ANALYSIS OF MUMMIFIED INTESTINES SAMPLES FROM THE EL CHORRILLO (CANARY ISLANDS, SPAIN): THE RECOVERY OF MACROSCOPIC AND MICROSCOPIC EVIDENCE OF DIETARY PRACTICES

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Abstract. The analysis of intestinal samples from the El Chorrillo Mummy resulted in the recovery of dietary residues. The intestine segments were rehydrated and the interior and exterior surfaces were analyzed for plant and animal residues. Starch, pollen, probable crustacean fragments, and a seed were recovered from the internal surfaces of the intestine segments. The analysis of the exterior surface was covered with silica sand with some environmental pollen types. The analysis shows that this individual ate wild seeds, heath flowers or foliage with flowers, cultivated grass, crustacea, and a source of starch.

Keywords. Dietary practices. Mummies. Archaeological Methodology. Canary Islands Archaeology.

1. INTRODUCTION

The dietary analysis of mummies has long been dependent on the recovery of preserved coprolites from the digestive tract. It is however, relatively uncommon to discover coprolites in the intestine. More commonly, mummies contain loops of bowel that have no distinct coprolites in them. The analysis of this mummy was the first attempt to extract dietary residues from preserved intestine that contains no obvious fecal remains. Because of the success of this method, the methods applied to the El Chorrillo mummy have become standard for archaeological and forensic sciences (Reinhard *et al*. 2017, 2018).

The analysis of the El Chorrillo Mummy from the Canary Islands, Spain, provided us with the opportunity to explore the potential of intestinal samples in providing evidence of dietary remains Two small segments of intestine were analyzed. This analysis shows that microfossils and macrofossils can be recovered from the internal intestinal mucosa and reveal aspects of diet and environment.

The mummy of El Chorrillo belongs to the Guanche Culture, an indigenous culture of Tenerife (Canary Islands) (Fig.1), which developed from the first millennium BC until the fifteenth century, when the Archipelago was incorporated into the Crown of Castilla.

It is a male between 20-25 years and 1.71m in height (Aufderheide *et al*. 1995: 122). It belongs to the old anthropological collection, from the late nineteenth century or early twentieth, which was formed in the *Gabinete Científico* of Santa Cruz de Tenerife and registered as "extremidades inferiores de guanche encontradas en El Chorrillo por D. Agustín Otazo y D. Camilo Delgado". Later he moved to

Fig. 1. Geographical location of Canary Islands and Tenerife (1) and El Barranco de El Chorrillo (Northeast of Tenerife).

the *Museo Municipal de Santa Cruz de Tenerife*, then to the *Museo Arqueológico de Tenerife* and today to the *Museo de Naturaleza y Arqueología* (MUNA) (Ref. MNH-M4, El Chorrillo) (Fig.2.1).

The body is dated by C14 (muscle tissue) in the *Cronos Project* (Aufderheide *et al*. 1995:122), with the result: GX-15940: 675±125 BP and Cal. 2 σ 1117-1453 AD (1307 AD) (Reimer *et al.* 2009) and consists of a vertebral column, pelvis and lower extremities (femurs, tibia and fibula rights), mummified viscera, lumbar vertebrae in anatomical position, soft tissues on the pelvis; it has approximately 50 cm of small intestine and lacks anterior abdominal wall. The pudendal area is covered with skin and has a penis (13 cm L x 2,5 cm W x 1 cm Thk). The legs are crossed, the left under the right, and preserves mummified tissue in the kneecaps.

Fig. 2. The mummy of El Chorrillo and sampling area (© M.C. Del-Arco).

2. MATERIALS AND METHODS

The mummy was sampled (Fig. 2.2) in the MUNA of Tenerife in conditions of asepsis and avoiding its contamination. Later it was sent to Lincoln to proceed for this study.

The intestinal sections measured approximately three cm long and consisted of intact intestinal cross sections. Dust was collected from each specimen bag. Each section was cut in half and one half of each was retained for future analysis. Therefore, smaller segments measuring about 1,5 cm each were analyzed. Then the intestine sections were moved to petri plates and rehydrated in 0,5% trisodium phosphate. The samples increased dramatically in size and regained the appearance and resilience of nearly fresh intestine samples.

