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The Social Organization of Ceramic Production in a Colonial Context: The Case of Panamanian Majolica and Criolla Ware

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Abstract
Due to the existence of wares that were produced both within and outside Spanish-tradition workshop in Panamá Viejo, this site offers an apt opportunity to study how coexisting but seemingly distinct potting communities organized their craft in a colonial context. To this end, a sample of two locally produced wares—one characterized by high-fired, wheel-thrown, and tin-glazed vessels known as Panamanian Majolica and the other by low-fired, handmade, and coarse-textured utilitarian vessels known as Criolla—were analyzed. The findings of the macroscopic and microscopic characterizations revealed that highly divergent potting communities, whose productions practices and craft organization varied drastically, coexisted at the site.

Keywords Ceramic production · Social organization · Panamá Viejo · Petrography

Introduction

In the production phase of a ceramic's life history, potters transform raw clay into artifacts through the selection and application of a set of procedures, known as techniques, at every stage. Because pottery making is an "additive process in which the successive steps are recorded in the final product," ceramic analysis can reveal relevant information on human behavior and culture (Rice 2005: 25). To this end, concepts employed in the social theory of technology have offered archaeologists a valuable mechanism to relate both technical and social knowledge and action because ceramic production is consciously and unconsciously embedded in an individual potter's social life (Dobres and Hoffman 1994). Because of the existence of locally produced wares within and outside of Spanish-tradition workshops in Panamá Viejo, this site's ceramic record presents an apt opportunity to study how coexisting but seemingly distinct potting communities organized their craft in a colonial context.

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Owing its prominence to its strategic geopolitical location, the city of Nuestra Señora de la Asunción de Panamá (now referred to as the Panamá Viejo archaeological site) was a pivotal component of a transcontinental commercial network that connected Spain and its South American colonies during much of the sixteenth and seventeenth centuries (Mena García 1992; Castillero Calvo 2006). The city's role as a commercial hub, which granted merchants access to other colonial markets, attracted potters from Spain who established workshops dedicated to the production of Spanish-styled ceramics. While multiple wares were produced in these workshops until Panamá Viejo's abandonment in 1673, among its most coveted product were the high-fired, wheel-thrown, tin-glazed serving vessels known as Panamanian Majolica (Jamieson 2001; Rovira 2001b). Contemporary with this industry was a low-fired, coil- or slab-built coarse ceramic craft that specialized in the manufacture utilitarian vessels known as Criolla Ware whose production likely occurred outside of the aforementioned workshops given the technological, morphological, and iconographic differences with the local Spanish-styled ceramic repertoire (Schreg 2010).

This article presents the results of the research project undertaken as part of my master's thesis (Pourcelot 2019) which focused on the production of the aforementioned contemporary but technologically and compositionally distinct wares. Through the application of both macroscopic and microscopic methods of analysis, this investigation aimed to determine if the organization of each ceramic ware reflected the existence of discrete potting units or communities and whether diachronic change or continuity was observable in each ware's production organization.

Background

The Social Dimension of Technology and the Organization of Ceramic Production

In recent decades, there have been significant paradigm shifts in ceramic studies as archaeologists moved away from traditional ecological and functionalist models for material and technological selection to also consider possible cultural factors. While this new approach does not pretend to discard potential constraints on a technological choice posed by the natural environment or the vessel's intended function, it maintains that the selection of certain techniques and knowledge can be influenced by the potter's social context (Albero Santacreu 2014).

This so-called social theory of technology draws mainly upon fundamental concepts developed by Pierre Bourdieu in his seminal work *Outline of a Theory of Practice* (1977), which examined the relationship between an established social structure and individual action within it. Among his central concepts, Bourdieu defined *habitus* as an organized set of regulated actions or habits that an individual or group develops through regular practice. In this sense *habitus* comprises embodied dispositions or "way of doing things" that are the product of a particular cultural and historical context. As actions or dispositions acquire a perception of "naturalness" and become unconsciously accepted as unquestionable, "taken for granted" truths among members of a social group, they are referred to as *doxa* (Bourdieu 2017).

In ceramic studies, these concepts offer a mechanism to relate both technical and social knowledge and action because pottery production is consciously and unconsciously embedded in an individual potter's social life, where cultural values can be transmitted through practice (Dobres and Hoffman 1994: 214). The concept of *habitus* is particularly useful in this sense because techniques are regulated, patterned actions that are generated through regular practice and often represent unconscious expressions of culture. Furthermore, material manifestations of *doxic* behavior can be linked to the establishment of a technological tradition in ceramic production which is defined as a social consensus regarding the set of technological choices required in the manufacture of a vessel that are "socially significant in a given context" (Albero Santacreu 2014: 241).

Because *habitus* socially situates technological choices in a particular historical context, it also draws attention to how these dispositions could change over time in response to a variety of demands and reasons (Dietler and Herbich 1998). By examining the transmission of production knowledge across generations of potters, it is possible to relate technological traditions to social groups. The existence of such groups implies that a learning structure operated which allowed potters to transfer his or her way of producing pots to apprentices for an extended period of time until the transmitted technical gestures became automatic (Lave and Wenger 1991; Roux 2011). Once the learning process concluded, the learned production practices were "embodied" by the apprentices through consistent and repeated practice (*habitus*) and it consequently becomes difficult (albeit not impossible) for them to perceive and manufacture objects in a different way than that which they had been taught (Dobres 2000; Roux 2016).

Nonetheless, while modifications to a ware's production sequence can occur, certain stages in a vessel's production process appear to be more resilient to change than others. Gosselain (2000) argues that techniques which are technically malleable and leave visible traces on the finished products, such as decoration techniques and post-firing treatments, are more susceptible to modification in response to changing trends or disposition towards innovation. On the other end of the spectrum are stages that leave no visible traces on the finished product, such as primary forming techniques, which are deeply embedded in a potter's *habitus* through constant and repeated practice.

