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PAINTINGS

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ABSTRACT

Glue-paste linings of (Western) canvas paintings have been performed with a variety of materials throughout history and are present in a very significant amount of artworks in col-

INTRODUCTION

The International Lining Project 2011–2014[1]

While the glue-paste technique is well described in the literature, little focus is given to the selection of ingredients in the recipes. Despite the fact that the proportion of glue-to-flour is widely thought to be critical in terms of responsiveness to relative humidity (RH) fluctuation and embrittlement of the adhesive on ageing, few sources discuss the care of collections containing glue-paste lined canvas paintings. This scarcity of literature sparked a research project aiming to understand the choice of specific ingredients (specifically: flour and fabrics) commonly used in the recipes. An initial survey provided information regarding material choice and practice for glue-paste linings. Archival sources were consulted and supplemented with questionnaires sent to those practicing the technique across Europe. Results were incorporated into a database and are reported elsewhere (Macarrón 2013).

The experimental phase involved testing mock-ups simulating recipes and variations in lining technique to determine stability over time. Variables were determined using data from the comprehensive survey of both historical recipes and current practice. Two types of linen canvas with differing weave densities and four types of flour were selected. The glue type remained constant, as did the proportion of water in the recipe. A custom-primed artist linen canvas was used to simulate a painting for all mock-ups. The same experienced conservator carried out all linings. Half of the mock-ups were artificially aged. The work presented in this paper presents part of the results of this three-year research project.

PERFORMANCE STUDY OF GLUE-PASTE ADHESIVE

Materials

Various considerations were discussed prior to selecting recipes and ingredients. The exclusion of frequently used non-standard ingredients, such as garlic, ox gall, Venice turpentine or alum was considered appropriate and reduced the number of variables within the research project. While it is certain that they play a role in the long-term performance of the glue-paste mixture (Ackroyd 1996, Ábalos 2011), it would be difficult

lections in Europe and elsewhere. Cereal flours and animal glues were usually the main ingredients because they were readily available or simply owing to tradition. A variety of different additives were commonly included in recipes, aiming to enhance performance or to prevent mould growth. This paper describes how varying dominant ingredients of the glue-paste recipe influence the mechanical performance and degradation processes of lined canvas paintings. The impact of cyclic relative humidity on the biological and physical stability of the laminate structure is reported. Carefully constructed mock-ups, simulating lined canvas paintings, were used to examine the effect of pest infestation, mould growth, mechanical damage and chemical changes to the glue-paste lining adhesive over time. Results indicate that the cereal protein content influences degradation phenomena.

Figure 1. Making mock-ups

to differentiate the influence of each component without carrying out a broader investigation.

Some studies have shown that the glue-to-flour ratio affects the performance of a glue-paste lining (Ackroyd 1995, Ackroyd 1996); however, the weave geometry of the lining canvas and types of flour chosen have not been studied in depth. For this reason, a simplified but representative recipe was selected with a single variable ingredient – the flour content – and two different grades of linen lining canvas were used.

Pre-selection of the ingredients and proportions within the recipe was vigorous. Flours types were selected for their increasing protein content: fine-milled Candeal white wheat T55 (F1); fine-milled Manitoba white wheat T55 (F2); rough-milled semi-whole wheat T80 (F3); and rough-milled semi-whole rye T70 (F4). Each flour type was mixed with water in a proportional ratio of 30% (w:w). The co-adhesive was selected after investigating the properties of four animal glues with different Bloom strengths. A bone glue with a 240–250 Bloom strength was chosen and swollen in water in a proportional ratio of 30% (w:w) prior to mixing with the soaked flour. The proportion of flour to animal glue was also scrutinised being 1 part glue/water to 6 parts flour/water for each recipe (a ratio frequently used by practicing conservators) (Table 1). The recipes and subsequent mock-linings were made by a single experienced conservator to ensure consistency (Figure 1).

Mock-ups were made using a custom-primed artist linen canvas simulating an actual painting and two different grades of linen lining canvas. Similar amounts of each glue-paste recipe were applied to a densely woven linen (13 × 15 threads/cm^2) and an open-woven linen (9 × 9 threads/cm^2). The choice of two lining canvases was introduced to establish if the weave density played a significant role in behavioural properties. One group of mock-ups was lined with both the canvases unrestrained. A second group was made where the lining canvas was first mounted on a stretcher. Two sets were made for each group. One set was kept unaged and the second set was subjected to cycles of fluctuating RH. Further testing of both the aged and the control samples was carried out under pre-determined climatic conditions to represent real-life scenarios (Table 1).