Once completely rehydrated, the intestine sections were cut open along the longest dimension and the samples were unrolled. The interior of each sample was scraped and the resulting residue was placed in centrifuge tubes. Then, the exterior of each intestinal sample was scraped and the resulting residue was placed in separate centrifuge tubes. Therefore, for analysis, two samples of residue were recovered from each intestine segment: one consisting of residue originally from the inside of the intestine and one from material from the outside of the intestine. Thus, a total of four samples of residue were analyzed. The intestine interior samples were labeled C and D and the intestine exterior samples were labeled A and B. Sample A is from the external surface of intestinal segment 1. Sample C is from the internal surface of intestinal segment 1. Sample B is from the external surface of intestinal segment 2. Sample D is from the internal surface of intestinal segment 2.

The sediment samples were screened for macroscopic residues. Then the microscopic residues were centrifuged and measured volumetrically. To each centrifuge tube, two *Lycopodium* spore tablets were added. The *Lycopodium* spore tablets serve several functions. They can be used for quantifiying the number of microfossils per volumetric or weight unit. They also serve as indicators of the efficiency of chemical treatment. Finally, for samples with very small pollen yields, they help maintain a plug of material in the centrifuge tube.

The sediment samples were then treated with 40% hydrofluoric acid in a hot water bath to dissolve silicates. After the hydrofluoric acid, they were then treated with hot acetolysis solution (8 parts acetic anhydride to 1 part sulfuric acid). The acetolysis solution dissolved cellulose and some chitin. The residues were then examined with a compound microscope at 400 power.

3. RESULTS

The intestinal samples turned the rehydration fluid a black opaque color. This is considered consistent with the reaction of fecal material.

During the chemical processing, significant differences were noted between the intestine interior and intestine exterior sediments. The interior sediments retained the black opaque color noted above in rehydration fluid. The exterior sediments caused the rehydration fluid to turn a transparent yellow color. The difference between the coloration indicates that the interior sediments were derived from feces, but not the exterior sediments.

The volume of the sediment samples differed. The interior sediments consisted of 7 mls of centrifuged material. The exterior sediment samples contained only 4 mls of sediment. After the hydrofluoric acid treatment, the interior samples still had 3 mls of sediment, but the external sediments were almost completely dissolved, leaving only a small film of material on the bottom of the centrifuge tubes. This indicates that the sediments scraped from the outside of the intestine were almost completely composed of fine sand. This is consistent with visual examination of the sediments before analysis. The external sediments were composed of sand and the internal sediments were more organic in their composition.

After acetolysis, there was no change in the external sediments. However, the internal sediments were reduced to 1 ml of material for each sample. This indicates that the majority of the internal sediment was from dietary residue (Table I). The extraction shows that nearly 100% of the sediment from the external surfaces was composed of silica. In contrast, 43% of the material from the interior of the

Table I

Samples	A	B	C	D
Before HF	4 mls	4 mls	7 mls	7 mls
After HF	0 ml	0 ml	4 mls	4 mls
After Acetolysis	0 ml	0 ml	1 ml	1 ml

Sample A: external surface of intestinal segment 1
Sample B: external surface of intestinal segment 2
Sample C: internal surface of intestinal segment 1
Sample D: internal surface of intestinal segment 2
HF= Hydrofluoric Acid

intestine segments was composed of silica, another 43% composed of cellulose, and 12% consisted of resistant residues such as pollen, starch, and charcoal.

Pollen counts show a profound difference in pollen abundance between the intestine interior (samples C and D) and the intestine exterior samples (samples A and B). The interior of the intestine contained an abundance of pollen from many different taxa. The exterior of the intestine contained almost no pollen (Table II).

Table II. Pollen

Samples	A	B	C	D
Lycopodium	193	110	365	486
Apiaceae	0	0	1	0
Asteraceae, High Spine	0	0	1	1
Asteraceae, Low Spine	0	0	0	1
Asteraceae, Ligulaflorae	0	0	1	0
Myricaceae	0	0	2	1
Brassicaceae	0	0	1	0
Cheno Am, degraded	0	0	0	1
Echinate type, degraded	0	0	0	1
Ephedra	0	0	1	0
Ericaceae	3	2	46	77
Fabaceae	0	0	2	1
Monocolpate	0	0	0	1
Syncolpate tipe 20µm	0	0	1	0
Pinus	0	1	13	12
Pinus fragments	0	0	8	3
Plantaginaceae	0	0	0	1
Poaceae, cultivated	0	0	0	3
Poaceae, wild	0	0	3	8
Primulaceae	0	0	1	0
Cf. *Quercus*, degraded	0	0	0	1
Rubiaceae	0	0	1	1
Unidentifiable	0	0	16	17
Unknown	0	0	5	7

