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The first quinoa (*Chenopodium quinoa* Willd) macrobotanical remains at Sierras del Norte (Central Argentina) and their implications in pre-Hispanic subsistence practices

M. Laura López [a,*], M. Andrea Recalde [b]

[a] *Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), División Arqueología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Intersección Av.122 y 60, s/n° (1900), La Plata, Argentina*

[b] *Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Área de Arqueología y Etnohistoria, Centro de Estudios Históricos "Prof. Carlos S. A. Segreti", Facultad de Filosofía y Humanidades, Universidad Nacional de Córdoba, Miguel C del Corro 308 (5000), Córdoba, Argentina*

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ABSTRACT

This paper presents a study of the first quinoa macrobotanical remains from the late pre-Hispanic site Quebrada Norte 7 (ca. 700 to 300 BP, Sierras of Norte, Córdoba, Argentina). The genus *Chenopodium* have been recorded since c. 7000 BP in several archaeological sites in Andean South America, from the Middle Holocene to the era of the Inca empire, suggesting that this plant has been used in multiple ways and has had economic and social importance continuing into the present time. Quinoa has been considered one of the primary subsistence resources available to societies in the sierras of Córdoba during the late Pre-Hispanic Period (800–1500 CE), but this inference was drawn from indirect data, such as Spanish documents and archaeological starch, grains, and pollen. The identification of *Chenopodium quinoa* was made via macrobotanical remains (achenes), examining quantitative and qualitative features. The presence of both quinoa and ajara, or *quinoa negra*, remains suggests that the Andean crop/weed complex was part of subsistence system in Central Argentina.

1. Introduction

Quinoa (*Chenopodium quinoa* Wild, Amaranthaceae) is an Andean domesticated pseudo-cereal with grains that are considered to be among the most nutritionally complete foods for humans. Presently, quinoa grows throughout South America, from Colombia to Argentina and Chile, with the highest diversity being found in the area between Sicuani (Peru) and Potosi (Bolivia), where it has adapted to variable climatic, soil and cultural conditions, leading to the presence of different ecotypes and genotypes (Maughan et al., 2004; Mujica and Jacobsen, 2006). Quinoa grains have high-quality proteins (12% to 16%) constituted by water-soluble albumins and globulins with high levels of digestibility (80%). They also have high proportions of essential amino acids, Omega 3, 6, and 9 fatty acids, vitamins, and minerals, such as calcium and iron. The carbohydrate content of quinoa is mainly organized as starch (50–60%). The content of free sugars in the grain id 6.2%, and total fiber is 7.8% (Cusack, 1984; Mujica and Jacobsen, 2006; Repo-Carrasco et al., 2003). Although the grains are the most commonly consumed part of the plant, the leaves are sometimes used in salad when still fresh or in porridges when dried. The leaves, stems and grains are also used in medicine, mainly because of their anti-inflammatory and analgesic properties (Romo et al., 2006).

Quinoa is still one of the main subsistence resources for many Andean communities. Bolivia and Peru are still the main quinoa producers, although the crop started to spread across all the continents in the 1980s (Bazile and Baudron, 2015). The current production of native quinoa in Argentina is only carried out in the North-western region where some families produce it in small farm plot for domestic consumption (Andrade et al., 2015). In the Central region it was recorded in Tototal Department (Córdoba Province) during the 1980s by Hunziker, but these seeds were imported from Bolivia (Zuloaga et al. 2016).

The use of this plant in the Andes goes back several millennia. Quinoa remains have been found at archaeological levels dating back several thousands of years BP, to the Inca period in different locations of Peru, Bolivia, Argentina and Chile (Holden, 1991; Bruno, 2008; D'Altroy and Hastorf, 2002; Planella et al., 2005, among others, see compilations in Planella et al., 2015). Hunter-gatherer groups, as well as agricultural societies, used this grain and some of its wild relatives. Quinoa remains

* Corresponding author.
E-mail addresses: mllopezdepaoli@yahoo.com.ar (M.L. López), recaldema@yahoo.com.ar (M.A. Recalde).

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have been found in multiple contexts, including hearths, burials, storage structures, human digestive tracts and coprolites. Such diversity suggests that this plant was used in multiple ways and for different purposes, having probably both economic and religious importance (Planella et al., 2015).

