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Research Article

# Residue analysis suggests ritual use of tobacco at the ancient Mesoamerican city of Cotzumalhuapa, Guatemala

Adam Negrin[1,2,*], Oswaldo Chinchilla Mazariegos[3,*], Cameron L. McNeil[2], W. Jeffrey Hurst[4,5] & Edward J. Kennelly[1]

[1] Department of Biological Sciences, Lehman College, City University of New York, USA
[2] Department of Anthropology, Lehman College, City University of New York, USA
[3] Department of Anthropology, Yale University, New Haven, USA
[4] The Hershey Center for Health and Nutrition, Hershey, USA
[5] Gretna Scientific LLC, Mount Gretna, USA
* Authors for correspondence ✉ oswaldo.chinchilla@yale.edu & adam.negrin@lehman.cuny.edu


The widespread significance of tobacco in Mesoamerica is documented in historical and ethnographic sources, yet recovery of the organic remains of this plant from archaeological contexts is rare. Here, the authors present evidence for the ritual use of tobacco at Cotzumalhuapa, Guatemala, during the Late Classic period (AD 650–950). Detection of nicotine in residue analysis of three cylindrical ceramic vases recovered from cache deposits near the El Baúl acropolis suggests that these vessels contained tobacco infusions or other liquid preparations. These results suggest an ancient ritual practice involving tobacco for which there was previously no physical evidence in Mesoamerica.

Keywords: Guatemala, Cotzumalhuapa, El Baúl, Late Classic period, LC-MS, nicotine, *Nicotiana*

## Introduction

Tobacco (*Nicotiana* sp., Solanaceae) is one of the most significant and ubiquitous ritual plants of the Americas (Linton 1924; Mason 1924; Wilbert 1987, 1979; Winter 2000). Early colonial accounts and modern ethnographic sources attest to the widespread use of tobacco for religious and medicinal purposes in Mesoamerica (Sahagún 1829; Thompson 1946, 1970; Robicsek 1978; Durán 1994). In all probability, these practices are ancient but direct evidence

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concerning the use of tobacco in archaeological contexts is elusive due to the poor preservation of organic material in much of Mesoamerica, and carbonised tobacco seeds are rarely recovered for macrobotanical analysis due to their minute size (Oyuela-Caycedo & Kawa 2015). Artistic representations and ethnographic sources indicate that the preferred method of use throughout the region is, and was, the smoking of dried tobacco leaves in cigars (Thompson 1970; Robicsek 1978), though evidence of such practices rarely survives (Domenici 2014).

In this study, we present evidence of ritual tobacco use in southern Mesoamerica. Residue analysis using liquid chromatography-mass spectrometry (LC-MS) detected nicotine in three ceramic vessels recovered from cache deposits near the El Baúl acropolis at Cotzumalhuapa, Guatemala, dating to the Late Classic Pantaleón phase (AD 650–950). The residues in these vessels raise important questions about the modes of consumption and the ritual uses of tobacco in ancient Mesoamerica.

## Residue analysis of tobacco

The genus *Nicotiana* consists of more than 80 herbaceous plant species with a centre of origin in South America, though endemic species have also been identified in Africa, Australia and the South Pacific (Goodspeed 1954; Knapp *et al.* 2004). Tobacco, broadly represented by *N. tabacum* L., *N. rustica* L. and several wild species containing nicotine and other alkaloids, is found throughout the Americas and has been utilised by indigenous cultures for thousands of years (Winter 2000). *Nicotiana tabacum* and *N. rustica* are the only species known to be widely cultivated throughout North and South America (Mangelsdorf *et al.* 1964).

Residue analysis of archaeological samples can identify chemical constituents of biological material associated with artefacts. The detection of plant metabolites provides evidence about the use and contents of excavated artefacts, complementing inferences based on their shape and context. Nicotine, a pyridine alkaloid present in *Nicotiana* species, has been used as a biomarker to identify the presence of tobacco in archaeological samples. Nicotine has been detected in pipe residues from the North American Eastern Woodlands (Rafferty 2002, 2006; Freimuth *et al.* 2012), the Southeast Woodlands (Carmody *et al.* 2018), the Northwest Coast (Tushingham *et al.* 2013, 2018) and central California (Eerkens *et al.* 2012), in artefacts used for smoking and grinding tobacco from Central Chile (Echeverría *et al.* 2014), in mineralised dental plaque from central California (Eerkens *et al.* 2018), in mummified human hair from San Pedro de Atacama in Northern Chile (Echeverría & Niemeyer 2013; Niemeyer *et al.* 2018) and in a miniature vessel from the Maya Lowlands (Zagorevski & Loughmiller-Newman 2012).

