Chapter 5 - *Cooking vessels*

This chapter presents the analysis of cooking vessels from Musarna and Populonia. These are "cooking" vessels in the sense that their fabrics and forms suggest that they would have been appropriate for cooking and thus they are typically described as cooking vessels in ceramic publications; however, we can complicate such assumptions with an examination of the use-alterations they bear. This chapter begins with a description of the two types of cooking wares recovered from Musarna and Populonia, namely *ceramica comune da fuoco* and internal red slip ware. I then proceed through an analysis of each cooking ware type, broken down by site. In each case the examination begins with the *ceramica comune da fuoco* category and is followed by an examination of the internal red slip ware category. The analysis will include a discussion of the forms present within those wares and their variation over time. I use a series of statistical tests – including chi-squared tests, analyses of variance (ANOVA), Kruskal-Wallis tests, and logistic regression analyses – to consider how vessel morphology and vessel size vary over the periods of interest at each site (see Appendix 2 for an explanation of the choice of statistical tests made in this dissertation). I then integrate this morphological analysis with my observations of vessel alteration. These alterations can include abrasion as well as blackening in different locations and to varying levels of opacity. I report trends which are statistically significant as well as selected changes which might well be significant if larger sample sizes were available. I then highlight several of the consistent and meaningful patterns evident in the data and what they reflect about cooking practices and food choices.

5.1. Categories of Cooking Vessels

5.1.1. *Ceramica comune da fuoco*

Ceramica comune da fuoco is a common Italian term to denote vessels that are literally "for the fire." Such vessels appear in a variety of forms including pentole, ollae, tegami, bowls, jugs, lids, and clibani.[507] Though *ceramica comune da fuoco* is not a "ware" in the strictest sense of being made from homogeneous clay or tied to a specific production location, there are a number of common characteristics that allow us to place a range of vessel types into this category. This category of vessels is defined by a non-calcareous (usually iron-rich) clay and coarse-bodied fabric, resulting from either naturally-occurring inclusions in the clay or from tempers added by the potter. These technological choices make these vessels resistant to thermal shock.[508] The examination of the fabric composition of these vessels from both Musarna and Populonia has allowed me to formulate a general impression of their thermal conductivity, that is, their ability to distribute the heat within a vessel evenly. If a vessel has low thermal conductivity it will result in uneven heating, permitting hot-spots to develop and potentially causing the food within to burn.[509] While the array of clay characteristics that contribute to thermal shock resistance are increasingly well-understood;[510] conditions that affect thermal conductivity in ceramics are much less well-established. Experimental trials of ceramic thermal conductivity on both calcareous and non-calcareous clay have revealed that quartz temper, especially in angular particles, seems to substantially increase thermal conductivity. The porosity caused by a combination of temper and specific orientation of pores greatly influence thermal conductivity.[511]

There is not a great amount of variability visible at the macroscopic level in the composition of *ceramica da fuoco* fabric. A common fabric description of this material is "rare subangular clear grains; medium black sand; rare grain-sized gold flakes." The clear grains are likely quartz or quartzite, the black sand is likely volcanic in origin (a type of basalt); however, both of these identifications are best confirmed through petrological analysis.[512] The gold flakes, when they are "grain-sized," are clearly-identifiable as biotite mica. These macroscopic observations suggest that the all of the *ceramica comune da fuoco* vessels from both Musarna and Populonia examined for this research were highly

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[507] A description of these forms can be found in chapter 3.
[508] Olcese 2003, 21–23.
[509] Müller et alii 2010; Müller et alii Forthcoming.
[510] Müller et alii. Forthcoming; Bronitsky and Hamer 1986; Tite *et alii*. 2001, 319–320; Olcese 2003, fig. 17.
[511] Elongated inclusions may also increase the strength of the vessel (Müller et alli. 2010, 2461).
[512] Quartz is easily confused with feldspar, for example.

conductive. The main fabric distinction between the *ceramica comune da fuoco* found is that the samples from Musarna have a higher frequency of clear grains ("rare" or "medium") and greater degree of grain roundness, as well as a higher frequency of gold flakes. These fabric distinctions hold constant for vessels from the 4th through the 1st centuries BCE.

5.1.2. Internal red slip ware

Internal red slip ware was a common type of ceramic produced in Italy from about the 3rd century BCE to the 2nd century CE.[513] Vessels of this ware have been recovered as far afield as England and Tel Anafa, Israel.[514] The ware can be easily identified by the layer of red slip on its interior surface.[515] This surface treatment has been interpreted both as providing an impermeable and "non-stick" internal surface, suggesting to scholars that the vessels were used for sautéing, baking, and frying.[516] Internal red slip vessels are always open-form and appear typically as tegami, and less commonly as deep pentole with sloped walls and lugs on their base.[517]

5.2. Musarna

5.2.1. *Ceramica comune da fuoco*, Part 1

Ceramica comune da fuoco appears in Musarna in several vessel forms: pentola, olla, jug, as well as several types of lids. There are also a few examples of the cooking bell, the clibanus, and a single example of a tegame with tripod legs.[518] Details of sample size and characteristics, together with the associated analyses, are broken-down by vessel form in the following sections.

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[513] This ware type was called "pompeian red ware," "*rouge pompeien*," or "*pompejanisch-roten*" in early publications because of the resemblance of the internal slip to the red of the walls of Pompeian houses (Löschke 1909; Goudineau 1970; Peacock 1977). J. T. Peña (1990, 647) says production of this ware began in the 3rd century BCE. Peacock (1977, 147) thought production began in the 1st century BCE. Leotta (2005, 115) says 2nd century BCE. The deposits examined here confirm a 3rd century date. Locations of production have been identified in the Bay of Naples and near Tivoli, in Lazio. Leotta 2005, 119.

[514] Peacock 1977; Berlin 1997.

[515] Typically the color according to Munsell conventions is "red" 10R 4/6 or 4/8.

[516] Leotta 2005, 115, 119.

[517] Goudineau 1970; Leotta (2005, 115) says that internal red slip is only produced as flat pans, but the evidence from Musarna, as well as Goudineau's earlier typology from Bolsena, clearly negates this.

[518] See the definition and diagram of each of these forms in chapter 3.

5.2.1.1. Pentole

Morphology

The sample of pentole consists of a rather small sample size of 66 rims and 3 whole vessels (which represent a total of 8.96 EVEs) (Table 12). Rim diameter ranges between 8 and 35 cm, with an overall mean of 19.20 cm and median of 18 cm (Figure 21). When we compare the distribution of rim diameters in Musarna's different periods of Republican habitation, there are several notable trends.[519]

Table 12. Pentola rim counts

Period	Frequency	Percent	Mean (cm)	Median (cm)
2	10	14.5	15.3	16
4	10	14.5	16.9	16
5	18	26.1	18.22	16.0
8	31	44.9	21.77	21
Total	*69*	*100.0*	*19.2*	*18*

First, the size distribution of rims in Period 2 (300-200 BCE) and Period 4 (250-150 BCE) is very similar.[520] Rims from Period 5 (200-100 BCE) and Period 8 (150-50 BCE) are also distributed similarly.[521] In contrast, when we compare Periods 2 or 4 with Period 8, the difference in size distribution is significant.[522] Rims in Period 5 and 8 vary much more in size and include many more examples of vessels with large rim diameters. Even though samples sizes are small, and these numbers must be treated cautiously, these figures represent the first of a trend we will see in other cooking wares at Musarna: increased range of size and increase in size generally over time.

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[519] See below for the alternative comparisons of mean diameters with an analysis of variance, or ANOVA. Since the distribution of pentola diameters is not normal, or even unimodal, and since samples sizes in each period have different spreads and are below 30, it is prudent to use a non-parametric test instead of analysis of variance (Drennan 2009, 178). Here I use a Kruskal-Wallis test to compare the rankings of diameters in different groups (Hamburg 1979, 316–318). See Appendix 2.

[520] χ^2=0.053 and there is low significance (p=0.818)

[521] χ^2=2.270 and there is low significance (p=0.132)

[522] Comparing Period 2 and 8, the χ^2 value is 6.996 ($p<0.01$). Comparing Period 4 and 8, the χ^2 value is 4.409 ($p<0.05$). Comparing Period 2 or 4 with Period 5 yields non-significant results, likely due to low sample sizes in all three groups.

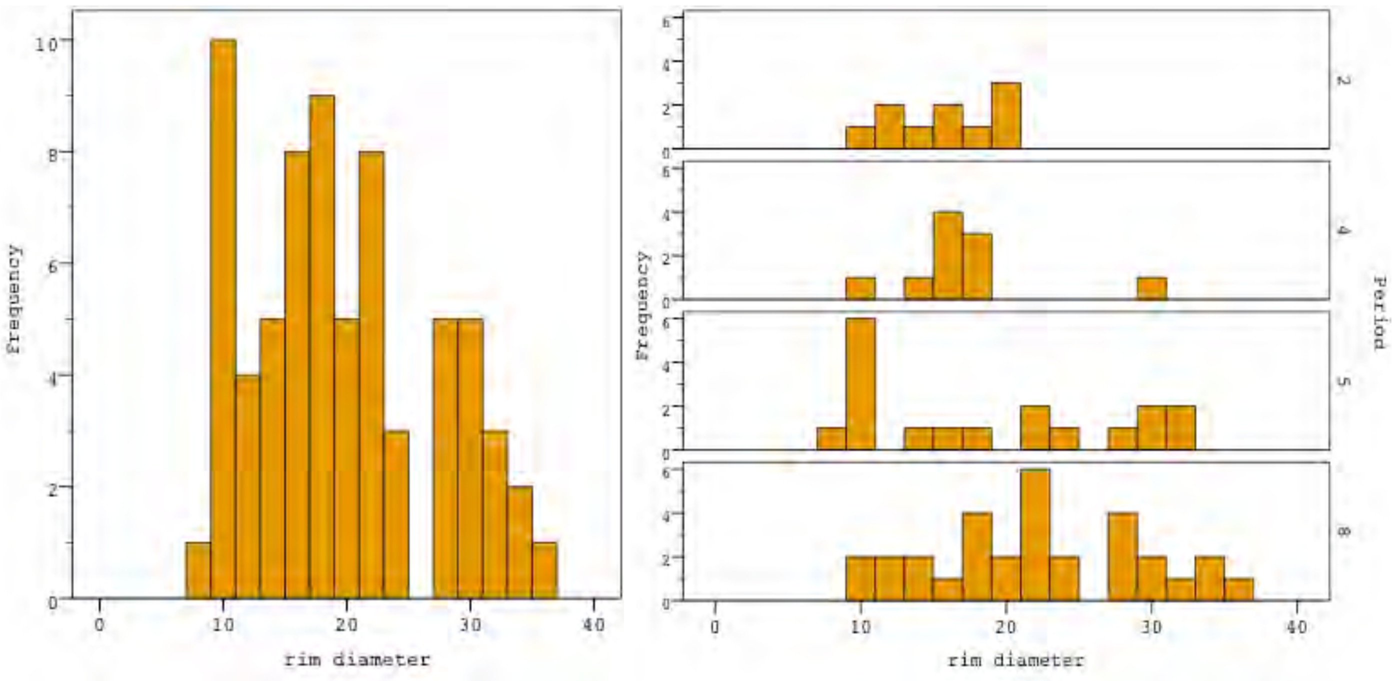

Figure 21. a) Diameters of all pentole at Musarna; b) Diameters of pentole by period

There is no significant difference in pentola wall thickness when measured both at the top of the rims and 3 cm below the rims.[523] Wall thickness varies across the periods only by fractions of a millimeter (Figure 22).

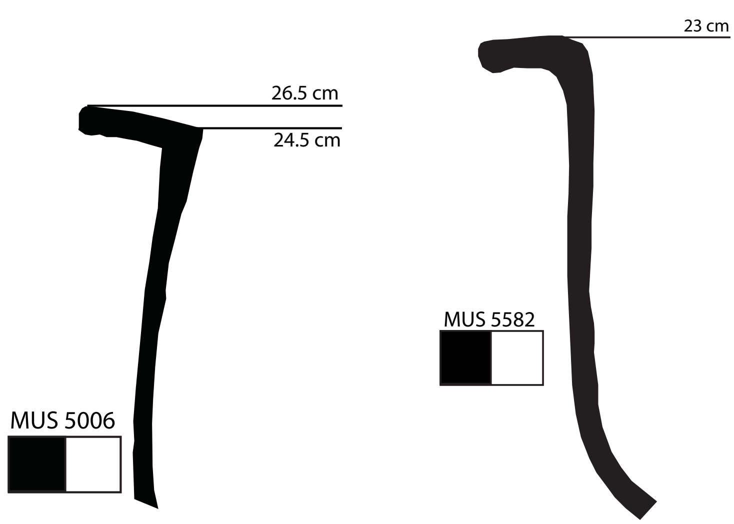

Figure 22. Pentola forms from Musarna

[523] Only 35 vessels were preserved for 3 cm or higher.

Similar to the trends in rim diameter, the angle of the rim opening exhibits greater variability in vessels from Periods 5 and 8 when compared to Periods 2 and 4. The difference in values, however, is not statistically significant, with the average opening angle not varying by more than 2.87 degrees and the median opening angle differing by 10 degrees or less.

Alteration: Blackening

A total of 57 of the 69 pentola rim fragments have blackening resulting from fire. Ninety-two percent of these are blackened on the exterior, 75% of them on the interior, and 67% on both the exterior and interior. This confirms that these vessels were indeed used in cooking and we also see that that there is a strong likelihood that if a vessel is blackened on the exterior of its rim, it will also be blackened on the interior of its rim.[524] The location of blackening on the interior and exterior of vessels is shown in Table 13. Blackening on pentole. The type corresponds to the diagrams explained in Chapter 3.

Table 13. Blackening on pentole

Type	Location of blackening[525]	Count (int)	Count (ext)
1	Around belly of vessel	1	1
2	Single patch on belly	6	8
3	Double patch on belly	-	-
4	Around top of rim	13	14
5	Around top of vessel below rim	7	3
6	Around bottom of vessel and on base	1	1
7	Forming a ring on base	-	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	20[526]	26[527]
10	Entirety of vessel	-	-
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

[524] χ^2=10.402 ($p>0.01$). This is probably largely affected by the fact that there is a strong correlation between location 9 (the whole vessel blackened except the lower wall and base) on the exterior and the interior (χ^2=8.228 where $p>0.01$).
[525] Obviously only some of these locations are applicable to rim fragments depending on the extent of their preservation. See below for an examination of base fragments.
[526] This is estimated/extrapolated in most of these circumstances, since the base is preserved in only 1 of these instances (forming a whole profile), but it would not be appropriate to label this vessel as being entirely covered in black.
[527] This is estimated/extrapolated in most of these circumstances, since the base is preserved in only 1 of these instances (forming a "whole" profile), but it would not be appropriate to label this vessel as being entirely covered in black.

