Distillation in Western Mesoamerica before European Contact[1]

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Distillation in Western Mesoamerica before European Contact. Fermented beverages are almost universal among ancient human societies. Ethanol is an analgesic, disinfectant, and mind-altering substance, and can help to preserve and enhance the nutritional value of food. Fermentation has therefore played a key role in human cultural and technological development. In Mesoamerica, codices and colonial-era sources describe a variety of fermented beverages produced before European contact. Distilled beverages, in contrast, have not been invented in all cultures, and their production in pre-contact Mesoamerica remains controversial. We tested the hypothesis of Needham et al. (1980) that Capacha gourd and trifid vessels described by Kelly (1974) for the Early Formative (1500–1000 BCE) in Colima state, western Mexico, could have been used to produce distilled beverages. Experiments using vessel replicas, techniques, and materials (including agave ferment) available in this region during this period successfully produced ethanol-containing distillates. We propose the possible origin and development of a "Capacha-type Mesoamerican still" from bean pots or from steamer pots used during this period, and discuss the possible production of spirits as part of the prevailing agricultural and cultural system. Average gourd and trifid vessel sizes, their archaeological context, and the ethanol yields of the replicas suggest that, if used as stills, they were used to produce a prestige product for ceremonial purposes, with high social and cultural relevance.

Destilación en el Occidente de Mesoamérica Antes del Contacto Europeo. Las bebidas fermentadas son casi universales entre las sociedades humanas antiguas. El etanol es una sustancia analgésica, desinfectante y alteradora de la conciencia, y puede ayudar a preservar e incrementar el valor nutritivo de los alimentos. La fermentación, por tanto, ha jugado un papel clave en el desarrollo cultural y tecnológico de la humanidad. En Mesoamerica, los códices y las fuentes de la época colonial describen una variedad de bebidas fermentadas producidas antes del contacto con los europeos. Las bebidas destiladas, en contraste, no se han inventado en todas las culturas, y su producción en la Mesoamérica pre-Hispánica permance controversial. En este trabajo probamos la hipótesis de Needham et al. (1980) de que las vasijas Capacha tipo bule y trífidas descritas por Kelly (1974) para el Formativo Temprano (1500–1000 antes de Cristo [A.C.]) en el estado de Colima, en el occidente de México, pudieron haber sido usadas para producir bebidas destiladas. Los experimentos, usando réplicas de vasijas, técnicas y materiales (incluyendo el fermento de agave) disponibles en la región durante ese periodo, resultaron exitosos para producir destilados conteniendo etanol. Proponemos el posible origen y desarrollo de un "Destilador Mesoamericano tipo Capacha" a partir de las ollas frijoleras o de las ollas vaporeras que se usaban en ese período, y discutimos la possible producción de bebidas destiladas como parte del sistema agrícola y cultural. Las dimensiones promedio de las vasijas tipo bule y trífidas reportadas, su contexto arqueológico, y los rendimientos de etanol obtenidos experimentalmente con las réplicas, sugieren que, si se usaron como destiladores, lo fueron para elaborar un producto suntuario con fines ceremoniales, con alta relevancia social y cultural.

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Introduction

Production and use of fermented alcoholic beverages is almost universal among ancient human societies, which discovered how to make them from sugar sources available in their local habitats. Ethanol can function as an analgesic, disinfectant, and mind-altering substance. Additionally, fermentation helps to preserve and enhance the nutritional value of food and beverages. Because of these properties, fermented beverages have played a vital role in human cultural and technological development, contributing to the advancement and intensification of agriculture and food-processing techniques. The oldest fermented beverage has been documented for China at about 7,000 years BCE (McGovern et al. 2004).

In Mesoamerica, pre-European contact codices and Spanish colonial sources document a variety of fermented beverages produced before contact using different portions of native plant species: *Agave* spp. inflorescence sap and "heads" (stems with attached leaf bases), corn grain and stalks (*Zea mays* L.), cactus fruit (*Opuntia* spp., *Stenocereus* sp.), hog plum fruits (*Spondias* spp.), mesquite fruits (*Prosopis* spp.), and balché bark (*Lonchocarpus longistylis* Pittier), among others (Bruman 1940; Godoy et al. 2003; Gonçalves de Lima 1986).