## Ritual deposits at Cotzumalhuapa

Cotzumalhuapa was one of the largest Late Classic cities in southern Mesoamerica (Chinchilla Mazariegos 2011, 2012). The distinctive Cotzumalhuapa sculptural style spread across the Pacific coast and central Guatemalan highlands, probably reflecting the extent of the city's cultural and political influence (Thompson 1948; Parsons 1969; Chinchilla Mazariegos 1996). Excavations conducted from 2006 to 2007 focused on an architectural group located 200m north-west of the El Baúl acropolis, dating to the Pantaleón phase (Figure 1). Labelled





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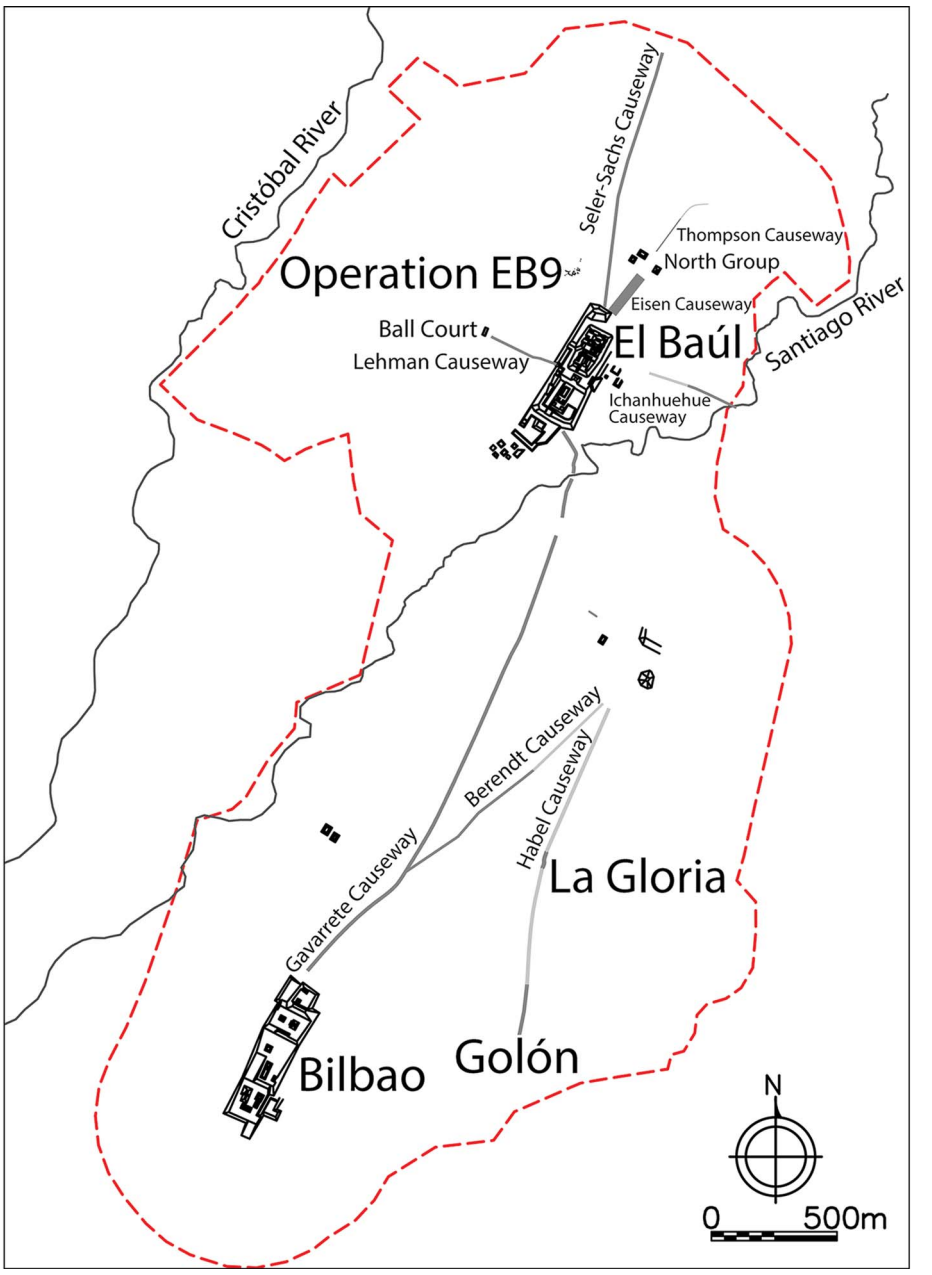


*Figure 1. Map of Cotzumalhuapa, showing the location of Operation EB9. The dotted line marks the estimated extent of the city in the Late Classic period (figure by authors).*

as Operation EB9, these excavations were motivated by the proximity of a large deposit of obsidian debitage and were designed to investigate the functions of the buildings in this group and whether they were related to the obsidian industry.





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The excavations revealed parts of two patios surrounded by buildings with stone bases, built on an artificial landfill delimited by a large retaining wall (Figure 2). The discovery of two sweat baths and 21 cache deposits under the clay floors of the buildings raised the probability that this architectural group served important ritual functions (Figure 3). The number of cache deposits in Operation EB9 is far larger than those recovered elsewhere at Cotzumalhuapa, attesting to the religious significance of this group. The objects found in these deposits include four ceramic figurines, one mushroom stone, seven small ceramic vessels, and 21 large ceramic vessels, eleven of which were covered with inverted ceramic bowls (Gómez González 2011, 2013). The predominant forms are tall cylindrical vases covered by inverted bowls that protected their contents at the time of deposition. Thirteen cache vessels contained a complete obsidian blade with no visible wear, and one vessel contained two unused blades.

