

# Ritual drinks in the pre-Hispanic US Southwest and Mexican Northwest

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**Chemical analyses of organic residues in fragments of pottery from 18 sites in the US Southwest and Mexican Northwest reveal combinations of methylxanthines (caffeine, theobromine, and theophylline) indicative of stimulant drinks, probably concocted using either cacao or holly leaves and twigs. The results cover a time period from around A.D. 750–1400, and a spatial distribution from southern Colorado to northern Chihuahua. As with populations located throughout much of North and South America, groups in the US Southwest and Mexican Northwest likely consumed stimulant drinks in communal, ritual gatherings. The results have implications for economic and social relations among North American populations.**

cacao | holly | US Southwest/Mexican Northwest | archaeology | ritual drinks

The discovery of cacao residues in ceramics from Pueblo Bonito, Chaco Canyon, New Mexico, demonstrated exchange with populations in the tropical areas where *Theobroma cacao* grew in the past as well as consumption of ritual drinks by at least A.D. 1000 in the canyon (1, 2). It also raised questions about the time depth and geographic extent of this exchange in the US Southwest and Mexican Northwest. This paper reports the results of a large National Science Foundation-funded study designed to examine the temporal and spatial distribution of cacao use in the pre-Hispanic US Southwest and Mexican Northwest. It details the organic residue analysis of 177 samples of ceramics from 18 sites located in Arizona, Chihuahua, Colorado, and New Mexico. We analyzed residue samples using liquid chromatography–mass spectrometry/mass spectrometry (LC-MS/MS) and show that populations in the US Southwest and Mexican Northwest consumed caffeinated drinks at a number of villages from as early as A.D. 750 until at least A.D. 1400.

What many US archaeologists define as the Southwest Culture area encompasses southern Colorado/Utah to Sonora/Chihuahua, and from western Arizona to eastern New Mexico. The region was occupied continuously from at least 10,000 B.C., and the present study included material from sedentary farming villages occupied between A.D. 500 and 1450. We selected fragments of ceramic drinking vessels from sites that represent a range of time periods and locations. Because we were specifically targeting residues from a plant species whose range extends no farther north than central Mexico (1), we primarily selected ceramics from sites that had other Mesoamerican trade items, particularly scarlet macaws, another species native to the humid lowlands of Mesoamerica (3–5). We also selected some samples from villages that lacked other known Mesoamerican trade items to avoid biasing the sample (Table 1).

## Materials and Methods

For this study, we analyzed 177 samples from fragments of pottery excavated at 18 sites (Fig. 1). All samples came from fragments of ceramic vessels, but the conditions of those samples varied. Twenty-four samples were collected in the field for this study. Sixty-six samples came from ongoing artifact analyses that stored samples in bags within boxes in laboratories. Another 76 samples came from older project collections stored in bags in boxes within museums for many years. Eleven specimens were from older project collections stored uncovered in drawers within cabinets and thus were more susceptible to contamination. Unfortunately, analysts had cleaned some specimens of particular interest by washing them in water; as documented in Table 1, a lower percentage of cleaned samples had positive results. Cleaning also introduces the possibility of contamination.

In addition to considering geographic spread, sampling took into account temporal spread and vessel form. We primarily chose fragments of vessels designed to hold drinks from particular sites and time periods, but we also chose some more generalized forms, such as bowls, that might have been used for eating solid and/or liquid foods. We assigned samples to 100-year time periods based on type and decorative style (Table 2). However, many of the types were produced for longer than a century, so the particular century assigned is open to interpretation.

The analysis was conducted using LC-MS/MS at the Keck Center for Instrumental and Biochemical Comparative Archaeology at Millsaps College. For conservation purposes, pieces ~1–4 cm<sup>3</sup> in size were removed from larger fragments (sherds) of archaeological ceramics. Initial sample preparation involved using a tungsten-carbide bit attached to a Dremel tool to burr the exterior surfaces from the sherds to reduce the risk of contamination from