Given that individual techniques and the order in which they are employed can impact a ceramic's formal properties, reconstructing a vessel's production sequence through the *chaîne opératoire* model allows researchers to visualize individual technological choices more effectively and facilitates the analysis of potential natural, functional, and social factors in play. This framework also offers the potential of addressing diachronic continuity and change in technological traditions and evaluate the successful generational transmission of production knowledge and practices (Roux 2011). By examining the degree of variability of ceramic assemblages at both macroscopic (i.e., vessel shape, manufacturing technique, dimensions) and microscopic (i.e., paste recipe) scales, important aspects of a group's history and the organization of its ceramic production can be determined. On the one hand, homogeneity or standardization of ceramic products tend to reflect specialized mass production in communities where pottery production is exclusively in the hands of only a few individuals (Albero Santacreu 2014; Tite 1999). On the other hand, heterogenous or highly variable ceramic assemblages tend to reflect the existence of multiple potting units or social groups (either ethnic-, language-, or family-based for example) with distinct *chaîne-opératoires* that do not share a common technological tradition (Albero Santacreu 2014; Roux 2016).

Colonial Ceramic Production in Panamá Viejo

While historical documents associated with the production of ceramics in Panamá Viejo are notoriously scarce—limited to two references of *tejares* or brickyards in the city written in 1541 (Mena García 1992) and 1617 (Castillero Calvo 1994)—the archaeological record provides compelling evidence of the existence of a local industry, strongest of which has been the discovery of pottery kilns a short distance from the city's center (Fig. 1) (Biese 1964; Dirección Nacional de Patrimonio Histórico 1979; Long 1964, 1967; Mendizábal and Gómez 2015). At present, arguably five wares are attributed to have been produced in Panamá Viejo during the sixteenth and seventeenth centuries ranging from low- to high-fired glazed and unglazed ceramics. These are known as Panamanian Majolica, Panamanian Lead-Glazed Ware, Panamanian Redware Containers, Panamanian Redware, and Criolla Ware (Alzate Gallego 2015; Ferrer et al. 2015; Jamieson and Hancock 2004; Linero

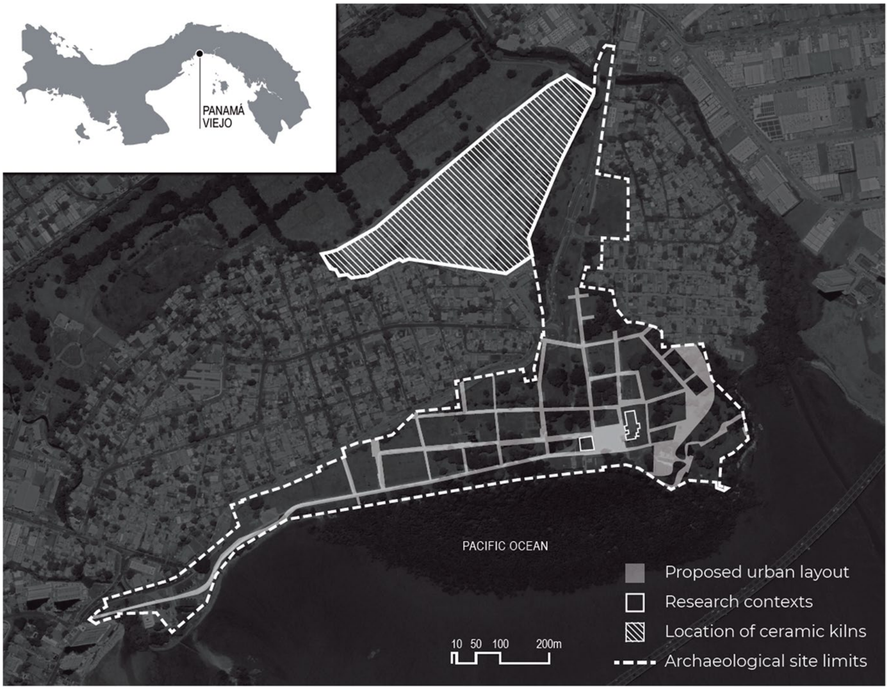

Fig. 1 Plan of Panamá Viejo's archaeological site limit along with its proposed original street layout, and locations of the selected research contexts and the ceramic kilns that have been reported. Source: Patronato Panamá Viejo. Credit: Ricardo López Sánchez

Baroni 2001; Rovira et al. 2006). This research focuses on two of these: Panamanian Majolica and Criolla Ware.

Panamanian Majolica are characterized by wheel-thrown vessels that have a fine and compact red- to orange-colored non-calcareous paste and are covered by a glossy and opaque white-colored vitreous enamel coating produced after adding tin oxide to a lead glaze and firing the glaze-covered vessel at high maximum temperatures (Deagan 1987). This ware is part of a broader colonial Latin American complex of tin-glazed ceramics whose production practices and organization were "implanted" in these new settings by emigrating potters from Spain (Lister and Lister 1987). Not surprisingly, many of the Latin American tin-glazed ceramics are morphologically and ichnographically very similar to those produced in Spanish production centers (Rice 2013; Rovira 2001a; Rovira and Mojica 2007). In addition, while local innovations in the manufacturing procedure have been reported in some of these wares (Iñañez et al. 2010), archaeometric evidence suggests that majolica potters in Panamá Viejo continued to adhere to European technological norms, particularly in regard to the glaze and black/brown-colored pigment recipes (Buxeda i Garrigós et al. 2014; Iñañez et al. 2013).

Panamanian Majolica is categorized into six types differentiated by the absence or presence of painted decoration and the combination of colors applied; this research analyzes three of these: Panama Plain (which lacks painted decoration), Panama Blue on White (which contains blue-colored motifs) and Panama Polychrome Type A (which contains a combination of blue, green and brown-colored motifs) (Fig. 2).