Sculptures in the Cotzumalhuapa style are rich in representations of plants. Tobacco leaves are believed to be sculpted on the headdresses of two royal portraits (El Baúl monument 12 and Pantaleón monument 1) that were originally placed in the Great Precinct of El Baúl (Figure 4) (Chinchilla Mazariegos 2012). The likely presence of tobacco leaves in royal headdresses suggests that the plant was relevant for political legitimation and royal rituals at Cotzumalhuapa.

## Materials and methods

### *Excavation and residue sampling*

At the time of excavation, there was no plan to test for nicotine; nevertheless, tobacco use was prohibited during excavations and subsequent handling of the objects. The vessels were taken to the project laboratory in the Museo Popol Vuh, Guatemala City, where they were kept in a tobacco-free environment. The exteriors of the vessels were cleaned and most of the soil from the interiors was extracted. The walls and the bottoms of the vessels were not cleaned or curated to allow sampling for residue analysis. The samples consisted of very fine powder removed directly from the vessel walls. The bulk sediment was not kept and was not tested. All sampling was conducted with metal utensils, except in the case of the miniature bottle (EB9D-I27-05) where a new bamboo pick was used. The metal tools were carefully cleaned with distilled water and Kimwipes™ between each new sample. Samples were placed in four-ounce sterile Whirl-pak™ bags and exported to the United States with permission from the Instituto de Antropología e Historia de Guatemala for testing.

### *Residue extraction*

Samples were processed in the laboratories of the Department of Biological Sciences, Lehman College of The City University of New York. Residue samples (~50–250mg) were extracted twice with 70 per cent aqueous methanol in borosilicate glass vials for 15 minutes in an ultrasonicator bath. Extracts were centrifuged for four minutes at 2500 rpm and the resulting supernatants were transferred into pre-weighed glass vials, evaporated to dryness under





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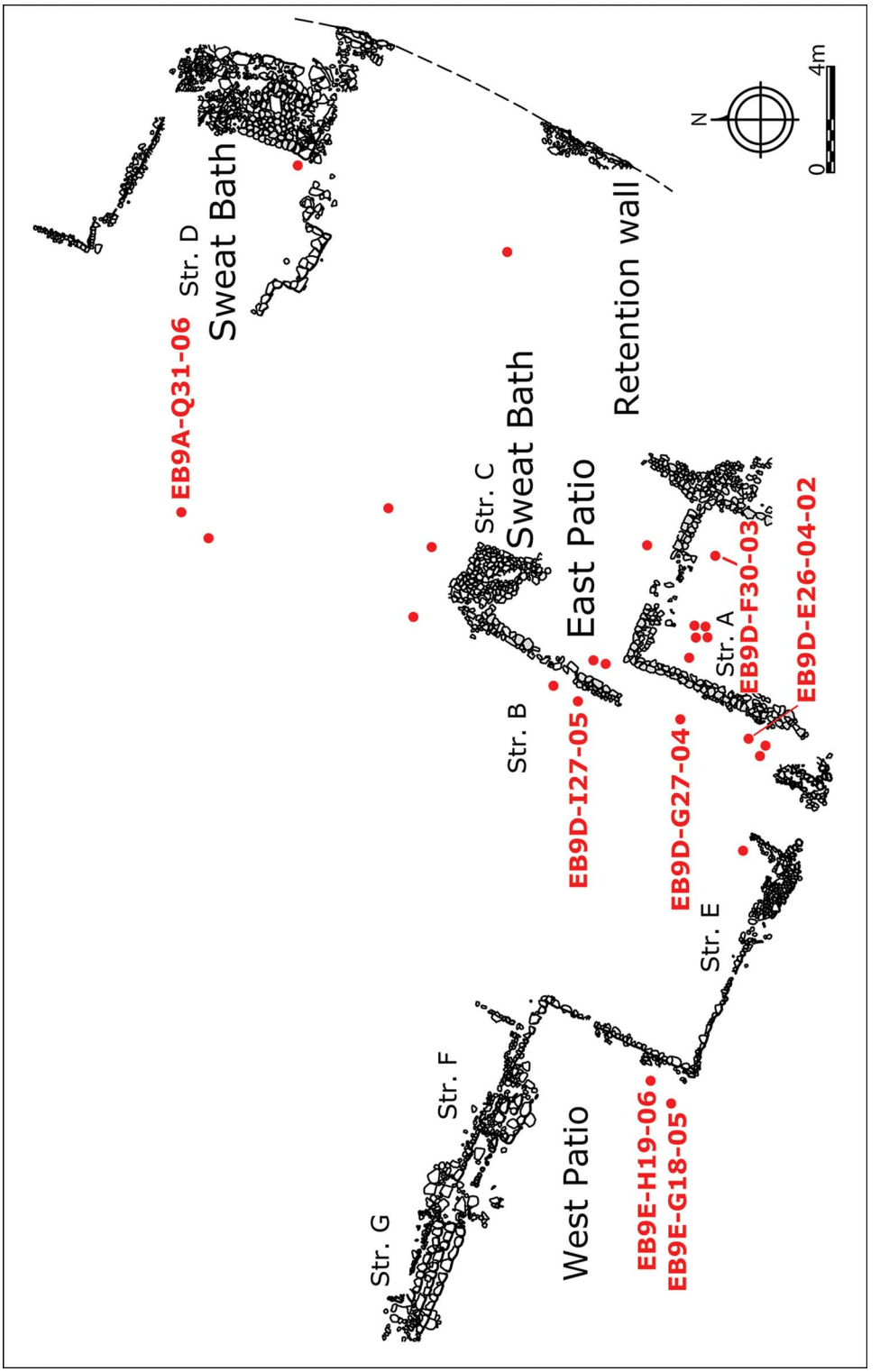


