



Exploring the culinary uses of *Santa María* and *Belén* painted vessels from the Late Intermediate Period in Catamarca, Argentina

Irene Lantos^{a,*}, Valeria Palamarczuk^b, Martín Orgaz^c, Norma Ratto^b, Marta Maier^a

^a Universidad de Buenos Aires, Consejo Nacional de Investigaciones Científicas y Técnicas, Unidad de Microanálisis y Métodos Físicos aplicados a la Química Orgánica (UMYMPOR), Facultad de Ciencias Exactas y Naturales, Intendente Güiraldes 2160, C1428EGA Ciudad Autónoma de Buenos Aires, Argentina

^b Universidad de Buenos Aires, Instituto de las Culturas (IDECU) UBA-CONICET, Facultad de Filosofía y Letras, Museo Etnográfico J B Ambrosetti, Moreno 350, C1091AAH Ciudad Autónoma de Buenos Aires, Argentina

^c Universidad Nacional de Catamarca, Escuela de Arqueología, Avenida Belgrano 300, Campus Universitario, K4700 San Fernando del Valle de Catamarca, Provincia de Catamarca, Argentina

ARTICLE INFO

Article history:

Received 23 December 2016

Received in revised form 27 February 2017

Accepted 12 March 2017

Available online 22 March 2017

Keywords:

Santa María

Belén

Vessel use

Late intermediate period

Catamarca

Organic residues

Lipids

Gas chromatography–mass spectrometry

GC–MS

ABSTRACT

Santa María and *Belén* vessels from the Late Intermediate Period (10th–15th centuries AD) in Northwest Argentina are strongly associated to funerary uses as “urns”. However, multiple recent findings of these vessels in domestic non-funerary contexts point towards diverse utilities. In this paper we carried out an exploratory analysis and selected two case studies of *Santa María* vessels and one of a *Belén* vessel, all recovered in household floors from three sites in Catamarca, Argentina. In order to enquire into the potential culinary uses of vessels, lipid residues were extracted from the ceramic matrixes and gas chromatography–mass spectrometry (GC–MS) analyses were carried out to explore their origins. In all three vessels lipid residues were recovered and characterized. Two samples showed evidence of plant and animal lipid mixtures, while the third sample only had animal lipids. The culinary utility of these vessels was confirmed, and uses may have included storage or service of liquids or stews. These preliminary results provide insight into an alternative interpretation of *Santa María* and *Belén* vessel use.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

The Late Intermediate period (10th–15th centuries AD) in Northwest Argentina was characterized by an increasingly complex social organization, demographic growth, political conflicts, and overall change in the mode of living (Tarragó, 2000). Evidence of this shift in lifestyle can be observed in architectural patterns, agricultural installations, and in new regional styles of ceramics, metals, textiles and rock art. In particular, two ceramic styles were dominant during the Late Intermediate period in some valleys of the province of Catamarca, Argentina: (a) the *Santa María* style in the Calchaquí and Yocavil valleys and nearby areas, and (b) the *Belén* style in the Hualfín, Abacacán and Andalgalá valleys (Bennett et al., 1948; González, 1950, 1977). These styles continued to coexist with Inca styles during the late 15th and 16th centuries AD when NW Argentina was incorporated into the empire (Calderari and Williams, 1991; González and Tarragó, 2005).

Santa María and *Belén* ceramic assemblages, despite their diversity, can be categorized in two main morphologies: vessels sometimes called “urns” (*tinajas* or *urnas*) and bowls (*pucos*) (Baldini and Sprovieri, 2014; Palamarczuk, 2014; Puente and Quiroga, 2007).

Vessels and bowls are usually associated with funerary practices (Amuedo, 2015; Marchegiani et al., 2009; Nastri, 2003). In many cases vessels were used as urns to hold human remains—usually young children—and bowls were used as lids. Vessels containing human remains have been found both in cemeteries and within domestic areas. Although the association of vessels to mortuary practices is well established, we believe it has been skewed by many studies using collections from late 19th and early 20th century expeditions, which targeted the recovery of funerary material remains (Podgorny, 2004; Ramundo, 2007). Recent studies have reported the recovery of *Santa María* and *Belén* vessel style fragments within the household floors and dump areas and with no link to funerary use. As a result, there is a growing consensus among archaeologists that vessels played important roles in daily life activities in domestic contexts (Greco et al., 2012; Iucci, 2016; Nastri, 1999; Orgaz et al., 2007; Palamarczuk, 2008; Piñeiro, 1996; Rivolta and Salazar, 2006; Roldán and Funes, 1995;

* Corresponding author at: Intendente Güiraldes 2160, C1428EGA Ciudad Autónoma de Buenos Aires, Argentina.

E-mail address: irenelantos@qo.fcen.uba.ar (I. Lantos).

Sempé, 1984, Sempé 1976; Sjodin, 2001; Williams, 2003; Wynveldt and Lucci, 2009; Wynveldt, 2008).

In spite of this, we often continue to refer colloquially to these vessels, beyond their context of recovery, under the name of “*Santa María* urns” or “*Belén* urns”, as these nomenclatures refer to well-known specific morphologies, emblematic in the archaeology of the Argentine Northwest (*Primera Convención Nacional de Antropología*, 1966). The label “urn” which has been used in the past, and continues being used today as a professional archaism, contributes to the persistent, possibly unconscious perception of *Santa María* and *Belén* vessels as funerary containers. It is relevant to point out that the vessels found in domestic contexts have the same morphological and decorative characteristics as those used as funerary urns.

Following Rice (1996), the “use” of a vessel refers to the specific way in which it serves a particular purpose. From an archaeological perspective specific uses can be inferred from the physical and morphological properties of the vessels, the presence of marks, wear patterns, impregnated materials, and from information on the finding context (Skibo, 1992).

Use-wear evidence is scarce and often ambiguous in *Santa María* and *Belén* vessels recovered from domestic and mortuary contexts. Although there is some extraordinary evidence that vessels or recycled large vessel neck fragments were used for processing or cooking (Amuedo, 2012; Greco et al., 2012; Tarragó et al., 1999), in most cases there is no evidence of soot or wear patterns resulting from exposure to heat. In addition, *Santa María* and *Belén* vessel morphologies are especially well suited for storage, given their large capacity, heaviness that inhibits transport, thick walls, robust bases, wide necks, everted lips designed to cover the mouth with textiles or animal hide (Orgaz, 2014). Palamarczuk (2002) has also proposed that vessels may have been used for water storage, given the high porosity of the pastes and wide neck that allows easy access to the content, possibly aided by bowls or ladles.

Although morphological and use-alteration analyses provide important information on potential vessel use, direct evidence of use can be obtained by organic residue chemical analyses (Skibo, 1992). Organic residues resulting from culinary activities such as preparation, storage, transport and service of foods and beverages can be well preserved in the porous matrixes of ceramic containers (Copley et al., 2005). Absorbed lipid residues are complex mixtures formed by the container's multiple uses during its life history (Evershed, 2008). Residues can be the unintentional result of culinary activities, or they can be the result of intentional coating of inner surfaces in order to seal pores and avoid evapo-transpiration of liquids (Deboer, 1974; Henrickson and McDonald, 1983; Schiffer, 1990; Skibo, 1992). Both types of residues may form palimpsests that can be difficult to interpret. The characterization of lipid residues has been successfully achieved by gas chromatography–mass spectrometry (GC–MS) (Colombini and Modugno, 2009; Evershed, 2008).

