In Search of Ancient Maya Foods: A Paleoethnobotany Study from a Non-elite Context in Sihó, Yucatán

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Abstract Feeding oneself and one's community is a fundamental activity encompassing various stages, including the acquisition, transformation, and eventual consumption of plants and animals. These steps carry social implications that incorporate identity, gender roles, labor division, worldview, and status differentiation, among other facets of cultural practices. In the Northern Maya Lowlands, paleoethnobotanical research has shed light on past plant consumption, expanding our understanding of ancient Maya dietary habits. Nonetheless, our knowledge of the dishes and plants consumed by non-elites remains limited, as the epigraphic and iconographic records primarily document the preferences of elites. This study focuses on identifying the plants exploited by residents of two lower social status domestic groups at the archaeological site of Sihó, Yucatán, Mexico during the Late-Terminal Classic period. By analyzing starch grains extracted from soil samples, we were able to identify staple crops like maize (*Zea mays*) and beans (*Phaseolus* spp.). Additionally, we identified the presence of plants less commonly represented in the archaeological record, including arrowroot (*Maranta arundinacea*) and tentatively Mexican yam (*Pachirhyzus* spp.). This research contributes to the study and identification of starch grains and provides valuable insights into agricultural and food-related practices within non-elite Maya households.

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Introduction

Food and cooking practices offer captivating insights into meaning-making, both in the past and the present. Archaeologists have employed diverse methodologies to unravel the intricacies of ancient Maya food procurement, including of animals and various plant species (Emery and Thornton 2008; Farahani et al. 2017). The archaeology of food practices has focused on understanding the specific techniques employed to transform raw plants into widely consumed and historically significant dishes (Ardren 2020). These investigations have revealed how food carries meaning and social significance, and have highlighted the role of agency at each culinary stage, from procurement to the presentation of food on the table (Staller and Carrasco 2010). As a result, food research has greatly enhanced our understanding of past human lifeways. Diverse inquiries have delved into various aspects, including social inequality (Cuéllar 2013), gastro-politics (Appadurai 1981), food preferences (Smith 2006), as well as identity, rituals, and feasts (Hastorf 2016), providing captivating insights into the broader context of food-related practices.

Through approaches rooted in paleoethnobotany, researchers have been able to recover valuable information about plants that were consumed in the past (e.g. Morell-Hart et al. 2022). These studies have shed light on the cooking processes and ingredient combinations used to create specific dishes (e.g. Cagnato 2019). In the Maya Area, most of our knowledge about food practices stems from records associated with elite contexts, such as text and images on finely decorated pottery and murals (Beliaev et al. 2010; García Barrios 2017), often neglecting the domestic contexts that pertained to non-elites. As such, there is a need to expand our understanding by examining food practices in non-elite settings as well.

It is important to note that commoners constituted a significant majority, representing more than eighty percent of the ancient Maya population (Lohse and Valdez 2004). More recently in the trajectory of Maya archaeology, there has been increasing interest in investigating the lifestyles of commoners, aiming to gain insights into the other side of pre-Columbian Maya society (Robin 2013). These investigations have encompassed various topics across different archaeological disciplines, including paleoethnobotany (Goldstein and Hageman 2010). Despite the progress made in understanding daily practices, there are still gaps that require further exploration, such as variation in plants cultivated and culinary preferences between regions. In light of these considerations, this paper documents the paleoethnobotanical analysis of recovered starch grains from the Classic Maya site of Sihó, Yucatán, Mexico, and discusses food preferences and practices within two domestic groups belonging to the non-elite strata.