It is possible that quinoa grains were part of subsistence among pre-Hispanic societies in the Sierras of Córdoba and their production could have been practiced post-1500 BP together with maize (*Zea mays* L.) (Pastor et al., 2012a, 2012b). The process of agricultural dispersion in Central Argentina remains a poorly understood and sparsely researched subject. This is in spite of the certainty that this process took place during pre-Hispanic times according to both archaeological and ethnohistoric evidence. Two types of hypotheses or explanatory proposals about the origins and dispersion of agriculture in the region have been advanced: 1) those involving an exogenous process linked to the arrival of immigrating populations from a neighbouring region such as northwestern Argentina (NWA), or from the Chaco plains, in the modern province of Santiago del Estero, where groups of sedentary agriculturalists already existed; and 2) as a local process of development and transformation of hunter-gatherer societies (Pastor et al., 2012a). Far from the rapid dispersion/adoption of agriculture by pre-Hispanic societies that have been assumed by both traditional hypothesis, the archaeological evidence supports a transitional process where local foragers added low-investment extensive horticulture in their diversified economy and not a population replacement and/or the arriving of a "package" of cultural traits that replaced pre-existing ones (Medina et al., 2016). The intensification process (sensu Freeman 2007) began at 3000 BP and agriculture was only incorporated in late contexts (c. 1100 BP). In terms of agricultural practices, discoveries related to the processing and consumption of cultivated plants by macro and microbotanical remains, including maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L. and *Phaseolus lunatus* L.), squash (*Cucurbita* sp.), become abundant only after 110 BP. Even then small-scale production would have been involved complementing a sustained process of intensification of hunter-gatherer practices, in continuous growth (Pastor and López, 2011). Therefore, the Late Prehispanic Period (henceforth, LPP) indicates that the boundaries between foraging and farming could be fluid (López et al., 2015a, 2015b; Medina et al., 2016) creating a mosaic of different horticulture systems (e.g. different species were produced according the environment and the mobility levels of human groups) along the Sierras of Cordoba.

Microfossils (starch grains) recovered in a domestic context at an archaeological site of LPP (800–1500 CE) were only considered in the context of processing and consumption practices of *Chenopodium* spp./*Amaranthus* spp. These results were significant to the study of subsistence strategies and to the spread of small-scale farming among late Holocene human societies in Central Argentina, where macrobotanical remains have been only poorly preserved in the archaeological record. However, the presence of quinoa crops was not suggested (López et al., 2014).

Other data about *Chenopodium* in LPP stem from palynological studies. The pollinic spectrum from two archaeological sites of the Sierras of Córdoba showed evidence of vegetational paleo-communities dominated by Amaranthaceae. This vegetable family shows a poor presence in modern pollinic samples. It is thought that the high proportions of Amaranthaceae might suggest the presence of pre-Hispanic *Chenopodium quinoa* crops in the areas surrounding the site. Further evidence, such as domesticated plant remains and agricultural tools, supports this hypothesis. Nevertheless, the high proportions of Amaranthaceae would also indicate successive abandonment and reoccupation processes at the residential camps, probably seasonally. Environments affected by anthropic activities might have contributed to the growth of these plants (Medina et al., 2008).

However, the processing and consumption of *Chenopodium quinoa* among the Holocene people of the Sierras of Córdoba are still archaeologically little-understood, despite numerous archaeological sites ranging from late Pleistocene to late Holocene being excavated during the last decade (Pastor et al., 2012a). The lack of information is related to the inadequacy of recovery methods employed during fieldwork, poor preservation conditions, and the agrocentrism bias toward maize studies (Babot, 2011; Nuñez et al., 2009).

The presence of *Chenopodium quinoa* grains in the central region of Sierras de Córdoba was only suggested in Spanish documents from the early colonial period (XVI–XVII centuries AD) where numerous references to the consumption of quinoa and to its importance to native peoples (Berberián, 1987) were made. Different names were used to refer to the same plant such as "bledo de Castilla" and "miju" especially when Spanish chroniclers described the plant when arrived to Andean region (Hunziker, 1952). The assimilation of quinoa and bledo (common name of *Amaranthus* spp. and *Chenopodium* spp. species) shows that chroniclers wrote about little seeds without knowing if they were the same species. Also, the colonial documents represent a subjective perspective of indigenous peoples' values, categories, events and actors (Bixio and Berberián 2006–2009: 326). In Sierras de Cordoba the colonial documents are not chronicles but visits, censuses, cadastres, lawsuits, and reports by authorities (Tell and Castro Olañeta 2011). However, as with any colonial documents the same consideration should be made. Spaniards viewed the native people from Sierras of Córdoba as agricultural societies similar to native people from Northwestern Argentina, when they actually had a mixed foraging and cultivation economy (see above). Also, wild seeds were not mentioned but only crops and tree-fruits were considered as vegetables resources for subsistence (Berberián, 1987), even during the Colonial times (Castro Olañeta, 2002). Therefore, to consider Spanish documents as an undeniable truth is a mistake (Bixio and Berberián 2006; 2006–2009). Quinoa in Central Argentina is not until to find archaeobotanical remains that confirms or discards its presence. In sum, although the Colonial documents can provide important evidence about the consumption of pre-Hispanic people, the presence of quinoa in Central Argentina cannot be confirmed or discarded until archaeobotanical remains support either possibility.