Artificial ageing was carried out in a Vötsch VC4034 thermo-hygrometric chamber at the Centre Interdisciplinaire de Conservation et de Restauration du Patrimoine (CICRP). The ageing sequence was composed of 50 cycles of a 16-hour program consisting of four steps lasting 4 hours for a total duration of 800 hours: 1st step at 35°C/75% RH; 2nd step at 35°C/20% RH; 3rd step at 15°C/20% RH; and 4th step at 15°C/75% RH. A maximum number of fluctuations, with a minimum duration (4 hours) to reach equilibrium of the materials, was preferred to a longer duration for each step. Successions of warm and wet, warm and dry, cold and dry, cold and wet were chosen in order to obtain the maximum level of degradation.

The recipe selections and mock-up design, combined with artificial ageing, allowed the interdisciplinary team to look at the mid- to long-term behaviour of four glue-paste mixtures from a narrow, but thorough, point of view. Varying the flour type led to a better understanding of how the chemistry of the flour content contributes to the mechanical and biological performance of the mixture. Artificial ageing reproduced representative damage patterns and effects that could be studied using a number of analytical methods.

Physical tests and analytical methods

Light microscopy

Cross sections of all mock-ups were studied and documented using light microscopy. Images were also taken of the reverse of each sample. A Leica

Table 1. Mock-ups: Materials, proportions and tests

Ageing	Type of mock-up	Lining fabric	Glue/ flour ratio	Glue (30% solution in water w/w)	Flour (30% in water w/w)	Lining ref.	Analysis carried out	#
Unaged (Group A)	Lined canvas mounted on stretcher (Group Ai)	LF 1	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-C	• Pest infestation tests • Isostrain tensile tests in fluctuating RH	1a
					F2	WMT55-C		2a
					F3	WT80-C		3a
					F4	RT70-C		4a
		LF 2	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-O		5a
					F2	WMT55-O		6a
					F3	WT80-O		7a
					F4	RT70-O		8a
	Lined canvas unrestrained (Group Aii)	LF 1	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-C	• Light microscopy • SEM • Peel tests	1b
					F2	WMT55-C		2b
					F3	WT80-C		3b
					F4	RT70-C		4b
		LF 2	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-O		5b
					F2	WMT55-O		6b
					F3	WT80-O		7b
					F4	RT70-O		8b
Artificial ageing (Group B)	Lined canvas mounted on stretcher (Group Bi)	LF 1	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-C	• Pest infestation tests • Isostrain tensile tests in fluctuating RH	1c
					F2	WMT55-C		2c
					F3	WT80-C		3c
					F4	RT70-C		4c
		LF 2	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-O		5c
					F2	WMT55-O		6c
					F3	WT80-O		7c
					F4	RT70-O		8c
	Lined canvas unrestrained (Group Bii)	LF 1	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-C	• Light Microscopy • SEM • Peel tests • Mould growth tests	1d
					F2	WMT55-C		2d
					F3	WT80-C		3d
					F4	RT70-C		4d
		LF 2	1/6	Kremer 63010 (240-250 Bloom Grade)	F1	WT55-O		5d
					F2	WMT55-O		6d
					F3	WT80-O		7d
					F4	RT70-O		8d
Control canvas	Raw lining canvas	LF1	n/a	CTS® Lining fabric 1 (LF1): 100% Flax fabric ref. 1111	n/a	n/a	• Isostrain tensile tests in fluctuating RH	n/a
	Raw lining canvas	LF2	n/a	CTS® Lining Fabric 2 (LF2): 100% Flax fabric ref. 2297	n/a	n/a	• Isostrain tensile tests in fluctuating RH	n/a

LF1: Raw linen lining canvas, close-weave, 13 × 15 threads/cm^2
LF2: Raw linen lining canvas, Open weave 9 × 9 threads/cm^2
F1: White Wheat Candeal T55 (fine-milled) flour, El Corté Inglès® Spain –10-11% protein content
F2: White Wheat Manitoba T55 (fine-milled) flour, Finestra sul Cielo® (Italy) –14% protein content
F3: Semi-whole Wheat T80 (rough-milled) flour, Minoterie DOM® (France) –11% protein content
F4: Semi-whole Rye T70 (rough-milled) flour, Minoterie DOM® (France) –7% protein content

DMR microscope was used to evaluate colour and morphological properties of the samples (reflected visible light; magnification of 25× and 40×).