## Significance

**This article presents the results of a large-scale National Science Foundation-funded study of organic residues from archaeological sites in the US Southwest/Mexican Northwest. It reveals widespread use of two different caffeinated plants, cacao and holly, as the basis for drinks used in communal, ritual gatherings. This is the largest study of its kind, both in terms of numbers of samples and in terms of temporal/spatial scope. It is the first to argue for holly beverage consumption in the US Southwest/Mexican Northwest. The combined evidence for cacao and holly beverage consumption has implications for our understanding of distant resource acquisition and shared cultural practices in North America.**

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**Table 1. Sherds analyzed by HPLC-MS/MS with contextual information and museum storage information**

Origin	Site	No. of samples	
		Unwashed	Washed
Field	Shabik'eschee Village	10	10
Field	Site 315	14	14
Laboratory	Pueblo Bonito*	34	34
Laboratory	Windy Knob	1	1
Laboratory	Monsoon House	3	3
Laboratory	Meadow View	1	1
Laboratory	Aztec Ruins*	10	2
Laboratory	Lake Roberts Site	10	10
Laboratory	Upper Santan Village	7	7
Museum box	Chetro Kettl*	8	6
Museum box	Guadalupe Ruin	10	5
Museum box	Pottery Mound Pueblo*	10	5
Museum box	Grasshopper Pueblo*	1	1
Museum box	Kinishba*	5	5
Museum box	Point of Pines Pueblo*	14	3
Museum box	University Indian Ruin	1	1
Museum box	Galaz Ruin*	20	6
Museum box	Snaketown*	7	7
Museum shelf	Pueblo Bonito*	5	5
Museum shelf	Snaketown*	6	6
Total		177	113
Positive results			30
Percent positive, %			10
			27
			17

Sites marked with an asterisk have other known Mesoamerican exotic items.

postexcavation handling and storage. Because the instrumentation is highly sensitive and the ceramics porous, samples may be contaminated from any contact with caffeine, so laboratory workers wore masks, gloves, and gowns and no caffeinated drinks entered the laboratory. Samples were then ground into a powder for analysis.

For methylxanthine analysis, ~500 mg of ground sample was weighed out into a test tube and ~3 mL of hot deionized water were added to the test tubes. The samples were then heated in the heating block at 85 °C for 20 min. Samples were then cooled to room temperature and placed in a centrifuge for 10 min at a speed of 16,000 × g. The supernatant was decanted into a 10-mL beaker and was reduced at 90 °C on the heating block until ~1.5 mL remained. Spiked solutions were created to confirm the trace peaks. Spiked solutions were made by taking a 495-μL aliquot of each 1.5-mL sample solution and spiking it with 5 μL of a standard solution of 1 ppm caffeine and theobromine. After mixing, this resulted in a spiked solution with an additional concentration of 10 ppb of caffeine and theobromine. All samples were transferred to autosampler vials for LC-MS/MS analysis.

The samples were analyzed using a Varian 325 LC-MS/MS. For methylxanthine analysis, the drying gas temperature was set at 400 °C; the voltage on the detector was set at 1,400 V. Separations were performed on a Grace 50- × 4.6-mm C18 reverse phase column with a mobile phase consisting of 85% of 0.1% ammonium acetate buffer at pH 4.2 and 15% acetonitrile at a flow rate of 200 μL/min. Table 3 lists the mass fragments used to monitor caffeine, theobromine, and theophylline in the electrospray ionization (ESI) mode. In *Supporting Information* we provide the data for samples 2012, 2030, and 2060, including chromatograms of standard and sample for quantification respectively for caffeine and theobromine as well the chromatogram for the primary mass fragments of caffeine and theobromine (Figs. S1–S4). Concentrations are based on area and corrected for the difference in response factor, so the concentrations reported are accurate and take into account that the compounds respond differently. All samples were routinely analyzed at least twice to ensure the accuracy of the results. Multiple blank samples were routinely analyzed between the archaeological samples to acquire a blank reference and to prevent contamination.

There were no signals for any of the compounds detected in any of our blank solutions. Limits of detection (LoDs) were calculated based on the International Union of Pure and Applied Chemistry method:  $3 * s / m$  (noise of the blank)/ $m$  (slope of the calibration curve). LoDs are defined by both the noise and the signal intensity. We set limits of quantitation (LoQs) of 2.0 ppb for caffeine or 1.0 ppb for theobromine as the lowest concentrations for meeting our goals for bias and imprecision. These LoQs provide conservative results. The number of samples analyzed with negative results (137 out of 177) confirms that we are not simply monitoring background contamination.