Thus, the first reliable evidence of *Chenopodium quinoa* in LPP in Córdoba province is presented in this paper. The identification was made using macrobotanical remains (achenes) recovered from the Quebrada Norte 7 archaeological site (Cerro Colorado, Sierras del Norte). The archaeological quinoa grains were compared with quinoas from several sites in Argentina, Chile and Bolivia in order to determine the possible precedence of this domesticated pseudo-cereal that arrived to Sierras of Córdoba within the process of agricultural dispersion. The earliest processing evidence of *Chenopodium* grains in Córdoba suggest an early knowledge about the annual growth of the wild chenopods but also about the technology required to remove the non-edible portion of the seeds. This knowledge could facilitate the incorporation of quinoa crop in the subsistence and represent a wild-to-domesticated continuum during Late Pre-Hispanic Period. Finally, the implications of this finding for pre-Hispanic subsistence were considered.

2. The northern sierras of the Córdoba study area

The Sierras del Norte area is characterized by longitudinal, subparallel and low-altitude hills (800–1000 m), separated by narrow valleys and cross faults. The Cerro Colorado archaeological area is located in the eastern slope of the Sierras del Norte (Fig. 1) and is composed of metamorphic rock, with two outcrops of the red sandstone abundant in this area (Michaut, 1979). The Los Tartagos basins are made up by several hills and streams, such as La Quebrada, Los Molles, and Pozancón. Cerro Colorado is an important archaeological area because farming is constrained to slopes circumscribed by well-irrigated and organic-rich soils. The surrounding vegetation is Sierra Chaco, which comprises a semi-arid forest dominated by small trees and shrubs with edible wild fruits such as algarrobo (*Prosopis* spp.), chañar (*Geoffroea decorticans*), ucle (*Cereus forbesii*) and mato (*Myrcianthes cisplatensis*),

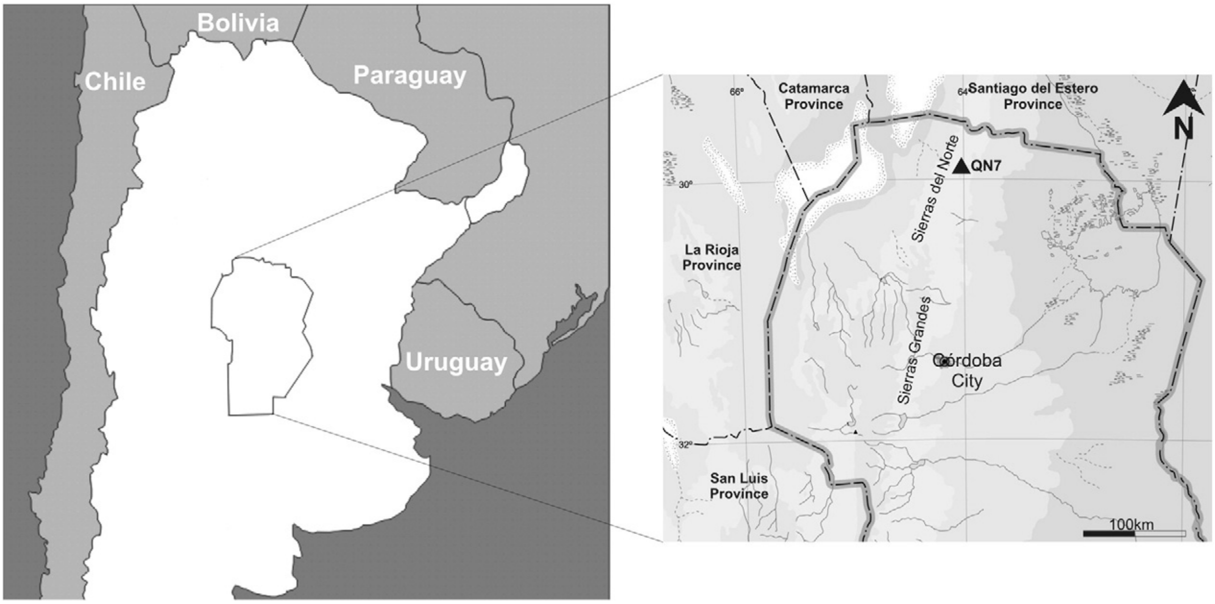

Fig. 1. Location of the Quebrada Norte 7 archaeological site.

the last of which is predominant in this area (Luti et al., 1979; Demaio et al., 2002). The fauna is dominated by low-diversity neotropical small-sized mammals adapted to close vegetation environments, such as brown-brocket deer (*Mazama gouazoupira*), vizcachas (*Lagostomus maximus*), armadillos (*Dasipodinae* spp.), small-caviomorpho rodents (*Caviinae* spp.), etc. (Bucher and Abalos, 1979).