There is not a strong relationship in this sample group between any of the locations of blackening. Surprisingly, location 4 (blackening along the top of the rim) on the interior and exterior is not significantly correlated.[528] The two examples that are blackened on the entirety of their base and along their lower walls are fragments of round-bottomed pentole, MUS 2347 from Period 2 and MUS 5007 from Period 8. The walls of both are preserved to a height of 5 cm, high enough to reach the underside of their curved bases. MUS 2347 has an exteriorly blackened base and lower wall, with some blackening in non-descript patches closer the rim (Figure 23). On its interior, it has a faint strip of blackening around its belly. Conversely, MUS 5007 has a blackened exterior base and lower wall, but its interior is blackened with thick powdery residue (Figure 24). This pattern of blackening is not consistent for this form of pentola at Musarna. Four other examples in this dataset have only a patch of blackening or are completely black on their exterior and their interiors have a ribbon of black around their rim, or they are completely black on their interior and exterior.[529]

Figure 23. Pentola blackened in location 6 on its exterior (MUS 2347)

[528] Only 1 example has both appearances of blackening (MUS 4648) and this is a unique form of pentola in this dataset.
[529] These examples are MUS 2346, 2348, 2349, and 2350.

Figure 24. Pentola blackened interior with powdery residue (opacity 5) (MUS 5007)

Logistic regression analysis suggests that there is no strong correlation between the diameter of the rim and the likelihood of being blackened.

Next, I examine the opacity, or darkness of the blackening on these vessels in order to consider the type and during of use.[530] Every level of opacity on the exterior and the interior appears in the full range of diameters in the sample. There is also no correlation between the amount of opacity and the chronological period (Figure 25). On the interior of pentola rims, all levels of opacity appear throughout the periods, with the exception of Period 5, which does not have the lightest blackening score "1" and Period 4, which does not have any fragments of the most extreme "1" or "5" scores.[531] Although Period 8 (150-50 BCE) has the most fragments which display blackening (n=24), when I compare the opacity of fragments across the different periods, it is evident that the majority of Period 8 pentole are relatively lightly-blackened. On the vessel's interior, the majority of Period 8 scored as "barely discernible darkening" whereas the distribution of the blackening in the other 3 earlier periods is centered on score 2 "obviously darkened, but vessel color still visible" and

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530 See chapter 3 for an a further explanation of blackening opacity.

531 Recall, opacity scores: 1 - barely discernable darkening; 2 - obviously darkened, but vessel color still visible; 3 - vessel color is barely discernible; 4 - surface is totally opaque black, but no excess material; 5 - black material is thick and flakey

3 “vessel color is barely discernible.” This suggests that vessels from earlier periods were used more repetitively or rigorously before breaking or being discarded than those of Period 8. On the exterior of these pentole, the most frequent blackening opacity scores in the middle ranged from score 2 “obviously darkened, but vessel color still visible” to score 4 “surface is totally opaque black, but no excess material,” with no major trends emerging from the data.

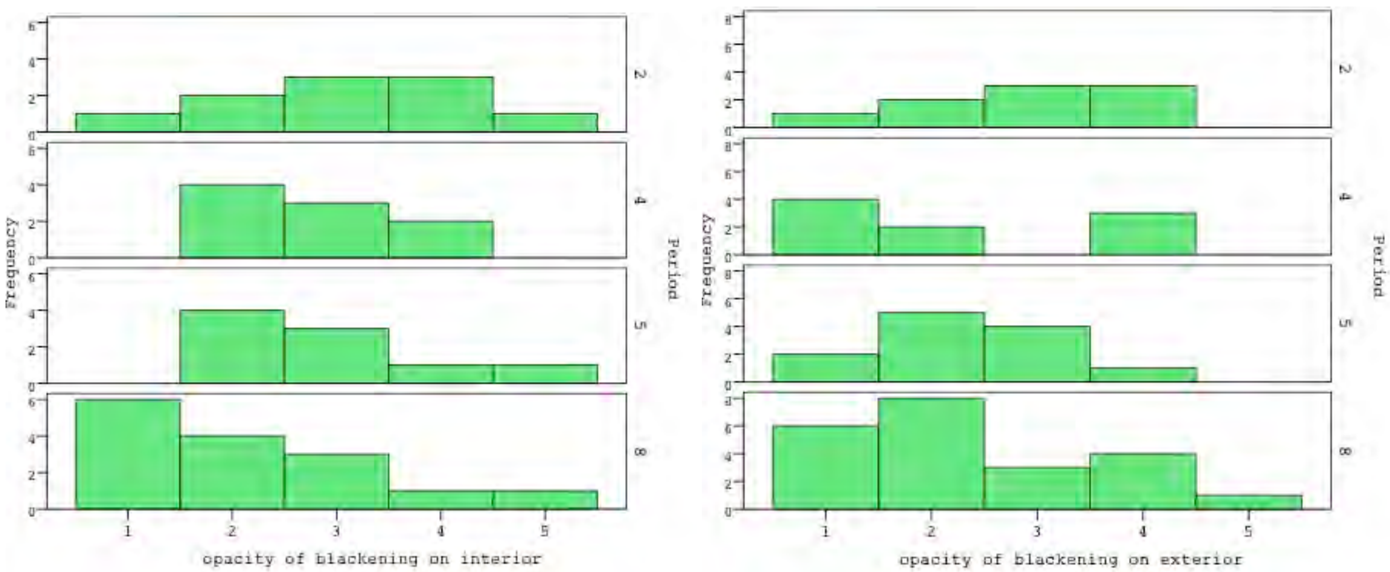

Figure 25. a) Interior opacity of blackening; b) Exterior opacity of blackening on pentole

Alteration: Abrasion

Only 33% (n=23) of the pentola fragments have any abrasion on them (Table 14). Of these, 25% have some type of interior abrasion and 9% have exterior abrasion, while only one fragment has both. This example is a large section of pentola (made up of four joining fragments), MUS 5582, which has a rough hole through its wall that may be from fire damage or extreme wear. There is discoloration around the hole. As such, this is hardly an example of regular wear.[532]

Table 14. Abrasion on pentole

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	-	-
Abrasion on wall	2	2
Abrasion on rim	16	4

[532] This example also has several radial scratches on its interior rim.

Fifteen out of 16 rims with interior abrasion have concentric wear; these rims represent 23% of the pentola sample. This suggests that there was some probable utensil abrasion resulting from accessing their contents; however, the fact that this abrasion is relatively uncommon (15 out of the whole sample of 69) and inconsistent suggests either that their contents were not regularly accessed, or more likely, that these open-form "unrestricted" vessels did not pose any difficulty to the users when accessing the contents.[533]

There is a small correlation between increasing diameter and interior abrasion; as the diameter increases by one centimeter, the odds of there being interior abrasion increases by 8%.[534] This result could be skewed by the samples from Period 8, which has the most examples of abrasion (n=11) and the largest diameters.[535]

There is no statistical relationship between the presence of blackening and the presence of abrasion. The low amount of abrasion is likely the reason for this. One interesting example of the co-occurrence of blackening and abrasion that reveals vessel use is evident in sherd MU 2347. This vessel has an interior opacity score of 5 in a large patch of black on its belly (location 2). Its preserved interior surface is almost completely cracked, a "patch" of abrasion that is actually a high degree of surface cracking on its interior wall (Figure 26, Figure 27). This demonstrates that this particular pentola was exposed to very high heat, which both burnt the food it contained and cracked the vessel surface. This fragment has a curved bottom with nearly its complete profile preserved, and on its exterior with blackening visible on its base and lower side walls (location 6).[536]

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533 Skibo 1992, 132; Wilson and Rodning 2002, 32.
534 This is determined through logistic regression. Here, the Expβ is 1.081, and $p=0.045$.
535 When I remove Period 8 from the sample, there is no longer a correlation; however, the removal of Period 8 also greatly diminishes the sample size making the production of significant results difficult.
536 See below for further discussion of the "exterior base floor" location and its implications for use.

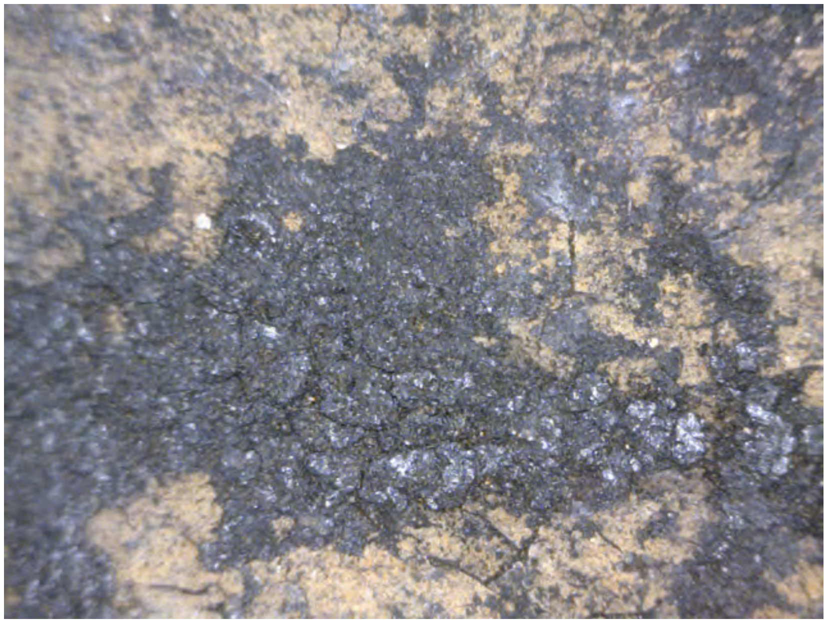

Figure 26. Interior carbon deposition at 50x magnification (MUS 2347)

Figure 27. Interior cracking at 20x magnification (MUS 2347)

5.2.1.2. Ollae

Morphology

The ollae are the most ubiquitous *ceramica da fuoco* vessels at Musarna (

Table 15). I analyzed a total of 259 rim fragments with 5% or more of their diameter preserved.

Table 15. Ollae at Musarna

Period	Frequency	Percent	Mean (cm)	Median (cm)
2	30	11.6	12.93	12
4	61	23.6	14.11	13
5	40	15.4	13.58	12
6	1	0.4	15.00	15
8	127	49.0	16.55	15
Total	*259*	*100.0*	*15.09*	*14*

Ollae range between 5 cm and 35 cm in rim diameter, with an overall site mean of 15.09 cm and a median of 14 cm (Figure 28). While there is a relatively unimodal distribution of rim diameters at Musarna overall, when subdivided by period, there are marked differences in the distribution of rim sizes across time. Before Period 8 (150-50 BCE), the rim diameters are under 20 cm except for a few isolated examples; whereas in Period 8, there is both a large selection of rims under 20 cm (n=83) but also a substantial number with diameters of 20 cm and greater (n=44). This change in distribution represents both a greater variability and a trend towards larger vessels in Period 8.

This trend becomes clearer when examining mean diameters by period. There is very little variability between Periods 2, 4, and 5, with mean rim diameter differing between 0.54 cm and 1.18 cm. Rims from Period 8 (150-50 BCE), however, are on average larger than those of all other periods. Period 8 rims are on average 3.62 cm larger than rims of Period 2 (300-200), 2.44 cm larger than Period 4, and 2.98 cm larger than Period 5.

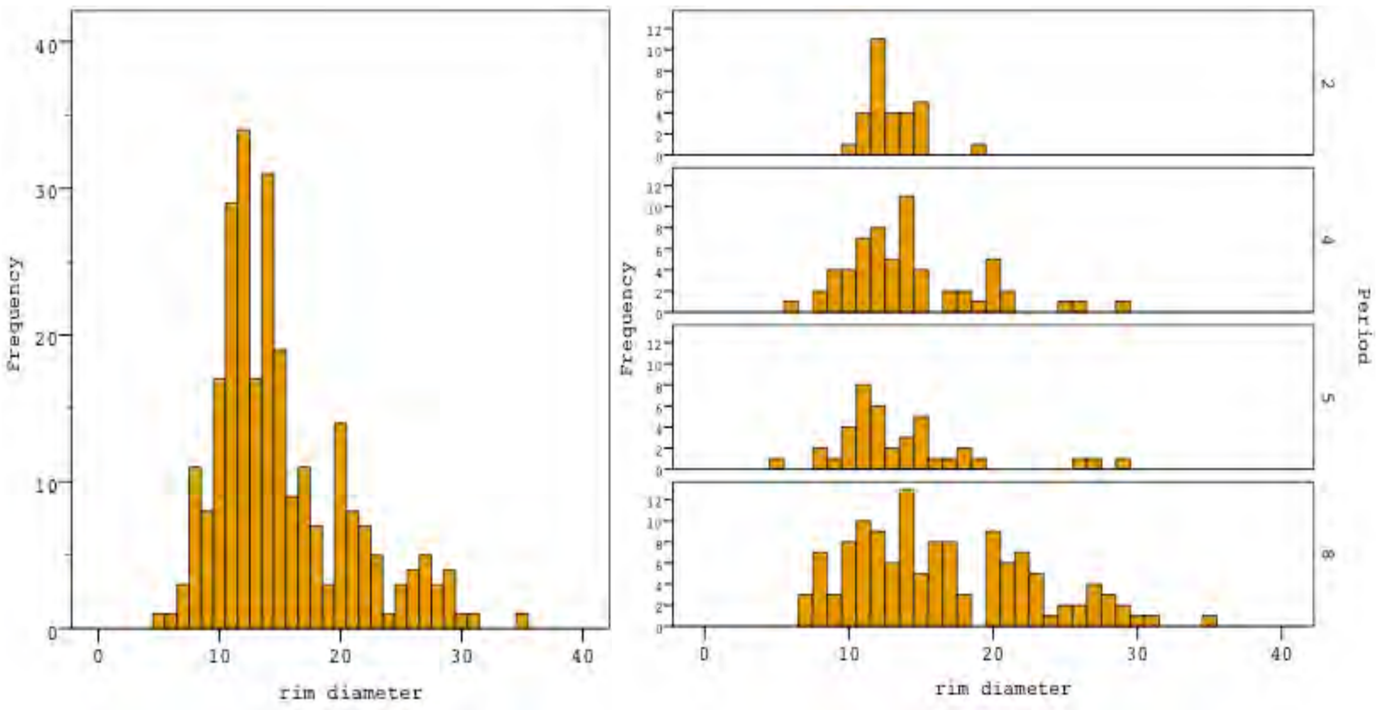

Figure 28. a) Diameters of all ollae at Musarna; b) Diameters of ollae divided by period

When we trim the means of these periods to discount the outliers at the 5th and 95th percentile of these diameters, the results are similar. With outliers removed, there are 238 fragments, and Period 2, 4, and 5 are even more similar (the largest inter-period differences are 0.21 and 0.98 centimeters). Vessels from Period 8, however, still have significantly larger rims with greater variability. On average, rims from Period 8 are 3.37 cm larger than rims from Period 2, 2.39 cm larger than Period 4, and 3.17 cm larger than Period 5.[537] The rim diameters correspond to an average volume of 4.28 liters for ollae in Period 2 and 5.47 liters in Period 8.[538] Therefore, between these two periods there was an average overall volume increase of 1.19 liters (or 28%) (Figure 29).

[537] The mean rim sizes in each period are: Period 2, 12.93 cm; Period 4, 14.11 cm; Period 5, 13.58 cm; Period 8, 16.55 cm.