Plant consumption among the ancient Mayas

The ancient Maya people made extensive use of a wide range of plants and agricultural techniques to sustain themselves and to create diverse dishes (Fedick et al. 2023; Morell-Hart et al. 2022). Early ethnohistorical records documented by friars, *encomenderos,* and other agents of Spanish colonialism provide valuable insights into Maya people's dietary habits and emphasize the variety of plant foods they consumed. Bishop Diego de Landa's work, *"La Relación de las Cosas de Yucatán"* (1985 [1566]), describes Maya traditions and customs related to agriculture, flora, fauna, and foods. Landa described varieties of maize, which differed in size and color, as well as beans, chile peppers, and squash, all of which continue to be staple crops in most parts of the Yucatan peninsula. Additionally, Landa highlights several lesser-known species consumed by the Maya, including a wide variety of sweet potatoes (*Ipomea batatas*) and *ciruelas* (*Spondias purpurea*), as well as sapodilla (*Manilkara zapota*), avocado (*Persea Americana*), dragon fruit (*Hylocereus undatus*), and Mexican yam (*Pachyrhizus erosus*) (de Landa 1985:172–175 [1566]). In addition to the aforementioned, Landa also notes that the Maya utilized many other species, such as palm fruits (Arecaceae), ramon seeds (*Brosimum alicastrum*), and various roots as "famine food[s]" during "times of scarcity" (de Landa 1985:172 [1566]). Early archives, such as the *Relaciones histórico-geográficas de la gobernación de Yucatán,* further substantiate the prevalence of numerous plants as primary food sources for the ancient Mayas. These documents reaffirm colonial period consumption of fruits and vegetables such as sapodilla, avocado, and squash, along with species from the Annonaceae family such as sugar apple (*Annona squamosa*) and cacao (*Theobroma cacao*; de la Garza et al. 1983:77). Such descriptions have contributed to our understanding of the extensive repertoire of plants consumed by the Maya at the time of Spanish colonization, which in turn can illuminate what people might have been eating in more ancient times.

Archaeological evidence for various types of plant tissues has been recovered and analyzed using paleoethnobotanical methods. These include macroremains, charcoal, phytoliths (Watson et al. 2022), pollen (León 2016), and more recently, the recovery of starch grain from floors and ceramics (Novelo-Pérez et al. 2019; Zimmermann 2019). These different sources of data have demonstrated the presence of staple plants such as maize, beans, squash, and chile peppers, indicating their continuous utilization over time. Paleoethnobotanical research has also brought to light the exploitation of a more diverse range of vegetables, fruits, seeds, roots, and other plant tissues by the ancient Maya (Fedick et al. 2023; Morell-Hart et al. 2022).

Despite the available information on a wide variety of plants and their potential use in Maya cuisine, our knowledge of the common daily practices associated with food in non-elite domestic groups is still limited. Recently, there has been a growing number of paleoethnobotanical investigations that examine food practices and ingredients utilized within domestic contexts (Fedick et al. 2023; Morell-Hart et al. 2022; Novelo-Pérez et al. 2019; Watson et al. 2022; Zimmermann 2019). This paper aims to contribute to the existing body of knowledge by exploring the diverse spectrum of Maya food practices among non-elites.

Methods

Study location

Sihó is a Maya site located in the northwestern portion of Mexico's Yucatan Peninsula (Figure 1). Archaeological fieldwork at the site was initially conducted in 2001 and 2003, and more recent investigations were carried out in 2013, 2015, and 2017 (Cobos Palma et al. 2004; Fernández-Souza et al. 2016). Site chronology was established based on ceramic analysis from excavations in elite groups encompassing elevated platforms and palatial and domestic structures. Occupation of the site spanned from the Middle-Late Preclassic period (c. 600/500-200/100 BCE), through the Early Classic (c. 250 BCE -600 CE), Late Classic (c. 550/600-750/800 CE), and Terminal Classic periods (c. 800-1000/1100 CE), with the latter two periods representing the main phases of occupation.

Archaeological evidence recovered at the site has contributed to an understanding of the settlement's complexity. The data have revealed a graded stratification, which is reflected in the architecture as well as variations in access to resources, including obsidian, greenstone, and certain types of fauna (Cobos Palma et al. 2004). This evidence has enabled Jiménez and colleagues (2017) to propose the existence of at least four social strata, ranging from the "royal and secondary elites" residing in the palaces, to domestic groups of middle, middle-low, and low status people who inhabited perishable constructions.