The Quebrada Norte 7 site (QN7) is located to 5 km northeast of the town of Cerro Colorado, between the southern slopes of the Vaca Errana hills and 100 m from the La Quebrada stream. QN7 covers 1.5 ha presenting high-density archaeological surface. Evidence from La Quebrada includes lithic artifacts, pottery fragments, and animal bones (Fig. 2A). Nearby, there are five grinding sites set into unmovable rock, two of them protected by rock shelters that include 60 grinding tools. On the south slope of the Vaca Errana hill, there are six rock art sites. Excavations were carried out over 9 m^2 with maximum depths of 50 cm (Fig. 2B). At the time of excavation, only Late Pre-Hispanic Period occupations had been identified, and the charcoal obtained from a hearth area was radiocarbon dated at 1280 $\pm$ 60 (LP-3212) (Recalde, 2015). The archaeological record is still being studied, but the characteristics of the faunal remains (i.e., *Lama* sp., *Cervidae* sp., and small-sized vertebrates), the macro-botanical remains (crops and wild species), the lithic artifacts, and the density and type of pottery fragments suggest an open-air, multi-purpose residential site.

3. Materials and methods

Charred macrobotanical remains from QN7 were systematically recovered during the excavations using fine-sieving 2 and 0.97 mm meshes and manual sorting of organic material found in the sediment samples according to standard archaeobotanical methods (Pearsall, 2000). All the sediment from the excavation (a total of 3000 liters) was sieved. No specific areas were selected to sieve the sediment to maximize the recovery of remains. A flotation system was not used, mainly to avoid the high fragmentation of carbonized material in contact with the moist medium. Once the samples had arrived in the laboratory, they were scanned for their contents and richness in plant remains. The charred plant remains were identified using a stereo-microscope with magnifications up to 100×, as well as using a modern seed reference collection, illustrations in seed atlases, and archaeobotanical reports. In the analysis of seeds, qualitative and quantitative attributes were considered to describe and distinguish the *Chenopodium* spp. seeds, following Bruno (2008); López et al. (2015a),

Fig. 2. A - View of QN7 site in the Sierras del Norte region. B - Detail of excavated area.

and Planchuelo (1975): morphology, pericarp texture, testa texture, margin configuration, and seed diameter.

Modern domesticated, weed and wild *Chenopodium* species were used as comparative samples (Table 1). Morphometric features of crop/weed Andean complex show domesticated *C. quinoa* var. *quinoa* fruits are lenticular, range from 1.6 to 2.3 (less frequently up to 2.8) mm in diameter and have a central starchy perisperm and peripheral embryo. The alveolate-reticular pericarp adheres to the seed. Seed shaped is discoidal to lenticular with truncate margins; its diameter ranges from 1.5 to 2.2 (less frequently 2.6) mm. Seed-coat or testa is thin with a smooth texture. Weed *C. quinoa* var. *melanospermum* fruits are similar to quinoa, whereas seeds have a diameter range from 1.4 to 2.2 mm, biconvex to rounded-truncate margins and its testa has a reticular texture. Other weed and wild *Chenopodium* species were considered, especially those growing in Córdoba province (sensu Planchuelo, 1975) such as weed-chenopods (*Chenopodium ambrosioides*, *hircinum*, *macrospermum* y *papulosum*). These species have different morphometric features, ranging from 0.6 to 1.2 mm in seed diameter. The papiraceo or membranous-alveolate pericarp and the notch in radicular area, among other features, (see Table 1) allow researchers to discriminate between products of the Andean crop-weed complex and those of the ancient agricultural system.

Qualitative features described are: 1 - lenticular form of grain and annular embryo, noting no post-harvest practices or charring processing that would result in the loss of this feature. 2 - Pericarp texture is reticulate-alveolate; post-harvest processing causes the detachment of the pericarp, often in full, but if the grains have not been processed, the pericarp remains intact, not being affected by carbonization (López and Nielsen, 2013; López et al., 2011). 3 - Smooth surface of quinoa seed-coat or testa surface and reticulate-alveolate ajara testa surface. 4 - Margin configuration in quinoa seeds is truncate whereas in ajara seeds it is biconvex, rounded or equatorially banded. Experimental works showed that seed-margin configuration and presence of embryo is not modified by carbonization processes, but that some post-harvest practices and taphonomic effects can eliminate it (López et al., 2015a).

Diameter and thickness were the quantitative features used in the grain analysis. The average diameter of quinoa grains is 2 mm, as a minimum, depending on Andean ecotypes and their ethnovarieties (Bertero et al., 2004; Planchuelo, 1975; Wilson, 1990; PROINPA, 2002, 2004; Mujica and Jacobsen, 2006). However, that measure is modified by carbonization effects. Experimental approaches to studying charred quinoa and ajara grains have shown that diameter and thickness are increased or decreased (López et al., 2011, 2015a).