Criolla is characterized by coil- or slab-built coarse vessels used for the preparation, storage, and serving of foods which are scantly decorated (limited to plastic designs), fired at low maximum temperatures, and exhibit pronounced variations in the paste color, wall thickness, and surface finish technique (Baker 1969; Schreg 2010; Zárate 2004). Given that this ware has no discernable pre-Hispanic precursor in Panamá Viejo (Long 1967) and its technological attributes and iconography are regarded as being "non-European," it has been argued that these ceramics

Fig. 2 Photograph of an assortment of Plain, Blue-on-White, Polychrome Type A Panamanian Majolica bowls, plates and cups recovered in Panamá Viejo

were likely manufactured by Indigenous and/or Africans potters (Gaitán-Ammaan 2012; Linero Baroni 2001; Schreg 2010). Nonetheless, the socioracial identity of its producers has yet to be conclusively determined. In colonial sites across Latin America, locally made utilitarian assemblages whose combination of production practices, morphology, and iconography differs from that of the Spanish-styled ceramic repertoire have also been reported (i.e. Fournier et al. 2007; Hernández Sánchez 2011; Smith 1986). Currently Criolla's typology is based on the presence or absence of a red-colored slip, referred to as Plain Criolla and Slipped Criolla respectively (Fig. 3) (Linero Baroni 2001; Rovira and Gaitán 2010).

Multiple instrumental neutron activation analysis (INAA) tests have been performed on wares produced in Panamá Viejo whose findings indicate that Panamanian Majolica and Criolla ceramics have very distinct chemical compositions. On the one hand, despite its typological differences, Panamanian Majolica conforms a single cohesive group that also clusters other locally made unglazed Spanish-styled wares known as Redware and Panamanian Redware Containers (Iñañez et al. 2012; Jamieson and Hancock 2004; Jamieson et al. 2013; Rovira et al. 2006). This suggests that in Panamá Viejo's workshops the same clay source was used to produce these three wares. On the other hand, while both Slipped and Unslipped Criolla conformed a single chemical group, this cluster was distinct not only from that of the aforementioned local Spanish-styled ceramics but also from a small sample of pre-Hispanic sherds recovered at the site (Rovira et al. 2006). The results of these INAA studies indicate that Panamanian Majolica and Criolla are compositionally distinct.

Sampling and Methods

The sample is comprised by a total of 60 sherds (evenly distributed between both wares) that were recovered from two contexts at Panamá Viejo whose temporal ranges have been established through historical documents and archaeological

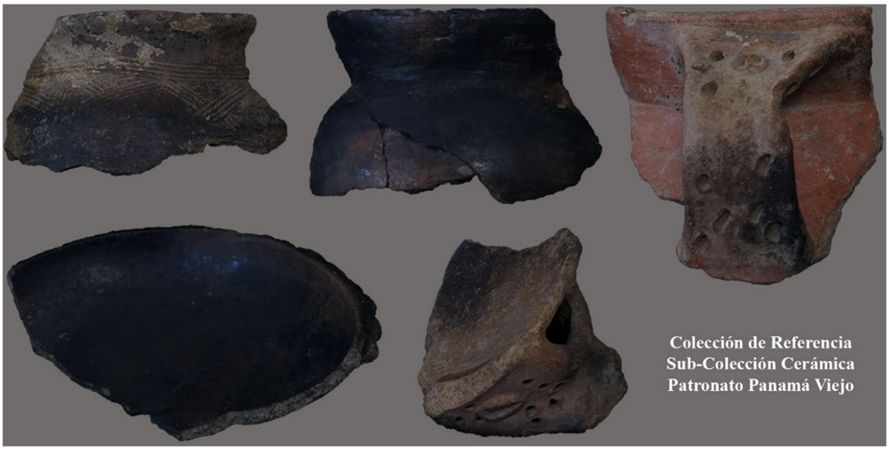

Fig. 3 Photograph of an assortment of Plain and Slipped Criolla bowls, plates and appendages recovered in Panamá Viejo

interpretation (Table 1). The early research context corresponds to a construction fill layer associated with the masonry construction of the city's cathedral dating between ca. 1612 and 1621. The late research context corresponds to a layer situated between the Western Houses' cobble stone floor and accumulation of clay tiles and iron nails, indicative of the collapse of a wooden ceiling that likely occurred sometime after the Panamá Viejo's abandonment in 1673 (Proyecto Arqueológico Panamá Viejo 1996a, b, 2000). Thus, a 50 to 59 year timespan separate these two contexts. Table 1 details the sample distribution by type and context:

Both macroscopic and microscopic characterizations were performed to describe each sherd's physical and compositional attributes. The first stage of analysis consisted of a visual characterization of each sherd's physical traits, noting attributes such as surface treatment, paste and pigments colors, and presence of firing cores. Subsequently, a microscopic characterization was carried out through petrographic analysis using thin-sections to examine a fabric's microstructure, groundmass, and aplastic composition (Peterson 2009). For this research, sherds were cut in a longitudinal orientation, adhered to standard glass slides using an epoxy mixture, and ground to a thickness of 30 μm (0.03 mm). The microscopic attributes were characterized using parameters described in Quinn (2013) for the fabric's area estimate, void shape, distribution, and orientation, and particle spacing, sorting, and distribution for the microstructural features, the groundmass' degree of optical activity and color in both plane polarized light (PPL) and cross polarized light (XPL), and the type, frequency, size range, angularity, and shape of the inclusions. A qualitative approach was used to characterize the microstructural, textural, and mineralogical components of each fabric, and each of the sherd's inclusions were extensively measured by randomly gauging the grains located in different parts of a thin section to obtain a more accurate representation of the inclusion's size range within the sample.

Sherds were later sorted into fabric groups, whereby visual patterns in mineralogical composition and microstructural characteristics formed the basis of fabrics. Sherds with similar mineral content and texture along with a comparable degree and type of chemical alterations (when present) were grouped together because they represent the product of a "paste recipe"—a term used to refer to the application of a specific set of production practices to a single clay source (Quinn 2013). Within each fabric group a small degree

Table 1 Sample distribution by research context and ware type

WARE	EARLY CONTEXT	LATE CONTEXT	TOTAL
Panamanian Majolica	15	15	30
Panama Plain	*5*	*5*	*10*
Panama Blue on White	*5*	*5*	*10*
Panama Polychrome Type A	*5*	*5*	*10*
Criolla	15	15	30
Plain Criolla	*8*	*8*	*16*
Slipped Criolla	*7*	*7*	*14*
TOTAL	30	30	60

of variations in the frequency and size range of the inclusions, and microstructural traits can be present as no two sherds are compositionally-identical. These differences were not used as the basis to conform a separate group unless they could be attributed to distinct changes in a paste recipe's production sequence. Additionally, while certain post-depositional and technological processes (i.e., the precipitation of secondary calcite and the rate of oxidation or maximum firing temperature) can produce visible differences between compositionally-related fabrics, these were disregarded during the grouping as they do not provide relevant archaeological information.

