Investigation of old textiles using scanning electron microscopy

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Abstract

Aim: The paper focus on some old textiles in Romania.

Methodology: Fungal contamination was determined using conventional techniques of open plates by Koch sedimentation method. Fibers and their (bio) deterioration phenomena was studied by scanning electron microscopy.

Results: Among the fungi identified on the investigated old textiles: *Aspergillus* sp., are common indoor and outdoor molds. It can cause problems in the conservation of cultural heritage and also pose risks to health and environment.

Interpretation: Monitoring of fungal contamination represents the basis for effective conservation strategy of indoor heritage environments.

Key words: Deterioration, Environment risks, Fibres, Old textiles

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Introduction

Tangible cultural heritage, represented by aged textiles, stowed in storage facilities is exposed to physical, chemical and also microbiological environmental risk factors, may have negative consequences on integrity and cultural function (Rădulescu *et al.*, 2018). Biodeteriogens are able to decompose the museum pieces. Fungal biodeterioration can contribute to aesthetical and structural damage of materials (Kavkler *et al.*, 2015), the effect increases due to improper deposition because of natural (floods) and/or anthropic hazards (fire, insolation etc). Decomposition of plant residues/tissues and the resulting release of nutrient elements are key functions of soil microorganisms (Rottmann *et al.*, 2010; Bargali *et al.*, 1993, 2015). Bio-aerosols can harm museum curators and visitors' health.

SEM is one of the most versatile instrument for examining microstructural characteristics of solid objects (Goldstein *et al.*, 1992). In addition, SEM is the most suitable technique for fibre analysis and one of the non-destructive methods to estimate the condition of some Coptic Egyptian textile objects (Abdel-Kareem *et al.*, 2005). The importance and relevance of the SEM method combined with other methods of investigation, regarding deterioration of the fibres of aged textile due surrounding environment, historical conservation process and fungi growth have been highlighted in studies conducted by Karadag and Torgan (2016), Ahmed *et al.* (2017), Osman *et al.* (2017), Scharff and Jørgensen (2017), Elamin *et al.* (2018). Also, in Romania, studies on the degradation of textiles using SEM have been done by Săndulache *et al.* (2018) who have analysed a textile sample from a national heritage collection in order to establish its level of degradation. Furthermore, studies using SEM corroborated with other methods on textile samples from the Romanian patrimony were conducted in 2018 by Mitran *et al.* (2018). The study aimed at examining both the chemical and physical investigation fibrous composition as well as the level of degradation of the samples. The impact of the fungi on heritage textile was highlighted by Rădulescu *et al.* (2018). The present paper aims to investigate the internal structure and deterioration process of the fibres composing old textiles of folk costumes, which come into direct contact with the skin and pose secondary negative effects.

Materials and Methods

In this study an accelerated *in-vitro* biodeterioration test using some microfungi strains isolated from The National Museum for Romanian Peasant (Bucharest) on a textile material made of 100% wool fibres in order to show the accelerated biodegradation process due to the contamination with microfungi. In this case, SEM was used to analyse the modifications produced on the surface of the wool fibres.

To characterize the structure of fibres in depth and on the surface, Scanning Electron Microscopy (SEM) was carried out to capture

high resolution images. For isolation of microorganisms on the fibres of folk costume, samples were taken from surfaces of approximately 1 cm² with the help of sterile cotton swabs (Fernandes, 2006; Ilies' *et al.*, 2018; Indrie *et al.*, 2019). The decimal dilutions were performed; the cotton swabs were dipped in 1 ml of sterile distilled water. Suitable dilutions of each sample were inoculated into nutrient agar on petri dishes to identify bacteria and on Sabouraud agar with chloramphenicol for isolation of fungi. The samples were incubated at 37 °C for 72 hr. Bacteria were isolated and samples were subjected to a temperature of 25 °C for 5-7 days in order to isolate the fungi. The morphological characteristics of fungal colonies were observed and identified according to Borrego *et al.* (2012).