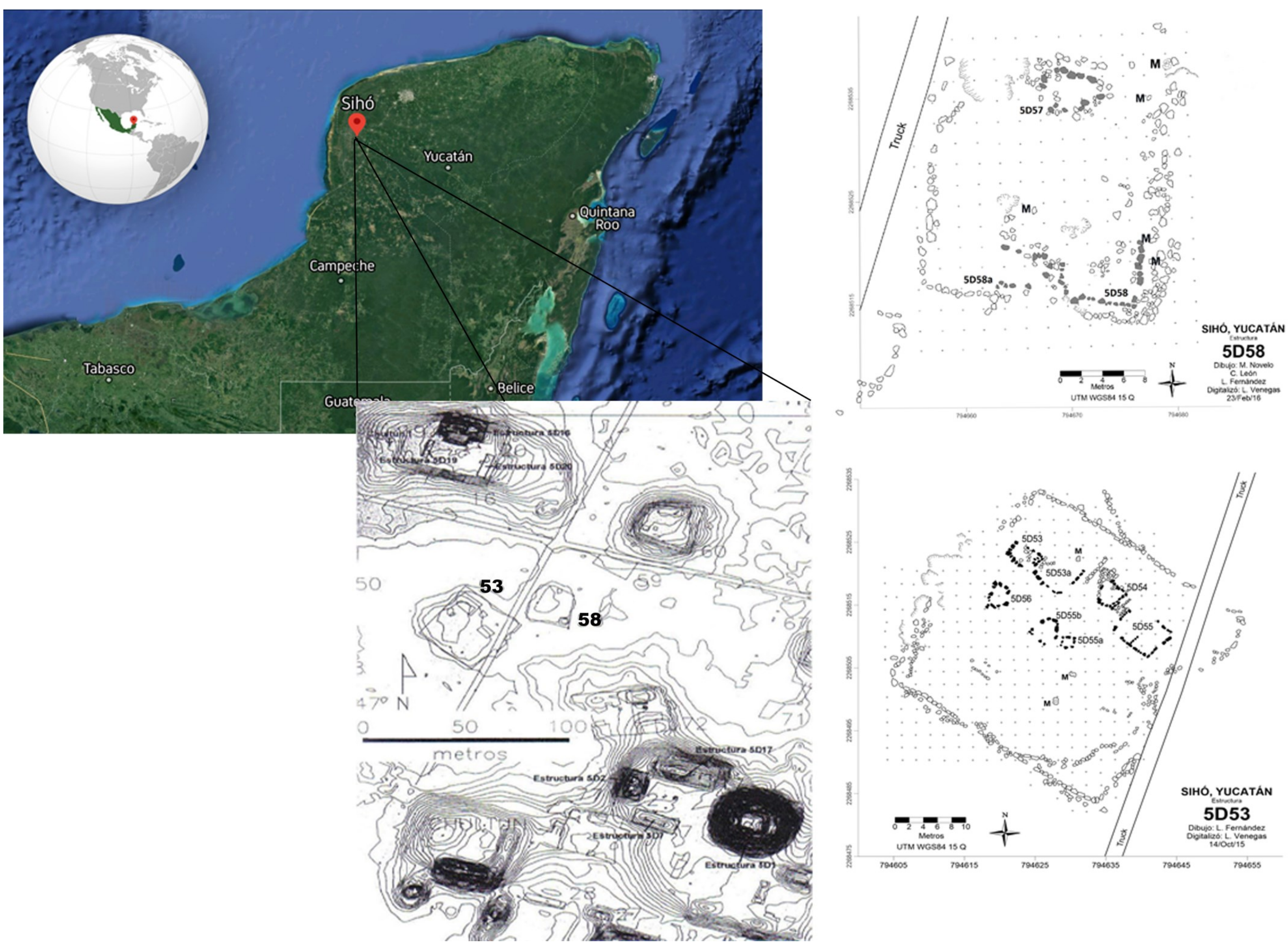

Figure 1 The location of Sihó in the Maya area, the map of the central site with the main groups, and the structures studied in this research. Map based on Google Earth, Cobos et al. 2004, and Fernández-Souza et al. 2016.