[538] This volume is calculated using the slope of the line in the linear correlation of rim diameter to vessel volume for ollae determined in Appendix 1.

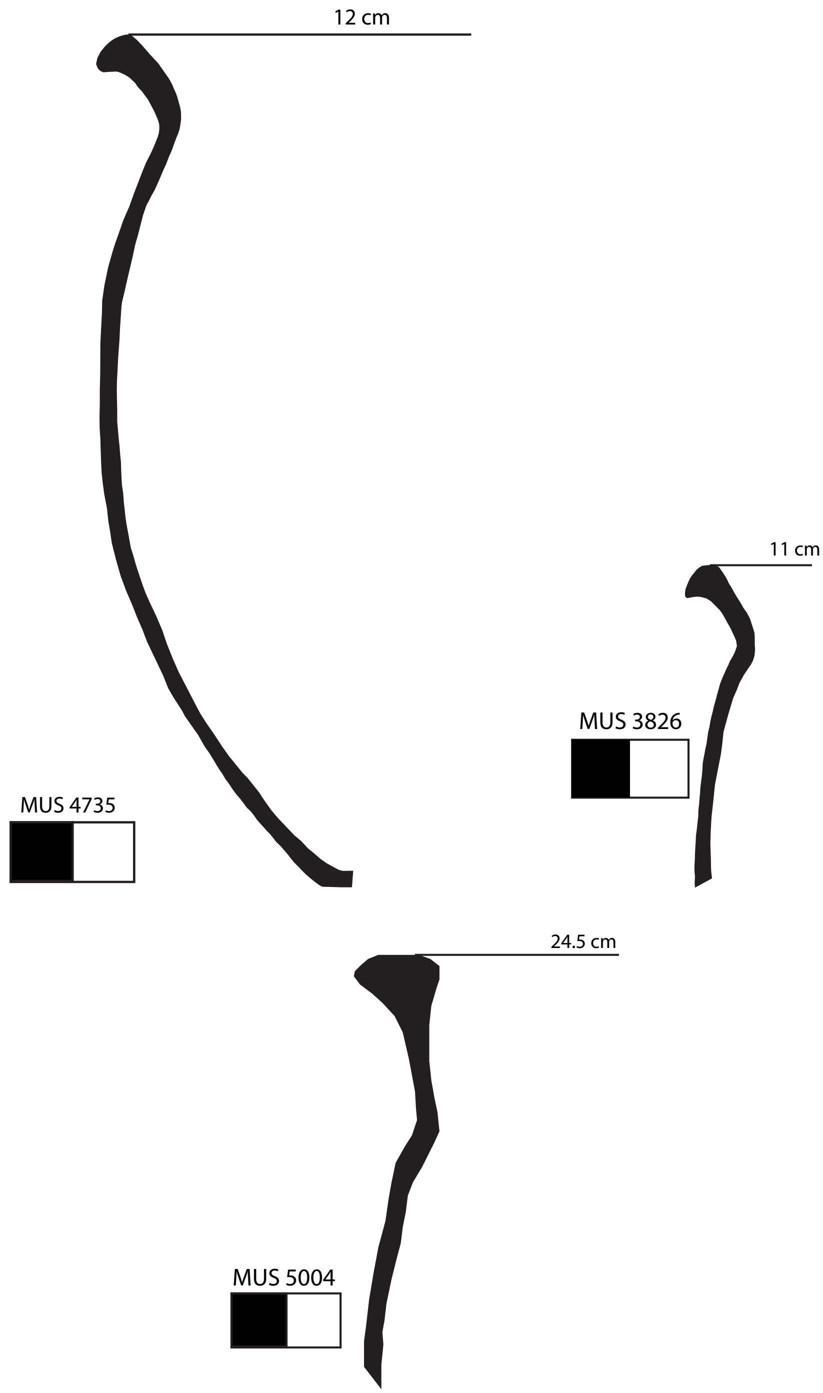

Figure 29. Olla forms from Musarna

The average wall thickness of the "upper" rim, that is, just below the vessel lip, over these periods does not vary by more than half a millimeter, each having a mean thickness of about 5 mm. In contrast, when examining the wall thickness of rims which have walls preserved more than 3 cm below the rim top (n=170), the thickness of walls in Period 2 is on average greater than during the other periods. The vessel wall below the rim in Period 2 is on average 0.74 mm wider than Period 4, 1.25 millimeters wider than Period 5, and 0.61 mm wider than Period 8.[539] Meanwhile, when we compare Period 8 to Period 5 wall thickness, Period 8 is 0.64 mm thicker.[540] When we examine rims fragments with a wall preserved more than 7 cm down (n=40), we can see very little difference in wall thickness, since it varies less than 0.57 mm between periods. David Braun suggests that the thinner the wall, the greater the thermal conductivity, "other things being equal."[541] These "other things" are fabric and temper differences. As discussed at the beginning of this chapter, the composition of *ceramica da fuoco* at Musarna is not noticeably different over time.

The angle of the opening rim flange of the ollae at Musarna exhibits a distinct increase over time, a move towards verticality. The orientation of rim openings from Period 2 is on average 7.28˚ lower than rims from Period 4, 10.21˚ lower than rims from Period 5, and 13.35˚ lower than rims from Period 8. Rims from Period 4 are on average 6.08˚ lower than rims from Period 8. Rims from Period 5 are on average 3.15˚ lower than rims from Period 8, though this is not statistically significant.[542] Trimming the values to cut out the 5^{th} and 95^{th} percentile of values leaves 245 examples. The differences in angle are even stronger, with Period 8 being between 8.60˚ and 14.91˚ more vertical than the other periods.

When we examine the body angle of the olla (the angle from the base of the rim to the shoulder) on the 183 fragments which are preserved enough for this measurement, there is very little variability within the Musarna sample. The walls of these ollae vary in their angle of departure only by 0.14˚ to 0.81˚ and show no temporal trend. This demonstrates that the overall shape of the belly of the vessels remained consistent over time.[543]

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[539] This last difference, however, has a significance value of only 0.081.
[540] While 1 mm difference of wall thickness may be a *significant* difference, it is not necessarily a *strong* difference. See Drennan 2009, 175 for a discussion of significance versus strength in ANOVA.
[541] Braun 1983, 118.
[542] The significance value is 0.323.
[543] This point further substantiates my demonstration of correlation between rim diameter and volume. See Appendix 1.

Alteration: Blackening

Of the 259 ollae in the sample, 78% are blackened on the interior and 88% on the exterior, 74% on both interior and exterior (Table 16). It is therefore highly likely that if a sherd is blackened on one side, it is blackened on the other.[544]

Table 16. Blackening on ollae

Type	Location of blackening[545]	Count (int)	Count (ext)
1	Around belly of vessel	20	6
2	Single patch on belly	50	34
3	Double patch on belly	2	5
4	Around top of rim	71	58
5	Around top of vessel below rim	18	31
6	Around bottom of vessel and on base	1	-
7	Forming a ring on base	-	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	66[546]	113[547]
10	Entirety of vessel	-	-
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	1	3

There is a strong relationship between several locations of blackening appearing on both the interior and exterior of a vessel. Here it is most useful to discuss the common blackening locations of this vessel and their variations in order of frequency.

The largest amount of overlap is in blackening location 4, along the top of the rim. Twenty-two fragments have this type of blackening on both their interior and exterior.[548] Therefore soot was deposited just on the top of the vessel (Figure 30, Figure 31).

The above pattern is followed in frequency by location 2, a patch on the vessel wall, with 18 fragments showing this on both their interior and exterior.[549] The presence of

[544] χ^2=38.03 ($p<0.01$)
[545] Obviously only some of these locations are applicable to rim fragments depending on the extent of their preservation.
[546] This value is estimated/extrapolated in most circumstances, since the base is preserved in only 1 of these instances (forming a whole profile); but it is inappropriate to label this vessel as entirely covered in black.
[547] This value is estimated/extrapolated in most circumstances, since the base is preserved in only 1 of these instances (forming a whole profile); but it is inappropriate to label this vessel as entirely covered in black.
[548] χ^2=4.16 ($p<0.05$)
[549] χ^2=28.42 ($p<0.01$)

black as a swath around the belly (location 1) is also highly correlated on the interior and exterior.[550]

Figure 30. Olla with blackening in interior location 4 (MUS 3785)

Figure 31. Olla with blackening on interior in location 4 (MUS 2370)

[550] χ^2=5.65 (p<0.01)

Figure 32. Olla with blackening in interior in location 4 and 1 (MUS 2357)

Location 1 is also highly correlated with an interior ribbon along the top of the rim, location 4 (Figure 32).[551] This ribbon of black around the interior rim of the vessel is also highly correlated with blackening on the entirety of the vessel excluding the lower wall and base on the exterior (location 9) (Figure 33).[552]

[551] $\chi^2=8.29$ ($p<0.01$)
[552] $\chi^2=25.81$ ($p<0.01$). This is an extremely high χ^2 value, yet there are only 3 examples of this pattern on interior and exterior.

Figure 33. Blackening on exterior of an olla in location 9 (MUS 4735)

Finally, location 12 (the vessel blackened except for a ribbon just below the rim on the interior) has a statistical association with blackening on the exterior in a ribbon just below the rim.[553]

The distribution of the blackening opacity on these vessels reveals some very predictable trends (Figure 34). First, as with the pentole, substantial powdery black residue appears only on the interior of the vessel. This is a result of food being cooked at a high temperature and charring (Figure 35). Examining the interior opacity, there is a strong similarity in the distribution of opacity between Periods 4 and 5, which tend to cluster towards level 2 "obviously darkened, but vessel color still visible," and between Periods 2 and 8, which tend to cluster toward the darker level 4 "surface is totally opaque black, but no excess material." Interestingly, the most significant differences are between

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553 χ^2=7.39 ($p<0.01$). Though this is a significant χ^2 value, it represents only 1 example of this interior and exterior pattern.

Periods 2 and 4 and Periods 2 and 5.[554] Periods 4 and 5 are not significantly different from Period 8.[555]

Conversely, when we examine the opacity of blackening on the exterior of ollae from Musarna, the opposite pattern emerges. There is not a significant difference in the levels of opacity between Period 2, 4, and 5; however, the differences between Period 4 and 8 and Period 5 and 8 are significant, with Period 8 being clustered more towards the darker level 4 and the earlier periods displaying a less opacity in their blackening.[556]

As the diameter of the rim increases, a vessel becomes 6% more likely to have a single patch of black on its interior belly (location 2).[557] As the rim diameter of the vessel increases, it is also 6% more likely to have black around the exterior rim (location 4).[558] Notable correlations between the presence of blackening and the size of the vessel may or may not reflect actual use.

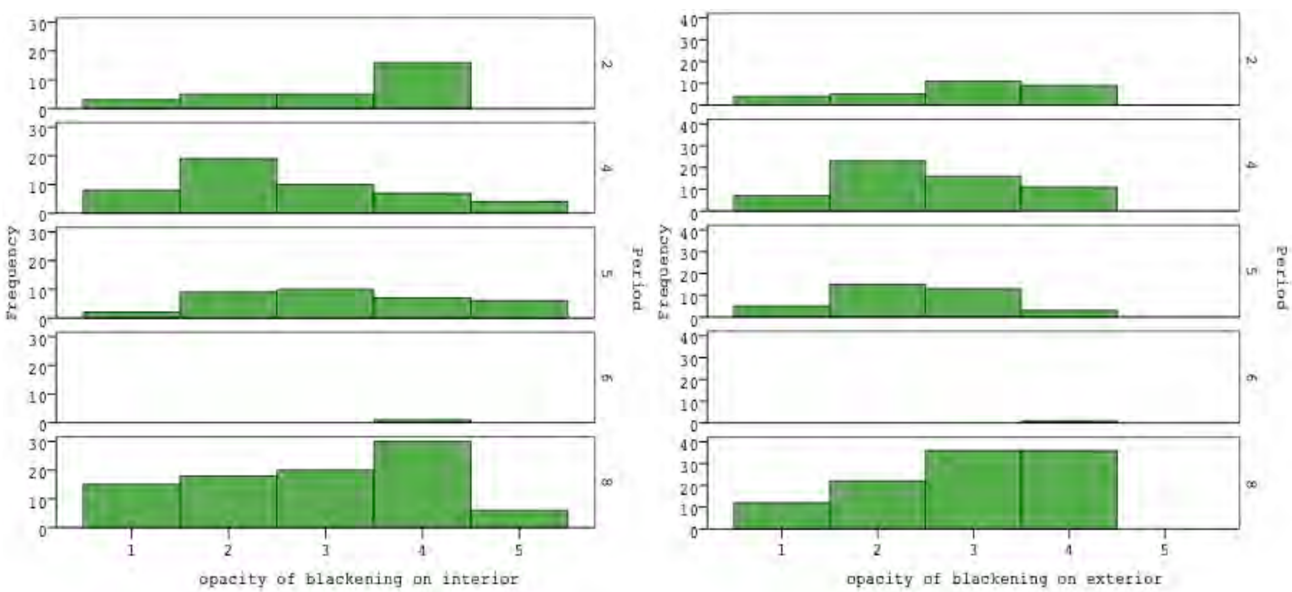

Figure 34. a) Interior opacity of blackening of ollae; b) Exterior opacity of ollae

[554] χ^2 value between Period 2 and 4 is 15.91 ($p<0.01$) and the χ^2 value between Period 2 and 5 is 12.21 ($p<0.05$).
[555] χ^2 value between Period 8 and Period 4 is 8.68 (p is only 0.069) and the χ^2 value between Period 8 and Period 5 is 7.472 (p is only 0.113).
[556] χ^2 value between Period 8 and Period 4 is 8.35 ($p<0.05$) and between Period 8 and Period 5 is 11.121 ($p<0.05$).
[557] Expβ=1.063 (p=0.024).
[558] Expβ=1.057 (p=0.032).

One final observation about the blackening of ollae at Musarna is that the probability that these vessels will be blackened at all over time changes. Logistic regression analysis suggests that as the periods increase incrementally, the likelihood that the exterior of ollae will be blackened decreases by 22.7%.[559] This means that vessels from later periods may have not been consistently used over a fire for cooking. I consider the possible implications for this result in a later section.

Figure 35. Olla with interior blackening 5 and exterior spalling of vessel wall (MUS 4715)

[559] $\text{Exp}\beta=0.773$ ($p<0.01$)

Alteration: Abrasion

Of the 259 olla rim fragments, 25% (n=64) have abrasion on their interior, 9.3% (n=24) on their exterior, and 4% (n=11) have both (Table 17).

Table 17. Location of abrasion on olla rims.

