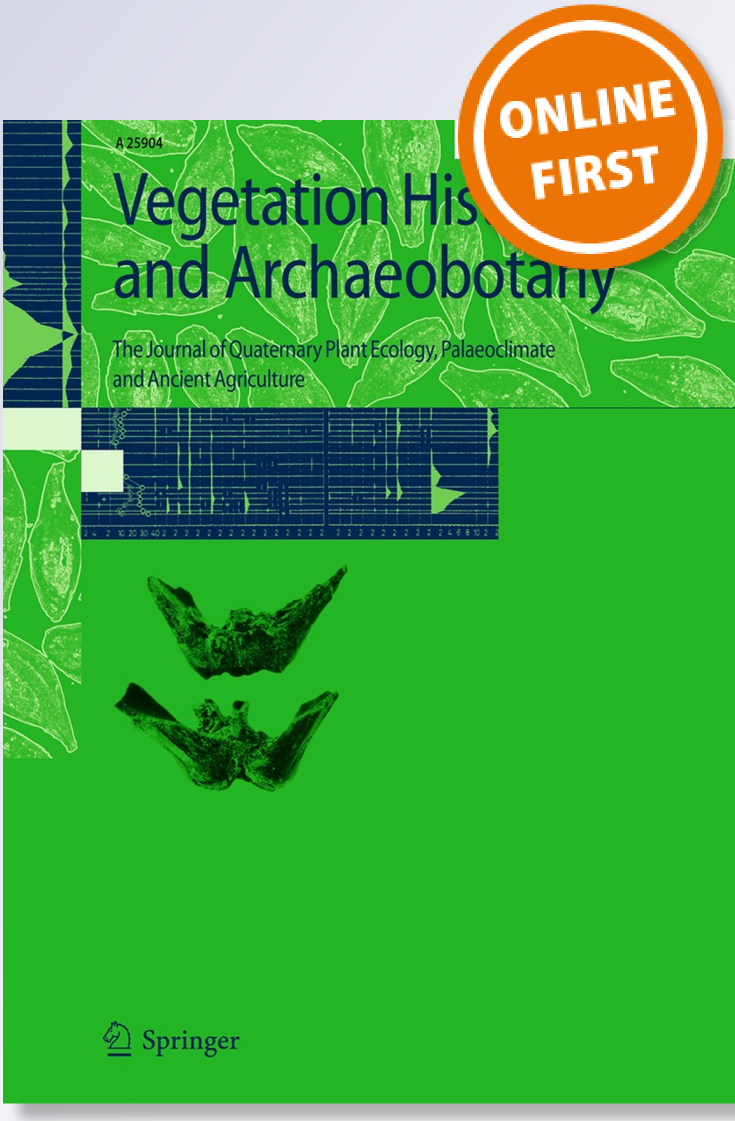
Food residues as indicators of processed plants in hunter-gatherers' pottery from La Pampa (Argentina)

M. Gabriela Musaubach & Mónica A. Berón

Vegetation History and Archaeobotany
The Journal of Quaternary Plant Ecology, Palaeoclimate and Ancient Agriculture - Official Organ of the International Work Group for Palaeoethnobotany

ISSN 0939-6314

Veget Hist Archaeobot
DOI 10.1007/s00334-016-0581-z



Springer

Veget Hist Archaeobot
DOI 10.1007/s00334-016-0581-z

ORIGINAL ARTICLE

Food residues as indicators of processed plants in hunter-gatherers' pottery from La Pampa (Argentina)

M. Gabriela Musaubach[1,2] · Mónica A. Berón[1,3]

Received: 29 May 2015 / Accepted: 27 June 2016

Abstract This paper presents the results of archaeobotanical studies of plant microremains adhered to the surfaces of charred cooking-pot residues, corresponding to a context of hunter-gatherer societies in semiarid environments (Western Pampa, Argentina). Microparticles (starch granules, phytoliths, micro-charcoal, ochre-coloured organic matter and fungal remains) were identified, and the taphonomic factors that affected the plant microremains were described. Results indicate the use of ceramic containers for processing wild plants (Poaceae and *Prosopis* sp.), cultivated plants (*Zea mays* L.) and other ingredients. This study suggests the importance of plants in the diet of Pampean hunter-gatherers and the effective use of ceramic containers for processing and preparation of these resources.

Keywords Hunter-gatherer · Western pampas of Argentina · Pottery · Phytolith · *Zea mays* and *Prosopis* starch grains

Communicated by A. Chevalier.

✉ M. Gabriela Musaubach
gabrielamusa@gmail.com

1 Consejo Nacional de Investigaciones Científicas y Técnicas. Museo Etnográfico J. B. Ambrosetti. Facultad de Filosofía y Letras, Universidad de Buenos Aires, Moreno 350, Ciudad Autónoma de Buenos Aires, Argentina

2 Cátedra de Etnografía II, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata Argentina, Buenos Aires, Argentina

3 Universidad Nacional del Centro de la Provincia de Buenos Aires, Buenos Aires, Argentina

Introduction

This paper presents the results of plant microremain analyses corresponding to a residential campsite context of hunter-gatherer societies in a semiarid environment of Western Pampa (southwest of La Pampa province, Argentina). In this environment the distribution and availability of fresh water is the main variable for spatial organization of pre-Hispanic populations. Hunter-gatherer populations lived throughout this region during at least the last 9,000 years, although not continuously in any given sub-area. These populations adopted different mobility patterns during this time, generally tied to water supplies. They used lithic tools, crafted items from organic materials like molluscs and made ostrich eggshell beads, worked leather and bone and had a diversified diet that included the hunting of large/small mammals and the gathering of wild plants. From 2,000 years ago onwards, they incorporated decorated pottery and intensified the use of different kind of ornaments, such as mineral beads, copper earrings and silver adornments manufactured with pre-Hispanic techniques. Also mobile and rock art production increased, the use of pigments intensified and finally burial in formal graves, some of them very complex, became more widespread. By these times temporary settlements were more frequent, located in the better watered parts.

At about 1,000 years ago, population growth is registered as well as violence and conflict and an increasing record of wide social networks going across the Andean range. It was surely induced by demographic pressure and the threatening expansion of European colonists, located on the east and west sides of their territories. Historical records mention several ethnic groups with defined identities and territories all around the area, reaching the Andean slopes. By the end of the 19th century (from 1879

Published online: 21 July 2016

to 1885), this complex socio-cultural system was destroyed by military campaigns carried out by the central Argentine government, paradoxically called the “Desert Campaign”.

Archaeological setting

The Tapera Moreira Locality (STM) is located in the Lihué Calel district, on the Curacó river bank (38°33′S, 65°33′W, Fig. 1). This locality extends over a large area of land where several discrete concentrations of surface and subsurface archaeological materials were recorded (Berón 2004). Five archaeological sites have been identified, showing important differences in terms of topographic and archaeological contexts. Excavations and radiocarbon analyses were performed at four sites (sites 1, 3, 5 and La Lomita), constituting the reference framework for research in this area, both chrono-stratigraphic and for evaluation of cultural and environmental change. A total of 23 radiocarbon dates were obtained, 18 corresponding to Site 1, three to Site 5, and the last two corresponding to human remains from Site 3 and La Lomita. Site 1 at STM presents the longest regional archaeological and chronological sequence. It is a multi-component site, occupied from the end of the middle Holocene (4,550 ± 60 years BP) till the end of the late Holocene (360 ± 25 years BP). Large and medium sized mammals like guanaco (*Lama guanicoe*) and pampas deer (*Ozotoceros bezoarticus*) were the main staples, complemented with small mammals, *ñandú* eggs (*Rhea americana*) and vegetal foods (Salemme and Berón 2003; Bastourre and Salazar Siciliano 2012; Musaubach 2014). Four other open air sites were identified in this locality. The remains of four individuals were found at Site 3 and La Lomita. These were affected by fluvial processes and three of the skulls show intentional, annular deformation (Baffi and Berón 1992; Berón and Baffi 2003). Sites 2 and 4 are superficial. Site 5 is unicomponent, corresponding to the final late Holocene, and is characterized by the presence of local pottery and some fragments of the bichrome red on white tradition (Vergel or Valdivia) dated at the same age as in the south of Chile (Adán et al. 2005).