In western Mesoamerica, aboriginal fermented alcoholic drinks were derived mainly from agaves and hog plum (Bruman 1940, 2000). Archaeological evidence clearly indicates the importance of agaves as food for Mesoamerican peoples, probably since 8750±350 BCE (Flannery 1986; Smith 1986). Their cultural relevance in ancient western Mexico as food, fiber, and fermented beverage is documented since at least the Late Formative (300 BCE to CE 100) (Benz et al. 2006; Butterwick 2000; Schöndube 2000; Valdez 2000; Zizumbo-Villarreal et al. 2009a). The ethnohistoric data demonstrate the continued economic and cultural significance of agaves and, at present, the production of agave spirits (known as mezcals, the most famous being tequila) is highly relevant in western Mexico (Colunga-GarcíaMarín and Zizumbo-Villarreal 2007).

Unlike fermented beverages, distilled beverages were not invented in all cultures. Distilling requires a technique for separating ethanol from water by exploiting ethanol's lower boiling point (78.4°C) or melting point (−114.3°C). This allows production of beverages with an alcohol content greater than 15%, the natural limit of fermented beverages. The techniques that take advantage of ethanol's lower boiling point involve four basic steps: (1) ferment production, using a natural sugar or starch source easily converted (e.g., by cooking) to a sugar; (2) ethanol evaporation, accomplished by boiling the ferment itself or boiling water to allow the steam to pass through a fermented mash; (3) ethanol condensation, allowing the ethanol vapors to contact a cold surface, usually a recipient cooled with water changed frequently or continuously (because ethanol has a lower boiling point, its vapor condenses before water vapor); and (4) ethanol collection.

The invention and development of spirits distillation have been comprehensively studied in China and the Middle East. After examining the available evidence, Huang (2000) proposed that distillation in China was probably first attained during the Eastern Han period (CE 25–220). In the Middle East, wine distillation and alcohol isolation are clearly described by the 8th and 9th centuries (al-Hassan 2002).

The presence of distilled beverages in Mesoamerica before European contact in 1521 is controversial. In the late 19th century, Bourke (1893) and Lumholtz (1902) suggested that distillation had developed before contact based on their findings that several cultures in western Mexico (Coras, Huichols, Nahuatls in Jalisco state, and Purépechas) produced agave spirits using a very simple still, clearly different from the Arab-type, introduced by the Spanish in the 16th Century. Bruman (1944) disagreed and proposed that these simple stills were derivatives of those introduced by Filipinos to the Colima region in the late 16th century for making coconut (*Cocos nucifera* L.) spirits. He based his proposal on their similarity to East Asian stills described by Feliciano (1926) and regional use of the Tagalog-origin word *tuba* (the Filipino term for fermented coconut beverage) to refer to fermented agave juice. Zizumbo-Villarreal and Colunga-GarcíaMarín (2008) provided supplemental evidence supporting Bruman's proposal.

Needham et al. (1980:109) and Needham and Lu (1985:50–59) seconded the theory that distillation in Mesoamerica may have originated before European contact. Their proposal was based on the similarity between the gourd and stirrup vessels which characterize the Capacha phase of the Early Formative period (1500–1000 BCE) in Colima state (western Mexico) as described by Kelly (1974, 1980) and pottery steamers they postulate as predecessors to Chinese stills (Mongol and Chinese type). In East Asia, Chinese pottery steamers are found in the archaeological record beginning in Neolithic times and were characteristic cooking utensils in the Shang and Zhou periods (1600–221 BCE). These authors observe that if a small catch bowl (recipient) were set on the grating of a Chinese steamer or in the center of the upper body of a Capacha period vessel, and a bowl of cold water (i.e., condenser) placed over the mouth of either vessel type, it mimics the Mongol-type still arrangement. They hypothesize that this was very probably the origin of the Chinese still, which they support by the fact that the perennial Chinese term for distillation is *chêng liu*, i.e., "steaming" (Needham et al. 1980:81, 96, 97, 109; Needham and Lu 1985:50–59).