A study of museum contamination called into question results run from reconstructed or whole vessels sitting on open shelving in museums and sampled by pouring water onto the surface and analyzing this wash (6). That study concluded substantial contamination from particulate matter found as dust on artifacts in museums. As noted above, our samples came almost entirely from material collected in the field and placed in closed bags inside boxes in museums, and therefore it was not exposed to airborne contaminants. However, as noted in Table 1, 11 samples came from sherds sitting open in drawers in museum cabinets, where the possibility of contamination is greater. Three of these 11 samples tested positive for methylxanthines, including two samples from Snaketown and one from Pueblo Bonito. However, we note that the other eight samples stored on the same shelves under identical conditions did not test positive. Our highest rate of positive samples (32%) came from recently excavated materials that were pulled for our study during or immediately after laboratory analysis. Because we burr off the exterior surfaces under controlled conditions and only analyze absorbed residues, we believe that airborne contamination of samples is not an issue in our study. In addition, experimental tests in the University of New Mexico laboratory where the samples were prepared demonstrated no detectable adsorbed or absorbed methylxanthine residues from airborne contaminants.

Few plants with the methylxanthines theobromine, caffeine, and theophylline grew in North America before contact (1, 7–9); these include *Theobroma cacao*, *Ilex vomitoria* Ait., *Ilex cassine* L., and perhaps *Franklinia alatamaha*, none of which is native to the US Southwest or northwestern Mexico. Indeed, there are no plants in the US Southwest or northwestern Mexico known to contain the methylxanthines of interest, so the residues must come from sources outside of the area. Two plants containing caffeine and theobromine are documented as having been used to create drinks during the pre-Hispanic period in North America: *T. cacao*, grown and used in Mesoamerica to make chocolate drinks, and *I. vomitoria* (the variety of holly also called yaupon), used in what is now the southeastern United States to create a caffeinated drink referred to in early historic accounts as “black drink.” Populations in South America continue to use different varieties of holly to make caffeinated drinks (7, 8). Based on distance to the sources, it is most likely that Southwestern populations prepared drinks with cacao or *I. vomitoria* rather than the more distant varieties of caffeinated plants found in South America (8). Fig. 1 shows the distribution of *T. cacao* in about A.D. 1500 (10) and the current distribution of *I. vomitoria*.

Distinguishing which plant was the source for the residues in southwestern pottery is difficult. The two plants have different ratios of the methylxanthines, which should be useful in distinguishing them. For instance, *I. vomitoria* has a ratio of caffeine to theobromine of about 5:1 (11), whereas *T. cacao* has a ratio of caffeine to theobromine of 1.4–1:7 (12). However, these are idealized ratios for plant parts rather than ratios derived from prepared drinks or archaeological contexts. A variety of factors can affect the ratios, including differential preservation due to conditions in the field or laboratory; differences in plant age and growing conditions; and differences in preparation, including fermentation, roasting/toasting, and dilution with water and other additives (7, 13). Groundwater tested in areas with native stands of *I. vomitoria* also has detectable traces of caffeine (14), which presumably may contaminate porous ceramics in those areas; because neither holly nor *T. cacao* was native or cultivated in the US Southwest and Mexican Northwest before contact, contamination from groundwater is not a source for the residues we identified. Direct contact with urine from individuals consuming caffeinated foods might also contaminate porous ceramics, because the methylxanthines are excreted in urine (15); however, this also is an unlikely source for the residues recovered from most archaeological ceramics. It is possible that southwestern populations used ceramics for many different varieties of drinks, possibly diluting or mixing the compounds found (13), so we cannot assume that the ratios determined represent a single episode of use. Finally, instruments vary in their detection of the methylxanthines, and the limits of detection for caffeine are considerably lower than for theobromine. As noted, our reported concentrations and LoQs take these differences into account.