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	-	1
Abrasion on wall	24	10
Abrasion on rim	48	18

Notably, eight of these fragments show abrasion on both their wall and their rim interiors. Based on these numbers, it is probable that a fragment that shows some abrasion on the interior also has abrasion on the exterior.[560]

While we might expect a high amount of interior abrasion from use and some exterior abrasion from daily movement and storage of these vessels, the strong correlation between interior and exterior wear requires a consideration of the effect of post-depositional factors on abrasion in this sample. Ninety-eight percent of these fragments had fractures which were classified as "sharp" and 2% as "slightly rounded." This suggests very minimal movement and disturbance from water or sedimentary movement after the vessels were broken. Furthermore, only 22% of the fragments have some evidence of mineral encrustation on them. Of those with encrustations on the interior (n=58), the mean percentage of the fragment covered or affected is 8% and the median is 5%, of those whose exterior has some encrustation (n=59), the mean amount 9.9% covered and the median 5%. The minimal amount of encrustation, therefore, suggests a low amount of post-depositional disturbance, as well as confirming that such layers are neither masking nor enhancing the observation of abrasion. With this information in mind, it is likely that the abrasions observed on these rim fragments stem mostly from pre-depositional activity.

Beyond the correlation between interior and exterior abrasion, overall there is a strong correlation between rim size and interior rim abrasion. For each centimeter of increase in rim diameter, the likelihood of interior abrasion increases by 16.3%. This

[560] $\chi^2 = 6.34$ ($p=0.012$)

relationship is consistent across time at Musarna.[561] This is unexpected, since I would have predicted that vessels with smaller rim diameters would have more interior abrasion; however, this unintuitive result may suggest a different activity was being undertaken with ollae of larger diameter that required more vigorous stirring. Furthermore, when we take into account a change in rim angle, this correlation becomes even clearer. Logistic regression analysis demonstrates that as the angle of the rim decreases, that is, the as the rim becomes more open, the effect of the rim diameter in predicting abrasion becomes even stronger. The likelihood of abrasion increases by 21%, as the angle decreases and the rim diameter increases (Figure 51).[562] We will address this trend more fully and the use of olla further in a later discussion section.

5.2.1.3. Lids

Morphology

There are only 59 lid fragments in *ceramica da fuoco* fabric, corresponding to one lid for every 5.4 pentole and ollae.[563] This may be because lid fragments are confused for vessel fragments. The lids in the sample appear in the form of rim fragments and as lids with enough of the profile preserved that the knob is included (n=5) (Figure 36, Figure 37). Lids occur in every period at Musarna, so I have collapsed the overlapping periods in order to manage and compare the data more easily (Table 18). The lid diameters have a fairly unimodal distribution, much like the ollae, ranging in size from 4 cm to 32 cm (Figure 38). There is a significant change in the rim diameters over time. The lids increase in size from a mean and median diameter of 13.53 cm and 14 cm respectively in Period 2 to a mean and median diameter of 19.73 cm and 19 cm in Period 8.[564] There is not quite a significant

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[561] This is the result of logistic regression analysis. While the odds ratio for the entire sample of olla rims at Musarna is 1.163 ($p<0.01$), when we isolate individual periods, the odds ratio is similar and remains relatively significant. In Period 2, the odds ratio is 1.561 (though, $p=0.090$). In Period 4, the odds ratio is 1.195 ($p=0.036$). In Period 5, the odds ratio is 1.216 (though $p=0.081$). Finally, in Period 8, with the greatest number of large vessels, the odds ratio is 1.234 ($p<0.01$), meaning that it is 23.4% more likely for there to be abrasion on the interior rim with each centimeter that its diameter increases.

[562] $\text{Exp}\beta=1.21$ ($p<0.01$) with both the diameter and the angle inserted as covariates.

[563] Michel Bats has noted that at many sites (including, for example, Cosa and Olbia de Provence) the number of lids is very low compared to vessels (Bats 1988, 70).

[564] $\chi^2=13.33$ ($p<0.01$)

difference in size between Period 2 and 5. However, when we compare Period 5 to Period 8, there is yet again a significant increase in rim size.[565]

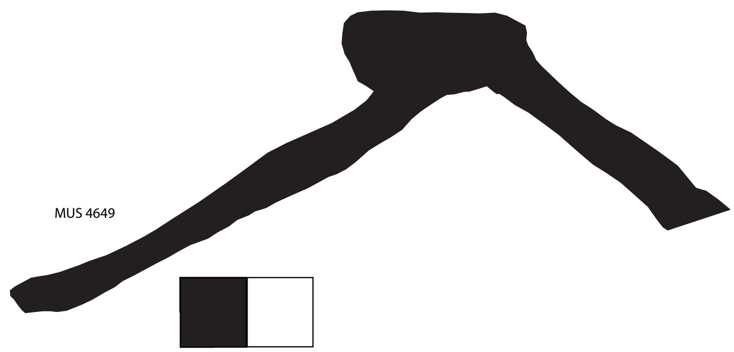

Figure 36. Lid in *ceramica da fuoco* (MUS 4649)

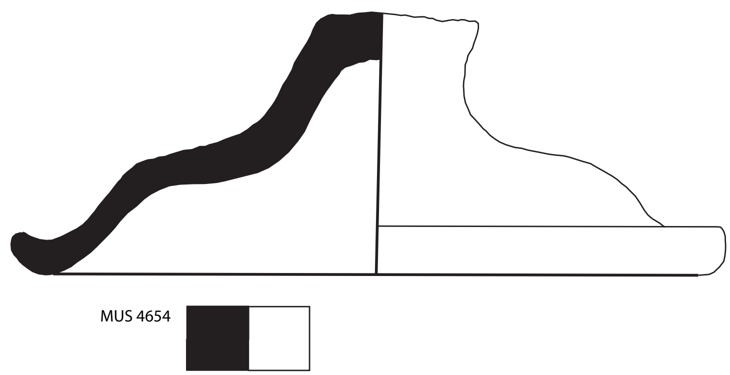

Figure 37. Lid in *ceramica da fuoco* (MUS 4654)

Table 18. Lids in *ceramica da fuoco* at Musarna

Period	Frequency	Percent	Mean (cm)	Median (cm)
2	17	28.8	13.53	14
5	20	33.9	15.90	13.50
8	22	37.3	19.73	19
Total	*59*	*100.0*	16.64	16

565 $\chi^2=8.35$ ($p<0.01$)

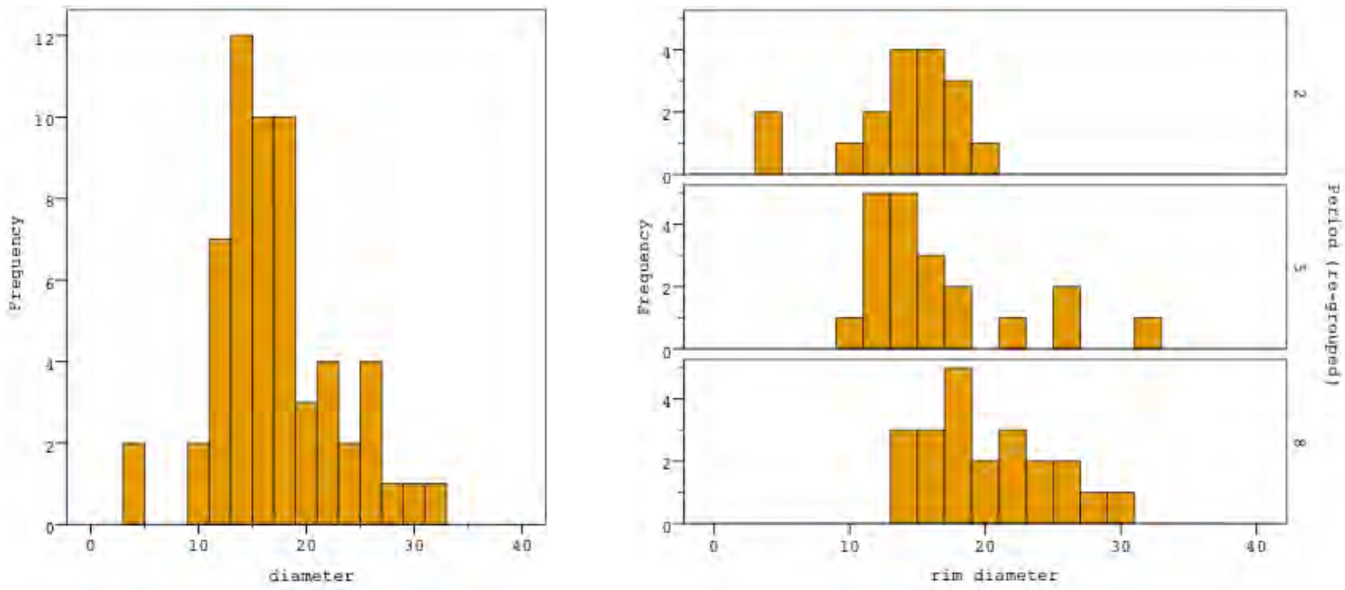

Figure 38. a) Diameters of lids in *ceramica da fuoco*; b) Diameters of lids divided by period

There is, however, no difference in wall thickness, with every period ranging from 3.5 mm to 9.48 mm. There is also no significant change in the angle of these lids' walls or rim.

Alteration: Blackening

Eighty-one percent of lids have blackening on their interior, 90% on their exterior, and 78% have both (Table 19).[566]

Table 19. Location of blackening on *ceramica da fuoco* lids

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	11	10
3	Double patch on belly	-	-
4	Around top of rim	23	23
5	Around top of vessel below rim	2	5
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	17	14
11	Patch in center of base (inverse of 7)	1	3
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

566 χ^2=10.16 (p<0.01)

There are several notable relationships in the presence of blackening in multiple locations on lids. Blackening on the interior in location 4 is strongly associated with blackening on the exterior in the same location.[567] Interior blackening in location 4 is also associated with the entire exterior being blackened (location 10).[568]

There is also a statistically significant difference in the distribution of different types of blackening in different periods. Blackening on the interior in location 2 occurs proportionally far more in Period 5 than in the other two periods (Figure 39).[569]

Figure 39. Lid blackened in exterior location 4 and interior locations 4 and 2 (MUS 4655)

There is also a significant correlation between the appearance of blackening on the interior of the lid with the rim diameter. This is a negative correlation. That is, as the diameter of the lid decreases by 1 cm, the rim is 11% more likely to be blackened on the interior.[570]

For the opacity of the blackening on *ceramica da fuoco* lids, there is no difference in the levels in different periods. There is no fragment recorded as having an opacity of 5, removal powdery residue, and opacity between 1 and 4 is generally evenly distributed in each period.

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567 $\chi^2=24.45$ ($p<0.01$)
568 $\chi^2=4.71$ ($p<0.05$)
569 $\chi^2=13.86$ ($p<0.01$)
570 $Exp\beta=0.89$ ($p=0.054$)

Alteration: Abrasion

There was very little abrasion observed on these lid fragments. Twenty-seven percent have interior abrasion, eight percent have exterior abrasion, and only 3% have both (Table 20).

Table 20. Location of abrasion on lids at Musarna

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	-	-
Abrasion on wall	4	2
Abrasion on rim	13	4

The number of examples with abrasion is too few to consider the statistical relationship between locations of abrasion and the direction of abrasion; however, it is notable that these lids are dominated by worn or flaked patches. On the rim exterior there are three examples of patched abrasion ranging from 1 cm^2 to 9 cm^2. There is also one example of a 64 cm^2 patch, essentially the entire fragment, on the exterior wall.[571] On the interior of the lids, the wall and rims have patches of removed surface material ranging in size from 3 cm^2 to 16 cm^2.

There is a significant correlation between the rim diameter of the lids and the likelihood of having abrasion on their interior rim. As the diameter increases by 1 cm, the likelihood of having abrasion on their rim interior increases by 13%.[572]

5.2.1.4. Jugs

Morphology

Only seven *ceramica da fuoco* vessels at Musarna can be confidently identified as jugs (five rims with handles and two whole vessels).[573] They appear in Period 4 and Period 8, all from cistern 635. Their rim diameters vary only slightly, with six examples between 9 cm and 11 cm and one example at 16 cm (Figure 40).[574] This larger vessel occurs in Period

[571] MUS 3430.
[572] $Exp\beta=1.13$ ($p<0.05$)
[573] Some of the bases may also be jugs, but it is not possible to tell.
[574] In my calculations, the rim diameter of jugs does not correlate with their volume in any sort of standard way because their maximum diameter and proportions vary drastically.

8, perhaps suggesting a new production group of large-mouthed jugs for a new function; however, the sample size is far too small to draw further conclusions (Figure 41).

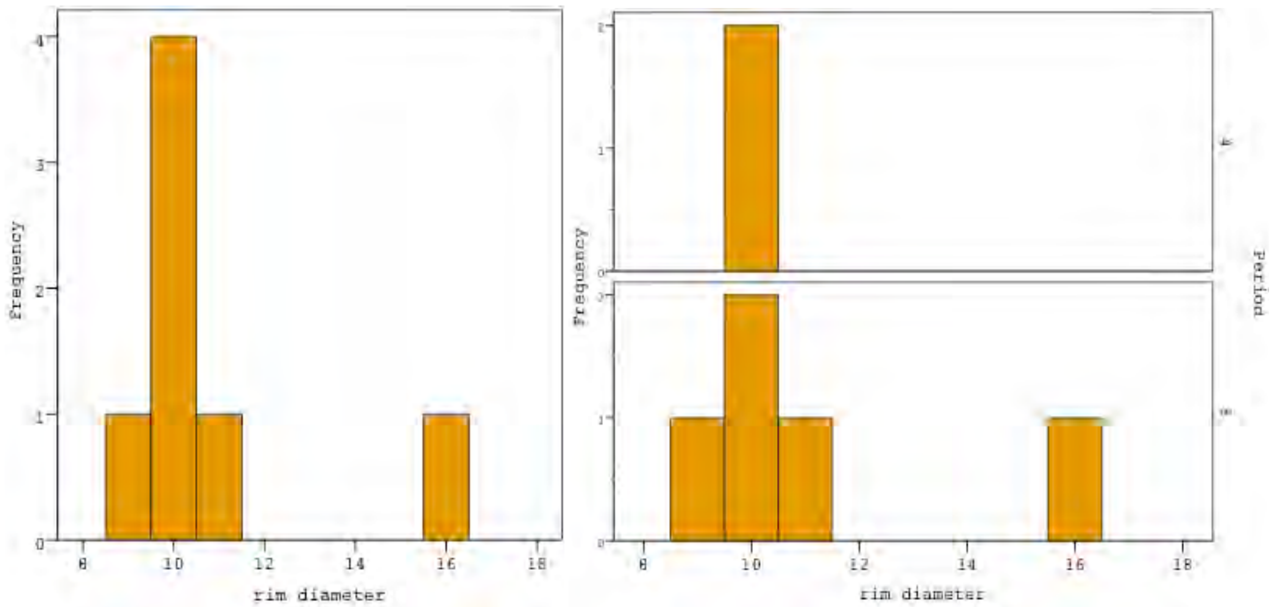

Figure 40. a) Diameters of all jug rims in *ceramica da fuoco*; b) Diameters of jugs by period

Figure 41. Jug of *ceramica comune da fuoco* (MUS 5759)

Alteration: Blackening

None of the jugs have evidence of blackening on their interior, but four have exterior blackening, in all cases a single patch (location 2). The whole vessels, MUS 4886 and MUS 5729, both from Period 4 (250-150 BCE), have a large patch of black on their belly and neck on the side of the vessel opposite to the handle. This location of blackening appears in a few other published examples of jugs of the same fabric from Roman central Italy.[575] A jug from Ponte di Nona dated, based on other material in the stratigraphy, to the second half of the 2nd century BCE is very similar in form and size to these Musarna examples (Figure 42).[576]

The other two examples with blackening in location 2 are both rim fragments with handles attached; both have blackening on the lower half of the handle. These examples are classed as having an opacity of level 3 "vessel color is barely discernible" or 4 "surface is totally opaque black, but no excess material." This suggests an accidental or unusual positioning of the jug with its handle facing the fire, or positioning of the vessel similarly to an olla with its base centered in charcoal and soot reaching all around it.