Tensile and peel tests

Uniaxial tests of restrained samples in changing RH were performed in purpose-built tensile testers placed in environmentally controlled custom-built chambers donated by the Smithsonian's Museum Conservation Institute. Samples cut from aged mock-ups (Groups Ai and Bi) were clamped between gauges and allowed to adjust to the conditions in the chamber for 24 hours. The restrained samples were subjected to a stepwise change in RH and the force developing in each sample was recorded (Andersen 2014). The tensile tests results were registered on a strain indicator as described by Mecklenburg (1991). The RH was recorded with a calibrated TV-4500Tinytag View 2 - Gemini data logger.

Adhesion peel tests were carried out on T-type specimens in a Shimadzu universal testing machine equipped with a 1-kN load cell following ASTM D1876-01 standard.

Mould growth

Mould cultivation took place in hermetic chambers in which three different pre-set RH levels (55%, 75% and 85%) were maintained using saturated saline solutions (respectively $Mg(NO3)_2.6H_2O$, NaCl and KCl at 25°C). A RH of 55% was chosen as the lowest value under which no mould is expected to grow. The control samples were kept at this value. A RH of 85% was chosen as the highest value. At this value, mould growth is expected for a large number of species that potentially attack glue-paste adhesive. A RH of 75% was chosen as a critical value to evaluate the influence of glue-paste recipes and the weave density on the activity of the different species (seeded and latent). This value differed from the standard maximum value for cultural heritage of 65% RH. Portable data-loggers (Plug and Track by Proges Plus) recorded the environmental conditions. Three sets of unrestrained squares taken from Group Bii mock-ups were contaminated with mould spores (5 spots containing 1000 spores each) to ensure reproducibility for each RH level. *Aspergillus amoenus* and *Chaetomium globosum* were selected, as these spores are often found in real-life scenarios. *Aspergillus amoenus* is considered a xerophylic species with a minimal activity of water between 0.7 and 0.8, whereas *Chaetomium globosum* has a higher activity of water starting at 0.9.[2]

Pest infestation tests

Mock-ups from Groups Ai and Bi were used for the pest infestation tests. ~~Some mock-ups were removed prior to the completion of the artificial ageing cycle, to provide younger samples.~~ *Stegobium paniceum* were selected from the breeding room at CICRP's laboratory, since they commonly infest traditional glue-paste lined paintings in Mediterranean countries (May 2009). Three representative mock-ups were placed in each chamber. Infestation occurred in isolated boxes to avoid cross-infestation. Each sample was defined by three characteristics: type of flour/type of canvas/ageing condition.

The experimental protocol for the pest infestation tests was inspired by previous research on glue-paste lining bio-deterioration (Fohrer 2006). Each sample was exposed to the same population of insects under the same environmental conditions. The first introduction of insects occurred in June 2014 (T0), with ten females and five males in each chamber. A second introduction of insects occurred in April 2015 (T1), with five females and five males. Optimal conditions of 65% RH were maintained by saturated saline solutions. Optimal temperature was maintained around 25°C (± 4°C). These environmental conditions were as close as possible of those published by Lefkovitch (1967) for the development of insects. Portable data-loggers (Plug and Track by Proges Plus), recorded the environmental conditions.

Results and discussion

Light microscopy

Observations of the cross sections show that the glue-paste adhesive functions well in the unaged samples, especially in Group Aii LF1 samples RT70-C and WMT55-C. The film thickness in these samples is uniform. The glue-paste adhesive generally appears dryer and more crystalline in the aged samples (Group Bii). No inter-laminate separation was observed for any of the aged Manitoba (F2) and rye (F4) mock-ups (Group Bii LF1 and LF2). Other aged samples demonstrated delamination (i.e. WT55-O) (Figure 2).