The present study focuses on the recovery of starch grains from soils associated with two middle-low domestic groups situated in the central area of the archaeological site. The first group, Group 5D53 (Figure 1), comprises a rectangular platform with seven foundations of various shapes atop its northern sector, indicating the presence of modest perishable houses (Fernández-Souza et al. 2016). In contrast, Group 5D58, located a few meters east of Group 5D53, is smaller in size (Figure 1). Group 5D58 consists of a quadrangular platform supporting three foundations, with two located in the south and one in the north (Fernández-Souza et al. 2016). The occupants of these structures likely played an essential role within the community, given their proximity to the elite groups. While previous research has investigated plant consumption in the elite and middle -status groups (Novelo-Pérez et al. 2019), identifying plants in low-status groups has yet to be done and contributes to our understanding of the complexity of food practices among different social strata at the site.

Data collection: Fieldwork and Sample Recovery

In 2015, excavations were carried out at Groups 5D53 and 5D58 to investigate artifactual assemblages, periods of occupation, associated architectonic features, and the recuperation of soils samples in order to understand day-to-day activities through chemical and paleoethnobotanical approaches. Both structures were systematically gridded at a size of 2x2m to ensure controlled spatial analysis and collection of artifacts. Horizontal excavations of the foundations of some structures were conducted to determine their dimensions, shapes, and extent. Furthermore, test pits were excavated to establish the construction and ceramic sequence associated with the platforms.

Samples were collected from a small area at the eastern corner of each unit, aiming to reach the same occupation level as evidenced by vertical and horizontal excavations. Soil samples were collected using a clean plastic spoon and placed into individual clean plastic bags. To prevent contamination, a different plastic spoon was used for each sample. These samples were carefully marked, labeled, and transported to the Laboratorio de Análisis Químicos y Microscópicos at the Facultad de Antropología of the Universidad Autónoma de Yucatán, in Mérida, Mexico. In order to narrow down contexts more likely to contain fruitful data, each collected sample underwent spot test analysis to obtain semiquantitative levels of phosphates, carbonates, pH, fatty acids, protein residues, and carbohydrates (Barba 2007). This initial step aimed to identify enriched areas, which can be indicative of spaces where food-related activities likely took place (see Herrera-Parra 2021). Previous research has suggested a correlation between high carbohydrate values and a significant presence of paleoethnobotanical material (Zimmermann and Matos Llanes 2015). However, other indicators, such as phosphates and protein residues, were considered in this study due to the combination of the results helps in a better comprehension of the uses of domestic spaces. Finally, specific areas associated with food-related activities, such as grinding, discarding, or processing of foods were selected as the most probable locations where plants would have been handled. This screening process based on soil chemistry and archaeological context resulted in a sample size of sixteen for starch grain recovery and identification. To establish a comparison between possible starch grains from modern milpa cultivation (open spaces) and those originating from pre-Hispanic occupation floors, control samples taken from the open areas surrounding the archaeological platforms also underwent analysis.

Laboratory Analysis: Starch Grain Recovery and Identification

In the laboratory, we followed a modified version of the starch grain recovery methodology originally proposed by Therin and Lentfer (2006) and further adapted by Pagan-Jiménez (2005). The application of Pagan's methodology has proven to yield positive results in various contexts, enabling the extraction of starches from different substrates and materials (Novelo-Pérez et al. 2019; Venegas Durán et al. 2021). The methodology involves separating the starch grains from the matrix in which they are embedded in, this case, the soil:

1. Approximately 1.2 g of soil sample was transferred to a centrifuge tube.
2. A mixture of water and cesium chloride (CsCl) with a density of 1.79 g/cm^3, ranging between 0.5 and 1 ml, was added.
3. The vials were covered and vigorously shaken until a homogeneous mixture was achieved.
4. The mixture was centrifuged at 2500 revolutions per minute (rpm) for 15 minutes.
5. The floating fraction, which consisted of particles with lower density (<1.79g/cm^3) including starch grains, was carefully collected with a sterilized

pipette. The collected fraction was transferred to a new set of vials, each appropriately labeled to distinguish between samples.

