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Fungal spores located in 18th century human dental calculi in the church "La Concepción" (Tenerife, Canary Islands)

José Afonso-Vargas [a], Irene La Serna-Ramos [b], Matilde Arnay-de-la-Rosa [a,*]

[a] Dpto. de Geografía e Historia, Universidad de La Laguna, 38071 La Laguna, Tenerife, Canary Islands, Spain
[b] Dpto. de Biología Vegetal (Botánica), Universidad de La Laguna, 38071 La Laguna, Tenerife, Canary Islands, Spain

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ABSTRACT

We present the results of our study of fungal spores found in two samples of mineralized dental calculi or "tartar" identified during the analysis of plant microfossils (phytoliths and starch granules), taken from individuals from the late 18th century, buried in graves in the church "La Concepción" (Santa Cruz de Tenerife). The identification of palynomorphs motivated the application of a specific methodology to investigate the nature of their presence in the dental tartar, seeking to discover whether this was the result of archaeological sediment contamination or of particles trapped within it. Comparative analysis of the palynomorphs found in the calculi, using reference material from the Palynotheque in the Department of Plant Biology, University of La Laguna, and analysis of the archaeological sediment, allowed us to confirm that the fungal spores were exclusively located inside the matrix of the calculi and did not originate from a contaminant source. Morphometric study of the spores, reference material and bibliographic descriptions allow us to propose that these are spores of *Ustilago maydis* (D.C) Corda, a parasitic corn (*Zea mays* L.) fungus. These results confirm, on the one hand, the historical consumption of corn as opposed to cereals produced locally until that time, such as barley and wheat, and, on the other hand, consumption of some shipments of maize contaminated by the so-called "corn smut" (*U. maydis*).

1. Introduction

The study of microfossils contained in partially mineralized human dental tartar or dental calculi is one of the sources of direct information about palaeodietary aspects (Lalueza Fox and Pérez-Pérez, 1994). From an archaeological perspective, the study of plant microfossils in dental calculus yields information on the diet of prehistoric ungulates (Armitage, 1975), historic ungulates (Middleton, 1990) and primates linked to the evolutionary chain (Ciochon et al., 1990), finally being applied to human populations in different contexts and periods of time (Scott-Cummings and Magenis, 1997; Juan-Tresserras, 1997). The first microfossils detected in these studies were silicophytoliths and starch granules, which also cause tooth enamel striation (Lalueza Fox and Pérez-Pérez, 1994; Lalueza et al., 1996) and both indicate the consumption of plants or plant products. As for palynomorphs as part of the microfossil record, distinguishing them from those found in non-human calculi (Middleton and Rovner, 1994), the first reference seems to be that of Torok et al. (1999), in this case in corpses from the 18th and 19th centuries. Fungal basidiospores were detected among microfossils such as oxalates and phytoliths, but without referring to specific taxa. More recently, Blatt et al. (2010) have also identified cotton fibre microfossils and other plant microfossils in historic human dental calculi from Ohio (USA). The history of oral hygiene shows the attention given in the past to the removal of dental tartar, with the use of a wide variety of specific instruments that varied in morphology and sophistication throughout history (González et al., 2003).

Dental calculus is mineralized bacterial plaque adhered to the surface of the tooth. Diet affects the formation of tartar, but it is not easy to establish the processes because of the numerous ways tartar can be formed. Some authors relate its formation almost exclusively to a protein-rich diet, for example, a diet based on meat products (Lillie, 1996; Malgosa and Subirá, 1996), while others link it to starch-rich diets, such as those based on cereals (Hanikara et al., 1994; Eshed et al., 2006; Afonso, 2007).

In terms of its composition, organic and inorganic components can be distinguished. Among the former there are remains of cells, food, bacteria and protein components from saliva, while the latter comprise calcium salts deposited on this matrix (Jin and Ying, 2002; Pérez et al., 2004). The components trapped in the tartar are an important source of information about the food consumed, because the presence of saliva is necessary for this process to take place. Therefore, many researchers suggest that this rules out the possibility that many of the components of the calculi were acquired after death and they defend its validity as a source of direct information about the products consumed (Afonso, 2007).

The extraction and study of this type of material has required numerous methodological reviews (Boyadjian et al., 2007; Afonso, 2007) focussing on the above-mentioned aspects. Unlike other archaeological

* Corresponding author.
E-mail address: matarnay@ull.es (M. Arnay-de-la-Rosa).

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materials, the samples involved must be destroyed to be analysed, in order to recover as much information as possible. In this case, the information takes the form of microfossils such as starch granules and silica phytoliths, which are not affected by the chemical treatments used, as opposed to calcium oxalates (Juan-Tresserras, 1997) which are completely dissolved. In this regard, we have evidenced the partial alteration of reference spores after chemical treatment, which supposedly also occurred in spores found within the dental calculi of the present study, but to our knowledge the literature contains no information on this.

From a historical research perspective, the information provided by plant microfossils contained in dental calculi allows a direct approximation of the diet at different periods of time and historical processes (González et al., 2003; Flandrin and Montanari, 2004; Juan-Tresserras, 1997).