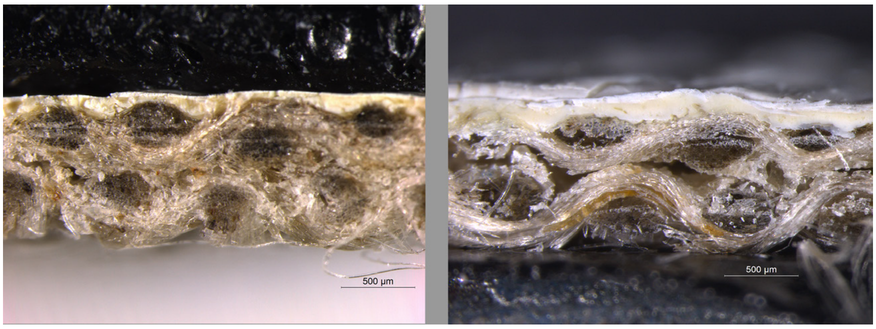

Figure 2. Composite image of cross sections showing adhesion (unaged) and delimitation (aged)

Tensile tests

When painting (samples) are restrained by a stretcher, they develop force instead of contracting at low RH. All restrained canvas samples showed high forces at low RH levels (Groups Ai and Bi), indicating that all mock-ups are highly responsive to changes in RH. There are, however, differences in the degree of response depending on recipes and weave density. Contraction forces in tensioned canvas paintings can lead to cracking in brittle films, and it could therefore be expected that the aged samples (Group Bi) would respond less to low RH levels as cracks act as stress release. Nonetheless, no significant difference was observed before or after artificial ageing. Consequently, only the results for aged samples (Group Bi) are represented here (Table 2).

Generally, the canvas type had a greater effect on contraction forces than expected, considering that the canvases (LF1 and LF2) without the glue-paste were non-responsive to low RH. The samples lined on the close-weave

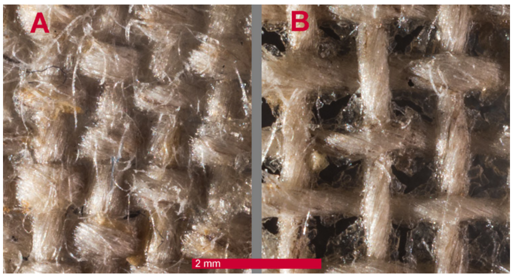

Figure 3. Glue-paste on close-weave (A) and open-weave (B) canvas (close-up photo)

canvas (Group Bi LF 1) responded more to RH changes than the ones on open-weave canvas (Group Bi LF 2), even though the amount of adhesive present in all samples was approximately the same. The weave geometry thus plays a significant role. The coherency of the glue-paste adhesive layer differed between open and closed canvas types (Figure 3). While the adhesive layer is continuous on close-weave samples, the adhesive did not cover the interstices between threads on the open canvas. This implies that the response to low RH will be significantly lower if an open-weave canvas is selected for this type of lining.

Table 2. Restrained response to humidity changes in aged lined samples (Group Bi)

Lining reference	Flour type	Lining canvas	Warp direction: Change in force per width (N/cm) (y) as a function of relative humidity (x)
RT70-C	F4 (Rye)	close weave	y = -0.1795 x + 14,657
WT80-C	F3 (Wheat T80)	close weave	y = -0.1366 x + 11,172
WT55-C	F1 (Wheat T55)	close weave	y = -0.1067 x + 8,7525
WMT55-C	F2 (Manitoba T55)	close weave	y = -0.0971 x + 8,446
RT70-O	F4 (Rye)	open weave	y = -0.092 x + 6,7644
WT55-O	F1 (Wheat T55)	open weave	y = -0.0829 x + 6,2142
WT80-O	F3 (Wheat T80)	open weave	y = -0.0759 x + 5,7789
WMT55-O	F2 (ManitobaT55)	open weave	y = -0.0562 x + 4,4878

The flour type also had a significant impact on the contraction forces measured. The rye flour (RT70-C and RT70-O) produced significantly more contraction forces, while Manitoba flour (WMT55-C and WMT55-O) produced the least. The highest response to changing RH (RT70-C) was more than three times larger than the lowest response (WMT55-O) (Figure 4). This suggests that the risk of damage due to contraction forces will greatly vary, depending on the chosen flour content in the recipe and particularly on the selected lining canvas.