Our reported concentrations for the third methylxanthine, theophylline, illustrate the problems with interpreting the results. Theophylline is not





**Table 2. Vessel forms and types for each time period and site analyzed for organic residues**

Time period	Site	Sample Forms	Types	Samples	Positive results
Pre-900	Shabik'eschee Village	Seed jars	Lino Gray	10	0
	Upper Santan Village	5 jars, 2 bowls	Indeterminate red on gray and red on buff	7	1 bowl/beaker, 1 jar
Totals	Snaketown	4 beakers, 1 jar, 1 box	Santa Cruz R/B	6	1 beaker
				23	3 (13%)
A.D. 900–1000	Snaketown	1 bowl, 1 jar, 1 beaker, 4 boxes	Sacaton R/B	7	1 jar, 1 box
	Pueblo Bonito	Pitchers	Red Mesa B/W	7	4 pitchers
Totals				14	6 (43%)
	A.D. 1000–1100	Pueblo Bonito	Cylinder jars	5	1 cylinder jar
A.D. 1000–1100	Chetro Kettle	Pitchers	Gallup B/W, Puerco B/W	6	0
	Guadalupe Ruin	9 pitchers/1 jar	Gallup B/W, Sosi B/W	10	5 pitchers
	Aztec Ruins	1 cylinder jar	Mancos B/W	1	0
	Galaz Ruin	1 pitcher, 2 seed jars, 4 jars, 8 bowls, 5 flowerpots	Mimbres Classic B/W	20	2 bowls
	Lake Roberts Site	9 bowls, 1 jar	Mimbres Classic B/W	10	1 bowl
	Totals			52	9 (17%)
	A.D. 1100–1200	Pueblo Bonito	Pitchers	Chaco B/W, Chaco-McElmo B/W	15
A.D. 1100–1200	Pueblo Bonito	Smudged bowls	Showlow Red Smudged	11	1 bowl
	Pueblo Bonito	Mug	Chaco-McElmo B/W	1	1 mug
	Chetro Kettle	Pitcher	Chaco B/W	2	0
	Aztec Ruins	Mug	McElmo B/W	1	1 mug
	Point of Pines Pueblo	Seed jar	Point of Pines Punctate	1	0
	Totals			31	9 (29%)
A.D. 1200–1300	Aztec Ruins	Mugs	Mesa Verde B/W	8	2 mugs
	Windy Knob	Mug	Mesa Verde B/W	1	1 mug
	Monsoon House	Mugs	Mesa Verde B/W	3	2 mugs
	Meadow View	Mug	Mesa Verde B/W	1	0
Totals			13	5 (38%)	
A.D. 1300–1450	Pottery Mound Pueblo	9 interior lug vessels, 1 jar	Rio Grande Glazeware	10	1 interior lug jar
	Kinishba	4 flowerpots, 1 bowl	Fourmile PC	5	1 flowerpot
	Point of Pines Pueblo	4 bowls, 9 flowerpots	Point of Pines PC, Fourmile PC	13	0
	Grasshopper Pueblo	1 bowl	Cibecue PC	1	0
	University Indian Ruin	1 bowl	Gila PC	1	0
	Site 315	1 bowl, 2 seed jars, 11 jars	Ramos PC, Babicora PC, Carretas PC, Ramos Black	14	4 jars, 1 seed jar, 1 bowl
	Totals			44	8 (18%)

B/W, black on white; PC, polychrome; R/B, red on buff.

chocolate-based drinks. The samples come from six sites dating from about A.D. 750–1400 and spread from what is now northern New Mexico (Aztec Ruins and Pueblo Bonito) to east-central Arizona (Kinishba), southwestern New Mexico (Lake Roberts Site), southern Arizona (Upper Santan Village), and northern Chihuahua (Site 315). Forms include a seed jar/tecomate, bowl, flowerpot-shaped vessel, two pitchers, four small jars, and three mugs.

Group 2 includes 19 samples that have caffeine but no detected theobromine or theophylline (Table 5). Although it is possible that these samples held chocolate-based drinks, it is more likely that they held drinks containing *I. vomitoria*. The samples come from eight sites dating between A.D. 750–1400 and spread over much the same geographic area as the group 2 samples: southwestern Colorado (Windy Knob), northern New Mexico (Pueblo Bonito, Guadalupe Ruin, and Pottery Mound Pueblo), southwestern New Mexico (Galaz Ruin), southern Arizona (Snaketown and Upper Santan Village), and northern Chihuahua (Site 315). Forms include a beaker, a ceramic box, three bowls, three jars, two mugs, and nine pitchers.