The remaining three fragments in this dataset, all rims with handle fragments with very little vessel wall preserved, have no blackening. This suggests that either they never had contact with fire, which is unlikely given their fabric type, or like our two whole examples, that the blackening would have been a patch on their belly that does not appear on our preserved fragments.

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[575] Bertoldi 2011, 90. This pattern also appears in the Palatine East pottery assemblage in the Imperial Period, though this material is unpublished. J.T. Peña, personal communication February 2011. In her study of Imperial pottery from Musarna, Cécile Batigne Vallet (2009, 121, fig. 94) identifies a vessel as a "pichet à feu" which has a very different form from any of the vessels in this dataset from Republican Musarna. The study of this vessel is notable because of its discussion of the presence of blackening and a vent or gouge made in the belly pre-firing.

[576] Though MU 4886 has a more sharply carinated shoulder than the Ponte di Nona example.

Figure 42. Jug with exterior blackening in location 2, Ponte di Nona (Bertoldi 2011, fig. 76a, b)

Alteration: Abrasion

Three of the seven jug fragments have abrasion. One of the whole vessels has a flakey exterior surface in patches throughout the area that is also blackened (Figure 43). This is likely due to spalling from the heat of a fire. The other fragment with exterior abrasion has a handle whose surface is totally worn away. This fragment is otherwise in good condition, and it is difficult to explain the eroded handle surface. Finally, a third rim and handle fragment has a number of concentric scratches on the rim interior, which may have originated from utensil use; however, given their uniqueness in their sample group, and the small sample size, there is little to be concluded from this.

Figure 43. Jug with flakey and blackened exterior (MUS 5759)

5.2.1.5. Bases

Morphology

I treat all base fragments of *ceramic da fuoco* as one unified category; it is not possible to reasonably identify them as pentole, ollae, or jugs since all of these forms have similar bases and can only be recognized from their upper half.[577] Though the following analysis of bases is not form-specific, conclusions can be drawn about ceramic use and function, and we can draw some connections with the identified forms discussed above.

In total, I analyzed 238 bases in *ceramica da fuoco* from the cisterns of Musarna.[578] As usual, the majority come from Period 8 (150-50 BCE) and in this case, none were recovered from Period 4 deposits (250-150 BCE) (Table 21). Base diameter has a unimodal

[577] I do not, for example, have enough whole ollae, pentole, or jugs to be able to estimate accurately what the standard angle for a base of any one of these forms is.

[578] This figure does not include the bases of the several whole vessels which have been classed as pentole, ollae, tegami, or jugs.

distribution clustered between 4 and 11 cm, with three outliers of more than 23 cm (Figure 44).

Table 21. Bases in *ceramica da fuoco* from Musarna.

Period	Frequency	Percent	Mean (cm)	Median (cm)
1	2	0.8	8	8
2	44	18.5	7.75	7
5	12	5.0	7.92	6.5
6	6	2.5	6.33	6
8	174	73.1	7.43	7
Total	*238*	*100.0*	*7.49*	*7*

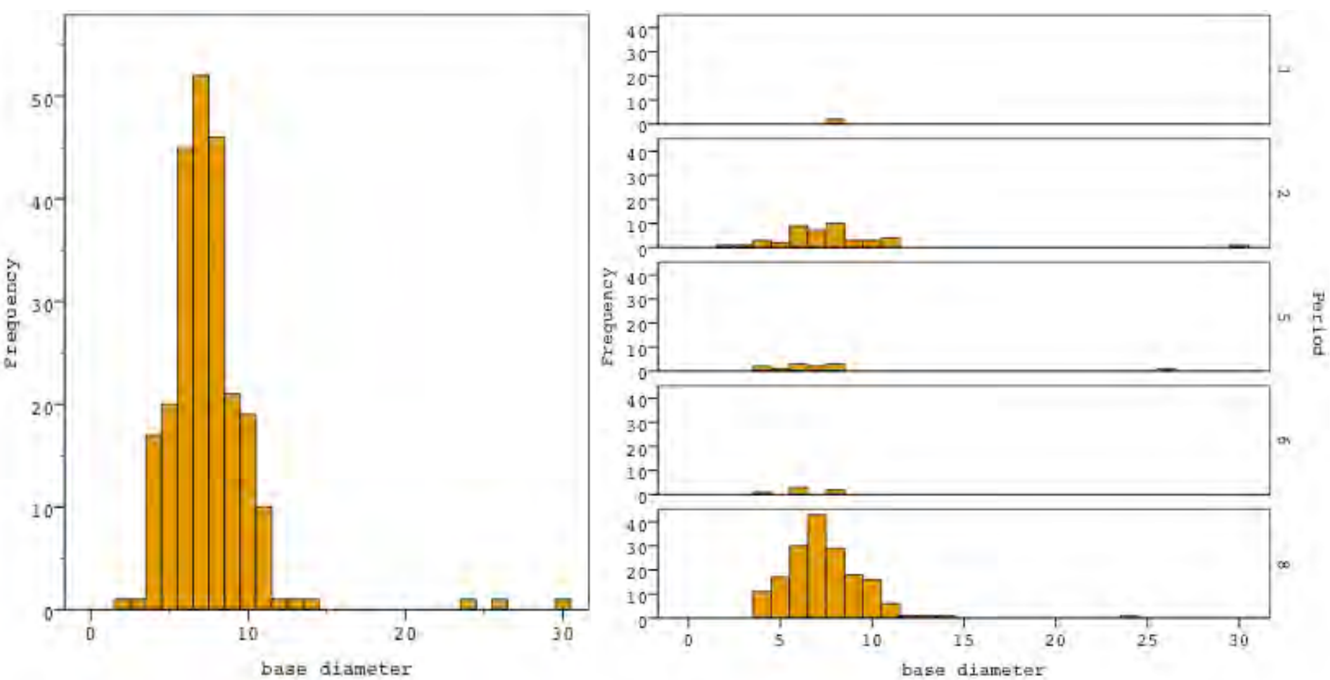

Figure 44. a) Diameters of all *ceramica da fuoco* bases; b) Base diameters by period

There is no significant difference in mean diameters between any of the periods under study.[579] Similarly, the angle between the floor and the wall of these bases has a unimodal distribution which does not differ significantly between periods. We might hypothesize that the 31 bases (14% of the *ceramica da fuoco* bases) that have angles between 100˚ and 120˚ are perhaps associated with the 69 pentola rims (16% of the 428

579 This is the case even when we remove the 3 outliers with diameters greater than 23 centimeters.

ceramica da fuoco rims), since pentole have nearly vertical walls. The other 237 bases may then be shared among the ollae, jugs, and perhaps bowls (Figure 45, Figure 46).[580]

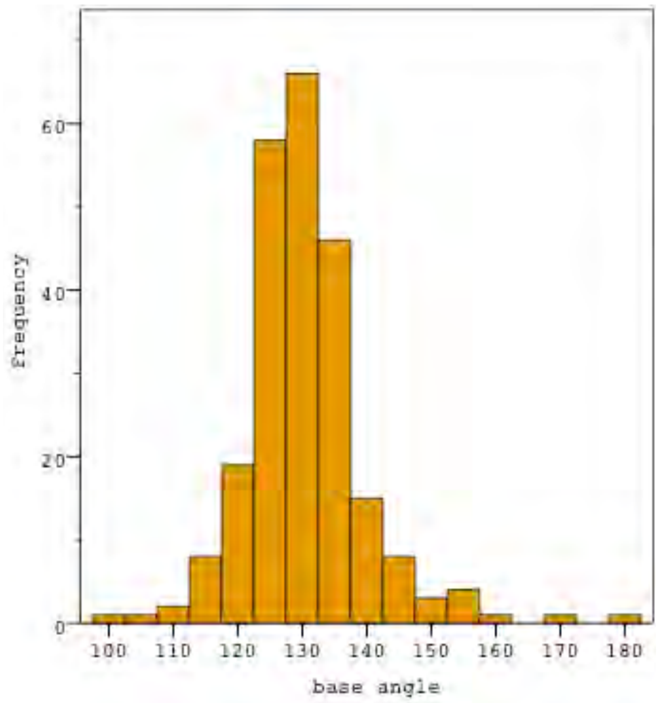

Figure 45. Angles of all bases of *ceramica da fuoco*

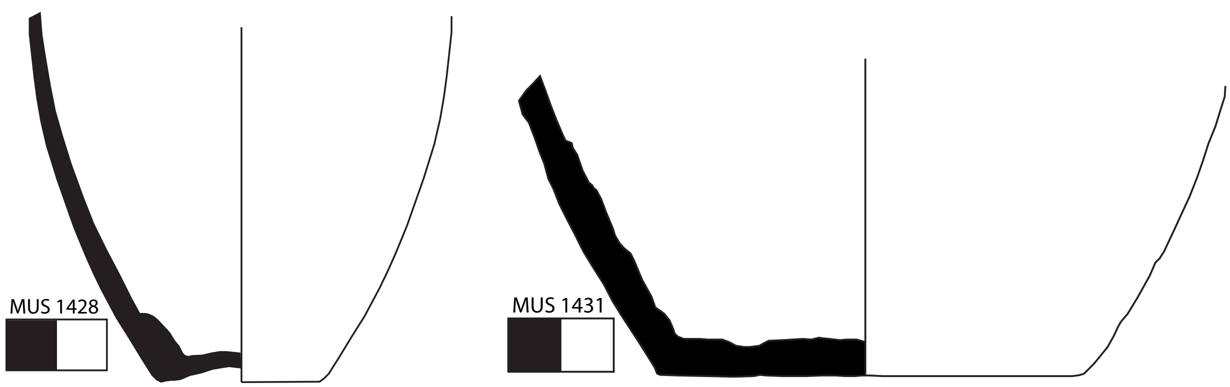

Figure 46. Bases of *ceramica da fuoco*

Alteration: Blackening

Of the bases of *ceramica da fuoco* at Musarna, 60% (n=142) have blackening on their interior and 71% (n=169) have blackening on their exterior. Fifty-two percent (n=124) of

[580] These make up 87% of the bases, whereas the ollae and jugs make up 62% of the rims.

the total are blackened on both their exterior and interior. There is a significant relationship, therefore, between blackening on the interior and blackening on the exterior (Table 22).[581]

Table 22. Location of blackening on bases from Musarna

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	32	11
2	Single patch on belly	18	23
3	Double patch on belly	1	3
4	Around top of rim	-	-
5	Around top of vessel below rim	-	-
6	Around bottom of vessel and on base	10	21
7	Forming a ring on base	3	4
8	Completely covering base	11	13
9	Entirety of vessel not including lower wall and base[582]	37	16
10	Entirety of vessel[583]	57	95
11	Patch in center of base (inverse of 7)	-	2
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

Due to sherd size, it is not always possible to determine whether the extant blackening derives from a larger swath around the belly of the vessel (location 1) or whether blackening entirely covered the vessel except on its lower wall and base (location 9) (Figure 47).

[581] χ^2=45.52 ($p<0.01$)

[582] This is extrapolated in most of these circumstances, since the rim is not preserved to confirm that blackening goes all the way to the vessel opening.

[583] This is extrapolated in most of these circumstances, since the rim is not preserved to confirm that blackening goes all the way to the vessel opening.

Figure 47. Various bases blackened on the interior in location 10, location 1 or 9, and location 1

Several correlations are evident between locations of blackening on the interior and exterior. Being blackened on the interior around the belly (location 1) is highly correlated with the same position on the exterior[584] and also with a ring of black on the floor of the base (location 7).[585] Similarly, when there is an interior patch of blackening on the vessel wall (location 2), it is correlated with an exterior patch of blackening or even two patches (location 2 or 3).[586] To a lesser extent, there is also a correlation between a patch of interior blackening and the whole exterior being covered in black.[587] There is also a strong correlation between 2 interior patches on the vessel wall (location 3) and on the exterior wall.[588]

Several patterns emerge in the blackening of the base floor itself. Bases which have been entirely blackened along the base interior and lower vessel wall tend to have similar

[584] χ^2=16.74 ($p<0.01$)
[585] χ^2=13.25 ($p<0.01$)
[586] χ^2=26.98 ($p<0.01$) and 15.18 ($p<0.01$)
[587] χ^2=4.389 ($p<0.05$). There is also a statistically significant relathionship between location 2 on the interior and location 11, the opposite of 7 (χ^2 value 5.19 where $p<0.05$); however, there are only 2 examples of location 11.
[588] χ^2=78.664 (<0.01)

blackening on the outside.[589] There is also a correlation to a lesser extent between having a ring of black on the base interior (location 7) and being entirely blackened on the exterior base floor (location 8).[590] There is also a statistically significant relationship between the interior base being blackened and the exterior of the vessel being totally blackened.[591]

When we examine the location of blackening on bases in different periods, there are several important differences between Period 2 and Period 8 (Table 23, Table 24). There is proportionally far more interior blackening in location 1, a swath around the belly of the pot, in Period 2 than Period 8.[592] On the exterior at location 1 there are proportionally far more examples from Period 2 than Period 8.[593] There are also proportionally more occurrences of location 2 in Period 2 compared to Period 8.[594] There are clearly more examples of location 3 in Period 2 compared to Period 8.[595] This is similar for location 7, a ring of black around the base.[596] The frequency of the other blackening locations is proportionally similar across all periods.

Table 23. Location of interior blackening on bases by period

Period	**Location 1**		**Location 2**		**Location 3**		**Location 6**		**Location 7**		**Location 8**		**Location 9 or 10**		**TOTAL**
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.
1	0	0.00	1	50	0	0.0	1	50	0	0.0	0	0.0	0	0.0	2
2	10	11.4	6	6.8	1	1.1	1	1.1	2	2.3	2	2.3	66	75.0	88
5	1	3.0	1	3.0	12	36.4	1	3.0	12	36.4	1	3.0	5	15.2	33
6	2	11.1	0	0.0	6	33.3	0	0.0	6	33.3	0	0.0	4	22.2	18
8	19	29.2	10	15.4	0	0.0	8	12.3	1	1.5	8	12.3	19	29.2	65
Total	**32**	**15.5**	**18**	**8.7**	**19**	**9.2**	**11**	**5.3**	**21**	**10.2**	**11**	**5.3**	**94**	**45.6**	**206**

Table 24. Location of exterior blackening on bases by period

Period	**Location 1**		**Location 2**		**Location 3**		**Location 6**		**Location 7**		**Location 8**		**Location 9 or 10**		**TOTAL**
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.
1	0	0.0	1	33.3	1	33.3	1	33.3	0	0.0	0	0.0	0	0.0	3

589 χ^2=22 ($p<0.01$)
590 χ^2=4.57 ($p<0.05$)
591 χ^2=5.18 ($p<0.05$). There is also a strong relationship between location 9 on the interior and location 9 on the exterior (χ^2 value 6.3 where p=0.012) and between location 9 on the interior and 10 on the exterior (χ^2 value is 6.98 where $p<0.01$).
592 χ^2=4.25 ($p<0.05$) where Period 2 is 25 % interior location 1 and Period 8 is 11 % interior location1
593 χ^2=5.78 (p=0.016)
594 χ^2=12.15 ($p<0.01$)
595 χ^2=7.98 (p<0,01) and Fisher's Exact Test used because the samples are smaller than 5.
596 χ^2=16.144 ($p<0.01$) and Fisher's Exact Test used because the samples are smaller than 5.

