposed to the weaker glove clippings glue. The three raw materials selected, yield very different glues. The goatskin completely dissolves in distilled water in 105 minutes, and forms an ochre-coloured turbid liquid. The liquid is slightly sticky. The calf parchment is nearly dissolved after 105 minutes boiling. The resulting liquid is light yellow, slightly turbid, very viscous and much stickier than goatskin. In contrast, the sheep parchment does not dissolve in water, even after 210 minutes boiling time. The light yellow, transparent liquid produced is very fluid and extremely sticky.

These differences are reflected in the Bloom values and viscosities of all these glues (See Appendix 18, Table 11.3). All the parchment glues have higher gel strengths than the goatskin glues, as well as higher viscosities.

11.3.4 Reconstruction results: effects of preparation variables

Although soaking does not seem to lead to noticeable changes in the glue, instrumental analysis shows that both the viscosity and the Bloom value of the glues are influenced by this treatment. Soaking of both the sheep parchment glue and goatskin glue results in a lower viscosity and Bloom value. Calf parchment shows an opposite reaction to soaking: a higher viscosity and Bloom value. At the moment no explanation is available for the different reactions to soaking of the calf and sheep parchment.

A comparison between glues prepared at 60°C and 100°C shows - not surprisingly - that a lower heating temperature results in less glue being extracted, but with a lighter colour and higher gel strength. The extracted glue is more transparent and has a lower viscosity (See Appendix 18, Table 11.3).

Sheep parchment heated for 210 minutes instead of 105 minutes, yields a more coloured glue with a lower viscosity and Bloom value. A larger amount of glue is extracted but of a

¹² Kolbe 1999: 18-21.

¹³ Although many impurities are washed out during the pre-treatment of the skin, in our case also while leather or parchment is prepared (Eastoe and Leach 1977: 76).

¹⁴ Eastoe and Leach 1977: 74-75.

lower quality than the glue extracted after 105 minutes of boiling.¹⁵

11.3.5 Reconstructions: application to canvas

As described above, the dried glues are re-dissolved in distilled water heated to approx. 45 °C. They are applied to canvas as a liquid and as a soft gel with a consistency that 'remains firm below the hand', but is similar to a 'trembling jelly', as described by Tingry (1803) in a recipe for a size layer for delicate subjects.¹⁶ A series of tests is executed to establish this concentration at room temperature.



Figure 11.3 Bulges and dents in canvas caused by liquid calf parchment and sheep parchment glues

The 'trembling jelly' concentration varies according to the raw material. For the goatskin glues, on average a 7% solution (w/w) has the desired characteristics, whereas for the parchment glues, typically a 5% solution (w/w) starts trembling.

Therefore parchment glues are applied at a different percentage than the goatskin glue. This is considered the best approach because historical recipes refer to gel consistency, not to glue percentage.¹⁷ (For some glue varieties, a lower percentage may even have had a good consistency, but to enable comparison between glues, no additional variations in concentration are introduced.)

Tests with parchment glue gels of 3% and 7% show why a 'trembling jelly' must have been chosen. A stiffer gel is pushed forward by the spatula and does not spread evenly over the surface. A very thin gel drips off the spatula; it wets and saturates the threads and its behaviour resembles that of liquid glue. We can conclude that practical considerations during application probably played an important role in the choice of gel concentration.

Reconstructions show that gel is more economical in use than liquid glue. On average, a third to half the amount of material is needed for a layer of gel, both for the first size layers and for subsequent size layers. When applied as a liquid, the first layer uses substantially more material than the second or third layer. Although the same is true for gel sizing, the difference is smaller (See Appendix 18, Table 11.4).

Liquid glue sizing discolours the canvas more than gel sizing because it penetrates the threads. It also results in a stiffer canvas.

¹⁵ 105 minutes heating: 0.32 gram of glue per gram of parchment; 210 minutes heating: 0.57 gram of glue per gram of parchment.

¹⁶ 'firm below the hand' was the consistency advised by the anonymous *École de mignature* in 1759: 102. See also Tingry 1803, vol 2: 263.

¹⁷ As said earlier, the concentration will vary with environmental temperature.