*Figure 2. Plan of Operation EB9, showing the stone foundations of structures (Str.) and the location of caches (red dots). Red labels identify vessels that were sampled for residue analysis (figure by authors).*





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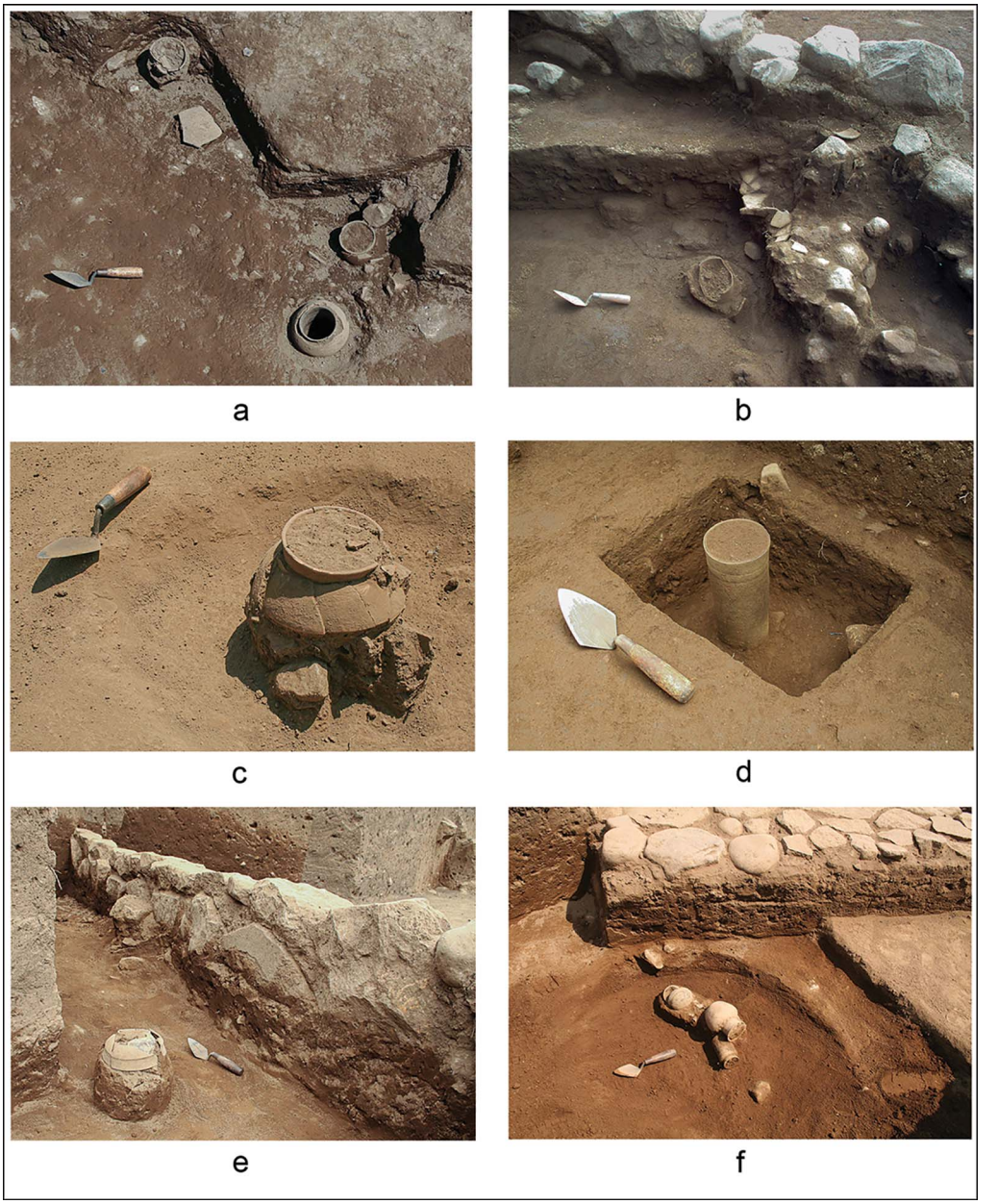


*Figure 3. Cache vessels from Operation EB9* in situ*, originally deposited below clay floors associated with the stone foundations of buildings. Trowels are oriented due north: a) EB9D-E26-04-2 and two additional cache vessels; b) EB9E-G18-05; c) EB9D-F30-03; d) EB9D-Q31-06; e) EB9E-H19-06; f) EB9D-I27-05 with three additional miniature vessels (photographs by Oswaldo Chinchilla Mazariegos).*

inert nitrogen gas and stored at -20°C until analysis. Dried extracts were resuspended in 70 per cent mass spectrometry (MS) grade methanol and filtered using a 0.45um syringe filter prior to analysis by LC-MS.