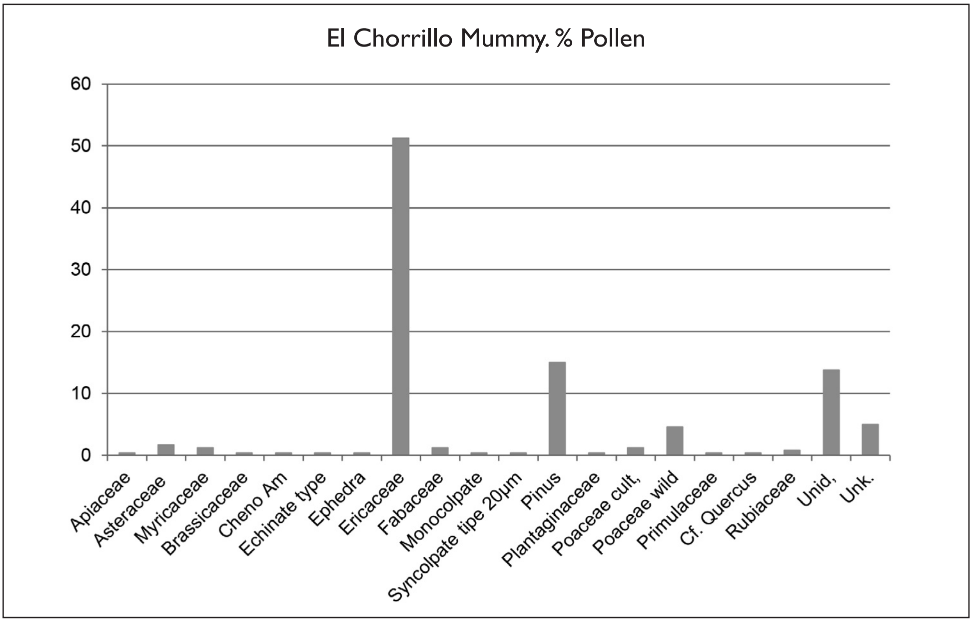
Pollen counts from samples. 240 pollen grains were counted from the intestine interior samples (C & D)

The pollen comes from a variety of plants. Importantly, of 240 pollen grains counted from the interior intestine samples (Graph. I), 123 come from the Ericaceae family, (46 from sample C and 77 from sample D). Therefore, 51% of the pollen from the intestinal tract is Ericaceae pollen. Other pollen types of interest are environmental types such as *Pinus*, Poaceae (grass family) and Myricaceae. Also, Poaceae pollen of very large size (exceeding 70 µm in diameter) were encountered. These are consistent with cultivated grass such as wheat.

Starch was present in the internal samples. Both internal intestinal samples contained starch granules. These were absent in the external samples.

One *Ascaris lumbricoides* egg was found in sample D (Table III).

Macroscopic remains were also found inside the intestine sections (Table IV). One grass caryopsis was found. This is not from a cultivated species of grass. The caryopsis is partly digested, but even in this condition it is obvious that it is too small to be from a cultivated grain. Several joints were found in both samples. These range in size from 2 to 4 cms. After extensive examination, it was determined that these were not of plant origin. It is possible that they are sections from fish fin rays. However, I think that it is more possible that they are from crustaceans.



Graph. I. El Chorrillo Mummy. Representation of observed pollens.

Table III. Other microfossils and parasites

Samples	A	B	C	D
Ascaris lumbricoides	0	0	0	1
Starch	0	0	14	24
Charcoal	0	0	0	1

Table IV. Macrofossils found in samples

Samples	A	B	C	D
Grass Caryopsis	0	0	0	1
Cf. Crustacean Joints	0	0	3	7

DISCUSSION

The analysis shows that the material recovered from the inside of the intestine has a different chemical origin then the material from the intestine exterior. The intestine interior is composed of a greater percentage of cellulose, insoluble starch, and pollen. The exterior surface was covered with sand. This indicates that the internal surface had food residue. Most of the food was derived from plants as indicated by the presence of a large proportion of cellulose.

The origin of the plant food was determined by the examination of microfossils and macrofossils. In this case, several dietary components can be identified from the intestine (Table 5). In a general sense, the food comes from three sources, wild plants, cultivated plants, and marine animals, probably crustaceans. Thus, the intestinal segments reveal diverse sources of food eaten before death.