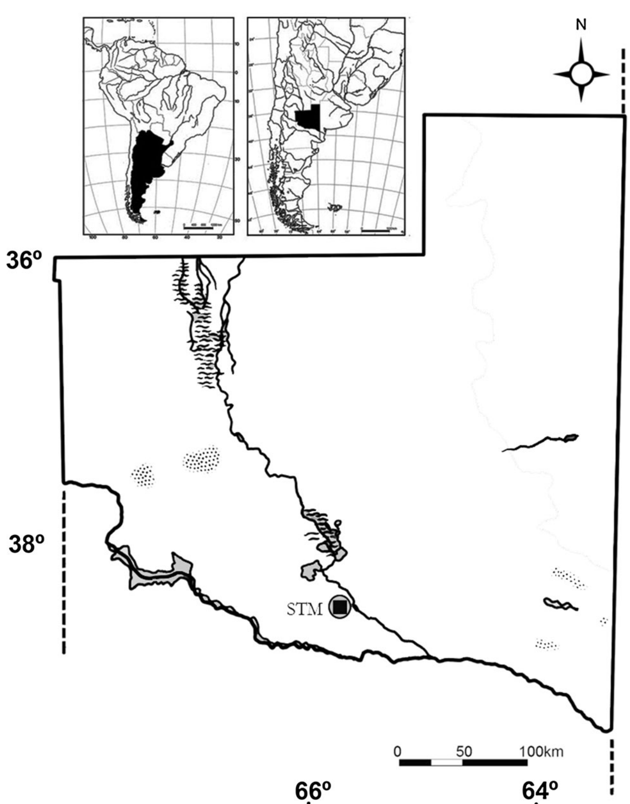


Fig. 1 Archaeological site location

Site 1 is a base camp located near a permanent source of water. In addition there are pools in the river that retain rainwater and allow concentration of *chañares* [*Geoffroea decorticans* (Gill ex Hook et Arn.) Burkart.] forests and game. Here multiple persistent occupations were detected and four units of analysis (Components) were delimited and defined, from the oldest to the most recent, as Lower (Summit and Lower Levels), Middle and Upper Components.

Lithic artifacts, pottery sherds, faunal remains, ochre, ornaments and pieces of mobile art were recovered and studied. The presence of extra regional items such as lithic raw materials (orthoquartzite, chert, obsidian) and fragments of Valdivia pottery indicate a wide spatial scale of interactions (Berón 2004, 2006, 2007; Giesso et al. 2008). We would like to stress that all these extra regional indicators establish clear connections with the Atlantic coast, located at its closest point at ca. 300 km to the East, and with central-southern Chile, more than 500 km distant to the west.

These societies maintained their hunter-gatherer way of life until they were subdued or exterminated by the “Desert Campaign” in the 19th century. Previously, the only known modifications so far caused by contact with the colonial regime had been the adoption of the horse (horse complex) and the trading of wild cattle (Mandrini 1984; Palermo 1986; Mazzanti 2007).

Mobility patterns and frontier region of pre-Hispanic agriculture

Several authors have proposed the existence of a frontier region of pre-Hispanic agriculture in the Americas (Lagiglia 1977; Gil 1997–1998, 2000, 2003). The possibility of farming in the southern area of Mendoza province (Argentina) has been discussed by several authors, in relation to the discovery of corn kernels in archaeological deposits in caves, but discounted by several lines of evidence, especially from direct indicators of diet such as isotopic analyses and oral health (tooth decay) (Novellino et al. 2004). During the contact period the south of Mendoza province, south of the Atuel river, functioned as a buffer zone between the semi-sedentary agricultural population of the Andes and the hunter-gatherers of Pampa and Patagonia (Gil 2003; Berón et al. 2009; Musaubach and Berón 2012; Musaubach 2014). In consequence, it is postulated that pre-Hispanic corn, while recorded from 2,000 years ago at the *Cueva del Indio* site (Lagiglia 1980), reached its southern limit about 1,000 years later in the buffer region between west-central Argentina and northern Patagonia. Despite *Zea mays* being the most common cultigen to the north of the Atuel river (Lagiglia 1977), corn was not quantitatively important in the diet of hunter-gatherers.

In the case of STM, Berón (1994, 2004) proposed three regional mobility ranges according to the availability of each of the resources required. The first was a close range, located between 4 and 5 km around residential bases, where groups could find water, certain types of rock, wood, wild fruits and some prey, especially smaller fauna, for hunting. The second was a middle mobility range, between 5 and 20 km, in which the exploitation of certain specific types of rock unavailable in the close mobility range as well as large mammal hunting activities were carried out. Finally groups would find specific materials, such as pink granite or copper minerals (malachite, chrysocolla) in the outer mobility range, between 20 and 50 km from the residential base, which required at least one day's journey.

With respect to macro scale circuits, Berón (2004, 2007) proposed the existence of:

> "(…) macro-regional mobility circuit for various purposes. This circuit would be based on social relationships or systems of social partnership. The spatial distance of social contacts in the research area has been wide and varied. Networks involving special places for lithic raw materials, ecologically different landscapes with access to various resources were established, and possibly ethnically distinct populations were involved. Such mobility would include a broad regional scale, connecting distant and ecologically different sub regions—in particular the Humid Pampa of southern Buenos Aires province, reaching the Atlantic coast, northern Patagonia, and westward, the mountain area and south-central Chile (Araucania). To the north the Central Hills and South Mendoza would be related to this circuit. Social contacts between populations have included the movement, control and exchange of people, goods, information and ritual knowledge. All these were mechanisms particularly important to ensure access to alternative supplies amid desert environments with limited resources or climatic fluctuations. The intensification of the connections between groups enabled the expansion of networks of social partnership and thus increased economic correlates involved in this interaction (…)" (Berón 2004, pp. 446–447, 2007).

In this macro-regional circuit, the procurement of *Zea mays* arises, as a result of an exchange system among Pampean hunter-gatherers and horticultural societies, probably from north of Mendoza province or south-central Chile.

In this article, an overview of the results obtained from the archaeobotanical study of organic residues on pottery will be presented. In addition we address the relevance of the protocol we used to study such contexts.

Materials and methods

The surface and stratigraphic ceramic analysis of archaeological material from STM, sites 1 and 5 was conducted by one of the authors (Berón 2004). It was oriented towards the organization of a ceramic taxonomy of "ceramic groups" based primarily on techno-morphological criteria. Nineteen ceramic groups for the Curacó area were defined, four of which correspond to pottery (STM H- STM S- STM I and STM U) decorated by different techniques (linear incised, ribbed, painted and rhythmic incised, respectively). For the definition and classification of ceramic groups, four basic attributes and their states were selected and observed at the macroscopic level: cooking atmosphere, size of the inclusions, surface treatment and decorative techniques. For the general description of each ceramic group another set of attributes and their states were observed in order to characterize them completely, such as composition, distribution and density of inclusions, texture, fracture characteristics, colour core, hardness, colour of external and internal surfaces and wall thickness (Berón 1989–1990/1991, 2000, 2004).

Experimental tasks performed with local clays, with the objective of evaluating the local/allochthonous origin of this technology, have provided information indicating the existence of basic local raw materials to produce pottery (Berón 2000, 2004). Other issues evaluated in relation to this technology have been the post-depositional stratigraphic record that affected the burial of the fragments (Berón and Scarafoni 1993; Berón 2004) and analysis of taphonomic factors and transformation processes that influenced the recording of pottery in these environmental conditions (Ozán 2009). Analyses of fatty acids have recently been conducted (Illescas et al. 2012), which are integrated together with archaeobotanical studies in this paper to address in a more precise way the potential foods eaten by these populations as well as their lifestyles.

A total of 57 samples attached to 23 sherds were studied during the project, to determine which vegetables were cooked at Tapera Moreira Archaeological Locality (Table 1). All the food residues studied were firmly adhering to either the interior surface (the majority) or to the exterior surface of the pottery fragments, and as such they were considered to reflect the original vessel contents and to represent the last or one of the last meals cooked in the pot. In order to test this assumption, they were sampled separately on both sides of the fragments.