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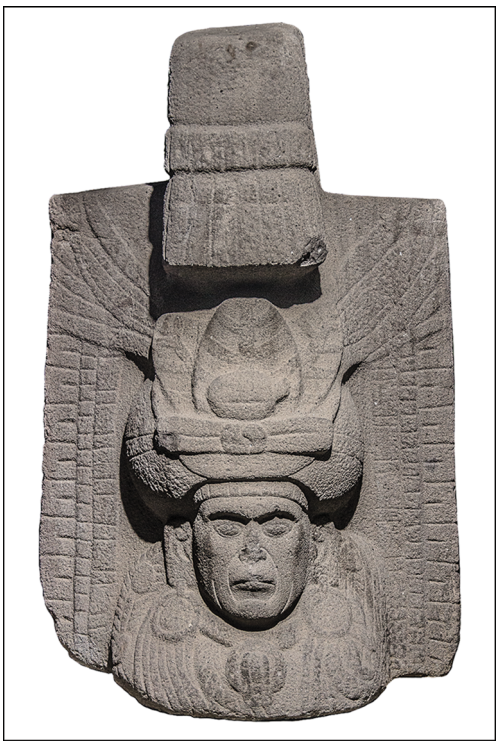

*Figure 4. El Baúl Monument 12, a royal portrait from Cotzumalhuapa (height 1.85m). The headdress features three ovate leaves whose shape, size and venation are suggestive of tobacco (*Nicotiana *sp., Solanaceae) (photograph by Oswaldo Chinchilla Mazariegos).*

*Liquid chromatography-mass spectrometry*

Two analytical methods using different column chemistry were employed to assess data repeatability: reversed-phase $C_{18}$ (RP-C18) and hydrophilic interaction liquid chromatography (HILIC). The two methods provide complementary evidence, modifying the order of gradient elution and sensitivity of the analyses. Analyses were performed on a Waters Acquity ultra performance liquid chromatography module tandem to a Waters Xevo triple-quadrupole mass spectrometer (UPLC-TQD-MS, Waters Corporation, Milford, MA). Separation by RP-C18 was achieved using a Phenomenex Kinetex UPLC $C_{18}$ column (50 × 2.1mm i.d, 1.7µm 100Å) with a Security Guard ULTRA guard column (Torrance, CA). The mobile phase conditions employed were as follows: MS grade 0.1 per cent formic acid (aqueous) for Solvent A, MS grade acetonitrile for Solvent B, 0.5mL·min$^{-1}$ flow rate, 40°C column temperature. Mass spectrometric parameters: 3.0kV capillary voltage; 150°C source temperature; 450°C desolvation temperature; nitrogen desolvation gas at 800L·h$^{-1}$; cone gas at 50L·h$^{-1}$; argon collision gas at 0.15ml·min$^{-1}$. A Waters HILIC Ethylene Bridged Hybrid (BEH) UPLC column (2.1 × 50mm, 1.7µm) for nicotine detection (Dobrinas *et al.* 2011) used a 0.5mL·min$^{-1}$ flow rate.

Targeted UPLC-TQD-MS analysis employed multiple reaction monitoring (MRM) of two or more ion fragments for metabolite detection. MRMs were optimised for instrument sensitivity using reference standards, plant extracts and ion fragmentation to enable detection of compounds in minute residue samples. Theobromine and caffeine were obtained from Chromadex (Irvine, CA), and (+/-)-nicotine (>99% purity, liquid) and theophylline from Sigma Aldrich (St. Louis, MO). Methanolic extracts of *N. tabacum* and *N. rustica* (nicotine), *Capsicum* sp. (capsaicin, dihydrocapsaicin) and *Bixa orellana* (bixins) were used for MRM optimisation and chromatographic separation. MRMs for capsaicin and dihydrocapsaicin followed published parameters (Powis *et al.* 2013). The analytical method only scanned for compounds which were optimised prior to residue analysis. Other food or psychoactive species were not targeted in the current analysis.

Detection of marker ion peaks employed a 6:1 signal-to-noise ratio using a peak-to-peak algorithm. Samples with peaks detected below a 3:1 signal-to-noise ratio were reanalysed. Limits of detection for the methylxanthines (theobromine, theophylline and caffeine) using reversed-





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phase $C_{18}$ analysis were empirically determined between 1–10 nanograms·$mL^{-1}$ using reference standards. Analyses of residue sample extracts were performed with blank solvent injections in between residue extract sample injections. Multiple extractions were prepared to retest residues, confirm marker compound signals detected and assess analysis repeatability.

## Results

Table 1 summarises the results of LC-MS conducted on samples from seven vessels (Figure 5). Nicotine was detected in residue samples from two cylindrical vases (EB9E-G18-05 and EB9D-G27-04) and a spherical vessel (EB9E-G19-06). All three vessels contained an obsidian blade. Nicotine levels were significantly higher in the residue sample from vessel EB9E-G18-05 as compared with the two other samples (Figure 6). Nicotine was not detected in residue samples in two other cylindrical vases. There were no meaningful distinctions related to the context or mode of recovery of the three vessels that yielded positive results, except that vessels EB9E-G18-05 and EB9E-G19-06 were found in proximity to each other (1.26m apart) on the west side of Structure E, during the 2007 excavations. Vessel EB9D-G27-04 was found near Structure A in 2006.