2	5	10.6	10	21.8	2	4.3	6	12.8	4	8.5	2	4.3	18	38.3	47
5	1	9.1	2	18.2	0	0.0	1	9.1	0	0.0	0	0.0	7	63.6	11
6	0	0.0	0	0.0	0	0.0	1	16.7	0	0.0	2	33.3	3	50.0	6
8	5	4.2	10	8.4	0	0.0	12	10.1	0	0.0	9	7.6	83	69.8	119
Total	**11**	**5.9**	**23**	**12.4**	**3**	**1.6**	**21**	**11.3**	**4**	**2.2**	**13**	**7**	**111**	**59.7**	**186**

When we examine the distribution of blackening opacity on the interior of bases in different periods, we see that although overall there is little variability in the frequency of different levels of blackening, there is significant difference between Periods 2 and Period 8.[597] There is no significant difference in the blackening level between Periods 2 and 5 or between Periods 5 and 8; however, since Period 5 has such a low sample size (n=8), this is not surprising. On the exterior of these bases, the blackening opacity coverage is similarly distributed over all periods of study.

When we consider what this opacity actually suggests about vessel use, we can look first at the opacity level 5 "black material is thick and flakey." From Period 2 to 8 there is a drop in the frequency of level 5 opacity.[598] This suggests that food was burned and adhered to the sides of the vessel less often in later periods. In Period 2, opacity scores 2 and 4 prevail, occurring twice as much as opacity 1, 3, and 5, which are all similar. In Period 8, however, there is a substantial frequency of opacity score 3 and 4, suggesting sustained periods of fire-exposure, or more repeated re-use of the vessels. Given that this blackening is on the interior of the vessel, and that the most frequent location of blackening in Period 2 are in locations 1, 9 and 10,[599] this patterning may in fact be related to low levels of liquid in the pot, or may result from the pot sitting empty for a long period and therefore being exposed to soot.

Alteration: Abrasion

Abrasion of the bases is less common than on rims of this ware. Out of 238 samples, 39% (n=92) have abrasion on their base exterior (that is, either on the floor of the base or the edge of the base) or on their exterior wall. Interior abrasion is less prevalent; only 12%

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[597] χ^2=13.83 ($p<0.01$)
[598] χ^2 value for the appearance of opacity score 5 between Period 2 and Period 8 is 7.96 ($p<0.01$)
[599] That is, a swath around the belly, the whole vessel except the lower wall and base, and the whole vessel.

(n=29) of the fragments show some abrasion (Table 25).[600] Ten percent (n=23) of the fragments have abrasion on both their interior and their exterior, indicating a very strong association.[601]

Table 25. Abrasion of bases of *ceramica da fuoco*

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	21	80
Abrasion on wall	9	17
Abrasion on rim	-	-

Of the bases which are abraded on their exterior floor, 91% of that abrasion was coded as "concentric," that is, parallel to the wheel marks of the vessel.[602] This almost exclusively takes the form of abrasion on the corner where the floor meets the wall of the vessel (Figure 48). This kind of wear can be attributed to everyday handling and vessel movement as the vessel is used and taken in and out of storage. Otherwise, exterior abrasion described as a "patch" makes up 6% of the sample. These patches range between 4 cm^2 and 36 cm^2, with a mean and median both of 16 cm^2. There does not seem to be a meaningful trend related to traceable repetitive actions.

[600] Seventy-nine percent of these fragments have "sharp" fractures, 21% have "slightly rounded" fractures, and only 1 fragment is "very eroded" and has been removed from this abrasion analysis.
[601] $\chi^2=22.46$ ($p<0.01$)
[602] Only 46% of these examples have any mineral encrustation on them.

Figure 48. Base with concentric abrasion on the edge of floor and location 9 blackening (MUS 2212)

When we examine exterior wall abrasion, patches of abrasion are the most prevalent type of wear, appearing on 9 out of 17 examples.[603] These patches range in size from 4 cm^2 to 36 cm^2 and have a mean of 17 cm^2 and a median of 16 cm^2. More than half of the nine specimens with this wear have fractures that are "slightly rounded" perhaps discounting their abrasion being use-related. Two examples, however, have exterior wear associated with blackening in the same spot. In one (MUS 1428), there is a very peculiar pattern of blackening on both the exterior and the interior and associated abrasion. The exterior of the vessel is entirely black except for one patch on the wall where the clay color is preserved (Figure 49). This may perhaps be due to burning off of the soot residue.[604] Several centimeters away from this light patch the vessel wall has a 4 cm^2 patch of abraded surface. On the interior of the vessel, the wall is blackened except for a tilted swath around the belly and on the vessel floor, which reflects the outline of the surface level of a liquid in the vessel when tilted sideways. Noting that one-handled cooking vessels often have a swath of exterior blackening on their base and vessel wall opposite their handle, Susan Rotroff suggests that this is because the vessel was frequently tipped away from the fire to

[603] Only 5 of these fragments have mineral encrustations on them (30%), and of these the crust covered 4 less than 40% or less.
[604] Skibo 1992, 160–161.

check its contents.[605] This could be the origin of this interior pattern of blackening, revealing the shape of tilted liquid (Figure 49). This example, however, is unique in the Musarna sample, and therefore cannot be taken as a common situation.

Figure 49. Exterior blackening with light patch; tilted interior blackening pattern from liquid (MUS 1428)

Despite the small spread of base diameters, there is a notable relationship between diameter and the likelihood of abrasion. For every centimeter the diameter increases, base fragments are 12% more likely to have exterior abrasion and 14% more likely to have abrasion on their base floor or edge specifically.[606]

When we turn to examine interior abrasion of the base floor, there are two examples each of concentric, radial, and chordal scratches. Fifteen examples (71%) have a patch of abrasion, all of which are described as having "sharp" fractures, and therefore, these patches can reasonably be attributed to use.[607] All but one of these examples have widespread cracking of their interior surface. This is likely due to the combination of heat and moisture from the food being cooked slowly degrading the vessel surface's integrity (Figure 50).[608] In several cases, this cracking is also associated with blackening of location 9 on the exterior of the pot and sometimes also on the interior. There are not enough samples of this cracking to be statistically significant.

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[605] Rotroff 2006, 169.
[606] For exterior abrasion in general, the $\text{Exp}\beta=1.12$ ($p<0.05$) and for exterior abrasion on the base, $\text{Exp}\beta=1.144$ ($p=0.017$).
[607] Only 38% of these have any mineral encrustations and all of these cover less than 10% of the vessel surface.
[608] Skibo and Schiffer 1987; Vuković 2009. The exception is one which is pedestaled (MUS 2315; a very small fragment).

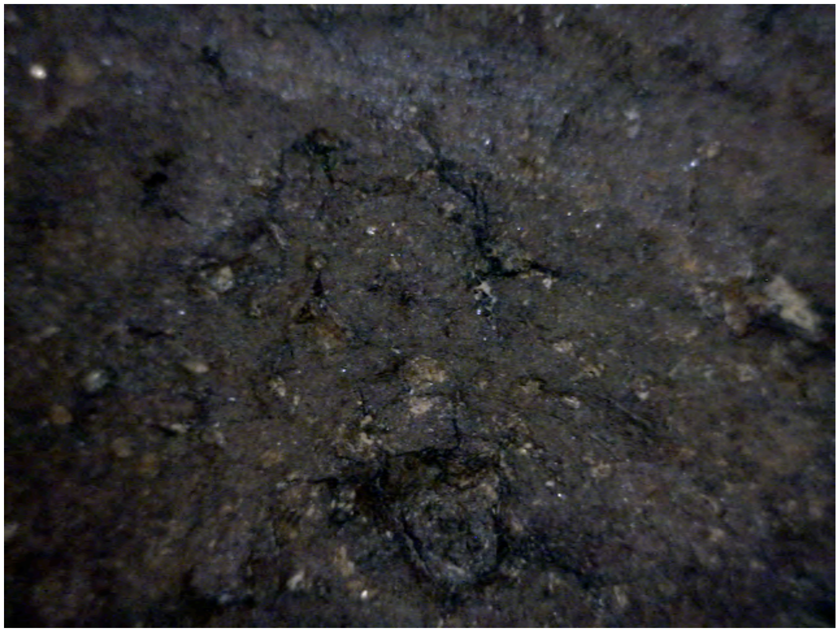

Figure 50. Cracked interior surface of *ceramica da fuoco* base at 20x magnification (MUS 2215)

5.2.2. Discussion – Pause for reflection

Before adding further data and complexity to this dataset, we should pause to reflect on the patterns observed thus far with *ceramica da fuoco* and what can begin to be concluded about cooking methods. Several points are worth summary and emphasis, and a few basic technological observations can be made. The prevalence of blackening on the interior of ollae, pentole, and their associated bases, all demonstrate that they were being used to heat foodstuffs, rather than simply water. If they heated only water, there would not be organic content to char on their interior walls. This can be contrasted with our seven jug examples, which have no interior blackening, suggesting their use as water-heating vessels.

Next, the blackening patterns on the lower halves and bases of these vessels suggests a great deal about cooking methods. For pentole, we do not have most of their whole profiles preserved, and in the one instance we do, its base is blackened. When we have the whole profiles of ollae preserved, they lack blackening on their exterior base, though they are commonly blackened on their exterior wall, often as location 1 or 9. From this blackening pattern we can conclude that ollae sat directly in a bed of charcoal on a flat, perhaps masonry stove. The charcoal was flaming enough to give off airborne carbonized resin which has become embedded in the ceramic body, but the part of the vessel which sat within the charcoal was not exposed to this matter in the air. I have confirmed this hypothesis with a simple experiment using commercially-available hardwood charcoal and a ceramic flower pot.[609] Below the line of the charcoal bed, the vessel is protected from soot and not blackened at all.

On bases, we have seen that a ribbon of black around the belly of the vessel is highly correlated on the interior and exterior. A possible origin for this, according to ethnoarchaeology by Skibo in the Philippines, is that the pot was seated next to the source of heat and was periodically rotated, thus the charring on the interior and sooting on the exterior would have originally been only one patch, but developed into a swath all the way around the vessel (location 1). The idea of using an olla next to an open fire is supported by the frequency with which ollae bear a large blackened patch. However, the linearity and evenness of most of my examples of this type of location 1 blackening on bases make the "rotating the pot" scenario questionable. An alternative scenario may be that these vessels also had their bases buried in charcoal and thus their lower exterior walls and bases have no trace of soot. But their interior lower walls also have no trace of charring because the charcoal lower down is extinguished and cools from lack of oxygen. Therefore it is not hot enough to burn the foodstuffs inside the vessel. These cooking methods are relatively consistent across time.[610]

The implications for foodways change of *ceramica da fuoco* emerge when we consider vessel size. It is immediately evident that trends in the size increase of ollae resemble those of the increase of lid diameter. With ollae, there is both a greater range of sizes in Period 8 than earlier as well as a greater prevalence of larger vessels. Although with the lid samples we do not see a greater range of sizes in Period 8, their diameters do get distinctly larger, likely in order to match the ollae. Lids are also likely responsible for the high frequency of location 4 blackening on the interior of olla rims. Flames and their

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[609] Appendix 3: Experiment Two, Test One.

[610] In her discussion of *chytra*, a vessel similar to an olla in its wide-bellied narrow mouth, but with the addition of a single vertical handle at the rim, Susan Rotroff proposes that they are "stewpots" because their exterior bases are blackened. She also identifies "disintegration" at the bottom of the pots as evidence of thermal shock, when it might be better termed spalling from heat of the immediate surface, rather than cracking of the wall. Rotroff 2006, 169.

associated soot seem to have been active enough to reach over the sides of the olla and into the interior to deposit soot. The lid sitting in the bend of the olla's neck was probably responsible for the even black line of soot which so commonly appears.

Evidence for fairly frequent use of a lid seems to suggest that ollae were often used for long-term slow boiling. A lidded vessel used to boil food will overflow if the heat of the fuel source is not monitored. On the other hand, the fact that heat and soot is being generated enough to reach the top and inside of the vessel suggests an active flame rather than a small fire for slow simmering.[611] An alternative source for the location 4 blackening on the interior of ollae is, of course, the height of the food contents of the vessel themselves.

The increase in larger ollae from Period 2 compared to every later period as well as Period 8, also suggests a shift in cooking practices at Musarna. There are several possible reasons for this. The first is that larger amounts of food were being prepared for larger groups of individuals. Large cooking pots have often been interpreted as evidence for communal feasting in pre-colonial America, Iron Age North Europe, and Bronze Age Greece.[612] Such feasting events create both unity and hierarchy within these societies, since they promote commensality while at the same time providing an opportunity for the hosts to distinguish themselves by displaying their resources. While 1st century BCE Italy is quite different from chiefdom societies of pre-colonial America in its complexity, some of these same conclusions can be posited for the Italian context at Musarna.

The increase in olla volume in Period 8 is on average slightly more than one liter, therefore ollae do not seem to provide evidence for large-scale public feasting. Instead, they may point to a change in household size or the number of people attending domestic meals. One might imagine a scenario where individual households are hosting private banquets with increased regularity. The practice of elite banqueting was present in central Italy long before the Roman period, at least in a funerary context, if not more often.[613] With the arrival of a new political order, elite and sub-elite alike may have used the dinner table as a bargaining table to connect and negotiate changing power relations with each other

[611] Or perhaps both: an active flame to bring liquid to a boil, and a more controlled flame for food simmering.
[612] See for example, Blitz 1993; Hayden 1996; Day and Wilson 2004; Pappa 2004.
[613] Small 1994; Zaccaria Ruggiu 2003.

and with new Roman officials.[614] An increase in olla size may reflect the need for an increased amount of socio-political negotiation and a spread of hosting and reciprocal dining among the non-elite as part of a new cultural practice.[615]

This picture is complicated by *popinae*, *cauponae*, *tabernae* and other food retail establishments of the Roman world. It has been suggested that the lower classes who lived in tenement apartments without cooking facilities dined out at these facilities every night.[616] This is based on literary evidence from the 1st century CE and on the prevalence of such shops at Pompeii and Ostia. The plausibility of this picture has been complicated recently by the question of whether "lower class" people could afford to purchase pre-prepared food with regularity.[617] There has been the suggestion that public eating establishments were for socializing, before or after dinner or a theater performance, rather than to assist people without kitchens, since cooking could be accomplished even in modestly equipped apartments using movable braziers.[618] The way in which middle or lower class people from a town like Musarna may have eaten "out" is unclear, since studies of the retail industry have focused exclusively on Rome, Pompeii, and Ostia.[619] It does not seem that Musarna necessarily had the same urban density or tenements of a city like Rome, nor the same transient population of a city like Ostia. Even Pompeii, three times the size of Musarna in hectares, seems to have been more densely populated at least by the 1st century CE, and its coastal location in a different region makes comparison difficult. It is nevertheless a possibility that larger cooking vessels at Musarna are also evidence for communal eating establishments in this "urban" Roman style.