In the case of the calculi from the church "La Concepción", the study provides insight into dietary patterns of the inhabitants of the Canary Islands and of Tenerife in particular, during the 18th century, a boom time for the city of Santa Cruz de Tenerife as a port and commercial centre, connected to the rest of the Canary Islands' capital cities, the Spanish mainland and the Spanish colonies in America. In terms of food, it also meant the expansion of habits that gradually changed the diet of the Canary population, probably starting with the upper classes, as suggested by the differential content of strontium/barium (Arnay et al., 2009) among individuals buried near the altar or far from the altar. As previously reported, tombs near the Altar were destined to individuals belonging to the high social class (Cioranescu, 1998). Among dietary change, it is important to highlight the increased consumption of corn or maize (*Zea mays*) compared to other common grains such as wheat or barley. The gradual production of the former from the late 16th century in islands such as Gran Canaria, resulted in exportation to the rest of the archipelago (Alzola, 1984). The 18th century was a period of great social crises and famines that led not only to the importation of cereals such as corn (or "millo" in the Canary Islands) but also to the proliferation of domestic cultivation and consumption.

The numerous human remains found in the subsoil of the church "La Concepción" have provided a considerable number of teeth that have been subjected to various palaeopathological and anthropological analyses, including the study of tartar as a variable of great interest in revealing the diet and oral health conditions of the population of the 18th century (Afonso, 2007; Gámez Mendoza, 2004; Arnay et al., 2009).

Early studies of microfossils in these samples confirmed the presence of silicophytoliths and starch granules, as well as palynomorphs in two of them, which were provisionally classified as spores (Afonso, 2007). A detailed study revealed that they could be identified taxonomically using morphometric and statistical analyses, including that of reference materials and sediments surrounding the human remains from which the dental calculi came.

Our study, based on the location of concentrations of fungal spores in the two aforementioned samples, expands the possibilities of obtaining historical information related to diet in the Canary Islands. In this case, we applied an interdisciplinary approach which allowed us to identify of the fungus *Ustilago maydis* and therefore confirms the consumption of corn (*Z. mays*) among part of the population of Santa Cruz de Tenerife in the late 18th century.

2. Materials and methods

2.1. Materials

The study material comes from the church "Nuestra Señora de La Concepción" in Santa Cruz de Tenerife. This was recovered during excavations carried out in two separate campaigns in 1993 and 1995, which brought to light an important part of the last burials in the subsoil of the inside of the church. Two hundred and seven burial pits were excavated and human remains belonging to at least 776 individuals were recovered. The available documentation allows us to chronologically place these burials in the period dating from the expansion of the church, in the early 18th century, when the fourth and fifth naves were built, until 1829, the year in which new floor paving was laid in the temple, which meant that it would be impossible to continue using it as a burial site (Arnay, 2009).

2.1.1. Specimens

Of the 537 specimens, belonging to 62 mandibles, analysed during dental pathology studies, we selected those that contained tartar, graded into different categories: Grade 1 slight: very thin continuous or discontinuous deposits, Grade 2 substantial: thick deposit covering almost all of a dental surface, and Grade 3 abundant: a very thick deposit covering the entire dental surface, following criteria established by Brothwell (1981), Delgado Darias (2009) and Chimenos (2003).

We finally analysed the 14 specimens that showed the greatest proportion of calculi, labelled with the initials of the archaeological site followed by the serial number (LC-24, LC-25, LC-39, LC-44, LC-45, LC-64, LC-112, LC-137, LC-608, LC-1192, LC-3369, LC-2173, LC-1962, LC-3382).

2.1.2. Contextual sediments

To test whether the spores or palynomorphs found really came from the calculi or whether they were also present in the archaeological sediment, samples were taken from the area surrounding the human remains from which they came, corresponding to burial pits 185 and 321, labelled LC-185 and LC-321 respectively.

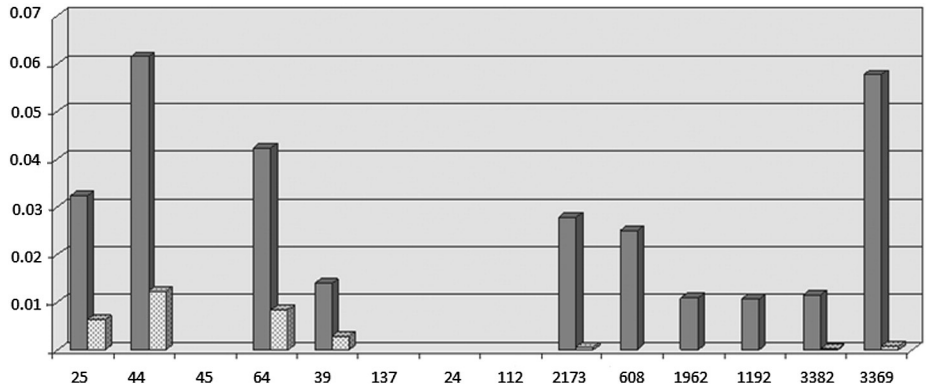

Fig. 1. Relationship between the weight (in grams) of the dental calculi before and after treatment. Grey bars represent the initial weights and white stippled bars the final weights of the samples after treatment. In the x axis we show the sample signature (The prefix LC [La Concepción] has been deleted due to space problems).