Nicotine was not detected in residues from a miniature bottle (EB9D-I27-05). Such miniature vessels from the Maya region, called flasks or 'poison bottles', are believed to have contained materials used in small amounts such as perfumes, medicines, spices, poisons or pigments (Loughmiller-Cardinal & Zagorevski 2016) and are sometimes labelled as 'tobacco houses', suggesting that they contained tobacco snuffs (Houston *et al.* 2006; Boot 2019).

Residue analysis was optimised for the chemical detection of diagnostic compounds from several important regional crops. Three methylxanthines (theobromine, theophylline and caffeine) from *Theobroma cacao,* bixins from achiote (*Bixa orellana*) and capsaicins (capsaicin and dihydrocapsaicin) from chili peppers (*Capsicum* sp.) were not detected in residues from any of the seven sampled vessels.

## Indigenous uses of tobacco

Indigenous peoples of the Americas have utilised tobacco for recreational, medicinal and religious purposes: historical and archaeological records show that smoking was the preferred method of consumption throughout the Americas before and after the arrival of Europeans (Wilbert 1987; Oyuela-Caicedo & Kawa 2015). Other forms of administration include chewing, sucking, snuffing, licking and drinking tobacco preparations (Mason 1924; Elferink 1964). Throughout North America (Winter 2000), for the Maya, and in South America (Rosengren 2006), it was believed that gods desired and fed upon tobacco in various forms. Tobacco offerings may be blown as smoke, wafted onto ritual objects (Thompson 1970), provided as burning cigars (Domenici 2014) or thrown in a formal manner within religious activity (Kroeber 1941).

Sixteenth-century reports show that tobacco was integrated into social life as part of meetings and ceremonies, used as a digestive aid after meals and considered as the proper conclusion to feasts (Durán 1994). Tobacco was smoked to increase success in hunting and travel on land and water, to mediate interactions with spirits, to engage in hospitality and friendship





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**Table 1. Results of residue analysis using LC-MS. N1, N2 and N3 refer to parent-daughter ion transition peaks employed for nicotine detection by multiple reaction monitoring using reversed-phase $C_{18}$ (RP-C18) and HILIC separation summed across multiple analyses. (+) = peak detected above a 6:1 signal-to-noise ratio; (•) = peak detected above a 3:1 signal-to-noise ratio; (–) = no peak detected.**

| | | RP-C18 | | HILIC | | |
|---|---|---|---|---|---|---|
| **Sample** | **Description** | **N1** | **N2** | **N1** | **N2** | **N3** |
| **EB9D-E26-04-2** | Cylindrical vessel containing obsidian blade, with bowl, found below sealed floor | + | • | – | – | – |
| **EB9D-F30-03** | Cylindrical vessel containing obsidian blade, found with bowl | • | • | – | – | – |
| **EB9D-G27-04** | Cylindrical vessel containing obsidian blade, found in exterior structure | + | + | + | + | + |
| **EB9D-I27-05** | Miniature vessel, with bowl and pitcher, found in exterior structure | – | – | – | – | – |
| **EB9D-Q31-06** | Cylindrical vessel with waterfowl design, found below sealed floor | – | – | – | – | – |
| **EB9E-G18-05** | Cylindrical vessel containing obsidian blade | + | + | + | + | + |
| **EB9E-H19-06** | Spherical vessel with bowl and obsidian blade, found below sealed floor | + | + | + | + | + |

with neighbours, to eliminate fatigue as a stimulant and to combat diseases and maintain general health (McGuire 1899; Breedlove & Laughlin 1993a). Tobacco was also perceived as dangerous, requiring attention to its presence in and around homes during use, storage and preparation and in social relations. Tobacco was a talisman to protect oneself, one's property or objects, used to suppress the work of witches, thwart evil, and to imbue 'heat' and potency to ritual objects (Breedlove & Laughlin 1993b; Groark 2019). It was applied to the skin or lips for spiritual protection and power (Thompson 1970).

Pipes were not widespread in Mesoamerica (Thompson 1946, 1970; Robicsek 1978), except in Postclassic West Mexico (Lister & Howard 1955; Cabrero García 1993). The modern Ch'orti' use wooden pipes, but the antiquity of this practice is unknown (Hull 2019). More common are cigars made entirely of tobacco or wrapped with leaves of other species such as sapodilla (*Manilkara zapota*), Barbados cherry/acerola (*Malpighia glabra*), allspice pepper (*Pimenta officinalis*) and common guava (*Psidium guajava*) or smoking through maize bracts and husks or the hollow stems of reeds (Benzoni 1857; Thompson 1970). Smoking tobacco is important in religious rituals and ancient Maya deities were sometimes portrayed smoking cigars (Tozzer 1907; Robicsek 1978; Tedlock 1996; Flores & Kantun Balam 1997). Tobacco is also commonly ground for consumption as a snuff (Starr 1904). The Mexica blended ground tobacco with calcium hydroxide as slaked lime to produce a snuff known as *picietl* (Thompson 1946, 1970). The Tzeltal still carry tobacco gourds for stimulant use and to alleviate hunger and fatigue (Groark 2010, 2019). Mazatec and Maya travellers carry tobacco snuffs to protect themselves against, or to cause, witchcraft (Starr 1904; Houston *et al.* 2006).