The second scenario in which we might imagine larger ollae to be adopted is when boiling or stewing was used as a cooking technique for a greater proportion of the meal

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614 D'Arms 1984. John Patterson includes both formal pledges of *hospitium* as well was informal contacts among the opportunities for social interaction between Italians and Romans and among Italians themselves in Pre-Social War Italy. *Hospitium* was a bond between two elite men from different communities who pledged to provide hospitality to the other. Patterson 2012, 218–224.

615 This might be where the so-called "middle classes" come in, as merchants and artisans who benefit from Italy's economic unification and boom in the late Republic adopt practices previously limited to the aristocracy. See Mayer 2012.

616 See, for example, Kleberg 1957; Kelsey 1991.

617 Thommen 2012, 101–102.

618 Dosi and Schnell 1986, 44–49; Foss 1994, 34–36.

619 Steven Ellis (2012) focuses on the Vesuvian cities, though he mentions counter tops from food establishments at Lucus Feroniae and Alba Fucens. Claire Holleran (2012) focuses on Pompeii and Ostia.

than a drier form of cooking such as roasting or grilling. Half of the material evidence here is missing since we have almost no grilling equipment from the ancient world; however the evidence from the pots themselves can provide clues to different uses.[620] When we turn to the results of the study of abrasion of the interior of olla rims, we can see a correlation between increasing rim diameter and decreasing rim angle (when the rim tends towards the horizontal) with the appearance of abrasion (Figure 51).

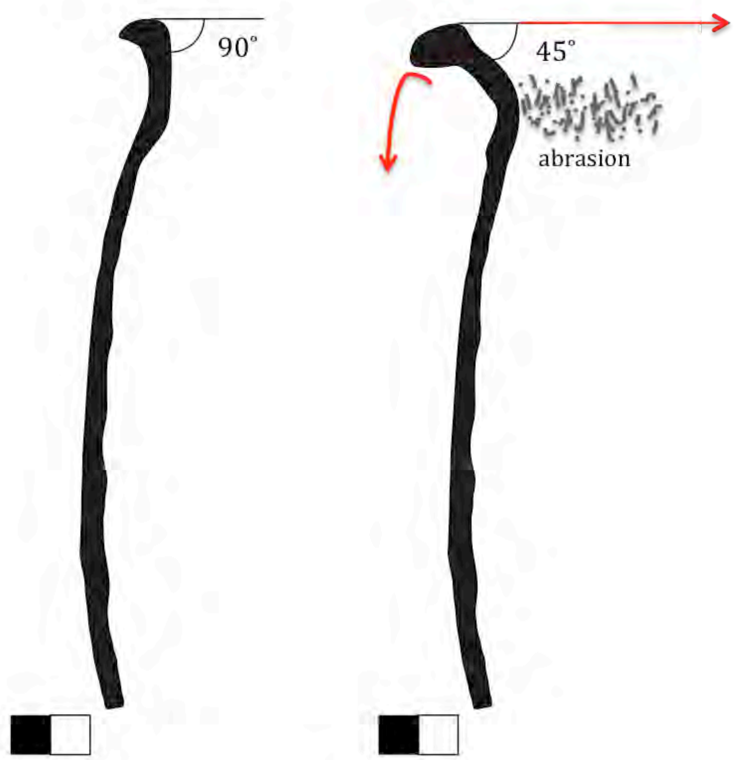

Figure 51. As diameter increases and rim angle decreases, interior rim abrasion is more likely

This result recalls observations made by James Skibo amongst the Kalinga people in the Philippines. As discussed in Chapter 3, he notes that pots which are used to cook vegetables and meat have heavier interior rim and neck abrasion than pots used to cook rice. Rice pots also have a more confined neck opening. He observed that people accessed the contents in the vegetable and meat pots, for both stirring ingredients and for serving, more often and repetitively than they did the rice pots. Throughout the cooking and serving process, a

[620] The exception is always Pompeii, where several small grills were recovered. Stefani 2005, 85.

utensil was only put into the rice pot when the rice was being served.[621] The differential traces of wear on differently sized ollae at Musarna suggests that in all periods different olla sizes were being used for different functions – the larger size containing food that required more active maintenance or more stirring. In this case we can recall Cato and many other authors' references to *puls*, emmer wheat porridge, as a classic staple. Cato himself mentions stirring as a requirement for its production in his Punic version of the dish.[622] Unlike white rice, which is set to boil and left untended, perhaps *puls* in all its versions required careful and constant stirring as a type of ancient risotto.[623] Meanwhile, a stew of vegetables, or legumes, with small pieces of meat to accompany it, cooked in a slightly smaller pot with plenty of liquid, could simmer relatively untended.[624] In every period, larger vessels are more likely to be abraded on the interior of their rim than smaller vessels suggesting that in every period they had differing uses. The fact that in Period 8 at Musarna there is an increased proportion of larger vessels may suggest that this stirred staple was increasingly-prepared or that boiled or stewed foods were increasingly popular. The examination of internal red slip ware vessels later in this chapter, particularly the tegame or pan form, will contribute to this idea.

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[621] Skibo 1992, 132.
[622] Cato, *de Agr*. 85. See chapter 2. Gloria Olcese suggests that ollae were used to make the staple *puls* based, it seems, purely on the ubiquity of the form in deposits in central Italy. She notes that 2/3 of the cooking pots at Cosa were ollae (Olcese 2003, 37–39).
[623] Modern emmer recipes vary in how much stirring they call for as well as how much time they need to cook. This seems to depend especially on whether one is using whole or cracked grains (*farro spezzato*). Compare for example, the recipes in a contemporary American cookbook with a reprint of a traditional Italian cookbook: Waters 2007, 278 and Fazzi 1994, 13–14. There is also a related technological component of larger cooking vessels for liquid heating and boiling. Foodstuffs cook faster when boiled in larger volumes of water. Although boiling water will maintain a constant 100°C temperature, the greater the number of hot water molecules available to transmit heat to the foodstuffs through the convective boiling action, the faster the food can be brought to ambient temperature. Wilson 2012, 26–29.
[624] See chapter 7 for a discussion of the specific plants and meats consumed.

5.2.3. *Ceramica comune da fuoco*, Part 2

5.2.3.1. Clibani

Morphology

An unusual member of the *ceramica da fuoco* category is the so-called clibanus.[625] It appears in only two periods at Musarna in five examples which have the "rim" of the vessel preserved between 13% and 28% (Table 26).[626]

Table 26. Clibani at Musarna

Period	Frequency	Percent	Mean (cm)	Median (cm)
4	1	20	27	27
8	4[627]	80	32.75	33
Total	*5*	*100*	*31.6*	*31*

Each of these vessels has been identified by its classic flange form. They range in diameter from 27 cm to 38 cm and the walls of all of them sit at an angle of either 55˚, 60˚, or 80˚.[628] The walls just past their rims are 7 mm to 9 mm in thickness (Figure 52).

[625] "So-called" because the term was codified to refer to one particular form of vessel by A. L. Cubberley, J. H. Lloyd, and P. C. Roberts (Cubberley et alii 1988) and has since become normal parlance among Italian archaeologists (Olcese 2003). See my formal description of the vessel's morphology in chapter 3.

[626] There is one further example from Period 2 (MUS 2892) which I have classed as "common ware" because of its calcareous clay, fine inclusions, and surface painting. Based on the orientation of the fragment, it appears to be part of the flange of a clibanus form; however, the features of its clay make the identification insecure.

[627] Two of these (MUS 5025 and 5074) have so many similar wear characteristics and such a similar form that they look like they should be the same vessel; however, their diameters (27 cm and 31 cm) and fabrics differ enough that they cannot be the same.

[628] These diameters are consistent with Cubberley *et alii*'s standard diameter of Republican clibani from Molise (Cubberley et alii 1988, 110.

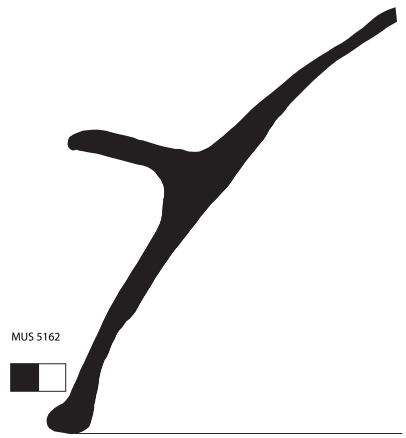

Figure 52. Clibanus from Musarna

Alteration

Four out of five of these clibani have blackening on their interiors and two out of five on their exterior. Two examples have both. The opacity of the interior blackening is inconsistent, ranging from a score of 1 "barely discernible darkening" to 4 "surface is totally opaque." Two fragments have a large patch of black while one seems to have either a patch of black or a swath around the vessel above the rim (location 5). The final fragment does not have a substantial enough amount of its interior surface preserved to assess its blackening.[629] This example has only its exterior flange preserved and it is completely black. The other vessel with exterior blackening has a large patch or swath of black (with an opacity of 4). This is MUS 5162 whose whole profile is preserved to reveal that it has little evidence of fire damage on its very top center (Figure 53).

[629] This is MUS 5650 which is a large piece of flange with very little of the clibanus wall preserved.

Figure 53. Clibanus blackened on exterior (MUS 5126)

These results refine the observations made by Brian Sparkes regarding cooking bells in Athens and the seminal 1988 article on Roman cooking bells by Cubberley, Lloyd, and Roberts. Sparkes noted that in the Balkans in the 1950s, cooking bells were hung over a bed of charcoal piled on the floor to warm the ceramic body. Then, the charcoal was swept away and dough was placed on the ground with the cooking bell on top. Charcoal was then piled around the vessel to bake bread.[630] The idea of bread-baking *sub testu* (understood to mean "under a clay vessel") has its earliest attestation in Roman sources in Cato who describes a series of recipes for bread cooked in this way.[631] The sequence of events and what a *testum* actually looks like has been a matter of some debate. Cubberley *et alii*'s work sorted through the textual evidence and etymological development of "baking covers" or "cooking bells" in the ancient world and into medieval Europe in order to determine that *testa* and clibani seemed to have relatively interchangeable contexts and meanings, with a clibanus often the vessel used to cook "*sub testu.*"[632] Cubberley notes that in Aristophanes' *Clouds* (95-7) the line, "men who persuade us that heaven is a *κριβανος*

[630] Sparkes 1962, 128 and n. 60. Sparkes calls the fuel "coals" and I can only assume he means charcoal.
[631] Cato *de Re Rustica*, 74-76, see chapter 2.
[632] Cubberley et alii 1988.

placed around us and that we are the coals" must suggest that coals were placed inside the vessel to warm it before it was used for baking.[633] Elevation above the fuel would provide an opportunity for sooting the interior of the vessel, as we have seen; though the examples from Musarna in this dataset, similar to many in central Italy, do not seem to have a handle on their top from which to hang them, there is at least one other example from Musarna which does have a handle (Figure 54).[634] It is possible that clibani without handles were elevated from their flange; however no evidence from this sample supports this idea.

Figure 54. Clibanus with no blackening on exterior from unknown context at Musarna

Blackening on the exterior of the vessel allegedly derives from the charcoal placed around or on top of it.[635] As we have seen with the bases of ollae, charcoal put in direct contact with the vessel walls would not leave it black, since the vessel would be protected from airborne soot. The fact that only two of the clibani from Musarna display external blackening supports this idea. This is also confirmed by a blackening experiment I

[633] *Κριβανος* is the Attic form of *κλιβανος*. This interpretation of Aristophanes assumes that the word *κριβανος* here was definitely referring to a baking cover and not to a form with some other function like a portable heater or incense burner (Olcese 2003, 91). Such an assumption is problematic given that Cubberley et alii's assessment of the literary evidence for using a cooking bell demonstrates that similar words in ancient texts were not always referring to the same vessel and that the same word, clibanus, referred to cooking several different things. The broad semantic range of terms for culinary vessels in ancient texts is explored in Donnelly, Forthcoming.
[634] Sparkes' example from Greece do have handles on their top. Sparkes 1962, Plate IV, n. 2.
[635] Unusually, Cubberley et al (1988, 106) observed blackening on the interior and exterior "foot" of the clibanus and on top of the exterior flange in order to support their understanding of the use of the vessel.

undertook involving the covering of an inverted vessel with flaming charcoal.[636] All three of the clibani from Musarna which are not blackened on their exterior have other signs of use (whether blackening on their interior or abrasion along their rim or inner wall), suggesting that their lack of external blackening does not mean that they were never used.[637] The opacity of the two examples which do have black on their exteriors does not make an understanding of their use easy. MUS 5162 (above), especially with its distinct and seemingly long-term signs of blackening, does not fit the idea of having had charcoal heaped on its walls. It is possible that it sat surrounded by, but not in direct contact with, flame, but we do not have other specific literary or archaeological evidence of this.

Abrasion on these vessels is rare with only two out of five having interior abrasion and one having exterior abrasion.

5.2.3.2. Tegami

As we shall see in more detail shortly, the tegame form at Musarna overwhelmingly appears as internal red slip ware. There is, however, a single tegame in *ceramica da fuoco*. This is MUS 4835, a largely-complete vessel which has tripod legs. Its rim diameter is 16 cm and it has a roughly vertical wall (measured at 85°), a horizontal everted rim, a slightly concave base, and its legs are 4.5 centimeters long. Its exterior blackening pattern is rare, being location 11, a patch in the center of the base (Figure 55, Figure 56). This is consistent with the vessel being elevated above a fire. Its legs have black on their upper halves. The vessel also has black around its upper exterior rim and slightly around its upper interior rim.

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[636] Appendix 3, Experiment Two, Test 2.

[637] This is in addition to the photo of the complete Musarna clibanus which also has no sign of exterior blackening (Figure 54).

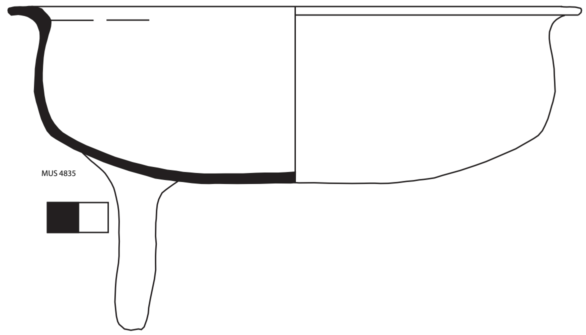

Figure 55. Tripod tegame form

Figure 56. Tripod tegame with blackening in exterior location 11 and interior location 4 (MUS 4835)

In her study of ceramics from the Athenian Agora, Susan Rotroff observes on *lopades* (the same "pan" form as tegame) that both rounded and flat bottom examples are entirely blackened on the exterior and the interior edge of the rim. Because of the regularity of this pattern, she attributes it to firing atmosphere rather than use.[638] This is certainly not the case for tegami at Musarna. Their original post-firing color varies from "light red" to "reddish yellow" (2YR 7/6 or 5YR 7/6). My assessment of cooking patterns for tegami will continue with the examination of internal red slip cooking vessels as detailed below.