Testa thickness is an important quantitative data to discriminate between domesticated and wild chenopod seeds. Domestication process reduced the testa thickness losing the control of germination dormancy (Gremillion, 1993, Smith, 1985; Wilson, 1981). Several studies showed that Andean domesticated chenopods have thin testa while wild chenopods have thick testa (Bruno, 2005, 2006; Bruno and Whitehead, 2003). Measures were obtained using Scanning Electron Microscopy (SEM) but when there are not possibilities to access the SEM, the difference between thickness testa can see with normal stereomicroscope but no measures can make (López et al., 2015a, 2015b). In this paper, the use of SEM was not possible, but images of thickness testa were offered to show the presence of ajara seeds.

The specimens presented here were also compared with charred quinoa and ajara grains recovered at macro-regional archaeological sites in order to analyze the possible provenance region of these pseudocereal grains in the Sierras of Córdoba agricultural expansion process (Table 2).

4. Results

Taxa from QN7 (N = 62) were notably diverse, including wild, weed and cultivated plants. All of these remains were carbonized. Fruits of *Ziziphus mistol* (mistol) (60%) *Condalia* spp. (piquillín) (2%) and *Zea*

Table 1
Quali-quantitative features of modern quinoa, ajara and *Chenopodium* grains that growing in Córdoba province, Central Argentina. Diam. = diameter. long. = longitude. lat. = latitude.

	Fruit			Seed				
Chenopodium TAXA	Shape	Pericarp texture	Diam./long. × lat. (mm)	Shape	Margins	Testa texture	Diam./long. × lat. (mm)	Other feature
C. quinoa Willd. var. *quinoa*	Lenticular	Reticular-alveolate	1.6–2.8	Lenticular	Truncate	Smooth	1.6–2.8	None
C. quinoa Willd. var. *melanospermum* Hunz.	Lenticular	Reticular-alveolate	1.4–2.2	Lenticular	Biconvex to round	Reticulate	1.4–2.2	None
C. ambrosioides Allen = *Dysphania ambrosioides* (L.) Mosyakin & Clemants	Lenticular	Papiraceo	0.6–0.7	Lenticular	Round	Sine data	0.5–0.7	Notch in radicular area
C. chilense Schrad.	Lenticular	With adpressed cilyndric hair or alantoid	1.1	Lenticular to globose	Round	Smooth	1	Translucent pericarp
C. burkartii (Aellen) Vorosch.	Lenticular	Membranous with adpressed hair	1.2–1.4 long. × 1.1–1.3 lat.	Lenticular and globose	Round	Smooth	1.1–1.3 long. × 1.1–1.2 lat.	None
C. hircinum Schrad.	Mildly gibbous	Membranous-alveolate	1–1.2	Lenticular mildly gibbous	Round	Alveolar	1–1.2	None
C. dessicatum A. Nelson	Lenticular to bi-conical	Membranous	1.1–1.2	Lenticular and bi-conical	Acute	Finely wrinkled	1–1.2	None
C. papulosum Moq.	Lenticular	Papillose with visible long papillae	1.7–1.9	Lenticular	Acute to sub-acute	Smooth	1–1.1	Notch in radicular area
C. pilcomayense Aellen	Lenticular y globose	Membranous, densely papillose	0.9–1.1 long. × 0.8–0.9 lat.	Lenticular to globose	Round	Wrinkled	0.8–0.9 long. × 0.7–0.9 lat.	Notch in radicular area
C. cordobense Aellen	Lenticular a globose	Papillose	0.9–1	Lenticular to globose	Acute	Wrinkled	0.8–0.9	None
C. macrospermum Hook. f.	Globose and elongate	Bifid stigma	1–1.1 long. × 0.9 lat.	Lenticular	Sub-acute	Wrinkled	0.8–0.9 long. × 0.8–0.9 lat.	Notch in radicular area
C. multifidum L. = *Dysphania multifida* L.	Lenticular	With adpressed vesicular hair	1–1.1 long. × 0.9 lat.	Lenticular	Sub-acute	Smooth	0.9–1 long. × 0.8 lat.	None

Table 2
Archaeological remains of *Chenopodium quinoa* found in Argentina, Chile and Bolivia that were used as comparative samples.