6. Approximately 0.5 to 1 ml of water was added to the new vials containing the low-density floating fraction. The samples were shaken and placed in the centrifuge again, ensuring a balanced arrangement.
7. The samples were centrifuged at 3200 rpm for 20 minutes.
8. In this stage, due to the density difference between the cesium chloride (1.5-1.79g/cm^3) and the water (1 g/cm^3), starches should have sunk. Excess water was pipetted and discarded without disturbing the sediment at the bottom of the vials.
9. Steps six, seven, and eight were repeated at least three more times, gradually adding less water in each subsequent step.
10. The final concentrated sample at the bottom of each vial was collected using a micropipette with disposable sterile tips.
11. Each sample was placed on a sterile slide, and a drop of glycerol was added. The mixture was then carefully mixed with a clean toothpick. Subsequently, a cover slip was placed on the slide, and the edges were sealed with transparent nail polish to secure it.
12. Finally, the samples were observed under a microscope for analysis.

The final prepared samples were examined using a metallurgical microscope with polarizing light at 20x and 40x magnifications. Starch grain identification was conducted based on morphological features described by Torrence and Barton (2006). Reference catalogs, such as the one made by Pagán-Jiménez (2015), were consulted to aid in identification. Additionally, a small reference collection of staple plants including maize, sweet potatoes, beans, among others, was assembled to facilitate comparisons with regional species. During the preparation and observation of the archaeological samples, strict measures were taken to maintain a sterile environment. Sterile gloves were worn, and clean spaces were utilized to minimize the risk of cross-contamination. After the preparation of the reference collection, all surfaces and equipment were thoroughly cleaned. Additionally, precautionary measures, such as observations of common materials under the microscope, were taken to ensure that substances such as glycerol, water, and slides did not contain any starch grains, thus avoiding any potential interference.

Results

A total of 16 samples underwent starch extraction, and only 10 out of 16 samples presented starches after processing (Table 1). Seven species were identified or showed morphologies related to known plants. The main plant species among the samples was maize (*Zea mays*), present in 9 out of 16, samples which aligns to previous known information about the consumption of maize given its culinary and cultural significance during the Late and Terminal Classic periods. From this group of maize samples, 6 out of 9 presented starches with damage resulting from cooking processes such as toasting, boiling, and grinding (Figure 2). The second plant found in relative abundance was sweet potato (*Ipomea batatas*), found in 7 samples; followed by beans (*Phaseolus* spp.) from one sample. Other species that have received minimal documentation in the archaeological record were also identified. These include Mexican yam or *jicama* (*Pachirhyzus* spp.). Starch grains of this species exhibit a combination of morphologies resembling those of tubers such as sweet potato and cassava. These include irregular and simple starch grains, truncated and pentagonal shapes, an open and centric hilum, uncommon presence of fissures, and the presence on starch grains larger than 10 μm; the extinction cross is primarily centric in most cases. A starch grain similar to *jicama* (*Pachirhyzus* spp.) was present in one sample. Arrowroot (*Maranta* spp.) and other Marantaceae starch grains exhibit single and triangular shapes, although elongate triangular shapes with obtuse angles are also commonly observed. The hilum is typically open and eccentric, and the lamellae is distinguishable by concentric rings. Occasionally, fissures can be found, and the cross of extinction tends to be eccentric. Two samples yielded evidence of arrowroot. A single starch grain likely belonging to Cucurbitaceae (*Cucurbita* spp.) was found in one sample. Squash grains have tubular-shaped forms, with an eccentric hilum and a single pressure facet. Lastly, manioc (*Manioc esculenta*) was recorded in one sample. Morphologies related to these species are characterized by a compound bell-shaped grain, eccentric hilum, a y-shaped fissure, smooth surfaces, no lamellae, and two pressure facets.

Two morphotypes were identified among starches with similar morphological traits. Morphotype 1 was present in 4 samples; these presented features similar

Table 1 Starch ubiquity from the processed samples.