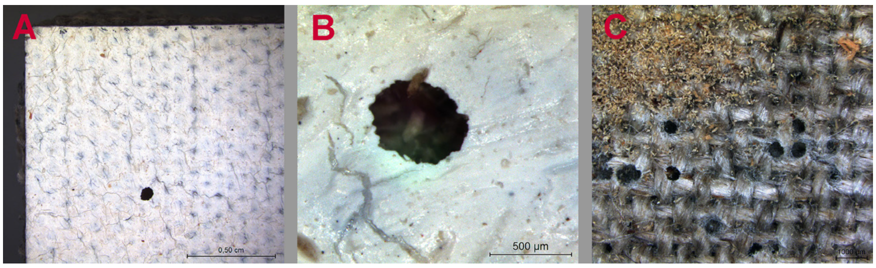

Figure 4. Development of force in changing RH for aged linings with rye and Manitoba flours

The average peel force for the samples in Group Bi was 5.75 N/cm with a standard deviation of 1.13. The linings on close-weave canvas (Group Bi LF1) require higher forces in order to peel them apart (6.52 N/cm) than those on the open-weave canvas (4.98 N/cm) (Group Bi LF2). Presumably, this is because there is more surface area of the close-weave canvas to which the adhesive can attach. No significant differences were recorded between recipes, though the aged samples (Group Bi) showed a slight, but not statistically notable, lower peel force than the unaged (Group Ai) samples.

Mould growth

~~Four~~ mould species were identified: *Aspergillus amoenus* (seeded), *Aspergillus penicillioides* (latent), *Eurotium amstelodami* (latent) and *Chaetomium globosum* (seeded). As expected, mould development was not observed at 55% RH on any of the samples. The opportunistic xerophylic species, *Aspergillus penicillioides*, developed minimally at 75% RH on all samples except for those made from Manitoba flour. Visible signs of mould development began after 8 weeks. Maximum growth occurred between 8 and 16 weeks. The growth development was faster and higher on *Chaetomium globosum* seeded samples, probably because *Chaetomium globosum* does not compete with the xerophylic species. This is likely due to its activity of water (aw=0.9), which is higher than that of the opportunistic species (aw≈0.75). The opportunist xerophylic *Eurotium* species was predominant at 85% RH; however, the seeded species *Aspergillus amoenus* also shows some significant growth on several samples at this RH. Differences were observed according to the flour type contained in glue-paste lining samples. For each species (seeded and opportunist), mould development is more important in semi-whole flour-based recipes in Group Bii (F3 and F4), leading to the total contamination of these samples (Table 3).

Table 3. Results of mould growth tests

Lining Reference Recipe	75% Relative humidity		85% Relative humidity	
	Seeded with *Aspergillus amoenus*	Seeded with *Chaetomium lobosum*	Seeded with *Aspergillus amoenus*	Seeded with *Chaetomium globosum*
WT55-O: F1/Glue 6/1	-	*Asp. penicillioides* +	*Eur. amstelodami* +++ *Eur. chevalieri* ++	*Eur. amstelodami* +++ *Eur. chevalieri* ++
WT55-C: F1/Glue 6/1	*Eur.* +/-	*Asp. penicillioides* +	*Eur. amstelodami* +++ *Eur. chevalieri* ++ *Asp. amoenus* +	*Eur. amstelodami* ++ *Eur. chevalieri* ++
WMT55-C: F2/Glue 6/1	-	-	*Eur. chevalieri* +++ *Eur. amstelodami* ++ *Asp. amoenus* ++	*Eur. chevalieri* +++ *Eur. amstelodami* ++
WMT55-O: F2/Glue 6/1	-	*Asp. penicillioides* +(-)	*Eur. amstelodami* +++ *Asp. amoenus* ++	*Eur. amstelodami* +++ *Asp. creber* +
WT80-C: F3/Glue 6/1	-	*Asp. penicillioides* +	*Eur. amstelodami* +++ *Eur. chevalieri* +++ *Asp. amoenus* +++	*Eur. amstelodami* +++ *Eur. intermedium* +++
WT80-O: F3/Glue 6/1	*Asp. penicillioides* +(-)	*Asp. penicillioides* ++	*Eur. amstelodami* ++++ *Asp. amoenus* ++	*Eur. amstelodami* ++++
RT70-C: F4/Glue 6/1	*Asp. penicillioides* +	*Asp. penicillioides* ++	*Eur. amstelodami* ++++ *Eur. chevalieri* ++++ *Asp. amoenus* +++	*Eur. amstelodami* ++++ *Eur. chevalieri* ++++ *Eur. rubrum* +++
RT70-O: F4/Glue 6/1	*Asp. penicilloides* +(+)	*Asp. penicilloides* ++	*Eur. chevalieri* ++++ *Asp. amoenus* +++	*Eur. chevalieri* ++++