Different methods to extract microfossils from a sample are described in the literature (Babot 2006; Loy and Fullagar 2006; Holst et al. 2007). In this study, a multistage protocol was used to extract the archaeobotanical material trapped in use-residues. At first, the residues still adhered to the fragments were observed and photographed under a ZTX-3E Zoom Stereo Microscope at ×10 magnification. Then the following variables were recorded and evaluated: face where they were deposited (inner-external); colour features (cream-ochre-black); texture (resin-grained-dusty); thickness and quantity (percentage of area covered on surface of the sherd); presence of clasts or precipitates

Table 1 Contextual information of STM sherds and type of sample analysed

Site	Number of sherd (provenance)	Ceramic group	Region sampled	Type of sample
1	1 (STM 89)	STM H	External wall	Superficial and internal black residue
			Internal wall	Superficial and, internal black residue
	3 (STM 90 GII_b)	STM S	Internal wall	Superficial, internal ochre and internal black residue
			External wall	Superficial and internal residue
	4 (STM 90 GIV)		Internal wall	Superficial and internal black residue
			External wall	Internal black residue
	5 (168)		Internal wall	Superficial, internal ochre and internal black residue
			External wall	Superficial and internal black residue
	6 (96)		Internal wall	Internal ochre residue
			External wall	Internal black residue
	7 (47)		Internal wall	Wall scraping, non-residue
	8 (116)		Internal wall	Superficial, internal and internal black residue
	9 (STM 90)		Internal wall	Internal black residue
			External wall	Internal black residue
	10 (49)		Internal wall	Superficial and internal black residue
	12 (221)	STM 7	Internal wall	Internal black residue
			External wall	Wall scraping, non-residue
	14 (STM 90 JII_b)		Internal wall	Internal black residue
			External wall	Internal residue
	15 (STM 95)		Internal wall	Internal black residue
	16 (152)	STM 4	Internal wall	Superficial and internal ochre residue
	19 (sin nro.)	STM 5	Internal wall	Internal black residue
			Neck rim	Black residue from neck rim
	20 (sin nro.)		Internal wall	Internal residue ochre
	21 (84)		Internal wall	Wall scraping, non-residue
			External wall	Wall scraping, non-residue
5	22 (STM 89)	STM H	Internal wall	Superficial and internal black residue
			External wall	Superficial and internal black residue
	26 (902)	STM U	External wall	Internal black residue
			Internal wall	Calcium carbonate
	13 (890)	STM 2	Internal wall	Superficial and internal black residue
			External wall	Superficial and internal residue
	30 (878 y 895)	STM 4	Internal wall	Superficial and internal black residue
	31 (STM 94 LI)		Internal wall	Superficial and internal black residue
	32 (STM 91 RI)		Internal wall	Superficial and internal black residue
	33 (863)	STM 5	Internal wall	Calcium carbonate and superficial calcium carbonate

(carbonates-other). Polarized light microscopy and the 400× objective of the JPL-1350 series was used for microscopic examination of organic residue material. Three main steps were developed to extract the samples: surface residues were wetted with distilled water; they were then removed by gently scraping directly onto microscope slides with a metallic point and finally were mounted in a water/glycerin solution (Musaubach 2014).

Our analysis focuses on two microfossil types, starch and phytoliths, but to allow for a more comprehensive analysis we also analysed associated residues such as micro-charcoal and other organic material (Coil et al. 2003; Babot 2007). Attributes used to describe the starch grains were: overall morphology, size range, hilum, lamella, fissures and other features following the guidelines provided by Holst et al. (2007) and the International Code for Starch Nomenclature (ICSN 2011). The starch granules were then assigned on the basis of published literature (Holst et al. 2007; Korstanje and Babot 2007; Giovannetti et al. 2008; Musaubach et al. 2013; among others). Taphonomic analysis of starch was conducted following Babot (2003). The descriptions and classifications of phytoliths were performed using descriptors based partially in the *International Code for Phytolith Nomenclature 1.0* (Madella et al. 2005). For taxonomic identifications, published reference materials were consulted in the following: (Babot et al. 2016; Bertoldi de Pomar 1975; Gallego and Distel 2004; Gallego et al. 2004; Fernández Honaine et al. 2006, 2008; Korstanje and Babot 2007; Piperno 1988, 2006; Twiss 1992; Twiss et al. 1969; Yost and Blinnikov 2011; Zucol 1996a, b, 1998, 1999, 2000, 2001; Zucol and Bonomo 2008).

In Musaubach et al. (2013) a detailed study was developed, from an archaeological perspective, of the morphological characteristics of the starch granules within the kernels of selected native wild grasses found in the Central Pampas of Argentina. Native wild grasses and maize starch grains were compared. They can be distinguished from each other based on their size, shape and other attributes. The majority of the studied wild grasses grains did not share morphological characteristics with maize starch grains. Regarding the grain shape of the species with simple grains studied, only irregular or polyhedral starch grains of *Sorghastrum pellitum* (Hack.) Parodi may be confused with maize due to the presence of pressure facets and transverse fissures, and also because it can reach 20 µm in maximum length. In maize, the maximum length of starch grains commonly ranges from 8 to 25 µm (Holst et al. 2007) but grains that surpass these limits have been reported, reaching 2–35 µm in length, with a mean of 11.1–15.8 µm (Winton and Winton 1932; Holst et al. 2007; Korstanje and Babot 2007). Grains with a maximum length above 20 µm are important in order to identify maize unambiguously when *Sorghastrum* is expected. Fortunately, the simple grains of this species only exceptionally have pressure facets and transverse fissures. Besides, only a minor proportion of them are produced by the plant, and the starch assemblages of *S. pellitum* show mainly compound grains in the form of supernumerary aggregates made up of small granules that fill in the plant tissue with a coat of amorphous starch, cementing grains. This latter class of starch is absent in maize. In sum, in the case of the Pampas environments, when irregular and polyhedral starch grains with transverse or radial fissures, dominate the starch assemblage, and when these grains include at least some particles larger than those of *S. pellitum* (20 µm maximum length), the identification of maize may be based on both morphology and size.

Carbonized food residue is an important archive of information on ancient alimentation. Preserved on the inside of cooking pots, this carbonaceous material may, potentially, be analysed for a variety of botanical and chemical proxies and directly dated. Carbonized residues are found in a wide range of archaeological contexts (Fujiwara 1982; Tyree 1994; Jones 1997; Staller and Thompson 2002; Piperno 2006; Craig et al. 2007; Zarrillo et al. 2008; Zucol et al. 2008; Boudin et al. 2010; Raviele 2011; Bonomo et al. 2012; Petö et al. 2013), and may provide a good micro-environment for starch preservation, as degradation rates are retarded, especially when they are in association with artifacts. The high temperatures to which carbonized deposits have been exposed can accelerate tissue degradation in plants making them more prone to subsequent organic degradation and enzymatic attack in soils as has been suggested by Haslam (2004). Nevertheless, starch grains and phytoliths, are often preserved much better than other plant tissues and offer the best target for analysis (Valamoti et al. 2008). Otherwise, it is assumed that plant microfossils identified within the matrix of carbonized surface residues are likely to derive from vessel use (Crowther 2005; Saul et al. 2012).

The fatty acid analysis performed by gas chromatography (GC) on a sample of ceramic fragments from STM (Illescas et al. 2012) provided information on the resulting organic waste from processing plant and animal resources (Table 2). Such remains are contained not only on the surface of the vessel walls, but also inside the same (ceramic paste), due to the absorption of residues during processing or storage of substances. Degraded animal fats were the most common residues detected in domestic pottery containers, particularly cooking pots (Charters et al. 1993). This is the case in the analysed sample from STM, judging by the presence of a high concentration of saturated fatty acids, particularly the components $C_{16:0}$ and $C_{18:0}$ (stearic and palmitic acids, Regert et al. 1998). The contextual information for STM ceramic fragments, which were studied by gas chromatography to analyse their fatty

Table 2 Contextual information and sherds data of relative abundance of methyl esters of fatty acids identified in the ceramic remains. Modified from Illescas et al. (2012, p. 391)

Sample	Provenance	Number	Ceramic group	Depth (m)	Palmitic acid (16:0) %	Stearic acid (18:0) %	Oleic acid (18:1) %
1	STM1 94 B_2 VIII	156	STM-2	S*	–	–	–
2	STM1 94 Q_1 III_a	69	STM-5	0.76	–	–	–
3	STM1 94 Q III_a	119	STM-6	0.67	traces	traces	99
4	STM1 94 C_2 IX	181	STM-5	S*	61	39	0
5	STM1 94 Q III_a	71	STM-1	0.49	68	32	0
6	STM1 94 C_2 VII	152	STM-4	2.05	57	43	0
7	STM1 94 C_2 V_b	115	STM-5	1.84	47	53	0
8	STM1 94 A_2 X	221	STM-1	2.20	71	29	0
9	STM1 94 A_2 IV_b	84	STM-5	1.62	–	–	–
10	STM1	96	STM-S	0.63	44	24	32
11	STM1	47	STM-S	0.67	8	6	86
12	STM5 L I	(–)	STM-4	(–)	47	24	29
13	STM5 R I	(–)	STM-4	(–)	31	17	52
14	STM5	863	STM-5	0,33	18	6	76

*S sieve

acid values, is summarized in Table 2, which shows the results from the data obtained from the processed samples (Illescas et al. 2012). Residues extracted from a ceramic fragment corresponding to the STM-S ceramic group (Fig. 2), were radiocarbon dated by AMS technique in the Center for Applied Isotopes Studies of the University of Georgia, USA. The result is 360 ± 25 years BP. Analysis of $\delta^{13}C$ on this residue resulted in a value of −25.2 (UGAMS 7446) (Musaubach and Berón 2012).