Results and Discussion

Analysis of fibrous composition of the embroidered peasant shirt, ascertained that it was flax/linen. In the past, flax/linen, was the most used raw material in the peasant households. This plant was cultivated by the peasants in their own homestead. One of the reasons for using linen fabrics for traditional costumes high hygroscopicity of the fibre which can absorb moisture from the surrounding environment up to 30% of its own mass, thus providing comfort to the body (Gribincea and Bordeianu, 2002). Analysing the SEM images of the fibres of peasant shirt (Fig. 1), it was found that it is a simple fibre linked structurally and functionally. Further high fibre degradation was observed over the years due to the chemical composition (80% cellulose content) of flax fibre and its structure (Preda and Preda, 1996). Oxygen and solar rays causes oxidative degradation of flax fibre. Also, depending on the relative humidity of the environment, the moisture content the strength and flexibility of these fibres over the years. Due to degradation of the fibres, the embroidered peasant shirt was both structural and colour, with oxidative yellowing over the years (Bordeianu, 2005). The microorganisms has first rotted the flax/linen and then disintegrated the fiber. Following the incubation of samples from the folk costumes, in this study *Aspergillus* was noted as a predominant fungal genera with known cellulytic activity (Fig. 2).

Influence on human health : Aspergillosis brings together all the diseases caused by *Aspergillus* in humans. *Aspergillus* is omnipresent in the environment, with multiple subtypes, species (over 200). Under certain favourable conditions, it becomes opportunistic, causing diseases. The risk of aspergillosis is mainly determined by the competence of immune system, the duration and frequency of exposure to *Aspergillus* spores. Generally, healthy body is able to neutralize the effects of spores in the body, the main risk factor is weak immune system, mainly in hematopoietic transplant patients, long-term neutropenia, solid organ transplantation, or immuno-suppressive therapy (Patterson *et al.*, 2016). The most common *Aspergillus* species encountered in humans are *A. fumigatus*, *A. niger*, *A. flavus*, *A. clavatus*, *A. versicolor*. *Aspergillus* spores are small size, about 2-3 microns,

Fig. 1 : SEM images of aged fabric with different magnifications: (A) x596; (B) x574; (C) x581; (D) x400; (E) x1380 and (F) x 3370.

resistant to external environment, have the ability to penetrate the respiratory tract, up to the alveolar level, leading to colonization, multiplication and dissemination of fungi throughout the body, on haematogenous pathway. Thus, inhalation of fungal spores is the most frequent pathway (Panackal *et al.*, 2010; Ilies *et al.*, 2018).

Another way of infection is through expose skin, with extensive burns, vascular lesions of new-borns, etc. (Etienne *et al.*, 2011), and also water contamination, rare but possible (Mesquita-Rocha *et al.*, 2013). The main symptoms of aspergillosis are wheezing, fever, haemoptysis, cough and chest pain.

Fig. 2 : A-B: Determination of fungi- *Aspergillus* spp.; C-D: ultures of microfungi.

There are mainly three major forms of Aspergillosis: Invasive Aspergillosis is the most severe and most important form with high mortality rate (90%) where infection from pulmonary level is propagated by haematogenous to other organs (eye, central nervous system, sinuses, bones, etc.); Chronic / saprophytic aspergillosis, infects varied localizations in the mucus tree or when there are chronic pulmonary diseases with pre-existing cavities (e.g. tuberculosis); Allergic aspergillosis is common in patients with asthma, bronchiectasis or cystic fibrosis. For certain diagnosis according to current guidelines, direct microscopic examination, culture and histopathological examination with pathogen identification are required (Ullmann *et al.*, 2018). Currently, there is an intense concern regarding this affection because it is widespread, and is currently an important cause of mortality in immuno-weak patients. As treatment is complex, multidisciplinary, depending mainly on the location and type of infection, the emphasis is also on the prophylaxis of patients with high risk of fungal infections (Lackner *et al.*, 2013; Heo *et al.*, 2017).

For old textiles, the identification of fibres and their assessment is important. Scanning electron microscopy can help in studying deterioration of fibers. Microorganisms can cause problems in the conservation of cultural heritage due to their biodeteriorative potential and can pose risks to both health and environment. Therefore, monitoring fungal contamination should be the basis for making appropriate strategy for the management of museums, to protect critical heritage environments.

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