Journal of Archaeological Science: Reports 20 (2018) 47–56

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

$\delta^{13}C$ and $\delta^{15}N$ in organic residues of Patagonia pottery. Implications for studies of diet and subsistence strategies among late Holocene hunter-gatherers

Cecilia Chaile[a,*], Augusto Tessone[b], Gisela Cassiodoro[c], Cristina Bellelli[d], Juan B. Belardi[e]

[a] UBA/FFyL, Puán 480 (1406), CABA, Argentina
[b] INGEIS (CONICET-UBA), Pabellón INGEIS, Ciudad Universitaria, C1428EHAs, CABA, Argentina
[c] CONICET, Universidad de Buenos Aires, Instituto Nacional de Antropología y Pensamiento Latinoamericano, 3 de Febrero 1378 (1426), CABA, Argentina
[d] CONICET, Instituto Nacional de Antropología y Pensamiento Latinoamericano, 3 de Febrero 1378 (1426), CABA, Argentina
[e] Universidad Nacional de la Patagonia Austral, ICASUR, Unidad Académica Río Gallegos, CONICET, 9400, Río Gallegos, Santa Cruz, Argentina

ARTICLE INFO

Keywords:
Pottery
Organic residues
Stable isotopes
Resources
Hunter-gatherers
Argentine Patagonia

ABSTRACT

This paper reports the results of stable isotope studies ($\delta^{13}C$ and $\delta^{15}N$) performed on organic residues in archaeological potsherds recovered from diverse Patagonian environments in Argentina. The objective was to identify the types and provenance of food cooked in ceramic vessels, thus contributing to the study of paleodiets and subsistence strategies among hunter-gatherer groups in Patagonia during the late Holocene. The sample included forty-six potsherds recovered from forest (n = 21), steppe (n = 15) and Atlantic coast (n = 10) sites located in different latitudes of the continental Argentine Patagonia. Our data indicates that the type of food processed in the ceramic vessels may have depended on the availability of resources in each environment. Lower-than-expected $\delta^{13}C$-values likely suggest the cooking of animal fat, while $\delta^{15}N$-values are good indicators of the environmental origin of the cooked resources. This is a reconnaissance study that seeks a broad inter-environmental comparison in order to understand the processing and consumption of food after 1000 years BP, when pottery was adopted by Patagonian hunter-gatherer groups.

1. Introduction

Since the stable isotope composition of animal tissue is determined by their diet (Ambrose et al., 2003), carbon and nitrogen stable isotope studies have been widely used for dietary reconstruction of animals as well as past human populations (Ambrose and DeNiro, 1986; DeNiro and Epstein, 1978; Newsome et al., 2004; Schwarcz, 1991; Tieszen, 1991). Archaeology incorporated these analyses to the study of a variety of issues, such as the introduction of corn, animal and plant domestication processes, social differentiation, breastfeeding and the timing of weaning among human groups, among others (Ambrose et al., 2003; Eerkens et al., 2011; Fogel et al., 1989; Schwarcz et al., 1985).

Hastorf and DeNiro (1985) were the first to apply C and N isotope analyses to the study of organic residues in ceramic vessels and potsherds in order to reconstruct the composition of the food cooked in the vessel, which provides direct evidence of pottery use (Boyd et al., 2008; Heron and Evershed, 1993; Rice, 1996). Whereas the C and N isotope composition of human remains is the result of the average diet of an individual during the last decade of their life —including both raw and cooked food that may or may not have been prepared/cooked in a particular vessel (Beehr and Ambrose, 2007), carbonized organic residues derived from the combustion of food provide direct information on the last foods cooked in the pot (Skibo, 1992). Thus, both types of analyses are complementary and allow expanding knowledge about the diet of past populations.

$\delta^{13}C$-values of carbonized organic residues depend on the biomolecular composition (protein, carbohydrates and lipids) of the resources processed, as well as on the mix of resources cooked, cooking time and the relative contribution of C by each type of food (Hart et al., 2012, 2009, 2007; Lovis et al., 2011). In contrast, $\delta^{15}N$-values derive only from the protein source, and for this reason they constitute a robust indicator of the trophic level of the processed organism (Craig, 2004; Craig et al., 2007).