Results and Discussion

The findings of the macroscopic and microscopic characterizations revealed that highly divergent potting communities coexisted in Panamá Viejo during the sixteenth and seventeenth centuries, whose productions practices and craft organization varied drastically and are reflected in the assemblages they produced.

Panamanian Majolica Characterization

The microscopic characterization of the 30 analyzed Panamanian Majolica sherds confirmed the ware's compositional and technological affinity as the entire sample conformed a single fabric group, referred to as Fabric 1. These results indicate that a single paste recipe and production sequence was used at Panamá Viejo's workshops for this ware's manufacture. This compositional cohesion mirrors Panamanian Majolica's strong chemical affinity, as previously determined in the aforementioned INAA tests, and further supports the hypothesis that this ware's clay was procured from a single deposit. Fabric 1 is characterized by a fine-textured fabric, whose paste was decanted of coarse sand-sized inclusions, formed by wheel, and fired in kilns under oxidizing conditions to maximum temperatures that were not sustained above 1100ºC for a prolonged period of time.

The raw clay appears to have derived from a sedimentary deposit of an intermediate igneous source composed of coarse-grained intermediate igneous rocks (likely from either granodiorite or tonalite), plagioclase feldspar, quartz, hornblende, and biotite minerals. The fabric's predominant textural uniformity, unimodal grain size distribution, and low proportionality of the coarse fraction strongly suggest that a refinement technique was applied to produce a fine-textured paste (Fig. 4). A previous petrographic study comparing the fabrics of Panamanian Majolica and Panamanian Redware Containers (a coarser-grained compositionally related ware) further supports this interpretation as mineralogical evidence of clay refinement was detected in the former ware's paste (Pourcelot 2017). Fabric 1 sherds appear to have sustained maximum firing temperatures above 1000ºC given the matrices' predominant very low to low optical activity, evidence of hornblende and biotite thermal alterations, and the presence of a tin-glaze layer which requires sustained temperatures above that threshold to properly mature and adhere to the clay body (Lister and Lister 1982). The absence of melted plagioclase feldspar crystals in the entire sample indicates that temperatures were not sustained above 1100ºC long enough to

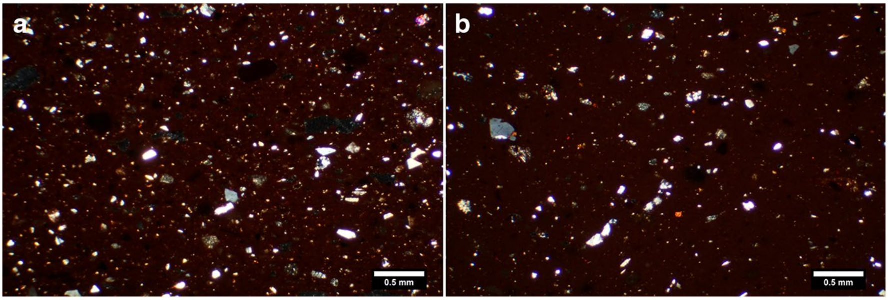

Fig. 4 Photomicrographs of the matrices of two Fabric 1 sherds in XPL. Note that there is a subtle but perceivable variation in the frequency of very fine sand-sized inclusions in these matrices. This difference could be attributed to the procurement of two separate sources within the same clay deposit (Pourcelot 2017)

allow this alteration to occur (Quinn 2013). Further macroscopic evidence, such as the paste's uniform color and lack of firing cores, indicates that oxidizing conditions were sustained long enough to allow complete oxidation of the paste.

Technological and Social Implications

The entire sample's sorting into a single group indicates that the same paste was used to produce Panamanian Majolica independent of the presence or absence of painted decoration and color combinations. Thus, the ware's typological distinctions reflect decorative choices and not significant technological variances. Furthermore, the ware's compositional and technological uniformity contrasts with observed diachronic changes in Panamanian Majolica's iconography and morphology in the archaeological record (Rovira 2001b; Rovira and Mojica 2007). While potters at Panamá Viejo's workshops adapted their vessels' forms and decorations to changing stylistic demands, they appear to have maintained the paste recipe and production sequence intact. Such a pattern is consistent with Gosselain's (2000) notion that certain stages in the production process (such as the primary forming technique and paste preparation) are less likely to be modified than a vessel's more visible attributes (such as decorative technique and iconography), because the latter superficial elements are more affected by changes in consumer taste.

However, arguably the most significant implication of these results is that the use of a single paste recipe reflects a diachronic continuity of production practices that was maintained when all potters adhered to a set of established norms to produce tin-glazed vessels. This temporal consistency strongly indicates that knowledge related to the production of this ware was successfully transferred from one generation to the next without discernable degrees of variation or innovation either in the original paste recipe or in other stages in the manufacturing process. While historical information related to the specific setting in which this transmission took place in Panamá Viejo is currently lacking, there are reasons to suppose that the training of majolica potters occurred through structured apprenticeships as it has been documented in the coeval production centers of Mexico City and Puebla in New Spain.

Apprenticeships promote adequate training and proper technical execution through regular supervision of the trainee by an experienced potter and long terms of training (Livingstone-Smith 2000). Historical data from the majolica production centers in Mexico City and Puebla reveal that a hierarchical training system composed of *maestros* (master craftsmen) and apprentices (who were usually adolescents) was in place, a system that required the former to provide the latter with proper training and housing in exchange for specialized labor in the workshop for a term that typically lasted between three to four years (Castillo Cárdenas 2007; Castro Morales 2002; Connors McQuade 2005; Lister and Lister 1987). Through recurrent, prolonged, and supervised practice, apprentices eventually internalized both technical gestures and production procedures until these became part of their unconscious behavior and action or *habitus*. Over time the *maestro*'s *chaîne opératoire* became *doxic*, to draw on Bourdieu's terminology. Changes or innovations in the established norms were unlikely to occur, especially in those stages of the manufacturing process that are more connected to a potter's technical behavior, such as the primary forming technique or paste preparation (Gosselain 2000). It is this set of instructed and internalized knowledge that would be transmitted to another generation of potters by now-skilled apprentices through a similar learning context (Dietler and Herbich 1998; Dobres 2000).