Group 3 includes nine samples characterized by both caffeine and theobromine, but with more caffeine than theobromine and no detected theophylline (Table 6). They may have held drinks containing either *T. cacao* or *I. vomitoria*, or perhaps both at different times. The samples date between A.D. 1000–1400 and come from four sites located in southwestern Colorado (Monsoon

**Table 3. Mass fragments used to monitor caffeine, theobromine, theophylline, and ursolic acid in the ESI mode**

Compound	Mode	Mass fragments
Caffeine	Positive	195.0 > 109.9
	Positive	195.0 > 137.9
Theobromine	Positive	181.0 > 138.0
	Positive	181.0 > 163.0
Theophylline	Positive	181.0 > 123.9
	Positive	457.4 > 297.3
Ursolic acid	Positive	457.4 > 411.3
	Positive	457.4 > 439.3
	Negative	455.0



**Table 4. Results of analysis for group 1 samples with only theobromine, higher theobromine than caffeine, or detected theophylline, interpreted as likely resulting from cacao drinks**

Sample no.	Theobromine	Caffeine	Theophylline	Site	Pottery type	Form	Washed/ unwashed
2060	16.1	ND	ND	Pueblo Bonito	Red Mesa B/W	Pitcher	u
2062	0.9	9.5	1.3	Pueblo Bonito	Red Mesa B/W	Pitcher	u
2168	4.3	ND	ND	Lake Roberts Site	Mimbres Classic B/W	Bowl	u
2125	1.8	0.6	ND	Site 315	Ramos PC	Jar	u
2126	1.5	1.0	ND	Site 315	Ramos PC	Jar	u
2127	1.4	1.0	ND	Site 315	Ramos PC	Seed jar	u
2129	2.3	1.7	ND	Site 315	Babicora PC	Jar	u
2135	1.9	4.4	5.0	Kinishba	Fourmile PC	Flowerpot	w
2157	1.2	0.6	ND	Aztec Ruins	Mesa Verde B/W	Mug	w
2158	7.6	0.5	ND	Aztec Ruins	Mesa Verde B/W	Mug	w
2159	5.7	0.3	ND	Aztec Ruins	McElmo B/W	Mug	u
2192	4.2	2.9	ND	Upper Santan Village	Indeterminate red on buff	Jar	u

B/W, black on white; ND = not detected; PC, polychrome; u, unwashed; w, washed.

House), northern New Mexico (Pueblo Bonito and Guadalupe Ruin), and northern Chihuahua (Site 315). Forms include two bowls, two mugs, four pitchers, and one cylinder jar.

### Discussion

Historical documents do not mention use of either *I. vomitoria* or *T. cacao* drinks in the US Southwest and Mexican Northwest (16). However, previous research has indicated use of cacao drinks in a number of contexts in this area (1, 2, 17). No study has argued previously for the presence of *I. vomitoria* in the US Southwest and Mexican Northwest, but we believe our results suggest that many samples contained residues from drinks based on high-caffeine holly rather than low-caffeine cacao. Historically, native groups in the US Southeast used both wild and cultivated stands of holly, and they traded the leaves and twigs to groups outside of the area where it would grow (9). They prepared drinks by parching holly leaves and small twigs and then placing the parched plant parts into water and boiling it. The mixture was agitated to create froth before consumption (9). This process is similar to that used to prepare cacao drinks in Mesoamerica: cacao nibs were fermented, roasted, and winnowed to remove the thin outer shell and the inner nibs were ground. Ground cacao might be made into cakes for storage and

later consumption. Bits of the cakes were then added to water (hot or cold), other substances were added to sweeten and flavor the drink, and the mixture was agitated to create froth. In both the US Southeast and Mesoamerica, these frothed drinks were consumed primarily in ritual, medicinal, and political contexts (9, 18), but cacao recipes varied with social status (13). In the US Southeast, historic documents describe men consuming large quantities of black drink and then vomiting as a form of ritual cleansing (9).