An archaeobotanical approach that included both ethnobotanical and archaeological methodologies was applied. Micro-remains that could correspond to potentially edible plants were discriminated from those with some kind of functionality related to symbolic aspects, medicinal uses, and vegetal raw materials. Chemical, physical or mechanical processes that might affect degradation or preservation of phytoliths and starch grains were recorded. Among them were registered those produced by natural agents as well as those resulting from human post-collection practices (boiled, fried, and/or grinding). Fungal and carbonate presence in the samples was recorded (Babot 2003, 2007; Barton 2007, 2009; Henry et al. 2009).

Results

With regard to texture, black waste is resinous and grainy, while in the ochre-coloured organic residue the material is dusty. In the particular case of the fragments of the STM-S ceramic group, black colour and grainy residue texture were recorded, also on the outer wall, deposited between the grooves (Fig. 3). Based on the counts and taxonomic

Fig. 2 *1 Challa* sherd, external face. *2 Challa* sherd, inner face. *3 Challa* pot in Neuquén Municipal Museum. Photo: M. Berón. *4* External residues at ×10 magnification (*scale bar* 1 mm). *5* Inner residues at ×10 magnification (*scale bar* 1 mm). Photos: M. G. Musaubach. *6* Sherds representative of STM-S ceramic group pot. Photo: M. Berón

assignments made on samples of different ceramic groups, qualitative and quantitative differences were observed in relation to the types of plant micro-remains recorded (Table 3). In the STM-S ceramic group the presence of starch granules of *Zea mays* (corn) and *Prosopis* sp. was recorded, both on internal and external walls of the fragments. *Zea mays* starch grains exhibited modification in the hilum. *Prosopis* starch grains with contour damage were also registered (Fig. 4). Most *Prosopis* sp. grains and those of oval morphology were recovered from the fragments corresponding to the ceramic groups STM-S, STM-H, STM-4 and STM-2.

Poaceae phytoliths were recorded in all ceramic groups of the sample. The main morphologies identified are trapeziform psilate short cell, tabular polygonal psilate epidermal cell, elongate psilate long cell, flat bilobate short cell/concave end flat bilobate short cell, normal saddle short cell and cylindrical rondel short cell (Fig. 5). In STM-H, STM-2 and STM-4 ceramic groups dicotyledonous phytoliths were recorded, among which is highlighted the globular type morphology known as facetate globular (Fig. 4). Those phytoliths found in a portion of rim corresponding to the ceramic group STM-H were surrounded by some type of birefringent substance, probably the remains of plant tissue that had contained them.

In the STM-H ceramic group, a polyhedral starch grain of *Prosopis* sp. was identified. An oval starch granule with contour damage and alterations in the extinction cross, measuring 10 µm long by 20 µm wide was also registered

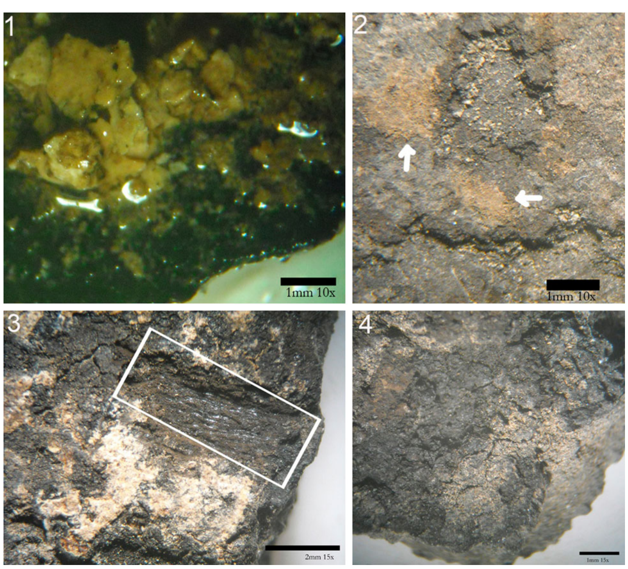


Fig. 3 *1* Ochre-coloured residues which were wetted with distilled water on the inner wall. *2* Ochre-coloured residues located above a layer of black residues on the inner wall. *3* Black and ochre-coloured residues on the inner wall, after extraction procedures. *4* Black residues with superficial cracks

(Fig. 5). Fungal zoospores and hyphae were also present in microfossil assemblages and sometimes associated with micro-charcoal residues (Fig. 4).

Discussion

Microfossil assemblages recorded on sherds allow us to define some trends regarding the use of ceramic containers for processing vegetables. One of them is the presence of cultigens such as *Zea mays*, indicating its consumption in the context of hunter-gatherers societies of Argentine Western Pampa. The presence of wild plants such as *Prosopis* sp. reveals that these plants were also consumed. The starch grains of *Prosopis* sp. found on sherds corresponding to STM-H, STM-S and STM-4 ceramic groups suggest the use of this food resource by the societies that occupied this territory.

These archaeobotanical data have been integrated with the information provided by other lines of evidence (analysis of fatty acid composition, technological and functional analysis of ceramics, ethnohistorical and ethnobotanical data), in order to achieve a more comprehensive understanding of cooking or eating practices of Pampean hunter-gatherer societies (Berón 2004, 2006, 2007; Musaubach and Plos 2010, 2015; Musaubach 2014). Gas chromatography analyses provided information on the fatty elements of food incorporated into the total diet, to complement the resulting organic waste from processing plant and animal food resources. The presence of oleic acid residues in STM-S, STM-4 and STM-5 could correspond to either corn oil or degradation products of polyunsaturated acids (Illescas et al. 2012). The lipids absorbed into the vessels are susceptible to attacks by microorganisms due to post-depositional contamination, so the results could come from lipids turned into other fatty acids (Eerkens 2007). However, the presence of unsaturated fatty acid 18:1 would indicate that the oxidative degradation of lipids within the sedimentary matrix of the sherds is minimal (Maier et al. 2007; Illescas et al. 2012). While this type of analysis fails to identify plants to the species level, the possible presence of maize can be recorded by these analytical methods.

Archaeobotanical analysis performed in pots called "*challas*", dated by radiocarbon to about 360 ± 25 years BP, showed the presence of maize starch grains in the context of hunter-gatherer groups of the Argentine Western Pampas (Musaubach and Berón 2012). According to ethnohistorical data (Coña 2000, among others), these kinds of pots were used among *mapuches* for cooking *muday* of maize or wheat, an alcoholic beverage. Even though the archaeological starch grains are not damaged by fermentation but by toasting, its occurrence in *challa* residues lets us think they could be an ingredient of these drinks. But at

Table 3 Summary of the types of microfossils identified by site and ceramic group. References: (X): present, (-): absent

STM Site, ceramic group	Starch grain				Phytolith		Plant tissue	Fungal zoospores and hyphae	Pollen	Micro-charcoal
	Prosopis sp.	*Zea mays*	oval	damaged	Poac.	Dicotyl.				
Site 1										
STM-S	X	X	X	X	X	–	X	X	–	X
STM-H	X	–	–	–	X	–	X	–	X	X
STM-2	–	–	X	–	X	–	X	X	X	X
STM-4	X	–	–	–	X	–	–	X	–	–
STM-5	–	–	–	–	X	–	X	X	–	–
STM-7	–	–	–	–	–	–	X	–	–	–
Site 5										
STM-H	X	–	X	X	X	X	–	–	–	X
STM-U	–	–	X	–	X	–	X	X	–	X
STM-2	–	–	X	X	X	X	X	X	X	X
STM-4	–	–	–	–	X	X	X	–	–	X
STM-5	–	–	–	–	–	–	–	–	–	–

the moment we have not found traces of yeast to endorse the hypothesis that the residues correspond to *muday*.

At that time there is no evidence of maize in the Argentine pampas, but the presence of corn in pottery found in the STM Superior Component coincides with the period of intensifying corn use (1,250–300 years BP) by contemporary hunter-gatherers groups from Mendoza and Neuquén (Argentina) to the south of the agricultural frontier proposed by several authors (Gil et al. 2009; Lema et al. 2012). As mentioned in the introduction, the area to the south of the Atuel river functioned as a buffer zone between the semi-sedentary agricultural population of the Andes and the hunter-gatherers of Pampa and Patagonia.