Sites and chronology	Context	Shape	Margins configuration	Pericap-texture	Testa-texture	Diameter (mm)	Species identified	Source
Gruta del Indio (Mendoza-Argentina) 260 a.C.	Burial	Lenticular with annular embryo	Biconvex to rounded and biconvex to truncate	Reticulate alveolar	Reticulate	1.2–1.6	*Chenopodium quinoa* var. *melanospermum*	Lagiglia, 2005;
Pampa Grande (Salta-Argentina) 700 d.C.	Burial	Lenticular with annular embryo	Sine data	Sine data	Sine data	1.8	*Chenopodium quinoa*	Hunziker, 1943
Finispatriae (Jujuy-Argentina) 800–1450 d.C.	Debris	Lenticular with annular embryo	Truncate No identified	Without pericarp Reticulate alveolar	Smooth Reticulate	1.5–2.6 1.9	*Chenopodium quinoa* var. *quinoa* *Chenopodium quinoa* var. *melanospermum*	Nielsen et al., 2014
Punta de la Peña 4 (Catamarca-Argentina) Ca. 1200–1400 d.C.	Associated to hearth	Lenticular with annular embryo	Sine data	Sine data	Sine data	2–3	*Chenopodium quinoa* var. *quinoa*	Rodríguez et al., 2006
Las Champas (Catamarca-Argentina) 1400 d.C.	Burial	Lenticular with annular embryo	Biconvex and truncate	Reticulate alveolar in some grains and without pericarp	Reticulate	1.35–1.65	*Chenopodium quinoa* var. *melanospermum*	Ratto et al., 2014
Pukara de Sedilla (Potosí-Bolivia) 1000–1450 d.C.	Domestic hearth	Lenticular with annular embryo	Truncate	Sine data	Smooth	1.1–1.85	*Chenopodium quinoa*	López, 2012
Chrurupata (Potosí-Bolivia) 1285–1380 d.C.	Domestic hearth	Lenticular with annular embryo	Truncate	Reticulate alveolar	Smooth	1.1–2.5	*Chenopodium quinoa*	López, 2012
Laqaya (Potosí-Bolivia) 1236–1479 d.C.	Storage structure	Lenticular with annular embryo	Truncate	Reticulate alveolar	Smooth	1.9–2.45	*Chenopodium quinoa*	López, 2012
Mallku pukara (Potosí-Bolivia) 1310–1630 d.C.	Domestic hearth	Lenticular with annular embryo	Truncate	Sine data	Smooth	1.3–2.7	*Chenopodium quinoa*	López, 2012
El Plomo (Central Chile) 1460–1340 a.C.	Debris	Sine data	Truncata to rounded	Sine data	Without testa	0.8–1	*Chenopodium* cf. *C. quinoa*	Planella et al., 2011
Alero Las Morrenas 1 (Central Chile) 1250–980 a.C.	Debris	Lenticular with annular embryo	Sine data	Sine data	Sine data	1.4	*Chenopodium* cf. *C. quinoa*	Planella et al., 2005
Lonquén (Central Chile) 100 a.C.–900 d.C.	Debris	Sine data	Sine data	Sine data	Sine data	0.8–1.3	*Chenopodium* cf. *C. quinoa*	Quiroz and Belmar, 2004
El Mercurio (Central Chile) 120–150 d.C.	Burial	Sine data	Sine data	Sine data	Sine data	1.3	*Chenopodium quinoa*	Planella et al., 2010
Sitios Alfarero Temprano (Central Chile) 400–1000 d.C.	Sine data	Sine data	Sine data	Sine data	Sine data	1.3–1.8	*Chenopodium quinoa*	Planella et al., 2015
El Cebollar (Central Chile) 815–1075 d.C.	Debris	Sine data	Sine data	Sine data	Sine data	0.8–0.9	*Chenopodium quinoa*	Quiroz and Belmar, 2004
C° Grande de la Compañía (Central Chile) 1310–1480 d.C.	Hearth	Sine data	Sine data	Without pericarp	Sine data	2	*Chenopodium quinoa*	Rossen et al., 2010

mays (maize) (11%), seeds of *Phaseolus vulgaris* (kidney bean) (3%) and cf. *Amaranthus* sp. (amaranto) (2%), and grains of *Chenopodium quinoa* (5%) were identified. Some macrobotanical remains were not yet identified (11%). Phytoliths recovered from hand-stones offered evidence of maize processing (López and Recalde, 2015).

Quali-quantitative features of *Chenopodium quinoa* seeds are presented in Table 3 (Fig. 3A and C). A seed identified as *C. quinoa* var. *quinoa* (quinoa) was characterized by lenticular shape, smooth testa surface, 2.4 mm of diameter and by displaying margin configurations that are truncate-to-biconvex. The two seeds identified as *C. quinoa* cf. var. *melanospermum* (ajara or *quinoa negra*) have lenticular shape, biconvex margins, reticulate testa surface and 2.2 and 2.3 mm diameters. Post-harvest grain-enhancement practices were evident in these seeds, especially through the absence of pericarp (López et al., 2011). Rinsing and rubbing were the methods probably used to eliminate steroidal compounds (saponins) in grains. Rinsing dissolves the saponins and

Table 3
Characterists of *Chenopodium quinoa* seeds of QN7.