In this paper we explored the use of vessels (*tinajas*) from non-funerary contexts in three case studies selected from the valley area of Catamarca province, in Northwest Argentina (Fig. 1). The aim of this preliminary study was to explore organic residues preserved in ceramic matrixes of vessels as potential indicators of culinary uses. All three case studies shared the fact of having been found in domestic floors and of showing no clear use-wear patterns that could signal culinary use, beyond the context of recovery. As a consequence, residue analysis was imperative to obtain evidence of their potential use as containers. This study is, to the best of our knowledge, the first to carry out organic residue analysis on non-funerary *Santa María* and *Belén* vessels.

2. Case studies of non-funerary vessels from Catamarca, Argentina

The first case study is from the site Fuerte Quemado-Intihuatana in the northern section of Yocavil valley, at an altitude of 1900 m.a.s.l. (Fig. 1). The Yocavil valley is part of the Calchaquí valley system that is

defined by the Sierra del Cajón mountainous chain to the West and the Calchaquí and Aconquija ranges to the East. The *Santa María* river runs along the valley North to South, and on each margin there are numerous alluvial cones from tributary streams that run into the main drainage system (Ruiz Huidobro, 1972). The site is defined by a group of buildings covering a total area of three square kilometers, and divided into six sectors. Sectors I, II, III, V, and VI were built during the Late Intermediate period (11th to 15th centuries AD), while sector IV was built during the Inca period (15th and 16th centuries AD) (Kriscautzky, 1999). The sample we selected for the case study was recovered during excavations in the 1970s and 1980s in Enclosure R-51 of Sector V (Fig. 2a). It is a spacious elliptic building made from well finished stone walls, and it has no direct access in or out. A functional study of the architectural features and ceramic assemblage suggested that this space, also occupied during the Inca expansion, was used for private commensal practices within a local elite residence (Orgaz, 2014). The selected vessel (V1) is *Santa María* style, carefully decorated in a bicolor design (black paint on cream-white slip). The recovered portion of the vessel is from the neck area, and it shows a geometrical serpent-like design which probably was part of the lateral panel (Fig. 3 a). This container has no evidence of soot in its outer surface, and it has some marks of wear in the inner surface.

The second case study is from El Colorado, a locality in the southern section of the Yocavil valley that covers approximately 60 ha, where the evidence of occupations are distributed between the piedmont and the alluvial plain of *Santa María* river (Fig. 1). The site was inhabited during a long period of time by small-scale agropastoralist groups from the Early period to the present. A small cluster of buildings located in the North Sector is composed by structures with Late period architecture (Palamarczuk, 2016). Within this cluster is Detection 2, a residential place composed of a minimum of seven enclosures. An intramural excavation in an extended area was carried out in one of them (E3; Fig. 2b), recording a sequence of occupations of the structure that reach to Early Colonial times¹. Fragments of a *Santa María* tricolor style vessel (black and red paint on cream-white slip) fractured *in situ* were found at a depth of 70 cm from the current surface lying on the initial occupation floor of E3, near a hearth. A sample of charcoal was dated using AMS obtaining a result of 624 ± 20 yr BP (YU-4564). The vessel (V2) fragments belong to the body, neck and lip, and they have no evidence of soot or other marks on their surfaces (Fig. 3b).

The third case study is from Mishma 7 site which is located in the Fiambalá valley (Sempé, 1984) (Fig. 1). The site has two large groups of buildings made up from various enclosures and surrounded by a perimeter wall. The site has a total surface area of 200 m². Investigations were carried out during the 1970s (Sempé, 1984) and 1990s when the occupation was dated between 1405 and 1573 AD² (Ratto, 2013). Ceramologic studies showed the coexistence of Late Intermediate and Inca material culture (Orgaz et al., 2007). The sample selected for this case was found in Structure A, a rectangular enclosure measuring 9.5 m length and 4 m width, lying on a floor at 60 cm below surface level (Fig. 2c). The archaeological context of this floor included hearths, burnt animal bones, plant remains and ceramic fine ware (Inca, *Belén*, Abaucán and Sanagasta styles) as well as ordinary cooking ware. Structure A was the only enclosure at the site where Inca style ceramics were recovered. Sempé (1984, 1976) believed that Structure A was used for storage of food and other organic materials. The sample included in this study is a fragment that belongs to the body of a *Belén* style small vessel (V3), with bicolor decoration (black paint on red slip) (Fig. 3c). It has no evidence of soot.

3. Materials and methods

Lipid extraction was carried out on archaeological samples V1, V2, and V3. In addition, reference samples of typical plant and animal food resources rich in lipids from pre-Hispanic Catamarca valleys were studied for comparative purposes.