~~Differences were observed according to the flour contained in glue-paste lining samples. For each species (seeded and opportunist), mould development is more important in semi-whole flour-based recipes (F3, F4) leading to the total contamination of samples.~~
Seeded: *Aspergillus amoenus* and *Chaetomium globosum*.
Latent: *Aspergillus penicillioides, Aspergillus creber, Eurotium amstelodami* ~~and~~ *Eurotium chevalieri*

- : no growth ; +(-) : few growth spots (less than 5) ;
+ low growth ; ++ significant growth;
+++ important growth ; ++++ : total contamination

Pest infestation tests

Results of pest infestation tests are based on two main criteria (Table 4). The first is the increase of the total insect population considering all stages of their life cycle. This criterion is related to the laying behaviour of insects and indicates the possibility of development in a given environment. The second one is the evidence of larva ingestion through examination of dry rot, holes and galleries in the lining adhesive (Figure 5). The latter is directly linked to the severity of the degradation of the adhesive.

Table 4. Results of infestation tests

Recipes	Lining fabric	Ageing	No. of imago at T0	No. of visible imago at end of the test	No. of larva	Dejection of larva	Holes of larva in paint layer	Alteration level of linings
WT55: F1/Glue 6/1	Open weave	Aged	10	10	0	0	0	-
		Unaged	10	10	2 a./2 d.	++	0	++
	Close weave	Aged	10	9	2 a./2 d.	++	0	+(+)
		Unaged	10	10	2 d.	++	0	+(+)
WMT55: F2/Glue 6/1	Open weave	Aged	10	10	0	-	0	-
		Unaged	10	10	1 d.	++	0	+(+)
	Close weave	Aged	10	10	0	+/-	0	+/-
		Unaged	10	10	0	-	0	-
WT80-C: F3/Glue 6/1	Open weave	Aged	10	10	4 d.	+++	3	+++
		Unaged	10	10	0	-	0	-
	Close weave	Aged	10	9	2 a./1 d.	+	0	-
		Unaged	10	10	5 d.	++++	2	++++
RT70-C: F4/Glue 6/1	Open weave	Aged	10	10	0	+/-	0	+
		Unaged	10	10	4 a.	+++	0	+++
	Close weave	Aged	10	9	9 d.	++++	1	++++
		Unaged	10	10	0	-	0	-

- : no growth ;
+(-) ; + low growth ;
++ significant growth;
+++ important growth ;
++++ : total contamination

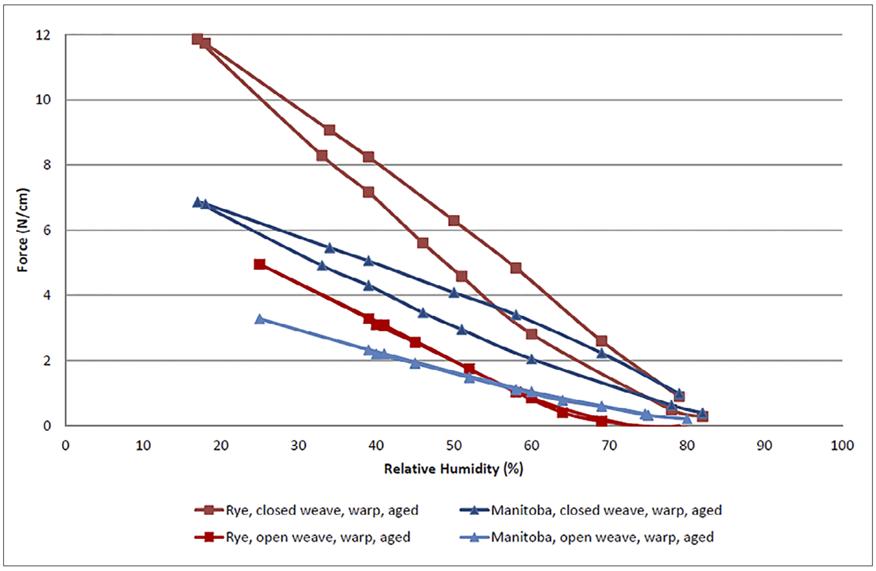

Figure 5. Insects degradation on Group Bii rye T70-C: a) hole in paint layer; b) hole in paint layer detail: c) holes and rot on the reverse of lining