Cacao consumption in the US Southwest and Mexican Northwest fits a pattern of importation of other ritually significant Mesoamerican items, including live scarlet macaws and macaw feathers, pyrite mirrors, pseudo-cloisonné objects, and copper bells (5, 19–21). Of the six sites with definite cacao residues discussed as group 1 samples above, Pueblo Bonito, Aztec Ruins, and Kinishba have such Mesoamerican trade items (21), whereas the excavations at the Lake Roberts Site, Site 315, and Upper Santan Village have not recovered other Mesoamerican imports. The varied vessel shapes with cacao residues indicate that different forms were viewed as appropriate for consuming this ritually important and exotic substance, including at different times pitchers, cylinder jars, and mugs at Ancestral Pueblo sites (Pueblo Bonito, Aztec Ruins, and Guadalupe Ruin), bowls in the Mimbres area

**Table 5. Results of analysis for group 2 samples with caffeine only, interpreted as likely resulting from *Ilex* (holly) drinks**

Sample no.	Theobromine	Caffeine	Theophylline	Site	Type	Form	Washed/ unwashed
2018	ND	5.7	ND	Snaketown	Santa Cruz R/B	Beaker	w
2020	ND	3.2	ND	Snaketown	Sacaton R/B	Jar	w
2025	ND	6.4	ND	Snaketown	Sacaton R/B	Ceramic box	w
2030	ND	7.4	ND	Galaz Ruin	Mimbres Classic B/W	Bowl	w
2035	ND	6.2	ND	Galaz Ruin	Mimbres Classic B/W	Bowl	u
2052	ND	3.4	ND	Pueblo Bonito	Chaco B/W	Pitcher	u
2056	ND	3.4	ND	Pueblo Bonito	Chaco B/W	Pitcher	u
2057	ND	3.5	ND	Pueblo Bonito	Chaco B/W	Pitcher	u
2059	ND	2.5	ND	Pueblo Bonito	Red Mesa B/W	Pitcher	u
2061	ND	3.6	ND	Pueblo Bonito	Red Mesa B/W	Pitcher	u
2064	ND	3.0	ND	Pueblo Bonito	Chaco–McElmo B/W	Mug	u
2065	ND	2.3	ND	Pueblo Bonito	Chaco–McElmo B/W	Pitcher	u
2066	ND	3.5	ND	Pueblo Bonito	Chaco–McElmo B/W	Pitcher	u
2102	ND	5.0	ND	Guadalupe Ruin	Gallup B/W	Pitcher	u
2104	ND	15.2	ND	Guadalupe Ruin	Gallup B/W	Pitcher/jar	w
2113	ND	5.5	ND	Windy Knob	Mesa Verde B/W	Mug	u
2128	ND	2.6	ND	Site 315	Ramos PC	Jar	u
2183	ND	8.4	ND	Pottery Mound Pueblo	San Clemente Glaze PC	Jar	u
2187	ND	23.9	ND	Upper Santan Village	Grooved red on gray	Bowl	u

B/W, black on white; ND = not detected; PC, polychrome; R/B, red on buff; u, unwashed; w, washed.

**Table 6. Results of analysis for group 3 samples with more caffeine than theobromine, interpreted as either cacao-based or holly-based drinks**

Sample no.	Theobromine	Caffeine	Theophylline	Site	Type	Form	Washed/ unwashed
2012	1.8	38.7	ND	Pueblo Bonito	Gallup B/W	Cylinder jar	u
2053	36.0	163.3	ND	Pueblo Bonito	Chaco B/W	Pitcher	u
2078	0.4	2.5	ND	Pueblo Bonito	Showlow Red Smudged	Bowl	u
2106	2.4	5.7	ND	Guadalupe Ruin	Gallup B/W	Pitcher/ jar	w
2108	8.5	11.3	ND	Guadalupe Ruin	Gallup B/W	Pitcher/ jar	u
2110	3.9	8.3	ND	Guadalupe Ruin	Gallup B/W	Pitcher	w
2111	2.6	3.5	ND	Monsoon House	Mesa Verde B/W	Mug	u
2115	1.9	9.2	ND	Monsoon House	Mesa Verde B/W	Mug	u
2133	1.4	1.5	ND	Site 315	Ramos Black	Bowl	u

B/W, black on white; ND = not detected; u, unwashed; w, washed.