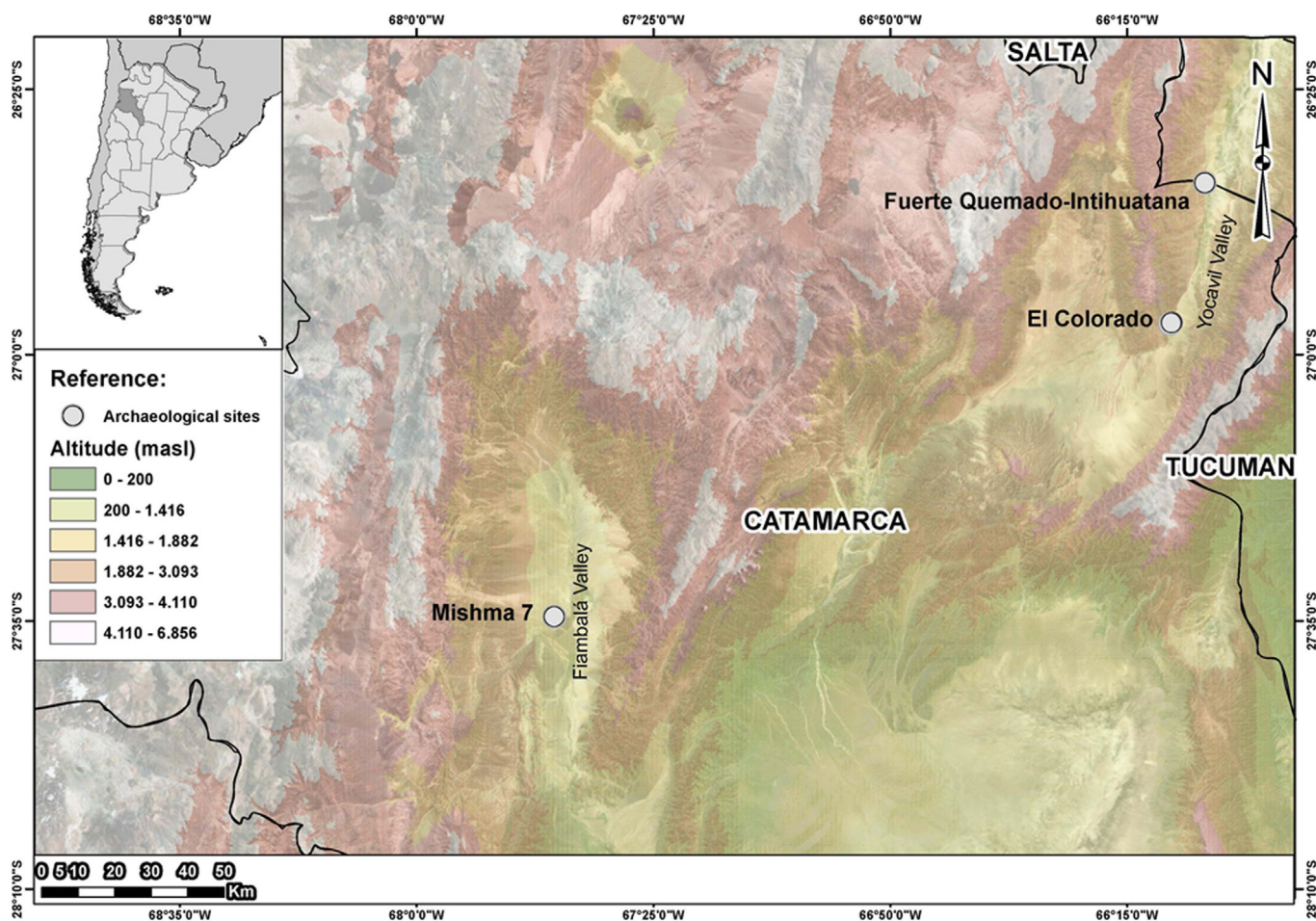


Fig. 1. Map showing the geographical location of the archaeological case studies in Catamarca, Argentina.

Powder of the references dry samples (R1 maize kernels, R2 mesquite pods, R3 chañar fruits, R4 beans) was obtained by grinding with a coffee mill. The llama fat (R5) was frozen and ground using a porcelain mortar and pestle. Samples weighing five to ten grams were taken from the archaeological vessel fragments (Fig. 3a, b, and c) and were rinsed on both surfaces with chloroform:methanol (2:1; vol/vol). Then they were broken into small fragments with a hammer and ground in a porcelain mortar and pestle. Sediment control samples were available for El Colorado and Mishma 7 samples, and were treated identically to ceramic samples. Lipids were extracted with chloroform:methanol (2:1; vol/vol) (Folch et al., 1957). All solvents were of chromatographic quality and pre-distilled before use. Each sample was placed in an ultrasound bath for 15 min (twice) and filtered; a few drops of distilled water were added, the organic phase containing the total lipid extract (TLE) was separated after centrifugation for 3 min (twice), evaporated under a soft nitrogen stream, weighed and then transferred to a 2 ml glass vial and stored at $-18\text{ }^{\circ}\text{C}$. An aliquot of the TLE was saponified with 1 ml of 4% potassium hydroxide in an ethanolic aqueous solution (2:1, vol/vol), at $60\text{ }^{\circ}\text{C}$ for 2 h (Colombini et al., 2003). After cooling at room temperature, the neutral fraction was extracted with 1.5 ml *n*-hexane and the aqueous fraction acidified with 2 N HCl solution to pH 3 and extracted with 1.5 ml diethyl ether. The ethereal phase containing the free fatty acids was evaporated under N_2 stream and 0.5 ml of 20% boron trifluoride in methanol was added and heated in a boiling water bath for 3 min. After cooling, 1.5 ml of chloroform and a drop of water was added, and the organic phase containing the fatty acid methyl esters (FAME) was recovered and stored in 2 ml glass

vials at $4\text{ }^{\circ}\text{C}$ for GC–MS analysis. Trimethylsilyl derivatives (TMS) of the neutral fraction were prepared by addition of 20 ml of *N,O*-bis(trimethylsilyl) trifluoroacetamide (BTSFA) with 1% trimethylchlorosilane (TMCS) (Supelco) and heating at $60\text{ }^{\circ}\text{C}$ for 20 min. After cooling, the TMS derivatives were dried under a soft stream of nitrogen, *n*-hexane was added and the solution stored at $4\text{ }^{\circ}\text{C}$. Samples were analyzed within 24 h of derivatization. Procedure blanks for lipid extraction, saponification, methylation, and TMS derivatization were prepared and analyzed.

Chemical characterization of FAME by GC–MS was performed with a Shimadzu GCMS –QP5050A (Kyoto, Japan). The system was equipped with a Zebron ZB5 capillary column (Phenomenex, 5% phenyl- 95% dimethylpolysiloxane, 30 m length, 0.25 mm i.d., 0.25 μm film thickness). Helium was used as carrier gas (0.9 ml/min continuous flow rate) and manual injection was in split mode at a temperature of $250\text{ }^{\circ}\text{C}$. After an initial temperature at $110\text{ }^{\circ}\text{C}$, the column was heated to $280\text{ }^{\circ}\text{C}$ at $10\text{ }^{\circ}\text{C}/\text{min}$ followed by an isothermal period of 45 min. The MS was operated in the electron impact mode at 70 eV with a source temperature of $280\text{ }^{\circ}\text{C}$. Compound identifications were carried out by comparing retention times of FAME standards and mass spectrometric fragmentation patterns. The relative abundances of individual FAME to total FAME in lipid extracts were calculated from total ion chromatogram (TIC) peak areas.

Chemical characterization of TMS derivatives of neutral lipids was carried out in a Shimadzu GCMS – QP5050A (Kyoto, Japan). The system was equipped with an Ultra 2 capillary column (Agilent, 5% phenylmethylpolysiloxane, 50 m length, 0.20 mm i.d., 0.11 μm film thickness).