Kelly (1974, 1980) described the gourd pot (*bule*) as a vessel with a central constriction resembling a *Lagenaria siceraria* (Molina) Standl. fruit, the origin of its common name. She described the stirrup pot as a compound vessel connected by two (bifid) or three tubes (trifid) with a stirrup-shaped mouth. Gourd pots are more characteristic of the Capacha phase, and bifid vessels the least common. Both gourd and stirrup pots are recorded as offerings in simple burials grouped in cemeteries, in association with hemispheric bowls (called *tecomates* due to their similarity to traditional bowls made with gourds or *Crescentia cujete* L. fruits), miniature cups, and single-body pots (*ollas*).

Commonly known in the region as bean pots, these single-body pots are the simplest of the vessels in these assemblages and the only form still used in the region. As their name indicates, they are used to cook beans (*Phaseolus vulgaris* L.) in water. While the beans are boiling at a low temperature in the pot, a clay bowl (similar to a *tecomate*) or a smaller pot containing water is placed on top of the main pot. In what is referred to as the "water cover" method, probably in use since at least the Early Formative (Mountjoy 2006), the water inside the covering vessel warms, is poured into the main pot, and then the smaller vessel filled again with fresh water.

The present study objective was to test the hypothesis of Needham et al. (1980:109) and Needham and Lu (1985:50–57) that Capacha gourd and trifid vessels described by Kelly (1974, 1980) for the Early Formative period (1500–1000 BCE) in Colima (western Mexico) could be used to produce distilled beverages. Employing the elements and techniques most probably available during this period, including agave ferment, we successfully produced an ethanol-containing liquid. We discuss the possible origin and evolution of the "Capacha-type Mesoamerican still" from bean pots or from steamer pots, also used in that time, within the context of the prevailing agricultural and cultural system. Based on average reported gourd or trifid vessel sizes, their archaeological context, and the ethanol yields produced with replicas in this study, it is probable that, if used as stills, they were used to produce a prestigious product for ceremonial purposes with high social and cultural relevance.

Methodology

Assembly of Experimental "Capacha-Type Mesoamerican Stills"

To test the hypothesis that the vessel types described above could have been used to distill ethanol, replicas of original trifid and gourd-shaped vessels were made based on specimens on display in the National Museum of Anthropology and History (MNA) in Mexico City (Vela 2005:64) and the Museum of Colima Regional History (MCRH) (Fig. 1). Four still assemblies were used in the experiments (Fig. 2): trifid and gourd-shaped stills with ceramic condensers and recipients (TSC and GSC), and trifid and gourd-shaped stills with gourd (*L. siceraria*) condensers and recipients (TSG and GSG). The ceramic condensers and recipients were replicas based on a hemispheric bowl (*tecomate*) described by Kelly (1980:59, Fig. 12d) and a miniature cup shown in Townsend (2000:133). Gourd fruit pericarp is a material used for container production in Mesoamerica for thousands of years (Erickson et al. 2005). Distillate recipients were placed in the upper reservoir of the trifid vessels, and held in place with agave fiber in the gourd-shaped vessels (Fig. 2). Condensers were sealed with clay to prevent vapor leaks.

Fig. 1. (A) Original trifid and (B) gourd-shaped vessels from the Capacha cultural phase (1500–1000 BCE) of Colima, Mexico, replicated for the experiments. National Museum of Anthropology and History, Mexico City (Vela 2005:64) and Museum of Colima Regional History. (A′ and B′) Replicated vessels (31 cm tall x 16 cm wide and 34 cm high x 20 cm wide).

All ceramic replicas were made with clay from the foothills surrounding the Valley of Colima. Pieces were fired at low temperatures in an open-air wood oven. They were also pretreated to prevent liquids from undermining the matrix. This pretreatment consisted of a traditional system in which clay vessels are boiled slowly for an hour in *nijayote*, the residual water produced during the traditional *nixtamal* process of cooking corn grain in a lime and water solution before grinding into a dough to make tortillas. Processing of corn by this method in Mesoamerica dates to at least 1500–1200 BCE (Coe 1994).