(Lake Roberts Site), small jars in the Hohokam area of southern Arizona (Upper Santan Village) and later in the Casas Grandes area of northern Chihuahua (Site 315), and flowerpot-shaped vessels in the Mogollon Highlands (Kinishba).

*I. vomitoria* grows to 8 m tall and is native to the coastal plain of the southeastern United States from Virginia to Florida and west to Texas, as well as parts of Chiapas and Veracruz (Fig. 1). Southwestern populations thus could have procured *I. vomitoria* from groups living as close as coastal Texas or in Mesoamerica (7, 9). Acquisition of objects and species from areas to the east of the US Southwest, including coastal Texas, is not as well documented as exchange in objects and species from areas to the south, including Mesoamerica. However, freshwater shell found in some southwestern villages attests to acquisition of some items from areas to the east (21). For instance, freshwater shell found at Pueblo Bonito derives from Arkansas and Texas (22), in the same general geographic areas that *I. vomitoria* would be found. Evidence for exchange between populations living in the US Southwest and groups living to the east increased after A.D. 1300, particularly among southwestern populations living in villages located east of the Rio Grande (21). However, *I. vomitoria* also grew in parts of Mesoamerica and could have been brought to the US Southwest from the south. The distribution overlaps to some extent with the distribution of cacao (Fig. 1). Interestingly, analysis of methylxanthines in vessels from Mesoamerica sometimes yields the group 2 pattern of caffeine without theobromine (23). The ritual drinking and purging associated with black drink in the US Southeast bears a resemblance to a ceremony enacted by the Tohono O’odham of southern Arizona, who prepare fermented saguaro cactus wine and then consume all of it, followed by vomiting, to bring rain (24).

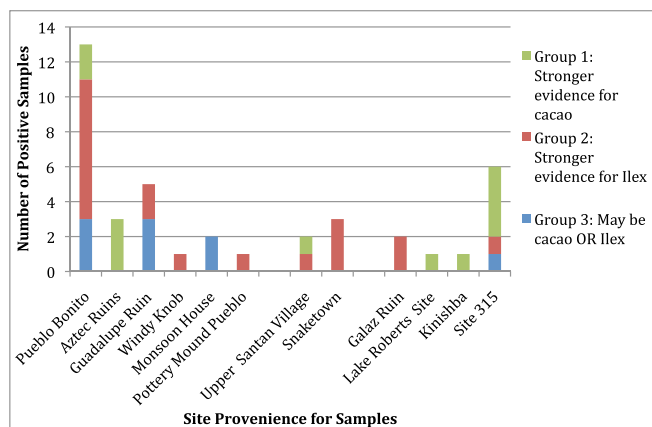
Evidence for holly drinks, as interpreted for our group 2 samples, comes from varied vessels found in the Hohokam area of southern Arizona (Snaketown), bowls from the Mimbres area (Galaz Ruin), pitchers and mugs from both Pueblo Bonito in Chaco Canyon and an outlying Chacoan site (Guadalupe Ruin), a mug from the Mesa Verde area (Windy Knob), and jars from northern Chihuahua (Site 315) and the northern Rio Grande area (Pottery Mound Pueblo).

As noted, the residues found in nine samples constituting our group 3 could represent cacao drinks or holly-based drinks, or perhaps both were consumed in these vessels at different times. Apart from Monsoon House, located in southwestern Colorado, all of the other sites with group 3 samples also have samples that fell into groups 1 or 2, or both.

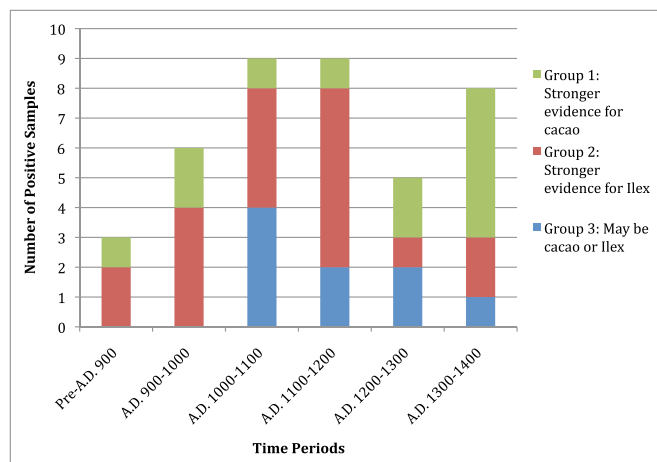
We are suggesting, then, that populations in the US Southwest and Mexican Northwest consumed both cacao and holly-based caffeinated drinks at various times and places. Fig. 2 shows the combined interpretations of this research by site and Fig. 3 presents the data by time period. The results indicate that caffeinated drinks were important ingredients of pre-Hispanic