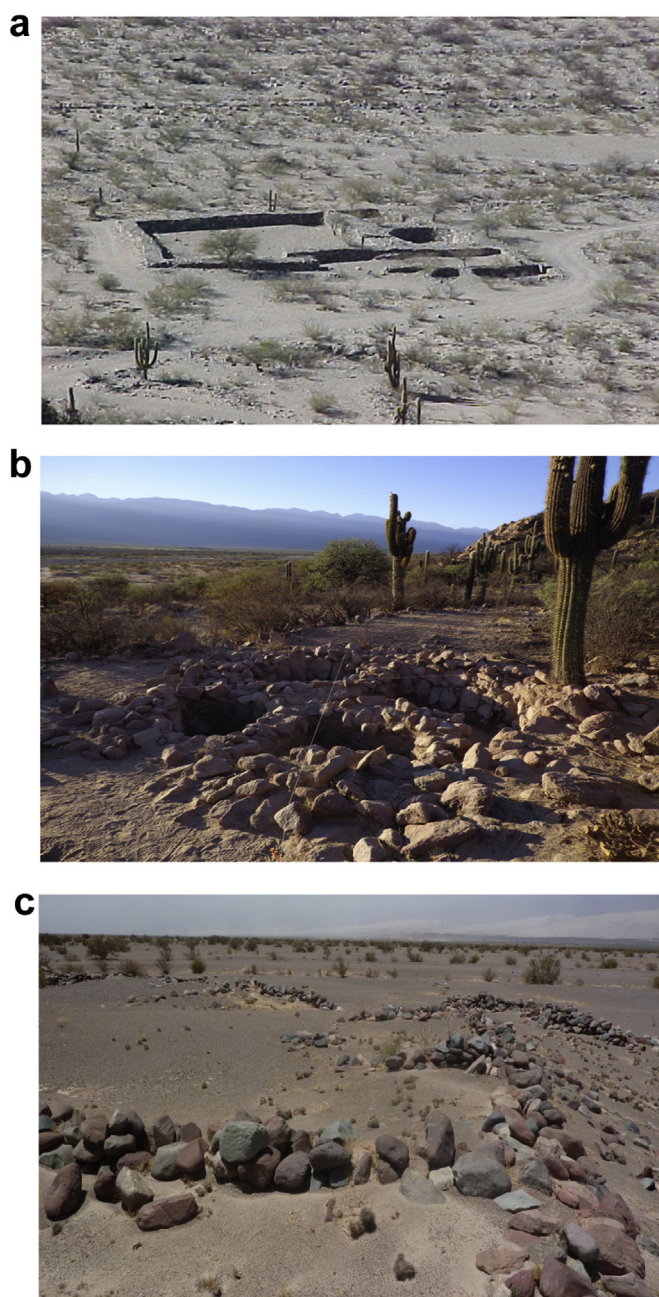


Fig. 2. Archaeological sites (from north to south): (a) Fuerte Quemado-Intihuatana, Yocavil valley, Catamarca, Argentina (b) El Colorado, Yocavil valley, Catamarca, Argentina; (c) Mishma 7, Fiambalá valley, Catamarca, Argentina.

Helium was used as carrier gas at a continuous flow rate of 0.9 ml/min. The injection was manual and in split mode at a temperature of 250 °C. The initial temperature was 100 °C, the column was heated to 240 °C at 10 °C/min followed by an isothermal period of 25 min, and then heated to 280 °C at 4 °C/min, followed by an isothermal period of 30 min. Alternately, Zebron ZB5 capillary column (Phenomenex, 5% phenyl- 95% dimethylpolysiloxane, 30 m length, 0.25 mm i.d., 0.25 µm film thickness) was used. Helium was used as carrier gas at a continuous flow rate of 1 ml/min. The injection was manual and in split mode at a temperature of 250 °C. The initial temperature was 240 °C, the column was then heated to 270 °C at 10 °C/min followed by an isothermal period of 25 min, and then heated to 290 °C at 8 °C/min, followed by an isothermal period of 30 min. In both cases, the MS was operated in the electron impact mode at 70 eV with a source temperature of 280 °C. Compound

identifications were carried out by comparing retention times of sterol standards and mass spectrometric fragmentation patterns.

4. Results

Results from chemical analyses showed that the three archaeological vessels (V1, V2, and V3) had organic residues resulting from contact with foods and/or drinks (Table 1). The lipid concentration per gram of ceramic matrix varied from 86.7 µg/g in sample V1, 100.9 µg/g in sample V2, and 190 µg/g in sample V3. These lipid concentrations were well above the limit required for organic residue analysis (Evershed, 2008). The high concentrations and fatty acid diversity (see Table 1) also suggested the endogenous nature of lipids, given that sediment control samples yielded very low lipid concentrations (10.0 to 17.0 µg/g) and poor fatty acid profiles with low intensity peaks for myristic, palmitic, oleic, and stearic acids³, which are typical of sediments without anthropic modifications (Bull et al., 2000, 1998). In addition, migration of soil lipids into ceramic samples is highly improbable due to semiarid conditions and no soil formation in the region.

The gas chromatograms from the archaeological vessels showed a series of methyl esters of carboxylic acids in the C₁₂–C₂₄ range (Table 1). The most abundant saturated fatty acids (FA) include capric (C_{10:0}), lauric (C_{12:0}), myristic (C_{14:0}), palmitic (C_{16:0}), and stearic (C_{18:0}) acids, maximizing at C₁₆ and C₁₈. Unsaturated fatty acids were palmitoleic (C_{16:1}) and oleic (C_{18:1}) acids. Sterols (cholesterol and sitosterol) were found in two of the three vessels (V1 and V2). Palmitic to stearic ratio was calculated as an indicator of animal or plant origin of lipids (Eerkens, 2005).

The fatty acid profile of sample V1 (*Santa María bicolor* vessel from Fuerte Quemado-Intihuatana) showed high abundance of palmitic acid (C_{16:0}), followed in concentration by stearic (C_{18:0}), oleic (C_{18:1}), myristic (C_{14:0}), and pentadecanoic (C_{15:0}) acids. The palmitic to stearic acids ratio (C_{16:0}/C_{18:0}) was 1.4 which could indicate that the origin of the lipids is animal, supported by the presence of myristic and pentadecanoic acids (Evershed et al., 2002). The fatty acid profile is comparable to that of llama fat (R5), which also has a low palmitic to stearic ratio (2.0), and both myristic and pentadecanoic acids in similar abundances to sample V1. The animal origin of the lipid residues is also supported by the presence of cholesterol in the neutral compound fraction (Chizzolini et al., 1999).

Sample V2 (*Santa María tricolor* vessel from El Colorado) has a more complex fatty acid profile that indicates a mixture of animal and plant lipids (Fig. 4). The most abundant fatty acids are stearic (C_{18:0}) and palmitic (C_{16:0}) acids. The palmitic to stearic ratio (C_{16:0}/C_{18:0}) was 0.9 which is similar to animal lipid ratios, although the lauric to myristic ratio (C_{12:0}/C_{14:0}) was 0.09 which borderline between plant and animal lipids (Eerkens, 2005). Other fatty acids such as myristic acid (C_{14:0}), and odd-chain pentadecanoic (C_{15:0}) and margaric (C_{17:0}) acids also point towards animal lipids. Small amounts of branched iso and anteiso carboxylic acids (12-methyl-tridecanoic, 12-methyl-tetradecanoic, 13-methyl-tetradecanoic, 14-methyl-pentadecanoic, 15-methyl-hexadecanoic, and 14-methyl-hexadecanoic) were also found, which in combination with the odd-numbered fatty acids, suggest the presence of ruminant animal fat (Martínez Marín et al., 2010; Spangenberg et al., 2006). South American camelids are the most probable sources (Lantos et al., 2015; Vázquez et al., 2008). Odd-chain and branched fatty acids were also found in the llama reference sample (R5). Eicosanoic (C_{20:0}), docosanoic (C_{22:0}), tetracosanoic (C_{24:0}), and hexacosanoic (C_{26:0}) acids were found in sample V2, indicating presence of plant lipids. This is also supported by di-carboxylic acids (hexanodioic, octanodioic, nonanodioic, decanodioic, undecanodioic, and dodecanodioic acids). These di-carboxylic acids are oxidation byproducts of longer mono and polyunsaturated fatty acids, which can be indicators of degraded plant lipids. Further evidence of the complex mixture is the presence of an animal sterol (cholesterol) (Chizzolini et al., 1999) and a plant sterol (sitosterol) (Hartmann, 1998). Sitosterol