Ceramic technology was adopted by Patagonian hunter-gatherer groups ca. 1000 years BP, but it constitutes a rare find in Patagonian archaeological sites, especially in high latitudes (Bellelli, 1980;

* Corresponding author.
E-mail addresses: Cecy.30.01@gmail.com (C. Chaile), atessone@ingeis.uba.ar (A. Tessone), gcassio@hotmail.com (G. Cassiodoro), bellelli@retina.ar (C. Bellelli), juanbautistabelardi@gmail.com (J.B. Belardi).

https://doi.org/10.1016/j.jasrep.2018.04.011
Received 21 June 2017; Received in revised form 31 March 2018; Accepted 15 April 2018

Cassiodoro, 2008; Castro et al., 2003; Cordero and March, 2013; Gradin and Aguerre, 1991; Schuster, 2014; Senatore, 1996; Vitores, 2010). Since cooking in ceramic pots requires less attention than using baskets with heated stones, the incorporation of ceramic technology might have reduced the time and work involved in cooking (Eerkens, 2001). This "extra time" could be then used for other tasks, such as childcare and gathering of plants and tubers (Eerkens, 2001). Furthermore, the ability to boil food allowed early Patagonian pottery users to structurally alter animal products, improve their nutritional quality, and efficiently extract bone fat (Lupo and Schmitt, 1997). This strategy might have been important in environments where the main prey species have lean meat, such as guanaco (*Lama guanicoe*) in the steppe and huemul (*Hippocamelus bisulcus*) and pudú (*Pudu puda*) in the Patagonian forest.

There are several hypotheses about the emergence and main uses of pottery, but most of them underline its role in increasing the efficiency of fat extraction in the steppe (Cassiodoro, 2008) and plant processing in the coast (Gómez Otero et al., 2014) in the context of demographic growth (Favier Dubois et al., 2009; Gómez Otero et al., 2014; Goñi, 2010) and social complexity (Gómez Otero et al., 2014).

Stable isotope composition and chemical analyses of organic residues in archaeological Patagonian pottery have shown that these vessels were used to process a wide range of terrestrial and marine animal and vegetable resources (Cassiodoro and Tessone, 2014; Cordero and March, 2013; Gómez Otero, 2007; Gómez Otero et al., 2014; Schuster, 2014; Stoessel et al., 2015). Thus, pottery use may have varied according to the particular situation and habitats occupied by each group. The possibility to determine the specific use given to ceramic vessels offers avenues for exploring different issues in regard to hunter-gatherers and their relationship with resources and environments (Eerkens, 2007; Heron and Evershed, 1993), particularly now that the systematic analyses of modern plants and faunal bone collagen have made available a detailed isotope ecology for Patagonia encompassing all of the biomes in the region (Barberena et al., 2011, 2009; Gómez Otero, 2007; Tessone, 2010; Tessone et al., 2014, among others).

The objective of this paper is to determine the type and environmental origin of resources cooked in ceramic vessels in order to contribute to the discussion about the adoption and use of ceramic technology among Patagonian hunter-gatherers. For this purpose, we analyzed ceramic fragments recovered from the steppe and the forest and coastal sherds available in the "Padre Manuel Jesús Molina" regional museum. We evaluate the variations in $\delta^{13}C$ and $\delta^{15}N$-values of organic residues in the light of the available Patagonian isotope ecology and human paleodiet isotope indicators, in order to discuss what was cooked in these vessels. This is the first study to undertake a comparative analysis of potsherd organic residues in a large spatial scale in the region, including the three main environments of Continental Patagonia.

2. Study areas

2.1. Environments

The Continental Argentine Patagonia comprises the provinces of Neuquén, Río Negro, Chubut and Santa Cruz (Fig. 1). From an isotope ecology point of view, the region can be divided into three ecological units, from west to east: the Andes mountain range forest, the steppe and the Atlantic coast. The steppe is the largest of these units, since it occupies the wide expanse of land that lies between the Andes range and the Atlantic coast. (See Fig. 2.)

