Journal of Cultural Heritage xxx (2017) xxx–xxx

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Original article

Preservation of bread-made museum collections by coating technology

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ARTICLE INFO

Article history:
Received 17 September 2016
Accepted 4 January 2017
Available online xxx

Keywords:
Active coating
Bread artifacts
Entomatic attack
Nanocomposite coating
Sardinia

ABSTRACT

Bread-made artifacts are the products of an ancient creative tradition in some parts of Sardinia. While early objects were intended for pagan events (e.g., grain harvest), later artworks were specifically made for Catholic celebrations, such as Christmas and Easter. Unfortunately, the cultural heritage linked to these objects is endangered by *Sitophilus granarius* (L.), a tiny insect that causes irreparable damage, such as ruptures and galleries through an intense boring action. In this work, we have evaluated the potential for the coating technology to protect bread-made artifacts from entomatic attack. Within this scope, a nanocomposite coating and an active coating were prepared, and the coated objects were characterized in terms of optical, mechanical, and insect-resistant properties. Overall, the deposition of the coating did not negatively impact the appearance of the objects, although some differences were detected instrumentally in terms of color and gloss. In addition, both coating formulations decreased the Young's modulus of the samples subjected to a flexural test, which was attributed to the plasticizing effect of the poly-methyl methacrylate and deltamethrin. The entomatic tests revealed that the nanocomposite coating was the most effective for preventing the wheat weevil attack, with no damages detected on the samples and high mortality of the insects due to hunger. The approach proposed here could be successfully extended to other art objects (e.g., museum collections) susceptible to insect attacks.

1. Introduction

Italian cultural heritage not only includes famous artworks that are glorified worldwide, but also a huge number of local creations that are largely unsung. However, the existence of these local creations is of utmost importance, especially from a local perspective. In fact, they reflect the tradition of a territory, and have kept the historical memory alive over the years. In addition, the survival of these local activities has an economic relevance for the domestic communities, because these creations, often grouped in small museum collections, are tourist attractions. Examples of minor artworks include laceworks, weavings, rugs, basketry, paintings, and pottery. All of these creations, although widespread across the entire Italian territory, can be found much more easily in those regions that, due to either geographical or cultural reasons, still have a well-rooted identity and a strong link with the past. Sardinia is one example that brings together ancient traditions and renowned handicrafts.

Among the large number of artworks, bread-made collections represent a peculiar type of Sardinian artwork that is widespread in some areas of the region. Local communities are engaged in the manufacturing of any sort of handicraft using bread dough, which, due to its plasticity, allows for the production of amazing art objects. In most cases, the production of bread-made artifacts is linked to specific periods of the year, either to celebrate religious festivities (e.g., Christmas, Easter, etc.) or social events (e.g., the grain harvest). Examples of these artworks are shown in Fig. 1. As with many local handicrafts, bread-made artworks are at risk of disappearing. Although social habits play a role in this (e.g., the youngest are less prone to perpetuating these traditions), the main reason for such risk is not directly related to humans, but rather to stored-product insects.

The wheat weevil, or *Sitophilus granarius* (L.) (Coleoptera, Dryophthoridae), is a common pest in granary goods [1]. The females lay many eggs inside the wheat matrix, and the larvae (white with a tan head) feed and grow until pupation, eating the immediate surroundings using robust chewing mouthparts. The

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http://dx.doi.org/10.1016/j.culher.2017.01.001
1296-2074/

Fig. 1. Examples of bread-made artifacts prepared for Easter (a) and Christmas time (b and c).

adults (reddish-brown color, 3–5 mm long) emerge from the inside the wheat matrix by drilling a hole with their elongated snouts. The life cycle takes from 5 to 15 weeks, depending on the season and local temperatures, whereas the adults can live up to 8 months after leaving the food [2]. Wheat weevils' attack on the bread-made artifacts causes severe damage, especially due to the action of the larvae. Broken parts and tiny galleries inside the artwork represent irreparable aesthetic issues that also impair the mechanical stability. As a result, each piece keeps its integrity only for few months to one year in the best cases. For this reason, local artisans must set the bread-made collections every year in order constantly to replace the damaged objects. In addition to being a time-consuming process, it does not allow for the preservation of the oldest pieces, causing the subsequent loss of cultural and historical heritage objects. Therefore, finding a solution to the entomatic attack of the grain weevil is highly necessary. Although prevention and monitoring are, in principle, the most effective approaches to prevent the attack, they are not feasible in all circumstances. Cleaning, even if thorough, is not enough to avoid the pest, and monitoring by pheromone traps is not affordable by many. Hence, strategies for treating the final artwork can be a complementary tool for efficiently preventing insect attack and, thereby, for preserving the admirable handwork of artisans. Although the use of protective boxes made of glass or plastic polymers (e.g., polycarbonate) possibly in combination with a controlled atmosphere was considered as a valid option, the negative impact on the visitors' in terms of overall perception of the artifacts boosted us to look for a less invasive strategy. The use of protective layers developed according to nanotechnology approaches is an established strategy to preserve our cultural heritage [3,4].

In this work, we propose for the first time the use of a coating technology to protect handmade artworks made of bread dough against the attack of the wheat weevil. Two multidisciplinary approaches are presented: on one hand, a nanocomposite coating has been conceived as a "passive" physical barrier against the boring action of the insect, thus preventing the eggs deposition; on the other hand, an "active" coating with insecticide activity has been designed as a chemical shield around the object. Although restricted to a specific regional context, we believe that the findings arising from this work can be extended to a number of similar applications where damages from entomatic attack represent the main cause of the deterioration of the artwork, eventually leading to its loss.

2. Materials and methods

2.1. Materials

2.1.1. Bread samples

Rectangular specimens ($15 \times 10\,cm^2$) were prepared by the artisans of the tourist association (Pro Loco) of Olmedo (Sassari, Italy) using the same wheat dough that is used to manufacture the handmade artworks. A metallic template was used to print the final shape on the dough. Once obtained, the specimens were stored at room temperature for 24 hours and then transferred to a desiccator for two additional weeks before the experiments. The residual moisture content, which was measured with a moisture analyzer HB43–S (Mettler Toledo, Greifensee, Switzerland), was $1.42 \pm 0.35\%$ and the average thickness was 0.8 ± 0.04 mm. Three-dimensional

Please cite this article in press as: C.A. Cozzolino, et al., Preservation of bread-made museum collections by coating technology, Journal of Cultural Heritage (2017), http://dx.doi.org/10.1016/j.culher.2017.01.001