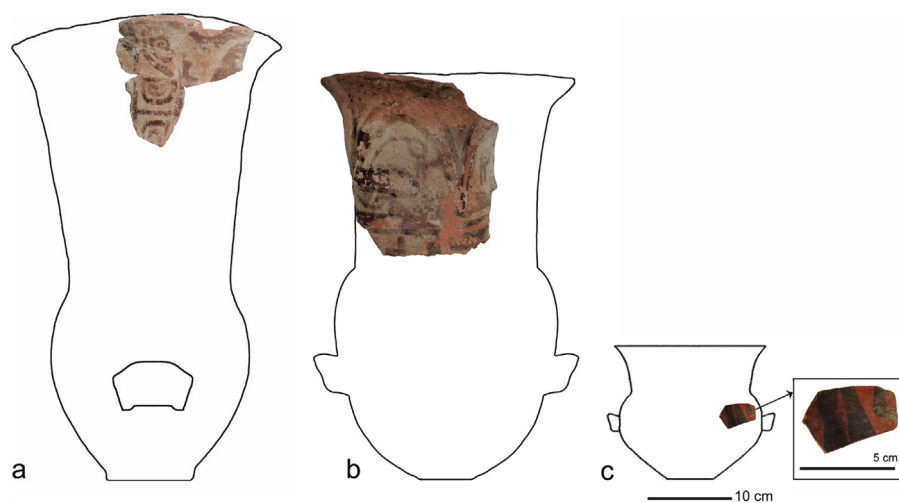


Fig. 3. Vessel samples: (a) Santa María bicolor vessel, Sector V, Fuerte Quemado-Intihuatana, Yocavil valley; (b) Santa María tricolor vessel, El Colorado, Yocavil valley; (c) Belén bicolor vessel, Mishma 7, Fiambalá valley.

was found in three of the four plant reference samples (R1 maize, R2 mesquite and R3 chañar) (Table 1).

The fatty acid profile of sample V3 (Belén bicolor vessel from Mishma 7) showed high abundance of palmitic acid ($C_{16:0}$), followed by myristic

($C_{14:0}$), stearic ($C_{18:0}$), palmitoleic ($C_{16:1}$), oleic ($C_{18:1}$), lauric ($C_{12:0}$), and pentadecanoic ($C_{15:0}$) acids. The palmitic to stearic acids ratio ($C_{16:0}/C_{18:0}$) was 4.0 which is high and possibly indicates some plant lipid contribution, as it is similar to some of the plant reference samples

Table 1
Lipid concentrations ($\mu\text{g/g}$), fatty acid (FA) relative abundances (%), and neutral compounds in archaeological vessels and modern reference samples from Catamarca (Argentina).

| Sample code | V1 | V2 | V3 | R1 | R2 | R3 | R4 | R5 |
|---------------------------------|--|---|---|--|---|---|---------------------------------------|--|
| Description | Bicolor Santa María vessel, Fuerte Quemado-Intihuatana, Yocavil valley | Tricolor Santa María vessel, El Colorado, Yocavil valley | Bicolor Belén vessel, Mishma 7, Fiambalá valley | Maize (<i>Zea mays</i> L., Dentado blanco) | Mesquite (<i>Prosopis nigra</i> Griseb.) | Chañar (<i>Geoffroea decorticans</i> Gill. Ex Arn.; Burkart) | Beans (<i>Phaseolus vulgaris</i> L.) | Llama (<i>Lama glama</i> L.) |
| Lipid conc. ($\mu\text{g/g}$) | 87 | 101 | 190 | 44,770 | 10,620 | 17,470 | 15,700 | 176,050 |
| C12:0 | | 0.4 | 5.3 | | | | | 0.4 |
| C13:0 | | 0.2 | | | | | | |
| C14:0 | 16.9 | 4.3 | 16.8 | | | | 0.6 | 6.5 |
| C15:0 | 1.4 | 2.3 | 7.3 | | | | | 1.4 |
| C16:1 | | | 9.5 | | 3.3 | | | 4.8 |
| C16:0 | 36.5 | 23.9 | 44.0 | 27.3 | 46.3 | 15.0 | 13.6 | 33.0 |
| C17:0 | | 0.9 | | | | | | 1.0 |
| C18:3 | | | | 0.8 | 1.5 | 10.4 | 42.5 | |
| C18:2 | | | | 28.5 | 10.6 | 40.3 | 33.4 | 0.7 |
| C18:1 | 19.5 | | 6.0 | 38.1 | 30.7 | 31.3 | 8.6 | 33.0 |
| C18:0 | 25.7 | 26.5 | 11.0 | 5.2 | 7.7 | 3.1 | 1.3 | 16.8 |
| C20:0 | | 2.6 | | | | | | |
| C22:0 | | 5.6 | | | | | | |
| C24:0 | | 4.3 | | | | | | |
| C26:0 | | 0.9 | | | | | | |
| C16:0/C18:0 | 1.4 | 0.9 | 4.0 | 5.3 | 6.0 | 4.8 | 10.5 | 2.0 |
| Other fatty acids | | 12Me-13:0 (0.3); 13Me-14:0 (1.3); 12Me-14:0 (1.0); 14Me-15:0 (1.4); 14Me-16:0 (0.4); 15Me-16:0 (1.6); hexanodioic acid (0.4); heptanodioic acid (0.3); octanodioic acid (0.6); nonanodioic acid (1.5); decanodioic acid (0.1); other unidentified FA (19.1) | | | | | | 12Me-14:0 (1.6); 14Me-16:0 (0.8); 9 t, 12 t-18:2 (1.3) |
| Neutral compounds | Cholesterol | Cholesterol, sitosterol | Negative analysis | Campesterol, dihydrocampesterol, stigmasterol, sitosterol, sitostanol/stigmastanol | Campesterol, stigmasterol, sitosterol | Sitosterol, stigmastanol | Octacosanol, dihydrositosterol | Cholesterol |