These findings are consistent with the hypothesis of the existence of macro-regional mobility circuits during the late Holocene in which the hunter-gatherer groups of STM were included. Such mobility circuits were based on a system of interaction, exchanges, social complementarity and population dynamics. Several pieces of archaeological evidence mentioned above support the large range mobility hypothesis. This mobility favoured the contact and exchange among these Pampean hunter-gatherers groups with agricultural societies from South-Central Chile, north of Mendoza and onwards. In order to identify the provenance of different extra-regional items, or raw materials, we developed a program of archaeometry. We analysed lithic raw materials (i.e. ortho-quartzite, chrysocolla, turquoise, obsidian) (Berón 2006, 2007), beads made of shells and snails from the pampean Atlantic coast (Cimino et al. 2004), sherds from the Chilean bichrome tradition (Vergel and Valdivia pottery styles) and ornaments made of metal such as a *tupu* and a copper ring from Araucanian region, among other findings (Berón et al. 2012; Mera et al. 2015).

Besides this material culture there is bioarchaeological evidence of funerary packages employed to transfer burials far from the place of death. An important cemetery called Chenque I site, next to STM, brings together individuals of different geographical origins (Berón et al. 2013). This cemetery is placed in the central Argentine pampas, a hilly semi-desert territory, about 100 km from STM. In order to establish the provenance of the individuals, $\delta^{18}O$ isotopic studies were performed in 10 interments. The results allowed us to differentiate local from extra-local individuals buried there. Two individuals (Burials # 17 and 19) show impoverished $\delta^{18}O$ values (-8.1 to -8.3 ‰), which means an Andean provenance (Berón et al. 2013). The identification of extra-local people buried in this cemetery is important evidence of mobility and interaction at that time on a large spatial scale. So, in relation to the macro-regional mobility hypothesis mentioned above, we propose that domesticated resources were obtained by Pampean hunter-gatherers through exchange networks.

In order to avoid ambiguous identifications of microremains, it was necessary to study the microbotanical particles produced by the native flora. So we made a comparative study of the starch grain assemblages of maize and native wild grasses of the Poaceae family from the central Pampean herbaceous steppe of Argentina (Musaubach et al. 2013). We compared this reference collection with starch grains on *challas* that were initially assigned to maize (Musaubach 2014). The results obtained allow us to confirm this latter botanical assignation for use-residues.

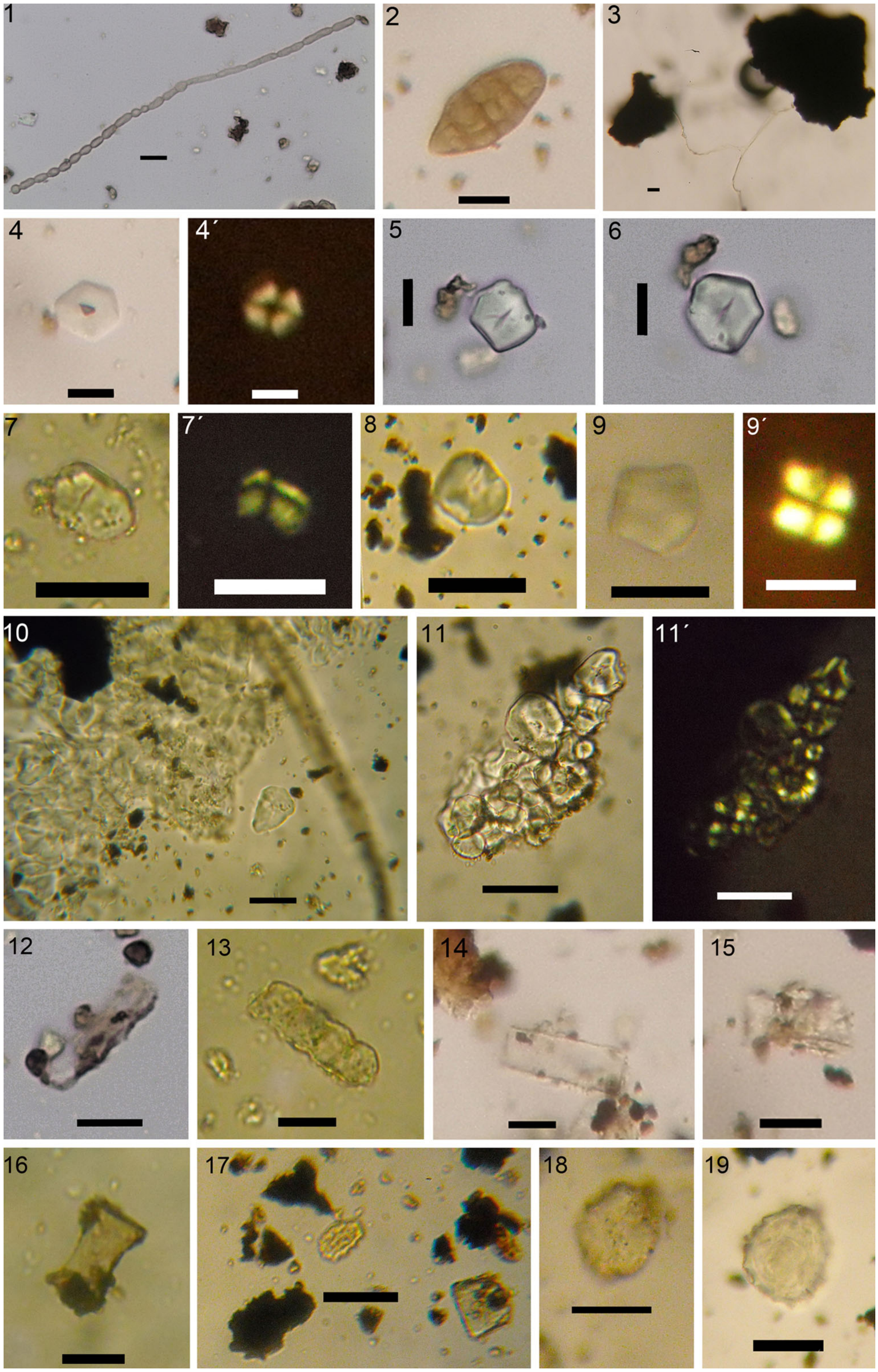


Fig. 4 *1* Fungal hyphae. *2* Fungal spore. *3* Micro-charcoal associated with Fungal hyphae. *4* Damaged *Zea mays* starch grain with modification in the hilum. *5*, *6* *Zea mays* starch grain. *7*, *7′*, *8*, *9*, *9′* *Prosopis* starch grain. *10*, *11*, *11′* Damaged *Prosopis* starch grain with contour damage. *12* Trapeziform psilate short cell. *13* Polylobate short cell. *14* Elongate psilate long cell. *15* Trapeziform bilobate short cell. *16* Elongate rondel short cell. *17* Oblong equinate. *18* Globular psilate. *19* Facetate globular. All images were taken at ×400 magnification (*scale bars* 20 µm)

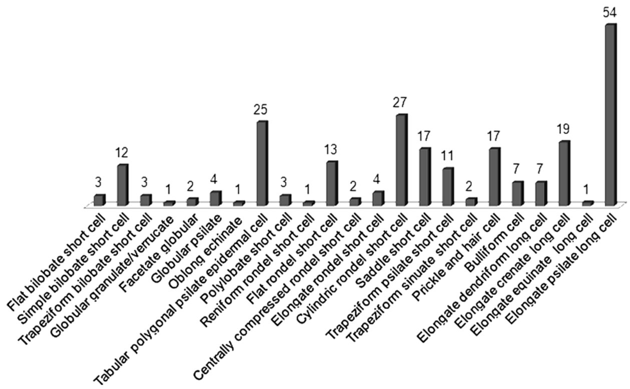


Fig. 5 Absolute number of phytoliths types from the total of carbonized residues

The comparative analysis of starch from native wild grasses negated the possibility that their seeds were eaten. However, Poaceae phytoliths identified in all ceramic groups of the sample correspond to wild grasses (Babot et al. 2016). The morphologies registered correspond to epidermal tissues, which occur in the leaves and axis. Probably wild Poaceae registered here were employed for other purposes than food (cleaning, thermal insulation for toasting or roasting food, among others).