Source Cuadricule and levels	Shaped	Margin configuration	Pericap-texture	Testa-texture	Diameter (mm)	Species identified
B2 c 0–10 cm	Lenticular with annular embryo	Biconvex	Without pericarp	Reticulate	2.3	*Chenopodium quinoa* cf. var. *melanospermum*
B2 c 0–10 cm	Lenticular with annular embryo	Biconvex	Without pericarp	Reticulate	2.2	*Chenopodium quinoa* cf. var. *melanospermum*
B1 c 10–20 cm	Lenticular with annular embryo	Truncate to biconvex	Without pericarp	Smooth	2.4	*Chenopodium quinoa* cf. *var. quinoa*

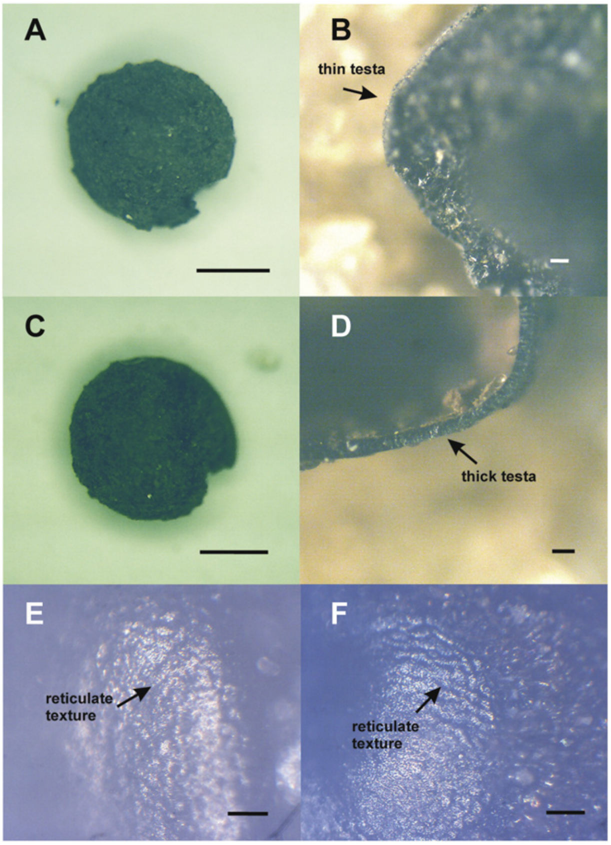

Fig. 3. Quinoa and Ajara grains of QN7: A, B - *Chenopodium quinoa* var. *quinoa* and detail of thickness texta. C, D - *C. q.* cf. var. *melanospermum* and detail thickness testa. E - Texture of seed coat of archaeological ajara from QN7. F - Texture of seed coat of modern ajara from Bolivia. A–C scale bar = 1 mm. B–D scale bar = 0.01 mm. E–F scale bar = 0.05 mm.

takes them away, while rubbing erodes the remaining fragments of pericarp from the grains. Rinsing and rubbing are repeated until no foam appears and the water is no longer white but transparent. The accidental charring of seeds probably resulted from routine daily practices of chenopod cooking.

Testa texture in not clearly seen in the photograph as under the microscope, both archaeological and modern ajara seeds (Fig. 3E and F). And, as above was mentioned, the access to SEM was not possibly. So, the difference between quinoa and ajara thickness testa was observed with normal stereomicroscope. Quinoa shows a thin testa while ajaras show a thick testa (Fig. 3B and D). Although measures of testa were not obtained of both chenopods, the different thicknesses are clearly observed. Thus, the poor visibility of the reticulate texture of the seed coat is complemented by the thickness testa to identify cf. var. *melanospermum* (weed chenopods).

The measures observed in the quinoa of Córdoba, by comparing with archaeobotanical data, allow researchers to infer that these grains are similar to the quinoa of the archaeological sites of North-Western Argentina and Central Chile. Diameter indicated that Córdoba quinoa was in an advanced state of crop selection and domestication.

5. Discussion

Taxonomic identification of macrobotanical remains, phytoliths, and starch grains in QN7 proved to be of great importance for the archaeology of Central Argentina, with its economic implications being discussed in different papers (López y Recalde, 2015; López et al., 2015b).

The first archaeological macro-evidence of *Chenopodium quinoa* in the central region of Argentina was presented. The genus *Chenopodium* has been recorded in several archaeological sites in Andean South America from the Middle Holocene to Inca era, suggesting a temporal tendency toward the manipulation and domestication of these species. Many archaeological sites from Argentina, Bolivia, Chile, and Peru show remains of *Chenopodium* spp. present since c. 7000 BP, suggesting that this plant has been used in multiple ways and has had economic and social importance, continuing into the present time (see archaeological data compilation in Planella et al., 2015). The identification of starch grains on grinding tools and sediments from North-Western Argentina have demonstrated that the genus was incorporated into subsistence c. 4700 BP, being cultivated since 3600 BP (Babot, 2011; Babot et al., 2009). The oldest microfossils of *Chenopodium* from Argentina were recorded in Quebrada Seca 3 (Catamarca province) and dated at c. 5000 BP, showing post-harvest evidence of roasting, removing pericarp, and dry grinding (Babot, 2011). A fragment of *Chenopodium* stem dated at c. 3500 BP was recovered at Peñas Chicas 1.3 residential site (Catamarca province), being the first evidence of non-food use of this taxa (Aguirre, 2007). *Chenopodium quinoa* macrobotanical remains have been found in multiple contexts. Seeds, inflorence, branches, and flowering stem were all taken from a hearth at the Punta de la Peña site (Catamarca province), dated at 760–560 BP (Rodríguez et al., 2006). The remains were recovered with other domestic and wild plant species and are evidence of the high dietary consumption. The existence of the association *C. quinoa*/*Deyeuxia eminens* (the former is edible; the second was used as a tool for toasting the seeds) is recognized for the first time. At the excavation of the Las Champas site (c. 600 BP) (Catamarca, Argentina), *C. quinoa* var. *melanospermum* were recovered from a funerary context, showing signs of boiling or soaking in water. It is possible that ajara was consumed as part of a burial ritual – an indirect indication of quinoa cultivation in the region (Ratto et al., 2014). Finally, charred grains of *C. quinoa* were recovered at the Finispatriae site (Rio Grande de San Juan, Jujuy, Argentina) (c. 1145–705 BP). The archaeobotanical material was found in a midden area and, therefore, it can be deduced that quinoa was consumed by the inhabitants of the site (Nielsen et al., 2014).