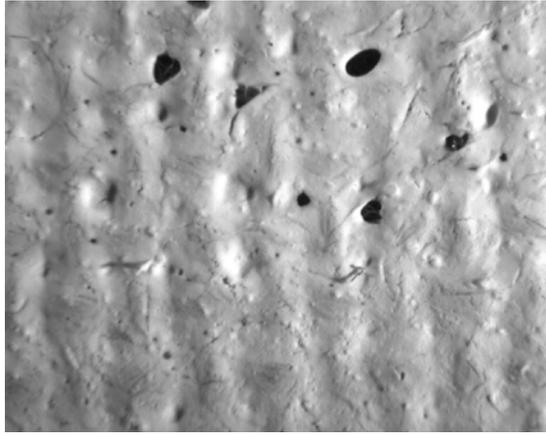


Figure 11.4a
Open weave canvas, sized with one layer of gelled sheep parchment glue. Size covered with a single layer of chalk in goatskin glue. (see also pinholes in the upper half)

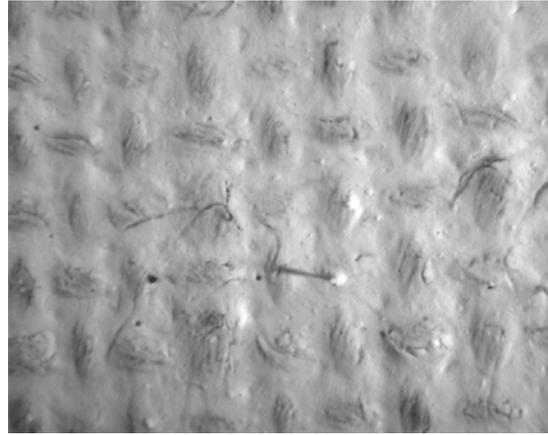


Figure 11.4b
Open weave canvas, sized with three layers of the same size. Size covered with a single layer of chalk in goatskin glue.

The stronger liquid parchment glues cause deformations (dents and bulges) in open weave canvas, especially when used liquid (Fig. 11.3). This confirms a comment in the Volpato manuscript (c. 1670): 'such glues as parchment glue, being strong and harsh, cause a certain shrinking of the canvas, which has a bad effect'.¹⁸

There is a clear difference between the surface characteristics of canvas sized with the weaker alum-tawed goatskin glue and with a parchment glue. Both parchment glues result in a rather shiny surface; the canvas is much more rigid and the canvas interstices are filled to a higher degree (Fig. 11.2a and b).

The possible influence that glue size layers may have on the visual characteristics of a painting become clear when ground layers are applied on top. In these reconstructions, sizing reduces the visibility of the canvas weave. When more size layers are applied, this effect is stronger (Fig. 11.4a and b). Gel size results in a more even surface than liquid size. Contrary to what is expected from the recipes, pumicing does not noticeably influence the visibility of the canvas weave.

Sizing reduces the amount of ground penetrating through to the back of the canvas. The degree of penetration is influenced first of all by the method used for ground application, which in turn depends on the ground viscosity. Spatula application, used for more viscous lead white and oil grounds, pushes the ground through the interstices to the back of the canvas, whereas the brush-applied aqueous chalk and glue ground remains more on the surface of the canvas.

¹⁸ Volpato c. 1670 (transcribed in Merrifield 1849 (1999): 729).