This study corroborates the preliminary analyses (Musaubach and Berón 2012) that showed the presence of maize residues in potsherds of the *challa*-type used by the hunter-gatherers that inhabited the western Pampas during the Late Holocene. We propose that *challas* were used in certain cases and for specific purposes such as the preparation and consumption of processed foods that included corn in their composition. However, the sparse occurrence of the latter has not been enough to leave isotopic signals, either in values of carbon and nitrogen isotopes, or through the total absence of caries in the individuals analysed (Berón and Mazzanti 2011; Luna and Aranda in press).

With regard to starches that show damage and changes in morphological attributes, it is proposed that they relate to a series of procedures for processing, cooking and storage of substances. Boiling, or in the absence of boiling, roasting or baking, and grinding was also evident. The identification of *Zea mays* starch granules and *Prosopis* sp. reinforces the idea that the pots would have served as utensils to prepare food substances, *muday*-type drinks, as well as other meals that included plant ingredients (carbohydrates).

The use of containers and ceramic pots by hunter-gatherers in Western Pampa came together with economic, technological and livelihood changes (Berón 2004). One of the most important changes was the ability to boil food together in the form of soups and stews, so that large amounts of nutrients, both animal and vegetable, were amalgamated into a single preparation (Berón 2004; Illescas et al. 2012; Musaubach and Berón 2012). In summary, the results indicate certain tendencies regarding the use of containers for processing vegetables. Among the microfossils recorded were both wild Poaceae phytoliths and starch granules of *Zea mays* and *Prosopis* sp.

Conclusions

The vegetable micro-remains identified in each ceramic group enable us to make inferences about the potential uses of the vessels and plants processed in them. In turn, the description of the particles that complete the microfossil assemblage (micro-charcoal and remains of ochre-coloured organic matter), helps us to identify possible differences regarding the functionality of each ceramic group and the social practices involved in it. The sample analysed in this paper corresponds to domestic pottery utilized for processing and preparing food which included vegetal and animal resources. STM-2, STM-4 and STM-H ceramic groups represent domestic pots used for everyday cooking activities. The presence of ochre-coloured organic matter in residues of STM-S and STM-4 ceramic group probably corresponds to preparations with a shorter exposure to fire, compared to those with large amounts of micro-charcoal. In return, the latter would indicate an increase in the exposure time to heat of ceramic containers during the preparations. Interestingly, data referring to commensality practices in Pampean hunter-gatherer societies indicate that preparing stews involved exposure for a long time of pots on the stove until people were served with their corresponding portions (Mansilla 2006).

The observation of the characteristics of the organic residue material under the microscope has contextualized the interpretations made on the cultural practices and the taphonomic factors involved in the formation and alteration of the archaeological record. The implementation of the proposed protocol for removal of the residues and the observation of the whole microfossil assemblages of archaeological interest in the same preparation have provided encouraging results.

The registration of taphonomic variables in the starch grains and the description of particles accompanying the assemblage (micro-charcoal, fungal remains and ochre-coloured organic matter), allow us to propose interpretations of the functional differences among the Pampean ceramic groups and about the social practices related to them. The registration of damaged starch granules allow us identify different practices associated with food preparation. Other taphonomic factors were the striking differences observed between the inner and outer walls of the fragments analysed with respect to the preservation of plant micro-remains, which is related to the uses of the containers.

Results obtained here confirm previous studies and discussion regarding Pampean hunter-gatherers foodways and economic organization that imply long distance product exchanges or long mobility cycles to get them. Also, this archaeobotanical study contributes to the current discussion about the role of domestic resources in Pampean hunter-gatherer contexts.

In the future, we will increase the number of carbonized residues samples for archaeobotanical studies of plant micro-remains. These studies will be complemented by more detailed observations and characterizations of residues and their micro-remain contents, using SEM. The analysis of $\delta^{13}C$ and $\delta^{15}N$, as well as fatty acids, will allow us to evaluate trends in diet and the contribution of plant resources in feeding the populations of hunter-gatherers in Western Pampa.

Acknowledgments The studies were conducted as part of Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) doctoral scholarship by one of the authors (MGM) and included in CONICET PIP 1293 and F-042 UBACYT (Universidad de Buenos Aires) projects, led by M. Berón. Jorge A. Gonzalez made the figures.

References

Adán L, Mera R, Uribe M, Alvarado M (2005) La tradición cerámica bícroma rojo sobre blanco en la región sur de Chile: los estilos decorativos Valdivia y Vergel. In: Actas del XVI Congreso Nacional de Arqueología Chilena. Escaparate, Concepción, pp 399–410

Babot MP (2003) Starch grain damage as an indicator of food processing. In: Hart D, Wallis L (eds) Phytolith and starch research in the Australian-Pacific-Asian regions: the state of the art. Pandanus Books for the Centre for Archaeological Research and the Department of Archaeological and Natural History. The Australian National University, Canberra, pp 69–81

Babot MP (2006) Damage on starch from processing Andean food plants. In: Torrence R, Barton H (eds) Ancient starch research. Left Coast Press, Walnut Creek, California, pp 66–67, 70, Plates 31–32

Babot MP (2007) Granos de almidón en contextos arqueológicos: posibilidades y perspectivas a partir de casos del Noroeste argentino. In: Marconetto B, Babot MP, Oliszewski N (eds) Paleoetnobotánica del Cono Sur: estudios de casos y propuestas metodológicas. Museo de Antropología, Facultad de Filosofía y Humanidades, Universidad Nacional de Córdoba, Córdoba, pp 95–125

Babot MP, Musaubach MG, Plos A (2016) An archaeobotanical perspective in the study of inflorescence phytoliths of wild grasses from arid and semi-arid environments of Argentina. Quat Int. doi:10.1016/j.quaint.2016.02.045

Baffi EI, Berón M (1992) Los restos óseos humanos de Tapera Moreira (La Pampa), y la deformación artificial en la Región Pampeana. Análisis tentativo. Palimpsesto, Revista de Arqueología 1:25–36

Barton H (2007) Starch residues on museum artefacts: implications for determining tool use. J Arch Sci 34:1,752–1,762

Barton H (2009) Starch granule taphonomy: the results of a two year field experiment. In: Haslam M et al (eds) Archaeological science under a microscope: studies in residue and ancient DNA analysis in honour of Thomas H. Loy. Terra Australis 30. Anu Press, Canberra, pp 129–140

Bastourre ML, Salazar Siciliano G (2012) Análisis arqueofaunístico del sitio 5 de la localidad Tapera Moreira (departamento de Lihué Calel, provincia de La Pampa). Intersecciones en Antropología 13:269–280

Berón M (1989-90/1991) Las ocupaciones tardías del Área Casa de Piedra, Provincias de La Pampa y Río Negro. Runa 19:95–115

Berón M (1994) El recurso y el método. Estrategias de movilidad y asentamiento en la Subregión Pampa Seca. Arqueología, Revista de la Sección Prehistoria del Instituto de Ciencias Antropológicas. Universidad de Buenos Aires 4:213–234

Berón M (2000) Implementación de diferentes vías de análisis para la contrastación de manufactura cerámica en grupos cazadores-recolectores pampeanos. In: Actas del XIV Congreso Nacional de Arqueología Chilena 1. Contribución Arqueológica 5. Museo Regional de Atacama, Chile, pp 311–336

Berón M (2004) Dinámica poblacional y estrategias de subsistencia de poblaciones prehispánicas de la Cuenca Atuel-Salado-Chadileuvú-Curacó (provincia de La Pampa). Ph.D. Dissertation, Facultad de Filosofía y Letras, Universidad de Buenos Aires, Ciudad Autónoma de Buenos Aires

Berón M (2006) Relaciones interétnicas e identidad social en el registro arqueológico. In: Williams V, Alberti B (eds) Género y Etnicidad en la Arqueología Sudamericana, Serie Teórica 4. FACSO, UNICEN, Olavarría, pp 119–138

Berón M (2007) Circulación de bienes como indicador de interacción entre las poblaciones de la pampa occidental y sus vecinos. In: Bayón C, Pupio A, González MI, Flegenheimer N, Frére M (eds) Arqueología en las Pampas. Sociedad Argentina de Antropología, Buenos Aires, pp 345–364

Berón M, Baffi EI (2003) Procesos de cambio cultural en los cazadores recolectores de la provincia de La Pampa, Argentina. Intersecciones en Antropología 4:29–43

Berón M, Mazzanti D (2011) Diacríticos de interacción social y cultural trasandino. Las challas no son sólo ollas. Revista del Museo de La Plata. Arqueología 12(86):45R–46R