Simulation of Ancient Distillation Method

Under the assumption that the traditional method currently used to cook beans in western Mexico has been in use at least since the appearance of gourd and trifid vessels during the Capacha period in this region, we used a procedure similar to that for cooking beans for the distillation experiment, and, as a reference, we cooked 0.5 kg of the local "Flor de Mayo" bean variety in 1 L of water in a bean-pot replica at the same time the experimental stills were being tested.

The still assemblies were prepared by filling each with 1 L of agave ferment (locally known as

Fig. 2. Assembling of the four experimental "Capacha-type Mesoamerican stills" using replicas of trifid (TS) and gourd-shape (GS) vessels from the Capacha cultural phase (1500–1000 BCE) of Colima, Mexico. (TSC and GSC) using ceramic condensers and recipients that are replicas of an hemispheric bowl described by Kelly (1980:59, Fig. 12d) and a miniature cup shown in Townsend (2000:133). (TSG and GSG) using condensers and recipients made with gourd (*L. siceraria*) fruit pericarp. Distillate recipients were placed in the upper reservoir of the trifid vessels, and held in place with agave fiber in the gourd-shaped vessels. All condensers were sealed with clay to prevent vapor leaks.

tuba), a raw material very probably available during the Capacha phase. Ferment was prepared by the master traditional mezcal producer Macario Partida from Zapotitlán, Jalisco state (see Colunga-GarcíaMarín and Zizumbo-Villarreal 2007). The bean pot was a replica of one on display in the Caxitlán Archaeological Museum (CAM), and the top bowl was a clay dish or a bowl of gourd fruit pericarp (Figs. 3 and 4). The water in the bean pot and ferment in the still assemblies were heated over a stone fire pit with wood as fuel (Fig. 4). We were measuring the water temperature in the bean pot, and when it began to evaporate (approximately 75°C to 80°C), heating temperature was lowered for all the vessels to maintain evaporation constant. One liter of fresh water was placed in the still condensers and in the bean-pot top bowl. When top bowl water temperature surpassed 40°C, it was poured into the bean pot and replaced with water at 20°C. Water in the condensers was kept at less than 27°C by replacement with water at 20°C.

Traditional cooking time for beans in ceramic bean pots is approximately two hours, which is when the distillation process was stopped. The distillates were then collected and taken to the

Fig. 3. (A) Original "bean pot" from the Capacha cultural phase (1500–1000 BCE) of Colima, Mexico, replicated for the experiments. Caxitlán Archaeological Museum, Colima. (B) Replicate pot (14.5 cm tall x 18 cm wide x 24.5 cm mouth).

laboratory to measure distillate yield (mL/L) and ethanol concentration (g/L and % [v/v]). The experiments were done from 18 to 20 September and 3 to 9 December 2008, with the assistance of Margarita Nava (65 years old), an expert in traditional bean cooking methods, and the master mezcal producers Apolinar Partida (85), Macario Partida (68), and Miguel Partida (28).

Fig. 4. Simulation of ancient distillation method using the trifid and gourd-shaped experimental stills. (A) Building a stone firepit using burning wood. (B) Using ceramic accessories. (C) Using gourd (*L. siceraria*) accessories. (D) Scoring of temperatures in the bean pot as a reference.

Distillation under Controlled Heating Conditions

Wood fires produce extremely variable heating conditions. To control for this variability in the simulation of traditional distillation methods, we repeated the experiments using the same materials and procedures, but using a gas stove as heat source. Five replicates were done for each of the four still assemblies. Distillate yield (mL/L) and ethanol concentration (g/L and % [v/v]) were measured. Ethanol production efficiency was calculated as the amount of ethanol obtained in g/L of ferment during the 2-hour distillation period.