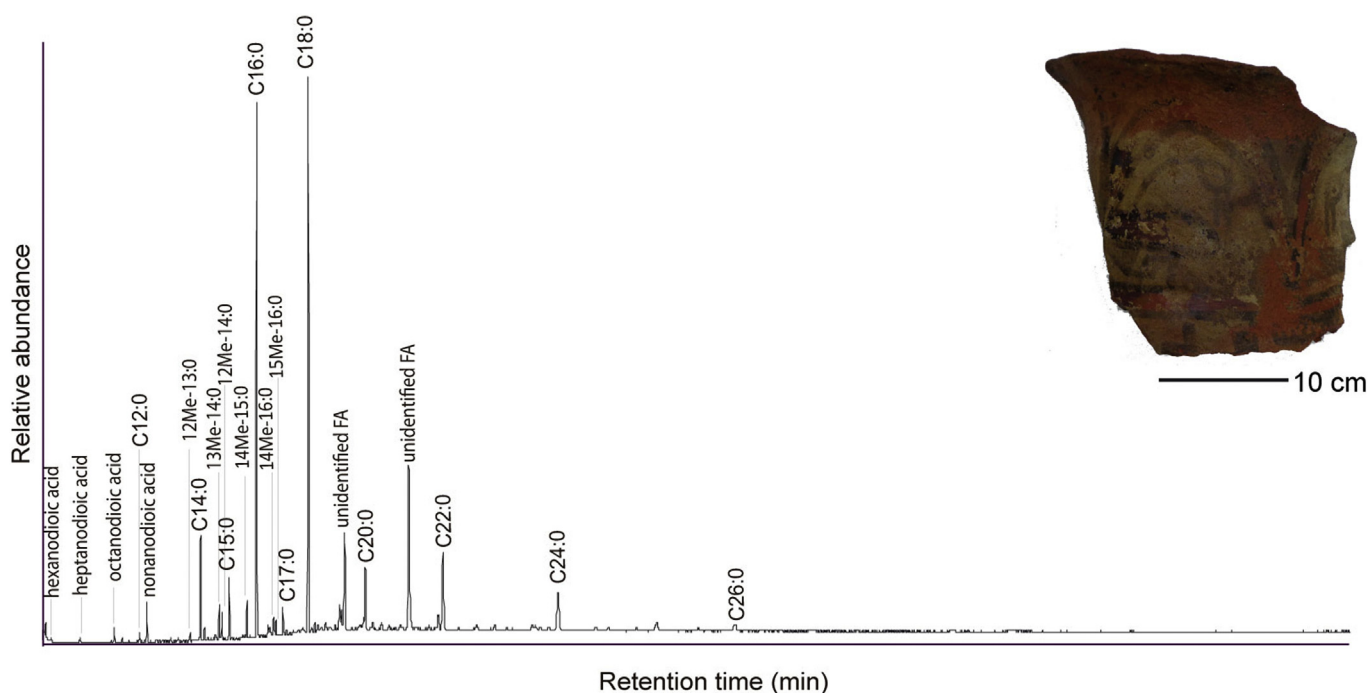


Fig. 4. Total ion chromatogram of fatty acid methyl esters (FAME) recovered in sample V2 from El Colorado, Catamarca, Argentina.

(R1, R2, R3, and R4). The lauric to miristic ratio ($C_{12:0}/C_{14:0}$) was 0.3, which is a further indication of plant lipids (Eerkens, 2005). No sterols were detected in the neutral fraction analysis.

5. Discussion

The results from this exploratory study are consistent with the culinary uses of the vessels. The results of the container from Fuerte Quemado-Intihuatana (V1) indicated that it was in contact with animal fat. The residues recovered from El Colorado vessel (V2) were the most complex mixture of lipids, as well as the best preserved. In this case, biomarkers of plant and animal lipids were detected as well as their degradation products. The third container from Mishma 7 (V3) also showed evidence of animal lipids, although the fatty acid ratios indicated possible mixtures with plant lipids.

The domestic contexts in which the three ceramics were found, together with the lack of soot or wear from heat exposure, point towards their use as containers for storage or service. The fact that all three vessels had biomarkers of animal lipids -in one case identified as camelid fat- could suggest the use of fat or marrow to seal their inner surfaces in order to make them optimal for liquid storage (Miyano et al., 2017). Liquids may have varied from water to fermented or non-fermented drinks. The container from El Colorado is especially interesting because there are clear signs that the substance that was stored included resources of plant origin, possibly a drink made from local plants. A less likely alternative hypothesis could be the use of vessels as short term storage containers to serve stews made from animal and plant products.

The profuse decorations and themes depicted in *Santa María* and *Belén* vessels are evidence that these containers were designed to be seen and to communicate relevant social messages (Basile and Ratto, 2011; Palamarczuk, 2014). The fact that they were used for culinary purposes does not yet clarify the problem of their role as everyday tableware or in commensalism practices. More contextual evidence will be needed to shed light on this issue.

Although this exploratory study included a small sample size, the results obtained from organic chemical analyses suggest that vessels in domestic contexts may have been used as part of the culinary

equipment, potentially for storage of liquids or stews. Given that organic residues are complex palimpsests, further analyses on a larger sample are needed in order to determine the origin of the organic residues recovered from the ceramic matrixes.

Nevertheless, these results provide insight into the potential uses of vessels that, until very recently in Argentine archaeology, were deemed as exclusive for funerary purposes.

6. Conclusion

In this study lipid organic residues were recovered and analyzed by organic chemistry techniques in order to explore potential culinary uses of *Santa María* and *Belén* vessels from the Late Intermediate Period in Catamarca, Argentina. The results of this study indicated that all vessels effectively were used for culinary purposes, potentially for storage of liquids or stews. Although the study is preliminary, strong evidence was obtained that contradicts the traditional view of vessels as exclusively funerary “urns” in Argentine archaeology. This exploratory study has provided sufficient evidence to warrant a broad study of organic residues in *Santa María* and *Belén* vessels in the future.

Notes

1. Evidence was also recorded in strata inferior to the foundations of E3 that indicate occupations prior to their construction, the oldest ones corresponding to formative moments.
2. Radiocarbon AMS dating was carried out duplicates of the same charcoal sample, which resulted in the following radiocarbon dates: 514 ± 35 yr BP (AA69979, 1405–1435 cal. 1 sigma) and 297 ± 26 yr BP (MTC15592, 1522–1573 cal. 1 sigma).
3. The fatty acid relative abundances from the control sediment sample from Los Colorados were: 11.2% miristic acid ($C_{14:0}$), 55.84% palmitic acid ($C_{16:0}$), and 32.95% stearic acid ($C_{18:0}$). The fatty acid relative abundances from the control sediment sample from Mishma 7 were: 62.7% palmitic acid ($C_{16:0}$), 25.7% stearic acid ($C_{18:0}$), and 11.6% oleic acid ($C_{18:1}$).

Funding

This work was supported by the National Research Council of Argentina [PIP-112-201,301-00288CO to MSM], the National Agency for Promotion of Science and Technology (PICT-2012-0196 to NR and PICT 2012- 0417 to VP), and the University of Buenos Aires (UBACYT 20020130100071BA to NR and 20020130100008BA to MSM).

Acknowledgments

We are grateful to Luis Coll for his help with the map design, and to Florencia Pretz for her help with some of the labwork. We thank the editor and reviewers for their insightful comments.