Table V. Dietary elements identified from different categories of residue

Residue Type	Dietary Elements Recovered
Pollen	1. Ericaceae foliage or flowers 2. Cultivated Grain
Starch	Roots or Seeds
Macrofossils	1. Wild Grass 2. Cf. Crustacea

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The fact that the pollen, starch, seed, and other dietary residues were recovered from the inside of the intestine and not from the external surface shows that the residues were within the intestinal lumen and not contaminants from the mummification process. This is very important with regard to the Ericaceae pollen. This is an unusual dietary item and its presence might by explainable as a result of contamination of the intestinal cavity during the process of mummification. However, its abundance in the intestinal lumen indicates that it was actually eaten. If the pollen can eventually be identified to genus, it may be possible to infer whether it was a food or a medicine. Its presence does not suggest that the individual ate the pollen from the plant. The pollen could have been consumed with buds, flowers, or foliage of heath plants.

To evaluate the role that plant resources had among the indigenous community (Del-Arco, 1993) we used archaeological evidence, which we already know shows minimal signal in the archaeological record when it has been ingested in its fresh state or with boiled preparations. Also, the accounts of the ethnohistorical and ethnographic sources contribute to show a wider panorama of the use of these resources.

In the popular tradition of the Canary Islands, all identified plant groups have a wide range of therapeutic applications (analgesic, antiasthmatic, antispasmodic, anti-inflammatory, carminative, emmenagogue, stomach related, febrifuge, pectoral, vermifuge ...), having as an active part in many cases the flowers, nectar, the stem or the whole plant, and its mode of consumption varies (infusion, decoction, tisane or fresh) (Pérez & Hernández 1999; Rodríguez & Casariego 1998).

On the contrary, according to the information provided by the mentioned sources (Del-Arco 1993; Del-Arco *et al.* 1990, 2000), the identifications made in our study show that the groups with edible taxa reach 33.33%.

Of these, among the Ericaceae (51,25% of registered pollens) is *Arbutus canariensis* Veill., mentioned in ethnohistorical sources in Tenerife (Viana 1604; Núñez-de-la-Peña 1676) and in Gran Canaria (Cedeño XVII, Gomez-Scudero XVII).

In the case of *Pinus* (15%), in addition to the testimony of the old stories that speak of the consumption of pine nuts in Gran Canaria (Cedeño XVII, Marín-de-Cubas 1687), the archaeology has also revealed through the analysis of the intestinal content (Mathiesen, 1960) of a mummy (Roque Blanco, Tenerife) that this individual had ingested pine nuts (*Pinus canariensis*) and a flour composed of cereals and different types of ferns (*Pteridium aquilinum, Pteris arguta -Pteris incompleta- y Pteris longifolia -Pteris vitata*).

Among the Poaceae, the cultivated (1,25%) such as *Triticum aestivum aestivo compactum* Schiem and *Hordeum vulgare* L. *polystichum* well identified by archaeology (Del-Arco. 1993; Del-Arco *et al.* 1990, 2000) and, among the wild (4,58%), they could be consumed *Avena canariensis* Baum, Rajh. & Sam., *A. sativa* L., *Hordeum murinum* L.

The Fabaceae (1,25%), in addition to the cultivated (*Vicia faba* L., *Pisum sativum* L., *Lens culinaris* Medic.), among the wild ones are *Cicer canariense*, *Lathyrus sativus* L., *L. odoratus* L. y *L. tingitanus* L.

Among the Myricaceae (1,25%), Myrica faya Ait. It is recognized as edible by the use of its fruits, the creces both fresh and in flour. In this case the testimonies are of ethnographic origin and of little value in the old stories of Tenerife (Viana1604) and El Hierro (Abreu 1602).

Finally, among Apiaceae (0,41%) is *Astydamia latifolia* (L.f.) Baillon, also edible according to traditional uses.

The spectrum provided by this pollen record, with a majority of wild taxa compared to the cultivated ones, seems to indicate that the diet included a greater number of plants than those recorded up to now by archaeology, without forgetting that a part of these residues could correspond to a therapeutic preparation.

On the contrary, the consumption of crustaceans is well known in archaeology, so their identification in this analysis confirms a diet on varied resources of the territory.

The most significant aspect of this study is the discovery of food remains inside of the intestine. Prior to our study, no analysis of mummified intestine unassociated with coprolites, has revealed dietary habits.

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