life from around A.D. 750 to at least A.D. 1400. Sample sizes are small, so any interpretation of spatial or temporal patterning must be made with caution. However, Fig. 4, which normalizes the data for two time periods, suggests a possible increase in the use of cacao and decrease in the use of holly after A.D. 1200. Four of the seven group 1 samples dating after A.D. 1200 come from a single site in northwestern Mexico (Site 315), so this pattern may have a spatial component as well, with populations living closer to the source of cacao having greater access. The diversity of vessel forms used for consuming stimulant drinks suggests variation in the preparation, serving, and consumption of the drinks as well (25). Ancestral Pueblo groups apparently preferred individual serving vessels, such as mugs, cylinder jars, and pitchers. The Mimbres people of southwestern New Mexico used bowls ranging in size from 11 to 25 cm in diameter, indicating drinks may have been prepared and perhaps consumed from communal vessels, then shared through the use of straws or dippers. Some Mesoamerican groups prepared cacao beverages in large ceramic bowls and then dipped them out with perishable gourd cups (13), and this practice would be a possibility for Mimbres groups as well. A smaller beaker/bowl and jar from southern Arizona and the small jars and bowl from northern Chihuahua again suggest preference for individual serving vessels in these areas.

Because consuming either stimulant drink used it up (24), any calendrical rituals or repetitive activities that required drinking these stimulants also necessitated ongoing means of procuring the ingredients, either through exchange or direct procurement, from



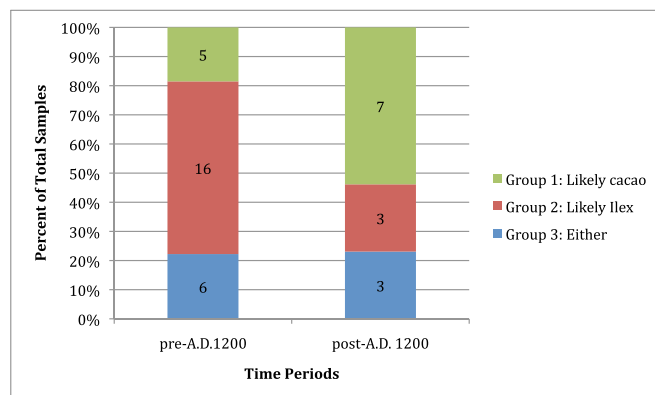
**Fig. 2. Summary of results showing numbers of positive samples from twelve archaeological sites grouped geographically into Ancestral Pueblo (left), Hohokam/southern Arizona (center), and Mogollon Highlands/northern Chihuahua (right).**



**Fig. 3.** Summary of results showing numbers of positive samples grouped temporally by century.

populations that lived in areas where the plants grew. This created sustained economic interactions with populations in those areas.

In the areas where cacao and holly grew, either to the southeast or south, populations consumed stimulant drinks largely in communal ritual and political contexts rather than as an everyday part of the diet, and it is highly unlikely that southwestern populations would drink them more frequently or more casually (but see refs. 2 and 17) than populations that had direct access to the ingredients. For this reason, we argue that these drinks were consumed in communal, ritual, or political contexts in the US Southwest and Mexican Northwest as well. Exchange in the ingredients to make caffeinated drinks created ongoing social and economic relationships between southwestern populations and distant populations. With the ingredients in hand, southwestern populations could create a variety of drinks and serve them in a variety of ways (25, 26). Preparing and serving the drinks provided opportunities for forging relationships and obligations,



**Fig. 4.** Normalized data for two time periods showing possible increase in use of cacao and decrease in use of *I. vomitoria* after A.D. 1200.

because the drinks served as tools of social inclusion and exclusion (26).

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