Semi-whole flour-based recipes (F3 and F4) are more severely infested by insects than fine-milled flour-based recipes (F1 and F2). The Manitoba T55 appears more resilient to insect attack than the Candeal T55 flour recipes. The rye flour close-weave mock-up (RT70-C) demonstrated the highest infestation rate and therefore the more drastic alteration. The semi-whole wheat flour close-weave mock-up (WT80-C) shows the same degradation level of the adhesive, but less larva were found in the box. Both semi-whole flour recipes (F3 and F4) showed a greater severity of degradation in the close-weave mock-ups than the open-weave ones. It is likely that the insects were protected from external light sources, dust and predators as the interstices were narrower (Lepesme 1944). The artificial ageing of these samples does not seem to influence the infestation process or severity.

CONCLUSION

This ongoing study presents an insight into the effects of different flours and fabrics on the mechanical performance and bio-degradation processes of lined canvas paintings. For this purpose, glue-paste lined mock-ups were accurately reproduced according to archival sources and different tests were carried out. The impact of cyclic RH on the biological, chemical and physical stability of the laminate structure was studied.

Early indications show differences in the mechanical and dimensional stability of glue-paste linings depending on the type of flour used and degree of milling, as well as the density of canvas chosen for lining. The extent of bio-degradation is not only related to the flour milling and flour/glue ratio but also to the nature of starch and protein when the flour/glue ratio is kept constant. Mechanical tests evidenced that semi-whole flour-based recipes, as well as weave density, caused higher contraction forces in restrained samples, and therefore a higher risk of cracking and delamination. This study provides specific knowledge on the effect of RH on paintings lined with this technique. The results indicate that glue-paste adhesives should be maintained within stable climatic conditions in order to maintain structural stability and optimal adhesive strength. Nonetheless, the choice of flour and canvas influences the specific risk of paint failure and delamination in each case. Until now, this knowledge was anecdotal.

Glue-paste linings made up from semi-whole flour-based recipes are more prone to bio-deterioration than those made up from fine-milled white flours. Both mould growth and pest infestation tests lead to this conclusion. The type of lining canvas seems also to play a role in the bio-deterioration process, as demonstrated by the linings with open-weave canvas, which are more contaminated by mould, but seem to be slightly less degraded by insects. In the open-weave canvas lining technique, the highly hydrophilic glue-paste film is directly exposed to the surrounding environment and possibly offers a better substrate for mould germination and growth. On the contrary, as the growth of *Stegobium paniceum* is disrupted by light, the close-weave lining canvas possibly acts as a protection from external aggressions for insects. This could explain a higher degradation level of close-weave canvas linings after pest infestation.

Considering the significant amount of glue-paste lined paintings that are nowadays in worldwide collections, the conservation strategies for their long-term care should be carefully considered depending upon the flour type present in the lining adhesive. While this project does not endorse the use of glue-paste linings, the results have implications for the choice of flour and canvas for those carrying out this technique. Paintings lined with rye flour should be maintained within specific and narrow climatic conditions. Or in other words, rye flour should be avoided if ambient climate conditions are not controlled. Aspects for future research could focus on the identification of flour types, especially rye, for existing historical linings in order to determine the risk of degradation.

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NOTES

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[2] Activity of water (aw) is the value of the RH in a material at equilibrium state needed for the germination of mould. The value is expressed as an index from 0 to 1.

MATERIALS LIST

100% Flax fabric ref. 1111 and 100% Flax fabric ref. 2297
CTS®, Italy

Bone glue (pellets) (ref. 63010)
Kremer®, Germany

Primed canvas with titanium white/zinc oxide bound in oil ground layer
Claessens®, Belgium

Semi-whole rye T70 (rough-milled) flour
Minoterie DOM®, France

Semi-whole wheat T80 (rough-milled) flour
Minoterie DOM®, France

White wheat Candeal T55 (fine-milled) flour
El Corte Inglés®, Spain

White wheat Manitoba T55 (fine-milled) flour
Finestra sul Cielo®, Italy

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