Distillate Ethanol Content

Ethanol concentration was measured using the potassium dichromate method (Williams and Reese 1950), which chemically quantifies ethanol by complete oxidation with potassium dichromate in the presence of sulfuric acid to produce acetic acid and the reduced chromic product $Cr_2O_7^{2}$ (Cáceres-Farfán et al. 2008). The calibration curves (ethanol concentration/absorbance) were calculated in a range of 0.2–2.0 g/L with anhydrous absolute ethylic alcohol. Readings to generate the curves and evaluate the samples were taken using a spectrophotometer (Beckman Model DU65) at 550 nm. A simple linear model (y = mx) was applied with the REG procedure in the SAS statistical software (SAS 1992) and produced a value of m = 18.85 (R^2 = 0.997, p=0.001). Ethanol production was also calculated as a percentage (v/v) of ethanol based on the density of the anhydrous ethylic alcohol (0.79 g/mL).

Vessel Size and Ferment Capacity

To estimate mean spirit production potential for the studied vessels, height, width, and mouth diameter were estimated for the seven trifid and ten gourd vessels reported by Kelly (1980). Measurements were also taken of 20 gourd vessels on display in regional museums: the MCRH (Fig. 5), the State Capitol Museum (SCM), and the CAM (Fig. 6).

Statistical Analysis

Comparisons between the four still assemblies in terms of distillate yield, ethanol concentration, and distillation efficiency were done with a one-way ANOVA and a Tukey's means separation

Fig. 5. Gourd-shaped vessels from the Capacha cultural phase (1500–1000 BCE) of Colima, Mexico on display in the Museum of Colima Regional History.

Fig. 6. Gourd-shaped vessels from the Capacha cultural phase (1500–1000 BCE) of Colima, Mexico on display in the State Capitol Museum (11–16) and the Caxitlán Archaeological Museum (17–20).

test (α = 0.05). A comparison among the trifid and gourd vessel dimensions reported by Kelly (1980) and those in the Colima museums was done with the GLM procedure and a Tukey's means separation test (α = 0.05). All statistical analyses were run using the SAS program (1992).

Results

Simulation of Ancient Distillation Conditions

After two hours at low heat, the GSC produced 72 mL distillate with an ethanol concentration of 162.1 g/L (20.5% v/v); the GSG produced 47 mL with a concentration of 202.2 g/L (35.5% v/v); the TSC produced 112 mL with a concentration of 93.9 g/L (12% v/v); and the TSG produced 44 mL with a concentration of 237 g/L (32% v/v).

Distillation under Controlled Heating Conditions

Average distillate yield in the 20 replicates was 49.5 mL/L (range: 16–85 mL/L), with an average ethanol concentration of 160.3 g/L (range: 93.9–255.4 g/L), 20.5 % v/v (range: 12–32 %), and an average efficiency of 7.8 g ethanol/liter ferment/2 h (range: 2.9–17.1). No differences were observed between the four still assemblies for these variables under these conditions (Table 1).

Vessel Dimensions

The gourd vessels reported by Kelly (1980) did not have significant differences from those displayed in the regional museums, and both had significantly larger height, width, and mouth diameter than the trifid vessel (Table 2).

Discussion

The distillate volumes and ethanol concentrations produced experimentally with the gourd and trifid vessels, when assembled following the Mongol-type still arrangement, confirm that distillation is possible with these vessels, as predicted by Needham et al. (1980:109) and Needham and Lu (1985:50–59). All the materials and procedures used in the experiments were, or could have been, contemporaneous to the Capacha vessels, suggesting the real possibility that distillation occurred in the Valley of Colima region in the Early Formative (1500–1000 BCE).

General average ethanol content (20.5 % v/v) was within the range of distilled beverages, i.e., > 15%, the natural limit for fermented beverages, showing that the procedure was worth the effort, especially considering that this is a first distillation, and a second one could increase the ethanol content. The 12% alcohol content observed here as the lesser value is higher than

TABLE 1. MEAN, STANDARD DEVIATION, AND CV OF THE DISTILLATE YIELD (DY, ML DISTILLATION PRODUCT/L OF FERMENT), ETHANOL CONCENTRATION (EC, G/L), PERCENTAGE OF ETHANOL (EP, % V/V), AND ETHANOL PRODUCTION EFFICIENCY (EPE, GRAMS OF ETHANOL/LITER OF FERMENT/2 HOURS) OBTAINED WITH THE FOUR EXPERIMENTAL "CAPACHA-TYPE MESOAMERICAN STILLS" ASSEMBLED WITH REPLICAS OF TRIFID (TS) AND GOURD-SHAPED (GS) VESSELS FROM THE CAPACHA CULTURAL PHASE (1500–1000 BCE) OF COLIMA, MEXICO. TSC AND GSC USING CERAMIC CONDENSERS AND RECIPIENTS. TSG AND GSG USING CONDENSERS AND RECIPIENTS MADE WITH GOURD (L. SICERARIA) FRUIT PERICARP.