	Structure 5D53										Structure 5D58					Ubiquity
Taxa	D4[1]	D8	H14	H16	J18	N7	N10	N14	N16	N20	P14	E4	E9	F3	G3	L4	(Total=16)
Maize (*Zea mays*)	3	2*	-	-	17*	8*	7*	9	-	-	2	-	-	10*	-	7*	9
Sweet potato (*Ipomea batatas*)	-	1	-	-	1	-	5	3	-	2	-	-	-	1	-	1	7
cf. Mexican yam/*Jicama* (*Pachyrhizus* spp.)	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1
Beans (*Phaseolus* spp.)	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1
Manioc (*Manihot esculenta*)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
cf. Arrowroot (*Maranta arundinacea* L.)	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	2
cf. Squash (*Cucurbita* spp.)	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Morphotype 1	-	1	-	-	-	1	-	1	-	3	-	-	-	-	-	-	4
Morphotype 2	-	-	-	-	-	1	1	-	-	-	1	-	-	-	-	-	3
Unknown	1	2	-	-	-	4	2*	3	-	3*	5*	-	-	-	-	-	7
Damaged	-	1	-	-	13	7	3	-	-	2	2	-	-	2	-	3	8

[1]Grid legend from the sample taken.
*Presence of starches with morphological damages.

to tuber starches in manioc species (Figure 2, o-q). Morphotype 2, on the other hand, was found in three samples. Traits of Morphotype 2 were characterized by an oval starch shape with a transversal fissure reaching one of the edges. The edges are not regular due to cracks that appear without touching the starch's hilum (Figure 2, r-t).

Finally, unknown starches exhibiting morphologies that have not yet been attributed to a particular taxon, were found in 7 out of 16 samples, while starch grains with damage in their structure due to culinary processes were recorded in 8 out of 16 samples. Morphological damages indicated specific culinary processes such as grinding, roasting, and boiling as demonstrated through experimental archaeology (Babot 2003; Babot et al. 2014; Henry et al. 2009).

Discussion

As was expected, maize stood out as the staple crop highly exploited in the past by the ancient inhabitants of Sihó. Maize is still a principal source of nourishment among traditional communities and a central ingredient in daily meals. In the past, maize was essential in Maya society as a personified divinity and staple food. Information about foods recorded in diverse contexts, such as *tamales, atoles,* or different maize-based dishes, demonstrates the wide range of maize uses in Classic times both for elites and commoners (Taube 1989). The versatile use of maize can be inferred from the starches with damage in their structure; at least three types of damage were recognized in the starches that suggested maize had been ground, toasted, and/or boiled (Figure 2, j-n). These three methods of processing could hint at the variety of ways maize was transformed into nourishing meals.

Conversely, the recording of sweet potatoes in archaeological samples has increased during recent years, which suggest that this plant species played an important role for Maya people in pre-Hispanic times (Morell-Hart et al. 2022; Novelo-Pérez et al. 2019; Trabanino and Meléndez Guadarrama 2016). Today, there are records of sweet potato consumption among the Mayan-speaking people, but in less quantity than