The forest area included in our study is the mountain sector southwest of Río Negro and northwest of Chubut. This broken landscape is the product of Andean orogeny and glaciations that excavated lake basins and interconnected glacial valleys. The prevailing vegetation is a mixed *Nothofagus* and *Austrocedrus* forest that occupies the band from the 1500 mm isohyet up to the mountain ranges to the east, where rainfall decreases to 500 mm (Fernández and Carballido Calatayud, 2015).

The steppe is represented by the western-central section of Santa Cruz, divided into highland sectors, located above 900 m.a.s.l. (plateaus of Cardiel Chico and Pampa del Asador), and lowland sectors (Lakes Salitroso-Posadas) (Belardi et al., 2013; Goñi, 2010). Highland sectors receive slightly more rainfall (200–400 mm/year) than the lowlands (100–270 mm/year). The steppe is characterized by shrub and grass plant communities (Goñi, 2010).

Finally, the northern coast of Santa Cruz is characterized by an arid to semiarid climate —200 mm/year— with precipitations highly concentrated in the winter. South of the Deseado river estuary there are sand dunes and aeolian mantles on terraces (Hammond, 2014). The vegetation is characterized by shrub steppes composed of grasses and *coirones* (*Stipa humilius* and *S. speciosa*) (Hammond, 2014).

2.2. Isotope ecology

The analysis of C and N stable isotope composition of plants and animal bone collagen has advanced knowledge of the isotope ecology in the Patagonian steppe, Andean forest and Atlantic coast (Barberena et al., 2011, 2009; Fernández and Tessone, 2014; Gómez Otero, 2007; Tessone, 2010; Tessone et al., 2014, among others). C_3 plants dominate all the vegetation communities, including local plant species suitable for human consumption (Gómez Otero, 2007); C_4 vegetation is limited to a few species of little dietary importance for herbivores (Fernández and Panarello, 1991). Accordingly, $\delta^{13}C$-values of herbivores reflect a predominantly C_3-plant diet (Barberena et al., 2009; Gómez Otero, 2007; Tessone et al., 2014). Steppe species such as guanaco and choique (*Pterocnemia pennata*) present higher $\delta^{13}C$ and $\delta^{15}N$-values than forest herbivores such as cervids (Barberena et al., 2011; Fernández and Tessone, 2014; Tessone, 2010). In turn, coastal guanacos and choiques present higher $\delta^{15}N$-values than their inland counterparts (Barberena, 2002; Favier Dubois et al., 2009; Gómez Otero, 2007; Martínez et al., 2009). This may be related to ^{15}N-enrichment of plants growing in soils that are more saline or exposed to sea spray (Gómez Otero, 2007). Finally, marine resources such as pinnipeds (*Otaria flavescens*), penguins (*Spheniscus magallanicus*) and cormorant (*Phalacrocorax* spp.) show the highest $\delta^{13}C$ and $\delta^{15}N$-values (Gómez Otero, 2007; Gómez Otero et al., 2014).

We present a compilation of $\delta^{13}C$ and $\delta^{15}N$-values of Patagonian animal and plant resources representative of the three areas of interest from the perspective of the resource catchment of archaeological sites (Tables 1–3), as a frame of reference for comparison with organic residue stable composition data from ceramic vessels. Therefore, these groups of data are not intended to represent the animal and plant communities of the three environments, but rather groups of resources readily accessible from the archaeological sites in each habitat type. For example, the area with the best representation of samples corresponds to inland of Santa Cruz, presents large amount of sample per species and spatial scale associated with provenance of ceramics (Table 2). On the other hand, forest area has isotopic values of local resources (huemul, Caviidae and *Ctenomys* sp.) but as a reference of the steppe animal prey, we use samples from the inland of Santa Cruz (Table 1). Finally, due to the low number of available samples, in the Atlantic coast we chose to pool coastal data in three broad categories: terrestrial resources, marine fish, and other marine resources, that include pinnipeds and birds. These values come from archaeological sites along the entire Atlantic coast from a larger spatial scale where the ceramics were recovered (Table 3).

2.3. Archaeological background

The Andean forest archaeological sites in our study area are, from north to south: Población Anticura, Paredón Lanfré and Campamento Argentino, all located in the lower Manso River Valley (Province of Río