The existence of a structured training system in Panamá Viejo's majolica workshops would account for Fabric 1′s strong diachronic compositional and technological consistency, as it could reflect a *maestro*'s control over the technological choices that were taught by means of direct supervision, thereby also guaranteeing adherence to a set of established norms. The existence of a supervised learning context would also explain the lack of significant technological and compositional variation in a span of 50 to 59 years of Panamanian Majolica production, as it would have deterred any modifications of the established *chaîne opératoire* without the explicit approval of the workshop's *maestro*, thus discouraging innovation from an early stage of a potter's training. The rigid adherence to a single production sequence for Panamanian Majolica vessels in itself suggests that a tightly controlled learning context prevailed, alluding to the existence of such a training system in Panamá Viejo's workshops.

While the establishment and maintenance of a single paste recipe for Panamanian Majolica vessels may have been the result of the potters' unconscious behavior or *habitus*, it could have also been influenced by conscious economic choices. Neither cultural nor functional factors explaining the low variability of the analyzed fabrics are mutually exclusive, for both can play an influential role in the formation of standardized products (Longacre 1999). Nevertheless, I believe that given the specialized nature of tin glaze production in both Spain and New Spain, possible economic factors influencing the use of a single paste recipe warrant consideration.

The consolidation of colonies in the Americas generated a widespread demand among immigrating Spaniards for commodities that they were accustomed to in their Iberian homes, commodities which included tin-glazed vessels that were initially supplied from Europe and later supplanted by local production centers (Rice 2013). It is possible that the development of local workshops provoked competition among artisans who, in turn, may have sought to standardize their production practices in order to guarantee a consistent quality of the vessels they sold in the local and international markets (Longacre 1999). In this sense, the establishment and strong adherence to a *chaîne opératoire* could represent a conscious effort by Panamá Viejos potters to ensure their product's quality and thereby its marketability.

Likewise, the use of a single paste recipe for tin-glazed vessels might have served as a mechanism to prevent possible economic losses during the firing stage. Firing is arguably the most critical process in the ceramic production sequence, as it is in this stage that clay loses its plasticity and is transformed to a synthetic material. If potters fail to adequately control several variables including temperature, atmosphere, and firing rate, they risk causing irreparable damage to their vessels (Rice 2005; Rye 1988). This risk would have been particularly significant for majolica potters in Panamá Viejo given that they imported some of the raw ingredients required for the glaze recipe such as the lead (Iñañez et al. 2016) (and possibly the tin and cobalt used for the blue-colored decorations (Rice 2013) as well). Since different clays contain distinct physicochemical properties that can react differently to the effects of firing, scholars such as Van der Leeuw (1984) observed that some contemporary potting communities (particularly those who engage in communal firings) tend to decrease the variability of their pastes to reduce failures in this stage of the ceramic production sequence. It could be argued that by standardizing Panamanian Majolica's paste, potters sought to ensure that every tin-glazed vessel loaded in the kiln had nearly identical physicochemical properties, thereby reducing the economic risk of firing failures.

Independent of the conscious and unconscious factors that might have influenced the establishment and maintenance of a single clay recipe in Panamá Viejo's majolica workshops, its successful generational transmission reflects the formation of a technological tradition in this city. The presence of a clear technological tradition in Panamá Viejo likely reflects a stable organization of Panamanian Majolica production whereby social norms persisted over time without significant modifications.

Criolla Characterization

On the other hand, Criolla fabrics exhibit pronounced compositional and technological variations, and this is reflected in the sorting of its 30 sherds into 18 fabric groups (Fig. 5). The largest group is composed of seven sherds (accounting for 23.3% of the sample), followed two groups with three each, and two groups with two sherds each. The remaining 13 fabrics could not be paired; thus, they are considered "loners"—a term used to refer to a classification category that is only comprised of a single sample (Quinn 2013). The main characteristics of the 18 fabric groups are summarized in Table 2.

Most Criolla fabrics are composed of non-calcareous sedimentary clays of either intermediate or basic igneous origins, whose pastes were either tempered or not processed in any way (except for a group that may have been refined). Crushed rock and minerals were the most common material used for tempering, followed by sand and grog. The primary forming technique was the most elusive element to determine, as both macroscopic and microscopic evidence could only be discerned in ten sherds (belonging to eight groups) which exhibited signs of being formed through coiling. Most samples were fired at low maximum temperatures (below 850º C) under predominantly oxidizing conditions (albeit at varying consistencies and rates) in open firing regimes (Table 3). In two Plain Criolla samples, a thin smudged layer was detected as well as a thin and heavily eroded glaze layer of probable lead-based origins.

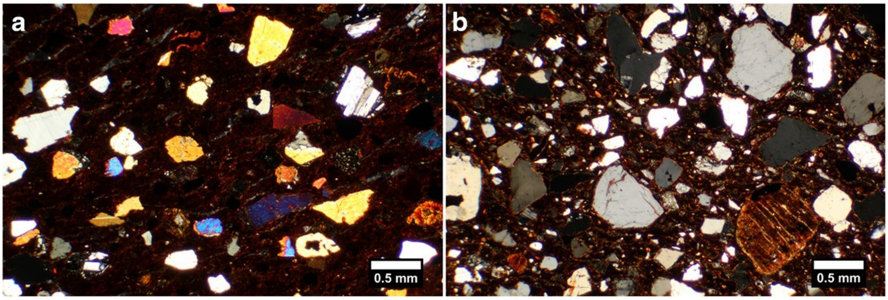

Fig. 5 Photomicrographs of the matrices of fabrics 4 (**a**) and 12 (**b**) sherds in XPL

When temporality is examined, it is apparent that some aspects of Criolla's production sequence remained stable over time, while others may have varied. On the one hand, the firing strategy was remarkably consistent, as low maximum firing temperature, the preference for oxidizing over reducing atmospheric conditions, and open firing regimes were predominant in both early and late seventeenth century sherds. On the other hand, the raw clay's geological provenience as well as the preference for paste preparation technique appear to have changed considerably over time as a temporal surge of basic-derived raw clay sources and non-processed fabrics is discernable (Fig. 6).