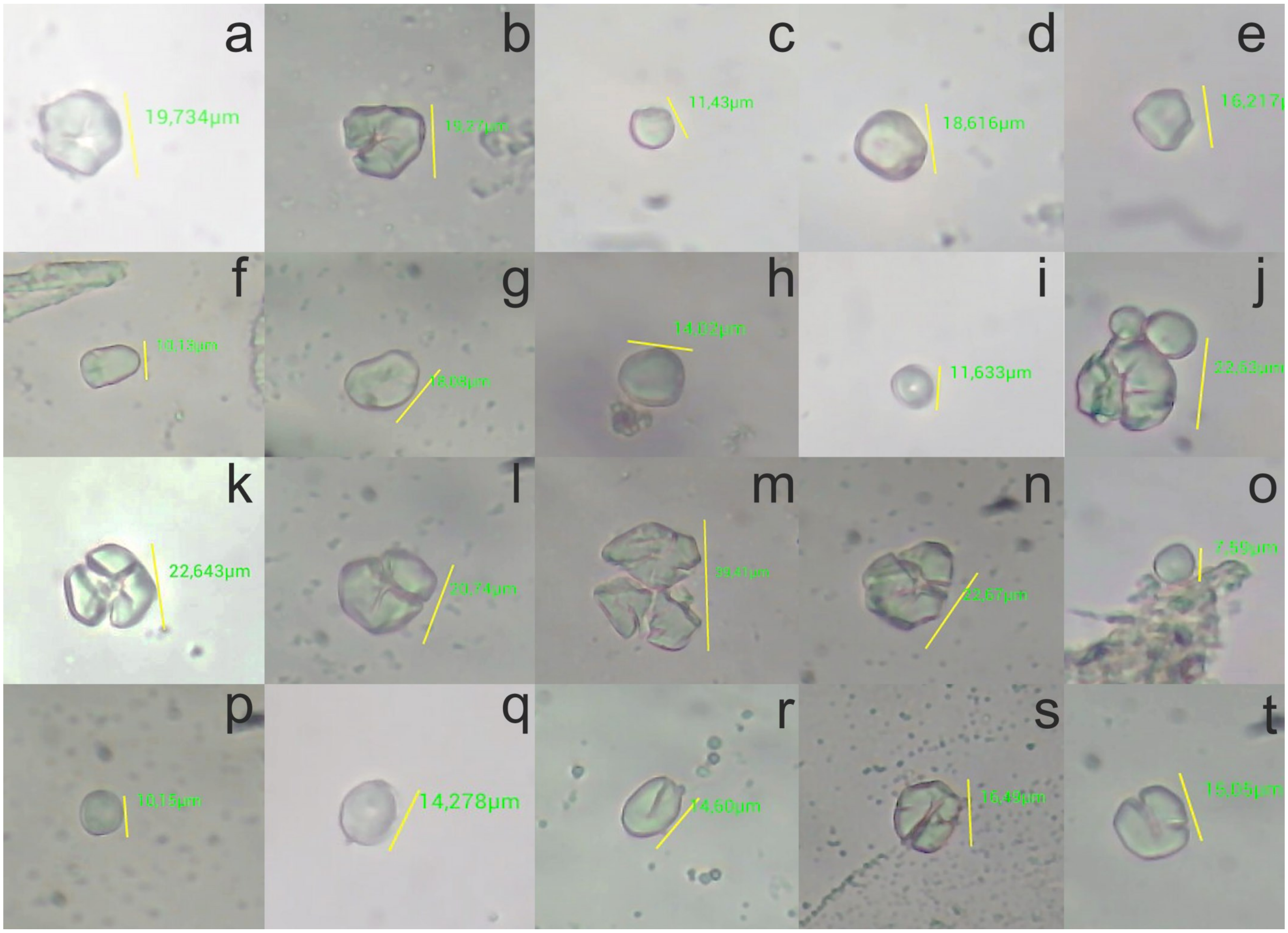

Figure 2 Starches identified in soils from structures 5D53 and 5D58 at Sihó, Yucatán. a) and b) maize (*Zea mays*); c) manioc (*Manihot esculenta*); d) and e) sweet potato (*Ipomea batatas*); f) squash (cf. *Cucurbita* spp.); g) beans (*Phaseolus* spp.); h) arrowroot (*Maranta arundinacea*); i) *jicama* (cf. *Pachyrhizu*s spp.); j) - n) starch grains with damage because of culinary processes; o) - q) Morphotype 1; r) - t) Morphotype 2. Photos by the author.

other plants or in side dishes such as desserts (Meléndez Guadarrama and Hirose López 2018). This plant seems to have played a more critical role in the ancient Maya diet than it does on the Peninsula at present. Landa (1985:172) mentions in his *relación*: "the other root that grows under the soil sowing it, it's bigger, with wide varieties, there are purple, yellow, and white ones, it can be eaten, cooked, and roasted, and they are good food…;" which demonstrates the diversity of sweet potato preparation and consumption by the Mayas in the sixteenth century.