Berón M, Scarafoni M (1993) Acción de roedores en el sitio 1 de la Localidad Arqueológica Tapera Moreira, provincia de La Pampa. In: Actas de las V Jornadas Pampeanas de Ciencias Naturales. Santa Rosa, pp 26–32

Berón M, Luna L, Barberena R (2009) Isotopic archaeology in the western Pampas (Argentina): preliminary results and perspectives. Int J Osteoarchaeol 19:250–265

Berón M, Mera R, Munita D (2012) Traspasando barreras, interacciones sociales y conflicto allende la cordillera andina. In: Actas del XVIII Congreso Nacional de Arqueología Chilena. Sociedad Chilena de Arqueología, Santiago de Chile, pp 351–357

Berón M, Luna L, Barberena R (2013) Isótopos de oxígeno en restos humanos del sitio Chenque I: primeros resultados sobre procedencia geográfica de individuos. In: Zangrando AF, Barberena R, Gil A, Neme G, Giardina M, Luna L, Otaola C, Paulides S, Salgán L, Tivoli A (eds) Tendencias teórico-metodológicas y casos de estudio en la arqueología de la Patagonia. Altuna Impresores, Buenos Aires, pp 27–38

Bertoldi de Pomar H (1975) Los silicofitolitos: sinopsis de su conocimiento. Darwiniana 19:173–206

Bonomo M, Colobig M, Mazzi N (2012) Análisis de residuos orgánicos y microfósiles silíceos de la "cuchara" de cerámica del sitio arqueológico Cerro Tapera Vázquez (Parque Nacional Pre-Delta, Argentina). Revista do Museu de Arqueol e Etnol, São Paulo 22:31–50

Boudin M, van Strydonck M, Crombé P, de Clercq W, van Dierendonck RM, Jongepier H, Ervynck A, Lentacker A (2010) Fish reservoir effect on charred food residue ^{14}C dates: are stable isotope analyses the solution? Radiocarbon 52:697–705

Charters S, Eversherd RP, Goad LJ, Leyden A, Blinkhorn P, Denham V (1993) Quantification and distribution of lipids in archaeological ceramics: implications for sampling potsherds for organic residue analysis and the classification of vessel use. Archaeometry 35:211–223

Cimino A, Guastavino M, Velárdez S (2004) ¡Cuántas cuentas…! Elementos de adorno del sitio Chenque I, Parque Nacional Lihué Calel, provincia de La Pampa. In: Martínez G, Gutiérrez M, Curtoni R, Berón M, Madrid P (eds) Aproximaciones contemporáneas a la Arqueología Pampeana. Perspectivas teóricas, metodológicas, analíticas y casos de estudio. UNICEN, Olavarría, pp 259–273

Coil J, Korstanje MA, Archer S, Hastorf CA (2003) Laboratory goals and considerations for multiple microfossil extraction in archaeology. J Arch Sci 30(991–1):008

Coña P (2000) Testimonio de un cacique mapuche. Texto dictado al padre Ernesto Wilhelm Moesbach, 6th edn. Pehuén, Chile

Craig OE, Forster M, Andersen SH, Koch E, Crombé P, Milner NJ, Stern B, Bailey GN, Heron CP (2007) Molecular and isotopic demonstration of the processing of aquatic products in northern European prehistoric pottery. Archaeometry 49:135–152

Crowther A (2005) Starch residues on undecorated Lapita pottery from Anir, New Ireland. Archaeol Ocean 40:62–66

Eerkens JW (2007) Organic residue and the decomposition of fatty acids in ancient potsherds. In: Barnard H, Eerkens JW (eds) Theory and practice in archaeological residue analysis., BAR International Series 1650Archaeopress, Oxford, pp 90–98

Fujiwara H (1982) Study of plant opal analysis (4). Detection of plant opals in Jomon vessels in Kumamoto region. Jpn Cult Sci Inst 14:55–56

Gallego L, Distel R (2004) Phytolith assemblages in grasses native to Central Argentina. Ann Bot 94:1–10

Gallego L, Distel R, Camina R, Rodríguez Iglesias R (2004) Soil phytoliths as evidence for species replacement in grazed rangelands of Central Argentina. Ecography 27:725–732

Giesso M, Berón MA, Glascock M (2008) Obsidian in Western Pampas, Argentina. Source characterization and provisioning strategies. IAOS Bull 38:15–18

Gil A (1997-98) El significado de los cultígenos prehispánicos registrados en el Sur mendocino: Discusiones en torno al límite meridional de la agricultura andina. Relaciones de la Sociedad Argentina de Antropología 22–23:295–318

Gil A (2000) Arqueología de La Payunia: Sur de Mendoza. Ph.D Dissertation, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata, Argentina

Gil A (2003) *Zea mays* on the South American periphery: chronology and dietary importance. Curr Anthropol 44:295–300

Gil A, Neme G, Tykot R, Novellino P, Cortegoso V, Durán V (2009) Stable isotopes and maize consumption in Central Western Argentina. Int J Osteoarchaeol 19:215–236

Giovannetti MA, Lema V, Bartoli CG, Capparelli A (2008) Starch grain characterization of *Prosopis chilensis* (Mol.) Stuntz and *P. flexuosa* DC, and the analysis of their archaeological remains in Andean South America. J Arch Sci 35:2,973–2,985

Haslam M (2004) The decomposition of starch grains in soils: implications for archaeological residue analyses. J Arch Sci 31:1,715–1,734

Henry AG, Hudson HF, Piperno DR (2009) Changes in starch grain morphologies from cooking. J Arch Sci 36:915–922

Holst I, Moreno JE, Piperno DR (2007) Identification of teosinte, maize, and *Tripsacum* in Mesoamerica by using pollen, starch grains, and phytoliths. PNAS 104:17,608–17,613

Honaine MF, Zucol A, Osterrieth M (2006) Phytolith assemblage and systematic association in grassland species of the SE Pampean Plains, Argentina. Ann Bot 98:1,155–1,165

Honaine MF, Laborde VB, Zucol A (2008) Contenido de sílice en gramíneas del pastizal nativo del sudeste bonaerense. In: Korstanje MA, Babot MP (eds) Interdisciplinary nuances in phytoliths and other microfossil studies. BAR Internat Ser 1870, Archaeopress, Oxford, pp 57–63

ICSN (2011) The International Code for Starch Nomenclature. www.fossilfarm.org/ICSN/Code.html. Accessed 22 June 2011

Illescas F, Cañizo A, Musaubach MG, Berón M (2012) De ollas, aceites y otras yerbas. Análisis complementarios sobre alfarería pampeana. In: Babot MP, Marschoff M, Pazzarelli F (eds) Las manos en la masa. Arqueologías, Antropologías y otras historias de la alimentación en Suramérica. Universidad Nacional de Córdoba. Facultad de Filosofía y Humanidades, Museo de Antropología UNC - Instituto Superior de Estudios Sociales UNT, Córdoba, pp 389–407

Jones S (1997) The archaeology of ethnicity. Constructing identities in the past and present. Routledge, London

Korstanje MA, Babot MP (2007) Microfossils characterization from south Andean economic plants. In: Madella M, Zurro D (eds) Plants, people and places: recent studies in phytolith analysis. Oxbow Books, Oxford, pp 41–72

Lagiglia H (1977) Dinámica cultural en el Centro Oeste y sus relaciones con áreas aledañas argentinas y chilenas. In: Actas del VII Congreso de Arqueología Chilena, Chile, vol 2, pp 531–560

Lagiglia H (1980) El proceso de agriculturización del sur de Cuyo: La cultura del Atuel II. In: Actas del V Congreso Nacional de Arqueología Argentina, Mendoza, vol 1, pp 231–252

Lema VS, Della Negra C, Bernal V (2012) Explotación de recursos vegetales silvestres y domesticados en Neuquén: Implicancias del hallazgo de restos de maíz y algarrobo en artefactos de molienda del Holoceno Tardío. Revista Magallania 40:229–247

Loy T, Fullagar R (2006) Box 9.8. Residue extraction. In: Torrence R, Barton H (eds) Ancient starch research. Left Coast Press, Walnut-Creek, pp 197–198

Luna L, Aranda C (in press) Salud bucal de los cazadores-recolectores en el sitio Chenque I. Tendencias temporales. In: Berón M (comp) El Sitio Chenque. Un Cementerio Prehispánico En la Pampa Occidental. Estilo de vida e interacciones culturales de cazadores-recolectores del Cono Sur Americano. Sociedad Argentina de Antropología, Buenos Aires

Madella M, Alexandre A, Ball T (2005) International code for phytolith nomenclature 1.0. Ann Bot 96:253–260