Technological and Social Implications

The fabric grouping revealed that there was little overlap between Slipped and Plain sherds, as only three groups (fabrics 3, 7, and 12) containing both types could be established, indicating that despite the ware's typological cohesion as determined by INAA (Rovira et al. 2006), the same recipe was used in only three of the 18 groups to produce both types of Criolla vessels. While confirmation is required through the analysis of additional samples, several preliminary typologically dependent patterns were observed. These include a preference towards intermediate derived clays over basic deposits in Slipped Criolla (63% versus 37%), a marked tendency of tempering Slipped pastes (70% versus 35%), and, conversely, an inclination to not applying any body preparation technique to Plain fabrics (60% versus 20%).

In addition, while the firing stage was consistent in both types a typologically dependent variation was observed in the rate of oxidation as Slipped fabrics were proportionally more completely oxidized (60%) than Plain fabrics (35%). Moreover, it was noted that on every incompletely oxidized Slipped sherd, the side of the vessel's wall where the slip layer was applied was always oxidized. Coupled with the absence of reduced Slipped fabrics in the sample, it appears that Criolla potters understood the firing atmosphere's effect on slip properties and took precautions to position Slipped Criolla vessels in an area within the firing pit where the exposure to circulating oxygen could be guaranteed. In contrast, the high frequency of incompletely oxidized and reduced Plain fabrics (50% and 15% respectively) suggests that their physical appearance was likely not a crucial consideration for potters (Fig. 7).

The sample's notable geological diversity, reflected in the use of intermediate and basic igneous-derived deposits in eight and seven fabric groups respectively,

Table 2 Characterization of Criolla fabric groups

Fabric Group	Defining attributes	Sample size
3	Unimodal and single-spaced fabrics predominantly composed of fine to medium sand-sized basic igneous origin minerals, such as plagioclase feldspar (whose crystals exhibit varying degrees of chemical alteration and zoning), olivine, orthopyroxene, and clinopyroxene	3
4	Unimodal and well to moderately sorted fabrics predominantly composed of fine to medium sand-sized basic igneous origin minerals, such as plagioclase feldspar (whose crystals exhibit varying degrees of chemical alteration and zoning), clinopyroxene, and orthopyroxene, and fine sand-sized opaque minerals	3
5	Unimodal, single-spaced, and very well sorted fabric predominantly composed of fine to medium sand-sized opaque minerals and orthopyroxene	1
6	Unimodal, single-spaced, and very well sorted fabric predominantly composed of fine to medium sand-sized basic igneous origins minerals, such as clinopyroxene and orthopyroxene, and opaque minerals	1
7	Unimodal and double-spaced fabrics with a small coarse fraction (less than 10% of the total area) that are predominantly composed of argillaceous inclusions. The paste appears to have been refined	2
8	Unimodal, single-spaced, and moderately sorted fabric predominantly composed of fine to medium sand-sized intermediate igneous origin minerals, such as plagioclase feldspar, quartz, clinopyroxene, and hornblende, to which coarse sand-sized grog inclusions were added as temper	1
9	Unimodal, single-spaced, and well sorted fabric predominantly composed of intermediate igneous origin minerals, such as fine to medium sand-sized plagioclase feldspar (whose crystals exhibit varying degrees of chemical zoning) and quartz, and very fine to fine sand-sized hornblende	1
10	Weakly to moderately bimodal and moderately to poorly sorted fabrics derived from the breakdown of a non-calcareous marine clay predominantly composed of basic igneous origin minerals, such as medium sand-sized plagioclase feldspar and clinopyroxene, very fine to fine sand-sized quartz, and bioclast (foraminifera)	2
11	Unimodal, single-spaced, and well sorted fabric derived from the breakdown of a non-calcareous marine clay predominantly composed of fine to medium sand-sized basic igneous origin minerals, such as plagioclase feldspar and clinopyroxene, medium to coarse sand-sized fine-grained igneous rocks (likely andesite and/or dacite) and bioclast (foraminifera)	1
12	Weakly to moderately bimodal, single-spaced, and moderately sorted fabrics predominantly composed of fine to medium sand-sized intermediate igneous origin minerals, such as quartz, plagioclase feldspar, and chemically altered biotite, to which crushed coarse-grained intermediate rock (possibly tonalite or diorite) inclusions were added as temper	7

Table 2 (continued)

Fabric Group	Defining attributes	Sample size
13	Strongly bimodal, single-spaced, and poorly sorted fabric predominantly composed of fine to medium sand-sized intermediate igneous origin minerals, such as plagioclase feldspar, quartz, and hornblende, to which crushed coarse sand-sized quartz and plagioclase feldspar (whose crystals exhibit varying degrees of physical alteration and chemical zoning) inclusions were added as temper	1
14	Strongly bimodal, close-spaced, and poorly sorted fabric predominantly composed of fine to medium sand-sized intermediate igneous origin minerals, such as plagioclase feldspar, quartz, and hornblende, to which large quantities of eroded medium to coarse sand-sized quartz and plagioclase feldspar (whose crystals exhibit varying degrees of physical alteration and chemical zoning) inclusions were added as temper	1
15	Moderately bimodal, single-spaced, and moderately sorted fabric predominantly composed of fine to medium sand-sized intermediate igneous origin minerals, such as plagioclase feldspar, quartz, and hornblende, to which crushed coarse sand-sized coarse-grained intermediate rock (possibly tonalite or diorite) inclusions were added as temper	1
16	Strongly bimodal, single-spaced, and poorly sorted fabric predominantly composed of very fine to fine sand-sized acid igneous origin minerals, such as quartz and potassium feldspar, to which crushed and chemically altered medium to coarse sand-sized coarse-grained acid rock (possibly granite) inclusions were added as temper	1
17	Moderately bimodal, single-spaced, and moderately sorted fabric predominantly composed of fine to medium sand-sized intermediate igneous origin minerals, such as plagioclase feldspar (whose crystals exhibit varying degrees of chemical zoning), quartz, and biotite, and medium to coarse sand-sized fine-grained intermediate rock inclusions	1
18	Strongly bimodal, single-spaced, and poorly sorted fabric predominantly composed of very fine to fine sand-sized intermediate igneous origin minerals, such as quartz and biotite, to which crushed medium to very coarse sand-sized coarse-grained acid rock (possibly granite) were added as temper	1
19	Strongly bimodal, single-spaced, and poorly sorted fabric predominantly composed of very fine to fine sand-sized quartz crystals to which crushed medium to coarse sand-sized coarse-grained intermediate rock (possibly tonalite or diorite) inclusions were added as temper	1
20	Weakly bimodal, single-spaced, and moderately sorted fabric predominantly composed of coarse sand-sized fine-grained basic rocks and fine-grained igneous rock inclusions, and fine to medium sand-sized plagioclase feldspar crystals and glassy rock inclusions	1