References

- Amuedo, C., 2012. Las conexiones entre las prácticas mortuorias de infantes y los alimentos. La materialidad y los significados generados en el movimiento cotidiano. In: Babot, M.P., Marschoff, M., Pazzarelli, F. (Eds.), *Las Manos En La Masa. Arqueologías Y Antropologías E Historias de La Alimentación En Suramérica*. Corintios 13, Córdoba, pp. 667–692.
- Amuedo, C., 2015. Las vasijas y su potencial como sujetos estabilizadores de seres incompletos: prácticas mortuorias de infantes durante el Período Tardío en el Valle Calchaquí Norte. *Estudios atacameños*: pp. 85–104. http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-10432015000100005&lng=es&nrm=iso.
- Baldini, L., Sprovieri, M., 2014. La especificidad de la alfarería del valle Calchaquí (Salta) en el contexto más amplio del espacio santamariano. *Revista Escuela de Historia* 13 (En prensa). http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1669-90412014000200002&lng=es&nrm=iso.
- Basile, M., Ratto, N., 2011. Colores y surcos: una propuesta metodológica para el análisis de las representaciones plásticas de la región de Fiambalá (Tinogasta, Catamarca, Argentina). *Boletín del Museo Chileno de Arte Precolombino* 16:75–88. http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-68942011000200006&lng=es&nrm=iso.
- Bennett, W.C., Bleiler, E.F., Sommer, F.H., 1948. *Northwest Argentine Archeology*. Department of Anthropology, Yale University, New Haven, Connecticut.
- Bull, I.D., van Bergen, P.F., R. Poulton, P., Evershed, R.P., 1998. Organic geochemical studies of soils from the Rothamsted classical experiments—II, soils from the Hoosfield spring barley experiment treated with different quantities of manure. *Org. Geochem.* 28, 11–26. doi:10.1016/S0146-6380(97)00114-9
- Bull, I.D., van Bergen, P.F., Nott, C.J., Poulton, P.R., Evershed, R.P., 2000. Organic geochemical studies of soils from the Rothamsted classical experiments—V. The fate of lipids in different long-term experiments. *Org. Geochem.* 31:389–408. [http://dx.doi.org/10.1016/S0146-6380\(00\)00008-5](http://dx.doi.org/10.1016/S0146-6380(00)00008-5).
- Calderari, M., Williams, V., 1991. Re-evaluación de los estilos cerámicos del noroeste argentino. *Comechingonia* 9, 75–95.
- Chizzolini, R., Zanardi, E., Dorigoni, V., Ghidini, S., 1999. Calorific value and cholesterol content of normal and low-fat meat and meat products. *Trends Food Sci. Technol.* 10:119–128. [http://dx.doi.org/10.1016/S0924-2244\(99\)00034-5](http://dx.doi.org/10.1016/S0924-2244(99)00034-5).
- Colombini, M.P., Modugno, F., 2009. *Organic Mass Spectrometry in Art and Archaeology*. Wiley, Chichester.
- Colombini, M.P., Giachi, G., Modugno, F., Pallecchi, P., Ribechini, E., 2003. The characterization of paints and waterproofing materials from shipwrecks found at the archaeological site of the Etruscan and Roman harbour area of Pisa (Italy). *Archaeometry* 45: 659–674. <http://dx.doi.org/10.1046/j.1475-4754.2003.00135.x>.
- Copley, M.S., Bland, H.A., Rose, P., Horton, M., Evershed, R.P., 2005. Gas chromatographic, mass spectrometric and stable carbon isotopic investigations of organic residues of plant oils and animal fats employed as illuminants in archaeological lamps from Egypt. *Analyst* 130:860–871. <http://dx.doi.org/10.1039/B500403A>.
- Deboer, W.R., 1974. Ceramic longevity and archaeological interpretation: an example from the upper Ucayali, Peru. *Am. Antiq.* 39:335–343. <http://dx.doi.org/10.2307/279592>.
- Eerkens, J.W., 2005. GC–MS analysis and fatty acid ratios of archaeological potsherds from the western great basin of North America. *Archaeometry* 47:83–102. <http://dx.doi.org/10.1111/j.1475-4754.2005.00189.x>.
- Evershed, R.P., 2008. Organic residue analysis in archaeology: the archaeological biomarker revolution. *Archaeometry* 50:895–924. <http://dx.doi.org/10.1111/j.1475-4754.2008.00446.x>.
- Evershed, R.P., Dudd, S.N., Copley, M.S., Berstan, R., Stott, A.W., Mottram, H., Buckley, S.A., Crossman, Z., 2002. Chemistry of archaeological animal fats. *Acc. Chem. Res.* 35: 660–668. <http://dx.doi.org/10.1021/ar000200f>.
- Folch, J., Lees, M., Sloane Stanley, G.H., 1957. A simple method for the isolation and purification of total lipides from animal tissues. *J. Biol. Chem.* 226:497–509. <http://www.jbc.org/content/226/1/497.full.pdf?sid=f01dad5b-686c-48d3-ace4-d8f4d41cd1a3>.
- González, A.R., 1950. Contextos culturales y cronología relativa en el área central del N.O. argentino (nota preliminar). *Anales de Arqueología y Etnología* 11, 7–32.
- González, A.R., 1977. *Arte precolombino de la Argentina: Introducción a su historia cultural*. Filmediciones Valero, Buenos Aires.
- González, L.R., Tarragó, M.N., 2005. Vientos del sur: El valle de Yocavil (Noroeste Argentino) bajo la dominación incaica. *Estudios atacameños*: pp. 67–95. <http://dx.doi.org/10.4067/S0718-10432005000100004>.
- Greco, C., Marchegiani, M., Palamarczuk, V., 2012. Tipologías estilísticas e inferencias funcionales de objetos cerámicos en momentos tardíos del Noroeste Argentino. In: Babot, M.P., Pazzarelli, F., Marschoff, M. (Eds.), *En Las Manos En La Masa. Arqueologías Y Antropologías de La Alimentación En Suramérica*. Corintios 13, Córdoba, pp. 505–526 P. Babot, F. Pazzarelli Y M. Marschoff.
- Hartmann, M.-A., 1998. Plant sterols and the membrane environment. *Trends Plant Sci.* 3: 170–175. [http://dx.doi.org/10.1016/S1360-1385\(98\)01233-3](http://dx.doi.org/10.1016/S1360-1385(98)01233-3).
- Henrickson, E.F., McDonald, M.M.A., 1983. Ceramic form and function: an ethnographic search and an archeological application. *Am. Anthropol.* 85:630–643. <http://dx.doi.org/10.1525/aa.1983.85.3.02a00070>.
- Iucci, M.E., 2016. *Producción, uso y circulación de cerámica tardía en el valle de Hualfín, Catamarca, Argentina*, Sociedad Argentina de Antropología ed. (Buenos Aires).
- Kriscautzky, N., 1999. *Arqueología del Fuerte Quemado de Yocavil, Catamarca*. Publicación de la Dirección Provincial de Cultura, San Fernando del Valle de Catamarca.
- Lantos, I., Spangenberg, J.E., Giovannetti, M.A., Ratto, N., Maier, M.S., 2015. Maize consumption in pre-Hispanic south-central Andes: chemical and microscopic evidence from organic residues in archaeological pottery from western Tinogasta (Catamarca, Argentina). *J. Archaeol. Sci.* 55:83–99. <http://dx.doi.org/10.1016/j.jas.2014.12.022>.
- Marchegiani, M., Palamarczuk, V., Reynoso, A., 2009. Las urnas negro sobre rojo tardías de Yocavil (Noroeste argentino): reflexiones en torno al estilo. *Boletín del Museo Chileno de Arte Precolombino* 14:69–98. http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-68942009000100005&lng=es&nrm=iso.
- Martínez Marín, A.L., Pérez-Hernández, M., Pérez Alba, L., Gómez Castro, G., Carrión Pardo, D., 2010. Metabolismo de los lípidos en los rumiantes. *REDVET, Revista electrónica de Veterinaria* 11. :pp. 1695–7504. <http://www.veterinaria.org/revistas/redvet/n080810.html>.
- Miyano, J.P., Lantos, I., Ratto, N., Orgaz, M., 2017. Animales e Incas o el oeste tinogastense (Catamarca, Argentina). *Lat. Am. Antiq. (In press)*.
- Nastri, J.H., 1999. El estilo cerámico santamariano de los Andes del sur. *Baessler-Archiv. Neue Folge* 47, 361–396.
- Nastri, J.H., 2003. Las urnas santamarianas para el entierro de párvulos (Valles Calchaquíes, siglos XI a XVII). Valores en juego en la investigación arqueológica. *Revista Argentina de Antropología Biológica* 5 (38). <http://sedici.unlp.edu.ar/handle/10915/5730>.
- Orgaz, M., 2014. Un estudio funcional de las estructuras del sector local-V- del sitio de Fuerte Quemado-Intihuatana. *Revista del Museo de Cachi. Estudios Antropología Historia. Nueva Serie.* 2, 75–97.
- Orgaz, M., Feely, A., Ratto, N., 2007. La cerámica como expresión de los aspectos socio-políticos, económicos y rituales de la ocupación Inka en la puna de Chaschuil y el valle de Fiambalá (dpto. Tinogasta, Catamarca). In: Nielsen, A.E., Rivolta, M.C., Seldes, V., Vázquez, M., Mercolli, P. (Eds.), *Procesos Sociales Prehispánicos En El Sur Andino*. Editorial Brujas, Córdoba, pp. 239–250.
- Palamarczuk, V., 2002. Análisis cerámico de sitios del bajo de Rincón Chico, Valle de Yocavil. Provincia de Catamarca (Tesis de Licenciatura en Ciencias Antropológicas). Universidad de Buenos Aires, Buenos Aires.
- Palamarczuk, V., 2008. Un análisis de la cerámica arqueológica de cuatro sitios en el bajo de Rincón Chico. In: Tarragó, M.N., González, L. (Eds.), *Estudios Arqueológicos En Yocavil*. Asociación de Amigos del Museo Etnográfico, Buenos Aires, pp. 19–80.
- Palamarczuk, V., 2014. Variantes “de tres colores” tardías en la alfarería Santa María de Yocavil, Noroeste argentino. Aportes para la diacronía de un estilo regional. *Revista Española de Antropología Americana* 44 (65). <http://revistas.ucm.es/index.php/REAA/article/view/41126>.
- Palamarczuk, V., 2016. Investigaciones arqueológicas en El Colorado, sur de Yocavil, Catamarca. *Argentina. Revista Andes* 27 (In press).
- Piñeiro, M., 1996. Manejo de Recursos y Organización de la Producción Cerámica en Rincón Chico. *Relaciones de la Sociedad Argentina de Antropología XXI*, Catamarca: pp. 161–185. <http://www.saantropologia.com.ar/textos/manejo-de-recursos-y-organizacion-de-la-produccion-ceramica-en-rincon-chico-catamarca/>.
- Podgorny, I., 2004. Antigüedades incontroladas. La arqueología en la Argentina, 1910–1940. In: Neiburg, F., Plotkin, M. (Eds.), *Intelectuales Y Expertos. La Constitución Del Conocimiento Social En La Argentina*, Paidós, Buenos Aires, pp. 147–174.
- Primera Convención Nacional de Antropología, 1966. *Facultad de Filosofía y Humanidades, Córdoba*.
- Puente, V., Quiroga, L., 2007. Percepción de la forma, variabilidad del conjunto estilístico Belén (Colección Schreiter). *Mundo de Antes* 5:157–186. <http://mundodeantes.org.ar/pdf/revista5/09-Puente-Quiroga.pdf>.
- Ramundo, P.S., 2007. Los aportes de los investigadores pioneros a la arqueología del Noroeste argentino. *Temas de Historia Argentina y Americana* 11:179–218. <http://bibliotecadigital.uca.edu.ar/repositorio/revistas/temas-de-historia11.pdf>.
- Ratto, N., 2013. A modo de introducción: la articulación de estudios arqueológicos, paleoambientales e históricos en el oeste tinogastense (Catamarca). In: Ratto, N. (Ed.), *Delineando Prácticas de La Gente Del Pasado: Los Procesos Socio-Históricos Del Oeste Tinogastense*. Publicaciones de la Sociedad Argentina de Antropología, Buenos Aires, pp. 17–45.
- Rice, P.M., 1996. Recent ceramic analysis: 1. Function, style, and origins. *J. Archaeol. Res.* 4: 133–163. <http://dx.doi.org/10.1007/BF02229184>.
- Rivolta, G., Salazar, J., 2006. La cerámica como indicador de la utilización del espacio. Un estudio en el sitio “Los Cardones” (Pcia. De Tucumán). *Comechingonia* 9, 91–102.
- Roldán, M., Funes, M., 1995. El espacio doméstico en la Loma Rica de Jujuil (Dpto. Santa María, Pcia. De Catamarca). *Comechingonia* 8, 97–123.
- Ruiz Huidobro, O., 1972. Descripción geológica de la hoja 11e, Santa María, provincias de Catamarca y Tucumán. *Boletín Servicio Nacional Geológico y Minero* 134, 1–65.
- Schiffer, M.B., 1990. The influence of surface treatment on heating effectiveness of ceramic vessels. *J. Archaeol. Sci.* 17:373–381. [http://dx.doi.org/10.1016/0305-4403\(90\)90002-M](http://dx.doi.org/10.1016/0305-4403(90)90002-M).