Capacha-Type Still	n	DY mL/L Mean	DY CV		EC g/L Mean	EC CV		EP % v/v Mean	EP CV		EPE g/L/2 h Mean	EPE CV	
TSC	5	34.4 ± 22.2	64.7	A[a]	163.1 ± 23.2	14.2	A	20.1 ± 2.9	14.2	A	5.2 ± 2.5	48.8	A
GSC	5	43.8 ± 21.9	49.9	A	171.1 ± 51.1	29.9	A	22.5 ± 5.9	26.3	A	7.8 ± 5.6	71.9	A
TSG	5	56.8 ± 25	44.7	A	139.8 ± 33	23.6	A	17.7 ± 4.2	23.7	A	7.6 ± 3.3	43.3	A
GSG	5	63.8 ± 12.9	20.3	A	167.4 ± 43.9	26.2	A	21.2 ± 5.6	26.2	A	10.6 ± 2.8	26.6	A

[a] Different letters mean statistically significant differences $p<0.05$.

the 9% distillate reported by Huang (2000:208) for two experiments done with a bronze-steamer still from a Chin period tomb (CE 1115–1234) in Hopei province, China.

The distillation process tested was effective at producing ethanol from agave ferment. Use of agave ferments for distillation during the Early Formative is plausible because ceramic representations in the archaeological record from the Valley of Colima and nearby areas, in conjunction with ethnohistoric evidence, suggest the ceremonial use of alcoholic agave beverages made from agave head juice (Butterwick 2000:107). Representations of miniature cups for drinking ceremonial beverages (see Townsend 2000:132) imply the use of distilled beverages. Ethnohistoric sources from the Early Colonial period (CE 1550–1580) include references to indigenous peoples in the area around the Colima volcanoes using agaves to produce "wine" (Alcalde-de Rueda 1580:158; Dávila-Quiñónez 1580:141; de Agüero 1579:69). The Spanish word *vino* (wine) can be used to refer to a distilled beverage, and the term *vino-mezcal* (mezcal wine) has been widely used for agave spirits in western Mexico since at least the early 17th century, when de Arregui (1621) described them as "clearer than water and stronger than *aguardiente.*" Spanish chroniclers also used the term *vino de cocos* (coconut wine) to refer to coconut spirits (Tello 1632–1636; Zizumbo-Villarreal 1996). Both corn and hog plum have been used to make very culturally significant fermented beverages in western Mexico and therefore constitute other possible ferment sources (Bruman 1940, 2000).

The regional relevance of the traditional bean cooking method makes it a plausible analogue for designing an ancient distillation technique. Beans have been a primary protein source in Mesoamerica for millennia (Gepts 1988), and western Mexico is proposed as the putative center of bean domestication in Mesoamerica (Kwak et al. 2009). The "water cover" method was probably a key cooking procedure among ancient cultures since it effectively eliminates beans' high cyanogenic content, and therefore "water cover" pot technology may have played a key role in the domestication process as a selective instrument. In addition, cooking utensils such as the bean pot can be considered as proto-stills because water evaporation and vapor condensation occur internally due to the cooling function of the water in the bowl (Needham et al. 1980:80–81).

TABLE 2. MEAN, STANDARD DEVIATION, AND CV OF THE HEIGHT, WIDTH, AND MOUTH DIAMETER OF TRIFID AND GOURD-SHAPED VESSELS FROM THE CAPACHA CULTURAL PHASE (1500–1000 BCE) OF COLIMA, MEXICO. TK, TRIFID VESSELS REPORTED BY KELLY (1980); GK, GOURD-SHAPED VESSELS REPORTED BY KELLY (1980); GM, GOURD-SHAPED VESSELS ON DISPLAY IN THREE MUSEUMS IN COLIMA: MUSEUM OF COLIMA REGIONAL HISTORY (MCRH), STATE CAPITOL MUSEUM (SCM), AND CAXITLÁN ARCHAEOLOGICAL MUSEUM (CAM).