Table 3 Geological and technological attributes of the Criolla sample

GEOLOGIC SOURCE	Groups	Sherds
Basic	**7**	13
Intermediate	8	14
Unknown[a]	3	3
BODY PREPARATION TECHNIQUES	Groups	Sherds
Refinement	1	2
Tempering	8	14
Crushed rock or mineral	*5*	*11*
Grog	*1*	*1*
Sand	*2*	*2*
No processing	9	14
MAXIMUM FIRING TEMPERATURE	Groups	Sherds
Low (< 850º C)	13	25
High (> 850º C)	5	5
ATMOSPHERIC CONDITIONS	Groups	Sherds
Oxidizing	16	27
Complete oxidation	*9*	*13*
Incomplete oxidation	*9*	*14*
Reducing	3	3
FIRING REGIME	Groups	Sherds
Open	16	28
Closed	2?	2?

[a]Due to some of the fabric's mineralogical composition, it was not possible to determine the likely geological origin of its raw clay

indicates that different clay sources were procured to produce Criolla vessels. While it is possible that a small number of these fabric groups may have come from the same clay source given their mineralogical similarities, the sample's high degree of compositional variation was a surprising finding given that they are again at odds with the ware's cohesive chemical affinity. Although the exact provenance of Criolla vessels requires additional research, the obtained results suggest that this ware was probably manufactured in multiple localities. While it is possible that some vessels currently classified as Criolla may have been imported to Panamá Viejo (as argued in Rovira et al. 2006; Schreg 2010), local production could still account for one or more of the identified fabric groups given the geologically heterogenous composition of the landscape surrounding the city. Further research is required to establish a correlation between the identified Criolla fabrics and clay sources available near Panamá Viejo to better understand the production and circulation of these vessels.

Overall, the high variability of paste recipes suggests that Criolla production was decentralized and that each potter was a discrete unit independent from the rest. Each potter developed a distinct recipe that reflected his or her unique preferences regarding clay sources, body preparation technique, and temper material. This proliferation of fabric groups within Criolla ware in itself suggests a potting

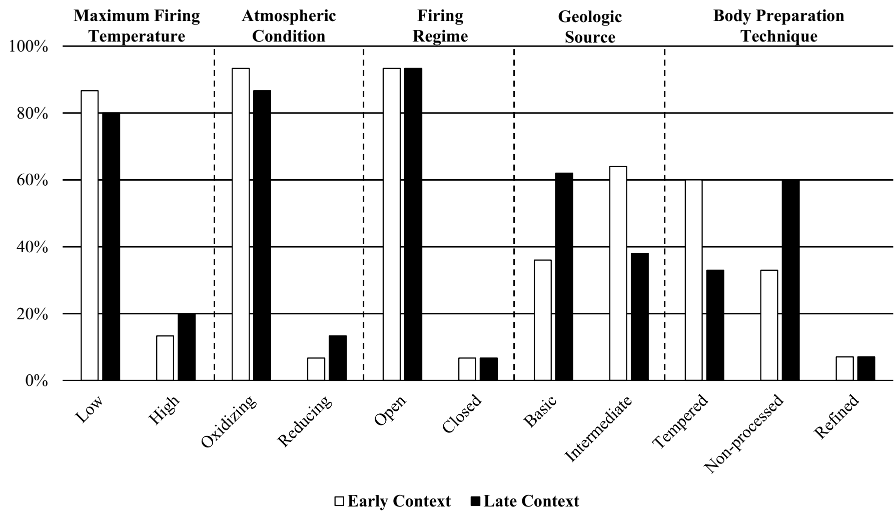

Fig. 6 Proportion of Criolla sherds by firing strategy, raw clay geological source and body preparation technique over time

industry that was much more ad hoc and transitory. However, it is important to bear in mind that it is common in petrographic analysis to merge initially different fabric groups when additional samples are analyzed because it allows for the end members of a larger group to be seen as part of a continuum rather than separate fabrics (Jennifer Meanwell, pers.l comm. 2019). Another salient aspect of these results is the very low degree of diachronic continuity of fabric groups, for only three of the 18 groups contain at least an early and a late context sherd.

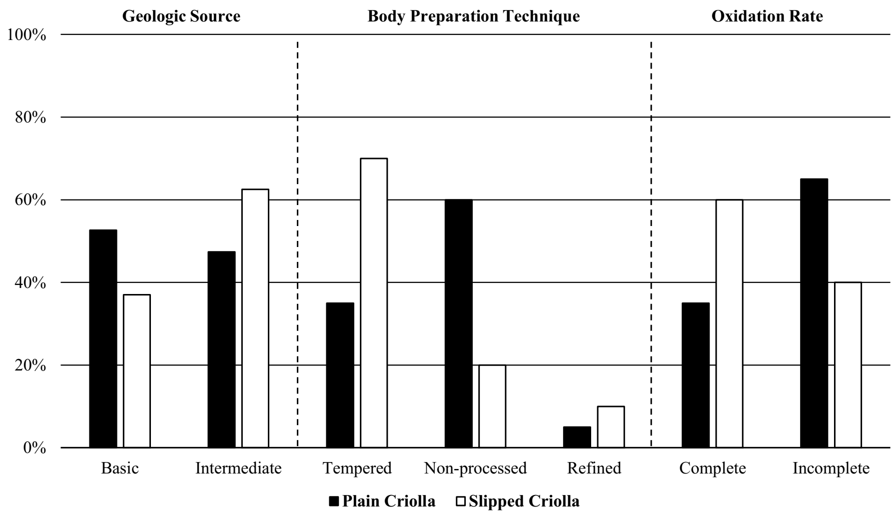

Fig. 7 Proportion of sherds' raw clay geological source, body preparation technique, and rate of oxidation by type of Criolla