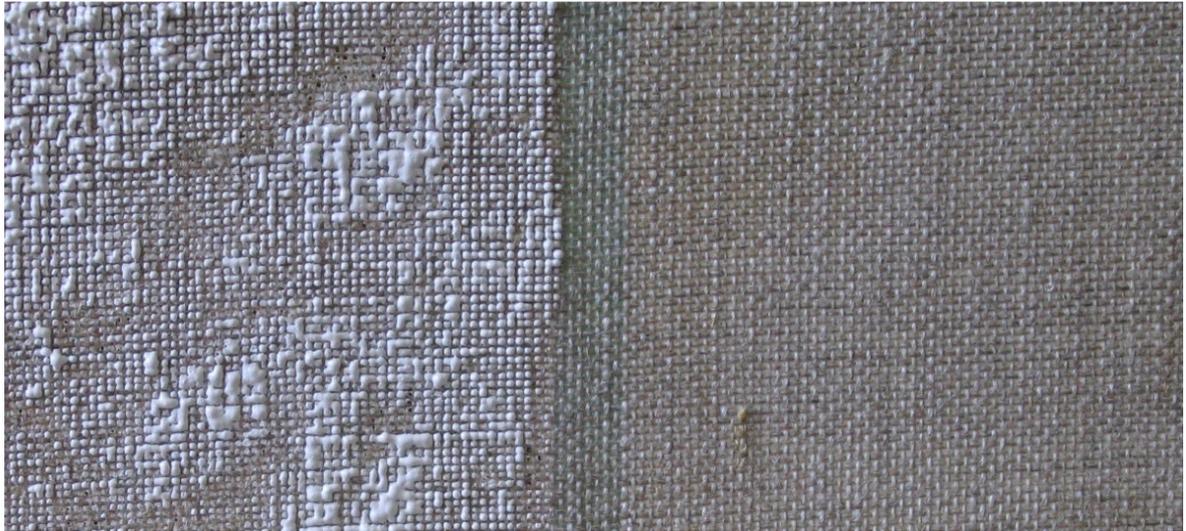


Figure 11.5

Effect of a glue size layer on ground penetration to the reverse side of the canvas.

Left side: calf parchment glue (5% w/w), applied as a liquid. Right side : goats skin glue (7% w/w), applied as a liquid. Both are covered with a layer of lead white in linseed oil. Although the calf parchment is the stronger glue (higher viscosity, higher Bloom value), it does not prevent bleeding through as well as the weaker goat's skin glue.

Depending on the glue type and size layer thickness the effectiveness of the size layer as a barrier against ground pushing through to the back is more or less pronounced. Surprisingly, stronger glues (in this case the parchment glues) are less effective as a method to prevent ground penetration to the back of the canvas (Fig. 11.5). Multiple size layers reduce ground penetration.

In many of the reconstructions pin-holes or craters form in the ground (diameter from 0.01 to 0.1 mm, see Fig. 11.4a).¹⁹ Pin-holes are important for a number of reasons: They may cause uneven absorption of paint binding medium, leading to matt and glossy areas; they are weak points in the ground layer which can act as a moisture bridge and finally they may influence the location and formation of age cracks.²⁰

In the reconstructions, pinhole formation depends on the ground's composition and application. In the unsized areas and in the viscous lead white/oil ground no pinholes appear. In the liquid chalk/glue ground, pin-holes form with a frequency that varies according to the size type and application method.

In areas where the 'weaker' goatskin glue is used, very few pin-holes are formed, whereas

¹⁹ Following Hess's definition (1965: 443-444), the holes seen in these ground reconstructions should be described as craters, since through them the support is visible.

²⁰ The extent to which pinholes may influence absorption of materials through the preparatory layers became clear when canvas that I prepared with a size layer and an animal glue/chalk preparatory layer were employed for reconstructions of glue-paste linings, executed by Laura Raven in the context of her Master Thesis at the University of Amsterdam. Liquid from the lining adhesive paste that Raven applied at the back of the canvas was transported through the pinholes to the ground layer, which was evident from the ca. 1 mm wide circles of absorbed brownish lining adhesive around the pinholes. Raven 2013.

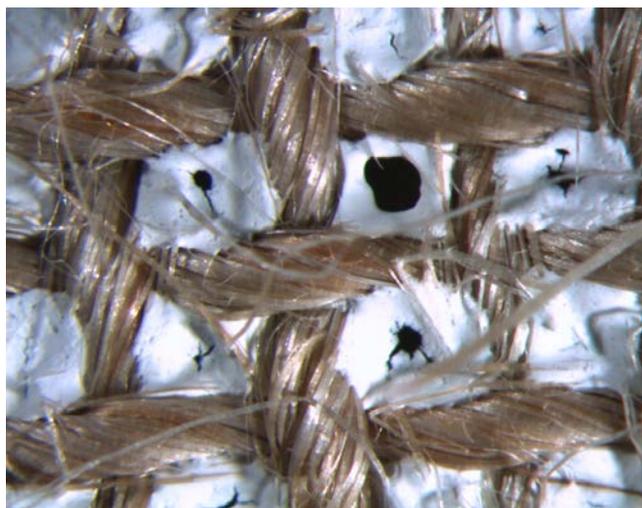


Figure 11.6 Pinhole formation seen from the reverse of a jute canvas covered with a chalk and glue ground layer.