- Sempé, M.C., 1976. *Contribución a la arqueología del valle de Abaucán*. (Tesis Doctoral inédita). Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata.
- Sempé, M.C., 1984. Mishma No 7. Sitio incaico en el valle de Abaucán, Dpto Tinogasta, Catamarca. *Revista del Museo de La Plata, Antropología*, VIII 65, 405–438.
- Sjodin, S., 2001. *Clay Pots and the Potters' Work: Archaeology and Ethno-Archaeology at Pichao*, BAR International Series. Oxford University Press, Oxford.
- Skibo, J.M., 1992. *Pottery Function, A Use-Alteration Perspective*. Plenum Press, New York.
- Spangenberg, J.E., Jacomet, S., Schibler, J., 2006. Chemical analyses of organic residues in archaeological pottery from Arbon Bleiche 3, Switzerland - evidence for dairying in the late Neolithic. *J. Archaeol. Sci.* 33:1–13. <http://dx.doi.org/10.1016/j.jas.2005.05.013>.
- Tarragó, M.N., 2000. Chacras y pukara. Desarrollos sociales tardíos. In: Tarragó, M.N. (Ed.), *Los Pueblos Originarios Y La Conquista*. Nueva Historia Argentina. Sudamericana, Barcelona, pp. 257–300.
- Tarragó, M.N., González, L., Corvalán, P., Doro, R., Manasiewicz, M., Peña, J., 1999. La producción especializada de alimentos en el asentamiento prehispánico tardío de Rincón Chico, provincia de Catamarca. *Cuadernos INAyPL* 18, 409–427.
- Vázquez, C., Maier, M.S., Parera, S.D., Yacobaccio, H., Solá, P., 2008. Combining TXRF, FT-IR and GC–MS information for identification of inorganic and organic components in black pigments of rock art from Alero Hornillos 2 (Jujuy, Argentina). *Anal. Bioanal. Chem.* 391:1381–1387. <http://dx.doi.org/10.1007/s00216-008-2038-4>.
- Williams, V., 2003. Nuevos datos sobre la prehistoria local en la quebrada de Tolombón. Pcia. de Salta. Argentina. Local, Regional, Global: Pre- Historia, Protohistoria E Historia En Los Valles Calchaquíes, *Anales Nueva Época. Gotemburgo* (p. 163:19).
- Wynveldt, F., 2008. Tecnología cerámica Belén: caracterización macroscópica y conceptualización en la manufactura alfarera. *Intersecciones en antropología*. : pp. 157–172. http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1850-373X2008000100012&lng=es&nrm=iso.
- Wynveldt, F., Iucci, M.E., 2009. La cerámica Belén y su definición a través de la historia de la arqueología del NOA. *Relaciones de la Sociedad Argentina de Antropología* 34: 275–296. <http://www.saantropologia.com.ar/wp-content/uploads/2015/01/Relaciones%2034/12%20Wynveldt%20final.pdf>.