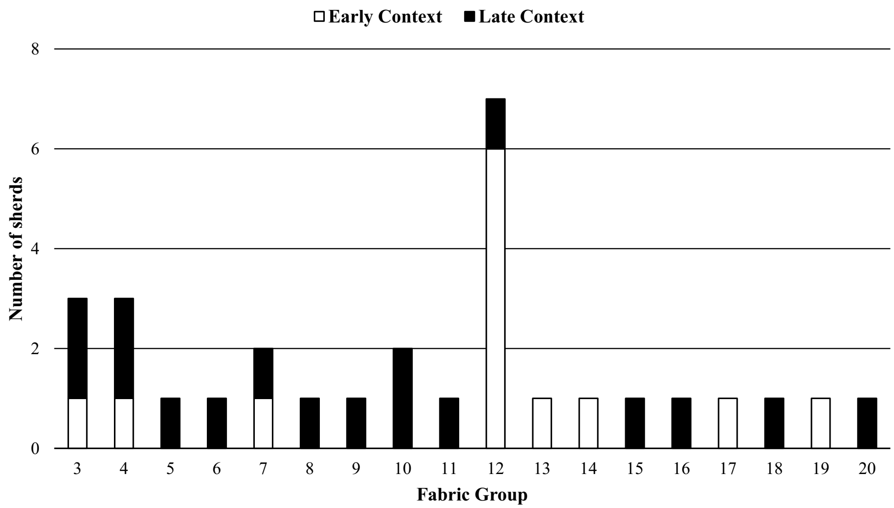

Fig. 8 Distribution of number of sherds by fabric group over time

While certain elements of the *chaîne-opératoire* persisted more than others, such as the firing strategy, it is evident that a specific combination of raw clay and body preparation technique did not prevail temporally in this sample. Furthermore, an increase in the number of temporally restricted fabrics (groups or loners that are only represented by sherds from a single context) from four to ten between the early and late seventeenth century was also noted. These preliminary results suggest that Criolla fabrics may have had limited lifespans and their numbers proliferated over time. Further research is required to verify both the low degree of diachronic continuity and increasing number of temporally restricted fabrics observed in this study sample (Fig. 8).

Possible Interactions between the Panamanian Majolica and Criolla Potting Communities

While both the macroscopic and microscopic evidence appears to indicate that Panamanian Majolica and Criolla production developed and remained independent from one another (whether due to social, political, economic, or geographical factors), it is worth mentioning that one Plain Criolla sherd in the sample shows evidence of possible lead glazing (TPPV-63) corresponding to the lone sample in Fabric 18. If further provenience analyses can prove that this sherd was produced in Panamá Viejo, it could suggest that some degree (albeit very small) of interaction between the Panamanian Majolica and Criolla potting communities occurred, for lead glazing indicates the application of one form of Spanish-introduced ceramic technology into the production of the latter's ceramic repertoire (Fig. 9).

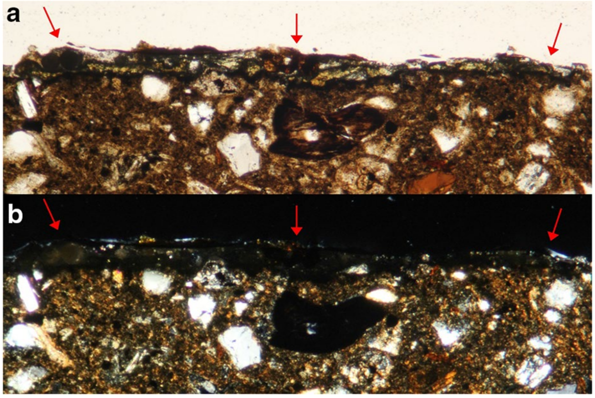

Fig. 9 Photomicrographs of TPPV-63′s possible glaze layer (indicated by arrows) in PPL (**a**) and XPL (**b**). Glass has isotropic properties, thus it is transparent in PPL and opaque in XPL (only the mineral inclusions within it are optically active in XPL)

Conclusion

The results obtained from this research contribute to an understanding of production processes and the organization of various forms of the potting craft in Panamá Viejo, and also highlight the divergence of these industries which is reflective of the potting communities that produced these vessels. These findings demonstrate that the production of Panamanian Majolica and Criolla differed greatly, not just in terms of the technological choices that were employed but most notably in the way each craft was organized and transmitted. In the case of the former, a centralized system was in place where social control was exerted by an established social hierarchy inside the workshop which ensured the adherence to a set of established production norms and is reflected in the low degree of compositional and technological variability of the analyzed sample. The transmission of potting knowledge and practices of Panamanian Majolica appears to have also been structured through a strictly supervised learning context that ensured the temporal consistency of a single paste recipe. In the case of Criolla Ware, production was decentralized and each potter appears to have been free to produce pots following his or her unique *chaîne-opératoire* without being subject to any form of political, social, or economic control, and this is reflected in the high variability of fabrics that were identified. This lack of collective understanding or consensus regarding technological choices involved in certain stages of Criolla production would explain why macroscopic attributes in Criolla vessels are so diverse.

While the size can and should be expanded to corroborate the patterns and interpretations elaborated in this study, the data produced in this research serves as a baseline from which future compositional studies of colonial assemblages in Panama and the Spanish American region can compare multiple themes related to ceramic production. The availability of a comparative database opens possibilities for future archaeological research, from establishing the existence of regional *chaîne-opératoires* in Spanish-tradition workshops across the Spanish Empire to examining the continuity and change in production practices among late pre-Hispanic assemblages in Panamá Viejo during the Spanish occupation.

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