		Height			Width			Mouth diameter		
		cm			cm			cm		
Vessel Type	n	Mean	CV		Mean	CV		Mean	CV	
TK	7	23.6±5.5	23.5	B[a]	12.1±2.5	20.8	B	9.2±2.5	27.1	B
GK	10	30.9±5.6	18.2	A	18.2±2.7	14.7	A	17.7±3.2	18.3	A
GM	20	30.7±4.8	15.6	A	20.0±4.4	21.9	A	20.4±4.0	19.6	A

[a] Different letters mean statistically significant differences $p<0.05$.

The key technological advance in the development of still assemblies would have been internal placement of a miniature cup for distillate collection and removal (Needham et al. 1980:89, 94–95). In fact, Kelly (1980:46) reported a miniature *olla* inside a bean pot. This finding suggests its possible use as a still. Based on this initial arrangement, more sophisticated still designs would have been developed, such as the bifid and trifid vessels. Their arrangement of two superimposed reservoirs joined by tubes allows a recipient to be placed in the upper reservoir, creating an arrangement very similar to the Mongol still. Indeed, a trifid vessel on display in the Regional Museum of Guadalajara (RMG) includes a miniature *olla* that would have functioned perfectly well as a recipient (Fig. 7A). A simplified version of this distillation system would have included a single tube connecting the two reservoirs, as occurs in gourd vessels, although this would require that the receptacle be hung and that the condenser apply pressure against the pot sides. This is how we arranged the still assembly using the gourd vessel for the present experiment, and a similar system was reported by Lumholtz (1902:184) for the Huichol people when using a Mongol-type still.

Needham et al. (1980:81) also considered steamer vessels to be possible proto-stills. Based on the similarities between Chinese steamer pots and gourd and trifid vessels from Capacha, Colima, these authors proposed that they could have functioned as stills. Kelly (1980:54) believed the gourd and trifid pots to have been utilitarian, although similar designs do not occur in current traditional ceramic technology in the region. One possible scenario is that the trifid and gourd vessels would have been designed initially as

Fig. 7. (A) Trifid vessel and miniature pot from the Capacha cultural phase (1500–1000 BCE) of Colima, Mexico that could be used as a recipient, on display in the Regional Museum of Guadalajara. (B) Gourd-shape vessel from El Pantano culture (1000–800 BCE) of Jalisco, that could be used as a steamer, on display in the Archaeological Museum of Mascota.

steamers and then evolved into stills. Both vessel types easily support wrapped, solid food in the upper pot for steam-cooking by the boiling water in the lower pot. Kelly (1980:55) even cites a secondary source referring to a gourd pot "whose upper and lower bodies were separated on the interior by a clay divider, pierced by spaced perforations," much like a steamer. There is also a gourd-shaped vessel in the Archaeological Museum of Mascota (AMM) with an interior grating in its constriction that would have allowed it to function as a steamer (Fig. 7B). Its shape differs notably from that of Capacha period gourd vessels—it is smaller in size and its waist is much more constricted—but it was recorded in a Middle Formative cemetery of El Pantano culture (1000–800 BCE) in the Mascota Valley, Jalisco, culturally associated with the Capacha phase (Mountjoy 2006). This suggests that western Mesoamerican cultures did make ceramic steamers, and could have adapted this technology for distillation, much as the Chinese did (Huang 2000; Needham et al. 1980).