Maier MS, De Faria DLA, Boschín MT, Parera SD, Del Castillo Bernal MF (2007) Combined use of vibrational spectroscopy and GC-MS methods in the characterization of archaeological pastes from Patagonia. Vib Spectrosc 44:182–186

Mandrini R (1984) Los araucanos de las pampas en el siglo XIX. Historia Testimonial Argentina 22. Centro Editor de América Latina, Buenos Aires

Mansilla L (2006) Una excursión a los indios ranqueles. Edicol, Buenos Aires

Mazzanti D (2007) Arqueología de las relaciones interétnicas posconquista en las sierras de tandilla. Ph.D. Dissertation, Facultad de Filosofía y Letras. Universidad de Buenos Aires. Ciudad Autónoma de Buenos Aires

Mera CR, Mille B, Munita D, Figueroa V (2015) Copper earrings in La Araucanía: earliest evidence of metal usage in southern Chile. Lat Am Antiq 26:106–119

Musaubach MG (2014) Estudios Arqueobotánicos en sociedades cazadoras-recolectoras de ambientes semiáridos. Análisis de microrrestos vegetales en contextos arqueológicos de Pampa Occidental (Argentina). Ph.D. Dissertation, Facultad de Filosofía y Letras. Universidad de Buenos Aires. Ciudad Autónoma de Buenos Aires

Musaubach MG, Berón M (2012) Cocinando en ollas en la pampa occidental. Datos desde la etnohistoria, el registro arqueológico y la arqueobotánica. In: Babot MP, Marschoff M, Pazzarelli F (eds) Las manos en la masa. Arqueologías, Antropologías y otras historias de la alimentación en Suramérica. Universidad Nacional de Córdoba. Facultad de Filosofía y Humanidades, Museo de Antropología UNC-Instituto Superior de Estudios Sociales UNT, Córdoba, pp 605-626

Musaubach MG, Plos A (2010) Conociendo las plantas de los cazadores recolectores de La Pampa. In: Bárcena R, Chiavazza H (eds) Libro del XVII Congreso Nacional de Arqueología Argentina en el bicentenario de la Revolución de Mayo Tomo II. Mendoza, pp 1,193–1,198

Musaubach MG, Plos A (2015) Las plantas de los cazadores-recolectores de la Pampa Occidental Argentina. Base de datos de recursos vegetales potencialmente utilizados. Comechingonia. Revista de Arqueología 19:257–280

Musaubach MG, Plos A, Babot MP (2013) Differentiation of archaeological maize (*Zea mays* L.) from native wild grasses based on starch grain morphology. Cases from the Central Pampas of Argentina. J Arch Sci 40:1,186–1,193

Novellino P, Gil A, Neme G, Durán V (2004) El consumo de maíz en el Holoceno tardío del oeste argentino: isótopos estables y caries. Revista Española de Antropología Americana 85(34):85–110

Ozán I (2009) Procesos de formación del registro cerámico en cazadores recolectores del centro-este y sudoeste de la provincia de La Pampa. Tesis de Licenciatura en Ciencias Antropológicas, orientación Arqueología Inédita. Facultad de Filosofía y Letras, Universidad de Buenos Aires. Ciudad Autónoma de Buenos Aires

Palermo MA (1986) Reflexiones sobre el llamado "complejo ecuestre" en la Argentina. Buenos Aires. Runa 16:157–178

Petö Á, Gyulai F, Pópity D, Kenéz Á (2013) Macro- and micro-archaeobotanical study of a vessel content from a Late Neolithic structured deposition from southeastern Hungary. J Arch Sci 40:58–71

Piperno DR (1988) Phytolith analysis: an archaeological and geological perspective. Academic Press, California

Piperno DR (2006) Phytoliths. A comprehensive guide for archaeologist and paleoecologist. Altamira Press, Lanham

Raviele ME (2011) Experimental assessment of maize phytolith and starch taphonomy in carbonized cooking residues. J Arch Sci 38:2,708–2,713

Regert M, Bland H, Dudd S, Van Bergen P, Eversherd R (1998) Free and bound fatty acid oxidation products in archaeological ceramics vessels. Proc R Soc Lond 265:2,027–2,032

Salemme M, Berón M (2003) Análisis intrasitio del componente faunístico del sitio 1 de la Localidad Tapera Moreira. Diferencias y Tendencias. In: Berberián E (ed) Actas del XIII Congreso Nacional de Arqueología Argentina Tomo III. Editorial Brujas, Córdoba, pp 325–345

Saul H, Wilson J, Heron CP, Glykou A, Hartz S, Craig OE (2012) A systematic approach to the recovery and identification of starches from carbonised deposits on ceramic vessels. J Arch Sci 39:3,483–3,492

Staller JE, Thompson R (2002) Multidisciplinary approach to understanding the initial introduction of maize into coastal ecuador. J Arch Sci 29:33–50

Twiss PC (1992) Predicted world distribution of C3 and C4 grass phytoliths. In: Rapp G, Mullholland SC (eds) Phytolith systematics. Emerging issues. Advances in archaeological and museum science, vol 1. Plenum Press, New York, pp 113–128

Twiss PC, Suess E, Smith RM (1969) Morphological classification of grass phytoliths. Soil Sci Soc Am 33:109–115

Tyree EL (1994) Phytolith analysis of olive oil and wine sediments for possible identification in archaeology. Can J Bot 72:499–504

Valamoti S-M, Delwen S, Bayram M, Marinova E (2008) Prehistoric cereal foods from Greece and Bulgaria: investigation of starch microstructure in experimental and archaeological charred remains. Veget Hist Archaeobot 17(Suppl 1):S265–S276

Winton A, Winton K (1932) The structure and composition of foods (Cereals, starch, oil seeds, nuts, oils, forage plants), vol II. Wiley, New York

Yost CL, Blinnikov MS (2011) Locally diagnostic phytoliths of wild rice (*Zizania palustris* L.) from Minnesota, USA: comparison to other wetland grasses and usefulness for archaeobotany and paleoecological reconstructions. J Arch Sci 38:1,977–1,991

Zarrillo S, Pearsall DM, Raymond JS, Tisdale MA, Quon DJ (2008) Directly dated starch residues document early formative maize (*Zea mays* L.) in tropical Ecuador. PNAS 105(13):5,006–5,011

Zucol A (1996a) Estudios morfológicos comparativos de especies de los géneros Stipa, Panicum y Paspalum (Poaceae) de la Provincia de Entre Ríos. Ph.D. Dissertation, Facultad de Ciencias Naturales y Museo. Universidad Nacional de La Plata

Zucol A (1996b) Microfitolitos de las Poaceae argentinas: I. Microfitolitos foliares de algunas especies del género Stipa (Stipeae: Arundinoideae: Poaceae), en la provincia de Entre Ríos. Darwiniana 34:29–50

Zucol A (1998) Microfitolitos de las Poaceae argentinas: II. Microfitolitos foliares de algunas especies del género Panicum (Paniceae: Panicoideae: Poaceae), en la provincia de Entre Ríos. Darwiniana 36(1–4):29–50

Zucol A (1999) Fitolitos de las Poaceae argentinas. IV: Asociación fitolítica de Cortaderia selloana (Danthonieae: Arundinoideae), de la provincia de Entre Ríos (Argentina). Nat Neotrop 30:25–33

Zucol A (2000) Fitolitos de Poaceae de argentinas: III. Fitolitos foliares de algunas especies del género Paspalum (Paniceae: Panicoideae: Poaceae), en la provincia de Entre Ríos. Darwiniana 38:11–32

Zucol A (2001) Fitolitos: III. Asociaciones fitolíticas de Piptochetium montevidense (Stipeae: Arundinoideae: Poaceae). Una nueva metodología descriptiva. Boletín de la Sociedad Argentina de Botánica 36:69–85

Zucol A, Bonomo M (2008) Estudios etnobotánicos del sitio arqueológico Nutria Mansa 1 (partido de General Alvarado, provincia de Buenos Aires): II. Análisis fitolíticos comparativos de artefactos de molienda. In: Korstanje MA, MP Babot (eds) Matices interdisciplinarios en estudios fitolíticos y de otros microfósiles. BAR International Series S 1870, pp 173–185

Zucol A, Brea M, Mazzanti D (2008) Análisis de restos orgánicos presentes en cerámicas arqueológicas de las Sierras de Tandilla (provincia de Buenos Aires, Argentina). In: Korstanje MA, MP Babot (eds) Matices interdisciplinarios en estudios fitolíticos y de otros microfósiles. BAR Internat Ser 1870, pp 201–208