In addition to the relative abundance of maize and sweet potatoes, the presence of other plants that have not been well documented in the archaeological record among middle-strata domestic groups sheds light into the diversity of species cultivated and consumed by Maya people. Landa mentions the consumption of Mexican yam or *jicama* in his writing: "they—the Mayas—have a wonderful, fresh, and tasty fruit that they sow, and the fruit is a root that rises as a fat and round turnip: it is eaten raw and with salt" (de Landa 1985:172). This vegetable is poorly known among the repertoire of plants consumed in the past and nowadays is generally consumed as a snack with lemon and chili pepper.

In this set of samples, beans were weakly represented in contrast with previous elite and middle -strata contexts analyzed at Sihó (Matos Llanes 2014:123; Novelo-Pérez et al. 2019). In high-status contexts, the presence of beans reached 50% of presence as noted by Novelo and colleagues (2019:92), while in the set of samples included in this study, starch grains with morphologies similar to beans were found only in only one sample. In contrast to the Mexican yam, diverse variety of beans were cultivated in the past, from which at least two species have been reported—*Phaseolus vulgaris* and *Phaseolus lunatus*. The seeming disparity in consumption of this crop among the domestic groups from structures 5D53 and 5D58 versus other contexts at Sihó could have many explanations, such as food identity, culinary preferences, or supply restrictions by the site's elites. This scenario has been proposed by Fernández and others (2020:211) and demonstrated through the evidence of differential access to meat consumption, and culinary equipment such as grinding stones, obsidian blades, and pottery containers.

Manioc is another crop found in low quantities among the samples. The presence of manioc starch grains in other contexts at the site seems to be at similar low levels, including at elite groups (Novelo-Pérez et al. 2019:211). This could mean that this plant was not highly consumed among the inhabitants of Sihó but nevertheless was cultivated and used to complement other dietary elements. In this case, there do not appear to be differential patterns of manioc consumption throughout the site. However, previous research has demonstrated that manioc was consumed in various places in pre-Hispanic and colonial times (de la Garza et al. 1983), and that its cultivation and consumption varied among sites, perhaps indicating food preference or differences in preparation of dishes (Cagnato and Ponce 2017).

Finally, the least common species found in this study were arrowroot and squash. Arrowroot seems to be the least common plant mentioned in colonial records, and its continuous low presence at the site suggests that this plant was likely used as a flavoring or condiment; however, more studies are needed to develop this idea since Marantaceae is increasingly being identified in phytolith samples. On the other hand, squash starch grains have been the less ubiquitous in the archaeological record in contrast to phytoliths and macroremains, from the same taxon, more commonly encountered in paleoethnobotanical studies (Morell-Hart et al. 2022). One of the possible explanations for the minimal presence of squash starch grains is that the entire gourd is processed and consumed, including its flesh, seeds, and flowers, through different cooking processes such as boiling, toasting, and baking. This low detection rate of starch grains in the archaeological record could imply the need for alternative sampling strategies to detect their presence through other proxies such as phytoliths. Furthermore, additional experimental studies are required to better understand the behavior of starches among different plant species.

In sum, inhabitants of structures 5D53 and 5D58 at Sihó centered their foods around maize (*Zea mays*). They likely cooked *tamales* and *atoles* due to the identification of starches with structural damage, which suggested specific cooking processes. They supplemented their meals with tubers such as sweet potato, perhaps crafting *atoles* made of a mixture of on maize and sweet potatoes like those identified in other Maya area regions (see Beliaev et al. 2010). The presence of other plants in the archaeological record, such as arrowroot, Mexican yam, manioc, beans, and squash, suggest that these plants were present as well during various stages of food processing; however, we cannot determine yet the extent to which these plants played a major or minor role in the day-to-day inhabitants' diets. More studies are needed in non-elite contexts around the Maya area to understand the procurement and usage of plants among this group of ancient Mayas, in addition to the diversity of plant-based dishes they consumed. Through archaeology, we can look to the past and bring to the present ancient agricultural and food practices, allowing us to better understand the social implications of people's dietary habits and preferences.

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