Image through the stereo microscope at ca. 20x magnification

size layers. This is puzzling, considering the frequency with which pinholes appear in reconstructions.²¹

11.4 Relationship between recipes and reconstructions

These reconstructions investigated the impact that size layers may have on the visual characteristics of grounds and therefore on the whole painting. Despite being very thin, the size layer turns out to be more important than its inobtrusive nature would suggest.

Multiple size layers reduce both ground penetration into the support and canvas weave visibility in the final ground. The preparation variables investigated result in measurable differences. However, their influence is negligible in comparison to the choice of raw material.

Reconstructions show that several seemingly unimportant or inexplicable details found in historical recipes have practical explanations: reconstructions clearly demonstrate why glue concentration or gel strength is described, and concentration is not prescribed as a percentage or weight ratio of glue to water. Considering pinholes and ground penetration to the back and canvas deformation, ‘weaker’ glues are more successful as a size layer than ‘strong’ glues. This explains why many historical recipes prefer the relatively weaker glues for this purpose: the strongest glue is not necessarily the best size layer material.

in areas covered with the ‘stronger’ parchment glues many pin-holes appear. Pumicing of the size layer has no effect on pin-hole formation. Pinholes are weave-related; they appear in the canvas interstices (Fig. 11.6). Sometimes pin-holes are visible in actual paintings (Fig.11.7a, with a detail shown in Fig. 11.7b). Whether these pinholes are really caused by the size layer or by defects in other paint layers is not completely certain. However they present very similar visual characteristics and a similar cause seems likely.

Even though this example proves the occurrence of pinholes in oil paintings, pin-holes are not mentioned in recipes for ground or

²¹ They also appear in the chalk and glue grounds of the reconstructions prepared for Chapter 16, and appear frequently in reconstructions executed by students as part of their training for the Master Conservation and Restoration at the University of Amsterdam. Pinholes are also described by Vandivere in her reconstructions. Vandivere 2013: 60.



Fig 11.7a
Vincent Van Gogh, Self portrait with a
straw hat (june 1886)
oil on canvas, 41.5 x 32.5 cm (h x w).

Collection of the Van Gogh Museum (Van
Gogh Foundation), Amsterdam.
Photo: © Van Gogh Museum (Van Gogh
Foundation)

Figure 11.7b

Detail from background showing pinholes 16 cm up and 1 cm left of the lower right corner.

Although recipes mention that pumicing reduces knots in the canvas and results in a more even surface, reconstructions did not show a noticeable effect on the roughness of the canvas. Sources describe the long-term influence of size layers on the stability and appearance of paintings. The effect of the oil binding medium on un-sized canvas is described as disastrous. The strength of the sizing material is a further reason for concern. According to several authors, strong size layers lead to flaking. Monitoring of the test canvases will reveal whether these effects can be confirmed with this set of reconstructions.

11.5 Evaluation

In the present study, reconstructions were used in an attempt to investigate the validity of information found in historical recipes for size layers for oil painting. Reconstructions were also used as a means to acquire a deeper level of understanding regarding the preparation details and choice of materials described in historical recipes.

During the first stage of recipe analyses the research took a step back from individual recipes and studied groups of recipes in order to establish general trends and developments over time. By looking at *groups* of recipes, the danger of attaching too much importance to single recipes was reduced. Once general trends were established, it became possible to determine which individual recipes can be considered as

representative examples. These were selected for reconstruction. Reconstructions were prepared using historically appropriate materials wherever possible. Not only did the resulting reconstructions illustrate certain effects described by the sources, but they also provided an explanation for some recipe-details whose meaning or importance was previously unclear, for example instructions about glue consistency. Thus these reconstructions offer the possibility of evaluating the reliability and meaning of information found in historical recipes. The reconstructions showed that this group of recipes is indeed a valuable source of information, that allows for new insights into the role of the size layer.

The success of the approach described has depended on several factors, amongst which were the availability of a substantial body of recipes, combined with detailed information on the ingredients. Where the conditions described are met, 'historically appropriate' reconstructions are an important tool for understanding and evaluating historical recipes, and for the interpretation of phenomena observed in paintings.