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*Figure 5. Archaeological vessels sampled for residue analysis from El Baúl, Cotzumalhuapa, Guatemala. From left to right, top row: EB9E-G18-05, EB9D-G27-04, EB9E-H19-06, EB9D-I27-05; bottom row: EB9D-Q31-06, EB9D-E26-04-2, EB9D-F30-03 (photographs by Oswaldo Chinchilla Mazariegos).*





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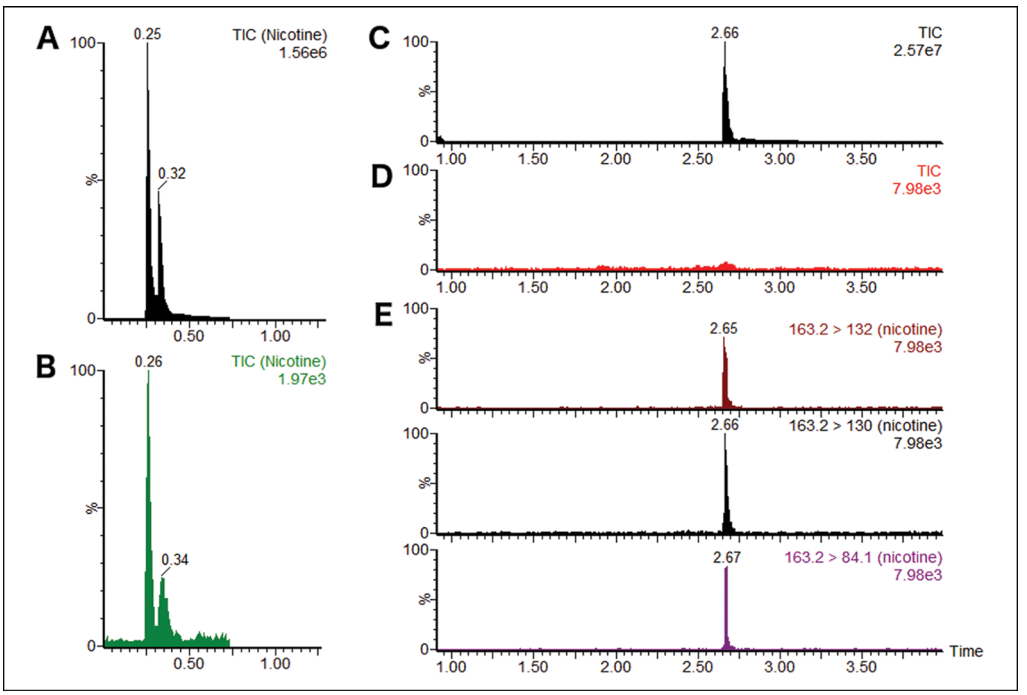


*Figure 6. Chromatograms of (A) (+/-)-nicotine reference standard and (B) (+/-)-nicotine detected in sample EB9E-G18-05 using reversed-phase $C_{18}$ chromatography UPLC-TQD-MS analysis. Chromatograms of (C) nicotine standard, (D) blank solvent injection (95% MS-grade acetonitrile) and (E) nicotine detected in sample EB9E-G18-05 using HILIC chromatography and multiple reaction monitoring of three parent-daughter ion transitions (figure by authors).*

While the consumption of tobacco in liquid form or as concentrated syrups is not the most common method of use throughout the Americas, there is some documentation for these practices in the Amazon and the Guianas (Wilbert 1987). Because oral intake of high quantities of nicotine is toxic and potentially lethal, such utilisation highlights tobacco use by ritual practitioners as narcotics to induce deep sleep, visions and divinatory trances (Monardes 1580; Elferink 1983). The use of tobacco as a psychoactive by the Maya was not documented by early explorers (Thompson 1970; Elferink 1983), but there are ethnographic testimonies of its use in historical and modern Maya rituals and healing practices. The Ch'orti' Maya of Guatemala apply tobacco juices to communicate with spirits and diagnose disease based on bodily responses to their inquiries (Wisdom 1940). Sixteenth-century Nahua sources describe *teotlaqualli* (food of god) as a black ointment preparation of venomous animals, ground tobacco and psychoactive ololiuqui seeds (*Rivea corymbosa*, Convolvulaceae), used in ceremonial offerings and priestly functions to communicate with spirits and achieve fearlessness during sacrifices (Elferink 1999). Bernardino de Sahagún mentioned *yiaqualli*, made of tobacco, soot and a plant similar to henbane (*Hyoscyamus niger,* Solanaceae) possibly used as a psychoactive (Elferink 1999). In Tlaxcala, large vases of *picietl* were placed among temple altar offerings and monitored for the appearance of an animal or eagle footprint in the ground tobacco powder as divination by priests (Muñoz Camargo 1984).