The bean-pot, trifid, and gourd vessels all have a wide mouth suitable for holding a hemispheric bowl or a small jar as a top. Mountjoy (2006) reported several assembled "water cover" bean-pot vessels in the Mascota Valley cemeteries mentioned above. The gourd vessels' larger size, greater ferment volume capacity, and consequent ability to produce larger distillate volumes suggest that they are the improved version of the "Capacha-type Mesoamerican still." They are also much more frequent in the Valley of Colima archaeological record. Indeed, almost half of the vessels recorded by Kelly (1980:55) are gourd pots, whereas bifid and trifid vessels are scarce in the record and almost absent in Mexican museums. This difference in vessel type frequency may be due to wider use of the gourd vessels, but may also be a result of the higher prices offered for bifid and trifid vessels on the illegal antiquities market. Assembled gourd, bifid, or trifid stills may yet be discovered, although it may be quite a wait since looting in the region has been very intense and extensive for a long time.

Capacha period ceramics have always been recorded as burial offerings, normally placed vertically on the body of the deceased or to one side, indicating the importance accorded them. Their ritual context and small distillate volume production capacity suggest that if they were used for this purpose, it was probably as a means to produce a prestigious product for ceremonial purposes. Archaeological evidence suggests that agave culture was significant during the Early Classic period (CE 200–550) in Colima, possibly in relation to its use in alcoholic beverage production and the use of these in religious ceremonies (Zizumbo-Villarreal et al. 2009a).

Presence of stills in the Colima region during the Early Formative period (1500–1300 BCE) would indicate that complex food systems were in place, and consequently that complex agricultural systems also existed, the structuring of which would have required long periods of time. It would also indicate that alcoholic beverages were part of their culture. Certainly, the Early and Middle Formative periods document the earliest sedentary populations in West Mexico and the continuing spread of agriculture across the region (Beekman 2009). Wild populations of the three main crops of the Mesoamerican diet are present in the region: corn (Buckler et al. 2006; Fukunaga et al. 2005; Moeller et al. 2007), beans (Kwak et al. 2009; Zizumbo-Villareal et al. 2009b), and squash (Sanjur et al. 2002). Given this coincidence, some researchers have proposed west Mexico as the most probable center of origin for cultivation and domestication of these species, about 9,000 calendar years B.P. (Matsuoka et al. 2002; Piperno et al. 2009; Ranere et al. 2009). Although very little archaeobotanical research has been done in the region (Benz 2002), bone isotope studies of the skeletal remains have revealed that the population of the El Pantano culture in the Mascota Valley, Jalisco, consumed maize (Cahue et al. 2002), and this fits well with the frequent appearance of grinding stones in Capacha burials (Kelly 1980). With respect to the cultural importance of alcoholic beverages, the ceramic of the Western Mesoamerican culture is highly illustrative of their importance, and the abundance of all kinds of exotic bottle forms is a shared and suggestive characteristic (Beekman 2009; Butterwick 2000).

Kelly (1980:2) defined the distribution of known Capacha cemeteries to be the Armería-Ayuquila-Tuxcacuesco and the Tuxpan-Coahuayana river basins, but predicted a wider cultural influence based on Capacha-affiliated pottery specimens (Kelly 1980:22). To date, however, the most spectacular Capacha-like ceramics, according to Beekman (2009), are those reported by Mountjoy (2006) from the Mascota Valley, Jalisco, that document the transition of

Capacha to El Pantano culture. The spatial and temporal depth of this culture's spread and influence, including the putative "Capacha-type Mesoamerican still" technology, remains to be described through future research.

Sources unequivocally referring to agave spirits production are colonial sources dating to the early 17th century. Introduction of the Chinese/Mongol-type still by Filipinos during the late 16th century very probably facilitated spirits production, bringing it to a noticeable scale (Zizumbo-Villarreal and Colunga-GarcíaMarín 2008). The Spanish Crown later prohibited production and sale of all fermented or distilled beverages by native populations. In Colima, ethnohistoric sources record that this prohibition led to destruction of ceramic vessels containing native-made wines and severe punishment for those making them (Sebastián de Vera [1612] in Sevilla-del Río 1977:60). Despite centuries of prohibition and persecution, tenacious preservation of ancient agave pit-cooking and fermenting technologies in the isolated ravines of the Colima volcanoes and other mountains of west Mexico, and their use for traditional spirits production, helped to keep alive the traditions that would bring the world mezcal and tequila (Zizumbo-Villarreal and Colunga-GarcíaMarín 2008). This tradition could be thousands of years old.

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