The archaeobotanical macrobotanical-remains from Central-Western Argentina are insufficient to indicate that quinoa came from this Argentinean region. Data of quinoa offer early chronological evidence in only one archaeological site in Mendoza province. On the contrary, data from NWA display evidence of quinoa and ajara grains of later times (Regional Development Period, 900/1000–500 BP) with similar measures to those of the Córdoba quinoa grains. Variation on quinoa measures could indicate different ecotypes (Bertero et al., 2004; Del Castillo et al., 2008) and ethno-varieties (López, 2012) that ancient people from Jujuy, Salta, and Catamarca provinces could have cultivated. However, macro-remains of *C. quinoa* at QN7 are similar to them.

The presence of quinoa and ajara remains indicated that, as has taken place in North-Western Argentina (NWA), these foods were part of the subsistence of the societies that inhabited the Sierras of Córdoba before the Spanish arrived in Central Argentina (XVI century AD). In the adoption of production practices since 1100 BP (Pastor et al., 2012b), *Chenopodium quinoa* crop/weed complex was included and probably both crop and weed seeds were consumed, as the Andean archaeological and ethnographic data have shown (Lagiglia, 2005; López, 2012; Ratto et al., 2014).

According to the above, the similarity of quinoa grains from Central Argentina to specimens from North-Western Argentina has encouraged considering the incorporation via exchange with farmer from NWA before LPP. The adoption of this step could represent a response to existing consumption and manipulation patterns of wild chenopods by hunter-gatherers. During the process of intensification of plant consumption, human groups implemented reproduction, harvest and post-harvest techniques that could be used to produce the quinoa crop (López et al., 2014). The saponins should be eliminated prior to consuming these grains, and rinsing and rubbing methods were possibly used by Córdoba's ancient people, a practice similar to those of NWA people, especially regarding the enhancement of sweet-quinoa (López, 2012). The absence of more macrobotanical remains of this species does not allow discussions about the local growth process of grain size, as in Chile (Planella et al., 2011). For the moment, domesticated quinoa is considered as one crop more in the farming economy post-1100 AP, without having been consumed earlier as maize was (Pastor et al., 2012b).

6. Conclusions

To the best of our knowledge, this paper describes the first study of the archaeological production and consumption of *Chenopodium quinoa* var. *quinoa* and *C. q.* cf. var. *melanospermum* in Córdoba. The macrobotanical remains analysis and the cultural context showed that these plants were cultivated, harvested and processed to cook during the Late Pre-Hispanic Period. Data from QN7 suggest a mixed foraging and farming economy, characteristic of late pre-Hispanic subsistence that was the result of an intensification process that began at 3000 BP (Medina et al., 2016; Pastor et al., 2012a). Likewise, this archaeological site offers new evidence that allows researchers to infer the use of an economic strategy characterized by including both crop and weed species in the archaeological area of Cerro Colorado. Both quinoa (crop) and ajara (weed) could be consumed for similar (subsistence) or different (ritual) purposes.

In sum, the QN7 evidence allows us to propose, first, that the quinoa of Córdoba was in an advanced state of crop selection and domestication, as indicated by their diameter. Second, the adoption of *Chenopodium quinoa* could respond to existing consumption and manipulation patterns of wild chenopods by hunter-gatherers. Third, the probable provenance of QN7 quinoa is from NWA, leading to the hypothesis that there were relationships among pre-Hispanic societies of both Argentinian regions. Fourth, this study suggests the probable use of a productive practice that included the crop/weed complex as a strategy to buffer the risk of crop failure. Finally, the presences of maize, quinoa, ajara and beans, the absence of pumpkin, and evidence of tubers (cf. *Solanum* sp. and cf. *Ipomea batata*) at other archaeological sites near QN7, indicate a different method of agricultural management in the Sierras of Norte. New research will facilitate the recognition of a mosaic of agricultural patterns in Central Argentina.

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