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The few documented preparations of tobacco in liquid form in Mesoamerica are medicinal (Monardes 1580; Sahagún 1829; Benzoni 1857; Breedlove & Laughlin 1993a). Drinking of tobacco juices in various forms (red, white and black) is mentioned as a cure for asthma in *The Ritual of the Bacabs* (Roys 1965; Thompson 1970) and for gastrointestinal treatments in modern ethnography (Berlin *et al.* 1990). Modern healing practices among highland Tzeltal-Tzotzil Maya of Chiapas, Mexico (Breedlove & Laughlin 1993b; Groark 2010), include preparations of *Nicotiana* spp. (*moy, moytik, bankilal, moy pox* or *yanal moy*) rubbed topically on the body, consumed in solid form or as teas prepared with water or cane liquor mixed with ash or slaked lime, in bathing, as plasters applied to the body for ritual cleansing (Wasson 1963), and for skin parasite removal (Houston *et al.* 2006). Tobacco extracted in cold or warm water may be blended with dried chili peppers (*Capsicum* spp.), garlic or other components rendering them 'hot'. Vessel imagery suggests that the Maya utilised aqueous tobacco extracts with possible plant admixtures as ritualistic enemas, psychoactive substances or medicine (Robicsek 1978; de Smet & Hellmuth 1986). Beer and wine made from palm, jocote fruit and honey were occasionally prepared with tobacco in the Maya lowlands (Dahlin & Litzinger 1986) and the West Indies (Gage 1677), and used as yeast inocula for fermentation, deterring unwanted bacterial/fungal growth (Litzinger 1983).

## Discussion

The function of ceramic vessels is normally inferred from their shape, size and archaeological context (Lesure 1998; Rice 2015). Mesoamerican cylindrical vases are commonly believed to have held liquids that were consumed directly from the vases or else poured into smaller vessels for drinking. In the Maya Lowlands, many cylindrical vases have inscriptions that identify various kinds of cacao or maize beverages as their intended contents, though they could also have served for other drinks (Hall *et al.* 1990; Reents-Budet 1994; Stuart 2009; Beliaev *et al.* 2010). The spherical vase (EB9E-G19-06), a variation of this shape, could have been used to serve and drink beverages. The detection of nicotine within residue analyses of three cylindrical vases from Cotzumalhuapa was therefore unexpected, suggesting the use of tobacco in liquid form and within vessels larger than miniature flasks, or 'tobacco houses', that are more usually associated with tobacco use (Houston *et al.* 2006; Boot 2019).

Vessels recovered from cache deposits served a terminal function as containers for offerings, forming part of ritual activities that concluded with their deposition and burial (Becker 1993; Lucero 2010). The ritual use of tobacco has been documented among the ancient and modern Mesoamerican peoples alongside cacao, flowers, esteemed objects (Sahagún 1829; Thompson 1970; Robicsek 1978), food, drink and other substances as offerings for the earth, for specific deities and even for the buildings within which the offering were cached, as buildings were conceived as animate beings that could cause harm to their occupants if not properly appeased (Vogt 1976). The cylindrical vases from Cotzumalhuapa may therefore have contained tobacco-infused offerings.

The proximity of sweat baths in the same architectural group as the cache deposits containing cylindrical vases at Cotzumalhuapa suggests that the tobacco infusions deposited in these vessels may have been employed in curing and purification rituals. The EB9 sweat baths consist of small spaces with stone floors laid out as concave surfaces (in one case shaped





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as a bathtub), with traces of fireplaces and burning. The drainage canals that are common in Mesoamerican sweat baths are absent, but the size, shape and layout of the spaces suggests that they functioned as sweat baths (Chinchilla Mazariegos 2011).

The sweat bath is especially important in therapeutic and ritual procedures related to childbirth and is associated with deities related to midwifery (Alcina Franch 2000; Chinchilla Mazariegos 2017). Archaeological and ethnographic evidence attest to the use of sweat baths in Mexico and Guatemala for spiritual and physical purification (Cosminsky 2001). In the Maya highlands, steam bathing is used for many health conditions. In Oxchuc, ritual steam bathing and bloodletting are used to cure diseases, while tobacco-wound coverings protect against the entrance of "pathogenic wind" (Groark 1997: 58). Uncured tobacco powders are orally consumed. The *temazcal* (sweat lodge) is used in Tzotzil apprenticeships, bonesetting and midwifery. Midwifes employ steam bathing for cleansing, massage, pathogen removal and elimination, infection prevention, removal of bad spirits from the body and purification of the baby (Cosminsky 2001). Among other possibilities, one potential use of the obsidian blades found in the Cotzumalhuapa vessels is for cutting the umbilical cord, as observed among the Huichol and Tarahumara until the mid-twentieth century (Huber & Sandstrom 2001).

## Conclusion

Previous work on the chemical detection of tobacco has focused on miniature flasks. Our study shows that nicotine can also be found in larger-volume vessels, providing novel contextual data suggesting ritual tobacco use at Cotzumalhuapa during the Late Classic period. Such chemical markers detected in residues could also reflect substances placed in the vessels prior to their terminal ritualistic use. Nevertheless, the presence of nicotine in three of the vessels that were examined suggests a pattern in the ritual activities that led to their deposition, rather than a casual utilisation of vessels that had previously contained tobacco. The presence of nicotine in these cache vessels is significant considering the ritual importance of tobacco in ancient and modern Mesoamerica and the rarity of its recovery in excavated contexts. This study highlights important questions about the uses of tobacco in religious rituals, while the proximity of the deposits to sweat baths documented in the same architectural group at Cotzumalhuapa suggests associations with curative and purification practices, including maternal care and childbirth. These implications warrant further research at Cotzumalhuapa and other Mesoamerican sites.

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