5.2.4. Internal red slip ware

5.2.4.1.Tegami

Morphology

My samples included 92 red slip ware tegami (71 rim fragments and 21 whole profiles) from Musarna, with 5% or more preserved (Table 27).[639] These represent a minimum number of 85 vessels.[640] Their rim diameter is an excellent proxy for total vessel volume, and will be used to examine their function (see Appendix 1). Diameters show a weakly bimodal distribution, with the majority under 24 cm, and a smaller number greater than 24 cm in diameter. These size classes are evident in both overall distributions at Musarna, and for each period (Figure 57).

Table 27. Rims and whole vessels of internal red slip tegami

Period	**Frequency**	**Percent**	**Mean (cm)**	**Median (cm)**
2	2	2.2	22	22
4	22	23.9	23.59	22.50
5	22	23.9	22.77	21.50
8	46	50.0	23.50	22.50
All	*92*	*100.0*	*23.16*	*22*

[638] Rotroff 2006, 185.
[639] This represents 12.79 EVEs.
[640] There are 7 fragments which join with other fragments having 5% or more preserved.

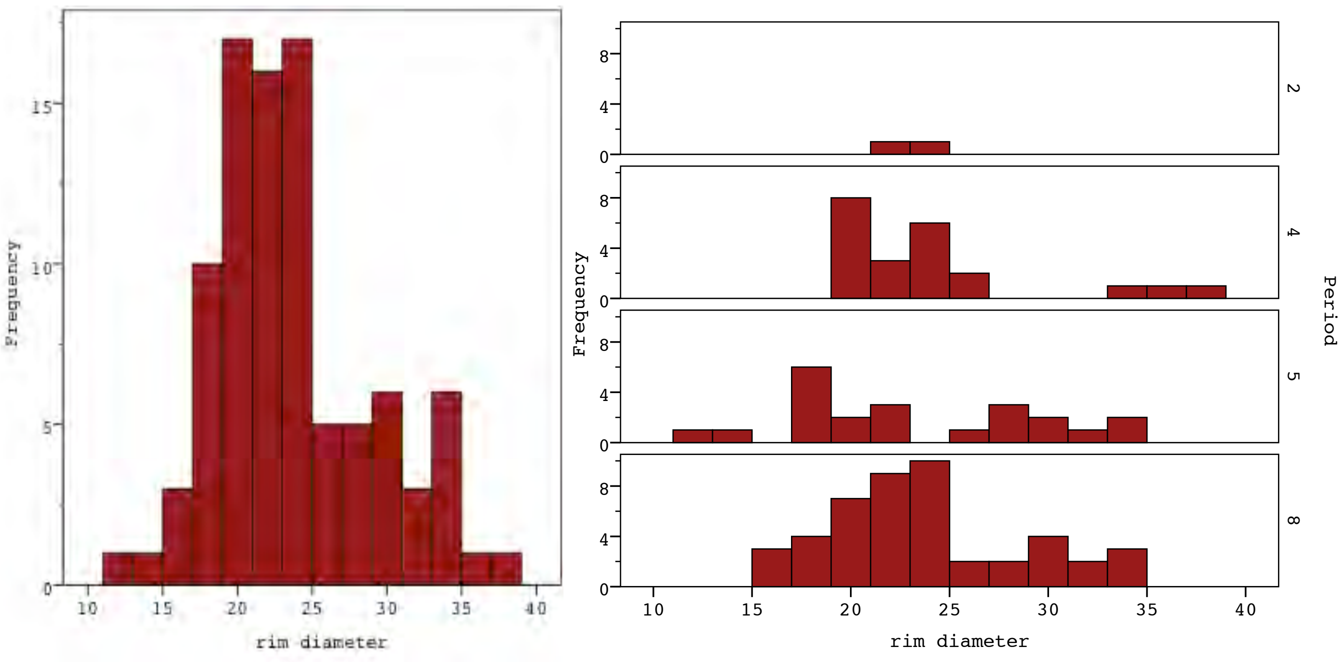

Figure 57. a) Diameters of internal red slip tegami at Musarna; b) Diameters by period

The occurrence of different diameter groupings in different periods at Musarna is striking for its regularity. In every period (excluding Period 2 where only two vessels were recovered), there is a relatively equal number above and below 23 cm or 24 cm in diameter. There is no significant difference between any of the periods in their distribution, median, or mean diameter.[641] When we divide these vessels into "smaller diameter" and "large diameter" groups, they have means of 19.27 cm and 27.41 cm and medians of 20 cm and 26.5 cm. Each period has a similar number of vessels in these two groups (Table 28, Table 29). This is quite different from the size distribution of pentole and ollae of *ceramica da fuoco*.

Table 28. "Large" tegami with diameters 24-38 cm

Period	Frequency	Percent	Mean (cm)	Median (cm)
2	1	2.3	24	24
4	11	25.0	27.09	24
5	9	20.5	29.56	30
8	23	52.3	26.91	26
Total	*44*	*100.0*	*27.41*	*26.50*

641 This is determined using a Kruskal-Wallis test (See Appendix 2).

Table 29. "Small" tegami with diameters 12-23 cm

Period	Frequency	Percent	Mean (cm)	Median (cm)
2	1	2.1	21	21
4	11	22.9	20.09	20
5	13	27.1	18.08	18
8	23	47.9	19.48	20
Total	*48*	*100.0*	*19.27*	*20*

The angles of opening of these tegami are also similar across time. Ranging from 57.25˚ to 59.76˚, on average, and with medians of 55˚ and 60˚, there is little variation.[642] There is little variation in the thickness of the upper wall of the tegami, with each period's median between 7.19 mm and 6.87 mm. For rim fragments with walls preserved higher than two centimeters, the measurements are similarly sized (between 5.9 mm and 7.5 mm) and similarly homogenous (Figure 58).

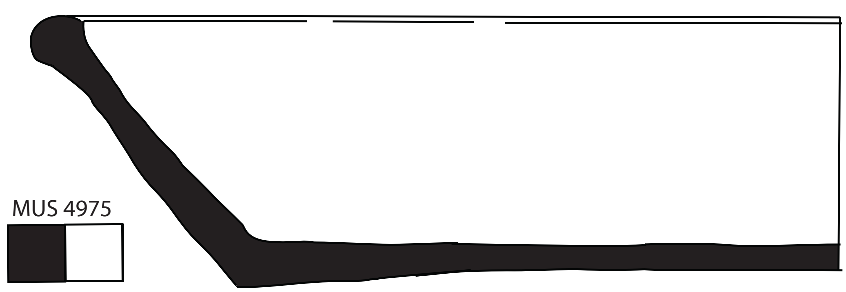

Figure 58. Typical internal red slip tegame form at Musarna

Alteration: Blackening

Blackening from fire on these internal red slip rims and whole vessels appears on 47% of vessel exteriors and 34% of vessel interiors (Table 30). Vessel fragments with both their interior and exteriors blackened make up 20% of the total sample. When we isolate just the 21 whole vessels, however, 14 of them (67%) have blackening on the exterior, five (24%) have blackening on both the interior and exterior, and none have blackening only on the interior.[643] The decrease in proportion of interior blackening on the whole vessels suggests that interior blackening of internal red slip tegami is related to the top half of the vessel wall (that is, only the rim needs to be preserved to see it), whereas the increase in

[642] Period 2's two examples (which are 40˚ and 60˚) have a mean of 47.5˚, but this is clearly not significant.
[643] There is not quite a significant correlation between interior and exterior blackening: $\chi^2=3.28$ (p=0.07).

proportion of exterior blackening suggests that blackening is related to the lower half of the vessel.[644] The location of blackening can be isolated to examine these trends further.

Table 30. Locations of blackening on internal red slip tegame rims and whole vessels

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	9	6
2	Single patch on belly	2	11
3	Double patch on belly	2	-
4	Around top of rim	11	9
5	Around top of vessel, below rim	7	2
6	Around bottom of vessel and on base	-	6
7	Forming a ring on base	-	1
8	Completely covering base	-	2
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	2	12
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

There are several strong associations in these patterns of blackening. Exterior blackening over the entirety of the vessel (location 10) is strongly correlated with interior blackening at the vessel's rim (location 4).[645] It should be noted that eight of the examples of location 10 may in fact be location 4 because the vessel wall in these instances is not preserved all the way down to the base. Four examples, however, are definitively completely blackened on their exterior. One of them, MUS 4975, is a nearly-complete tegame which will be examined further below (Figure 59, Figure 60). Another significant relationship appears between interior blackening along the rim (location 4) and exterior blackening along the rim (location 4).[646]

Finally, the only other relationship present among the rims and whole vessels is between interior swath of black (location 1) and exterior blackening just below the rim (location 5).[647] In reality, because of the low walls of the tegame form, locations 1 and 5 are very similar positions to each other. The origin of these patterns will be elucidated below, together with an examination of base fragments of this vessel type.

[644] This will be articulated further in the section on bases of internal red slip tegami below.
[645] Five fragments have both: $\chi^2=11.57$ ($p=0.001$).
[646] $\chi^2=4.33$ ($p<0.05$)
[647] $\chi^2=3.74$ ($p=0.53$)

Figure 59. Internal red slip tegame with exterior blackening in location 10 (MUS 4975)

Figure 60. Internal red slip tegame with interior blackening in location 4 (MUS 4975)

The opacity of the blackening on these vessels is suggestive of consistent use through time. The interiors of these fragments are mostly opacity of type 2 “obviously darkened, but vessel color still visible” and slightly less of type 3 “vessel color is barely discernible” (Figure 61). There is only one example of interior blackening with powdery residues (score 5), which occurs in Period 8. On the exterior of the vessels, opacity is similar in each period and also relatively equal across the different scores.

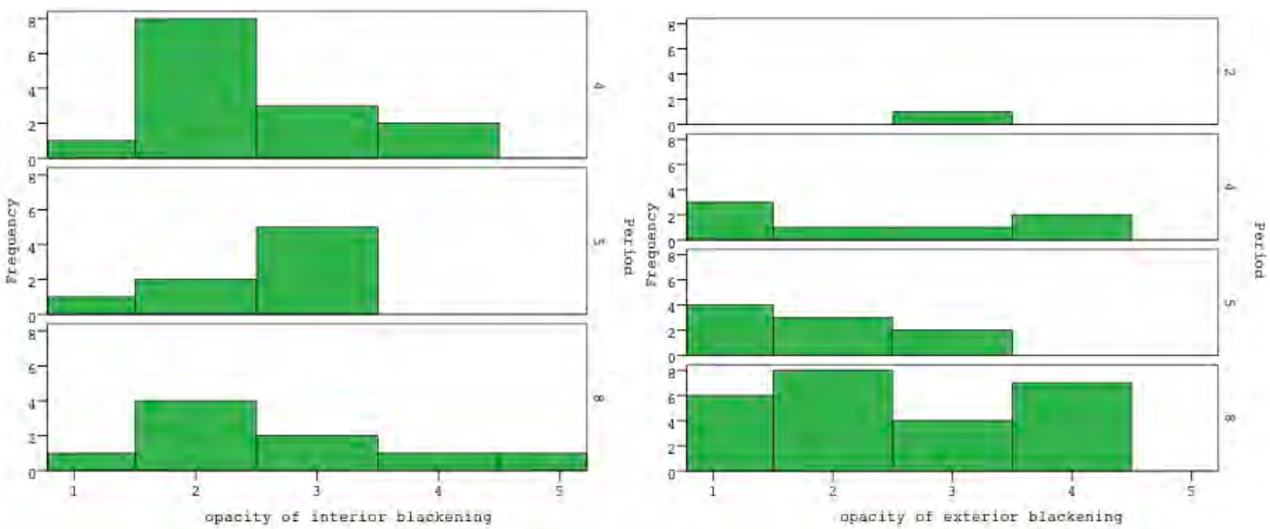

Figure 61. a) Interior opacity of blackening on internal red slip tegami; b) Exterior opacity

There is no correlation between vessel size or angle of opening and the likelihood of any particular type of blackening. This is potentially because of low sample sizes (n=43 vessels with exterior blackening of any kind); however, a lack of correlation between size and blackening may simply result from consistency of use of internal red slip tegami, regardless of their size.

Alteration: Abrasion

Out of the 92 tegami rims and whole vessels in internal red slip, 63% (n=58) have interior abrasion and 13% (n=12) have exterior abrasion. Only three (3%) fragments have abrasion both on their interior and exterior (Table 31).[648] The high percentage of abrasion in the interior of these vessels is likely due to the easier visibility of scratches in slip, relative to the difficulty of identifying abrasion of un-slipped ceramic surfaces of *ceramica*

[648] This demonstrates that there is not a strong correlation between abrasion on the interior and the exterior.

da fuoco.[649] It may also be that slipped surfaces are more susceptible to abrasion leaving a mark.[650]

Table 31. Location of abrasion on internal red slip tegami

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	6	4
Abrasion on wall	30	3
Abrasion on rim	44	5

There is a relationship between interior and exterior base abrasion, since 3 fragments have both.[651] Otherwise, none of the other locations of abrasion are statistically associated with each other.

On the rim interior, the large majority of abrasion marks are either chordal or concentric scratches (10 and 32 respectively). There is, therefore, a strong likelihood that rim abrasion is concentric.[652] On the interior wall chordal and concentric scratches appear in equal numbers (n=11).[653] Concentric abrasion might be attributable to stirring or to rotating of the tegame while handling its contents; chordal abrasion on the rim and wall may be attributable to stirring or flipping the interior contents.

[649] 92% of these fragments were assessed to have "sharp" fracture edges, and the remaining 8% "slightly rounded" suggesting very minimal post-depositional disturbance. Likewise, only 27% of the fragments had any mineral encrustations and 80% of these are less than 30% covered.

[650] See the discussion in chapter 6 regarding the visibility of abrasion on slipped surfaces of black gloss vessels.

[651] $\chi^2=32.17$ ($p<0.01$)

[652] For concentric scratches on the interior rim, the χ^2 value is 14.95 ($p<0.01$).

[653] For chordal scratches, $\chi^2=5.37$ ($p<0.05$) and for concentric scratches, $\chi^2=12.35$ ($p<0.01$).

5.2.4.2. Tegame bases

Morphology

There is no significant difference in the size or distribution of base diameters between any of the four periods (Table 32).[654] All are distributed between 7 cm and 30 cm. There is also not as distinct of a division in size groups between "small" and "large" evident in the bases as in the rims; however, the sample size is too small for statistical tests to be significant (Figure 62).

Table 32. Base fragments of internal red slip tegami

Period	Frequency	Percent	Mean (cm)	Median (cm)
2	1	3.3	19	19
4	10	33.3	15.22	14
5	5	16.7	19.2	17
8	14	46.7	15	13.5
Total	*30*	*100.0*	*15.93*	*14*

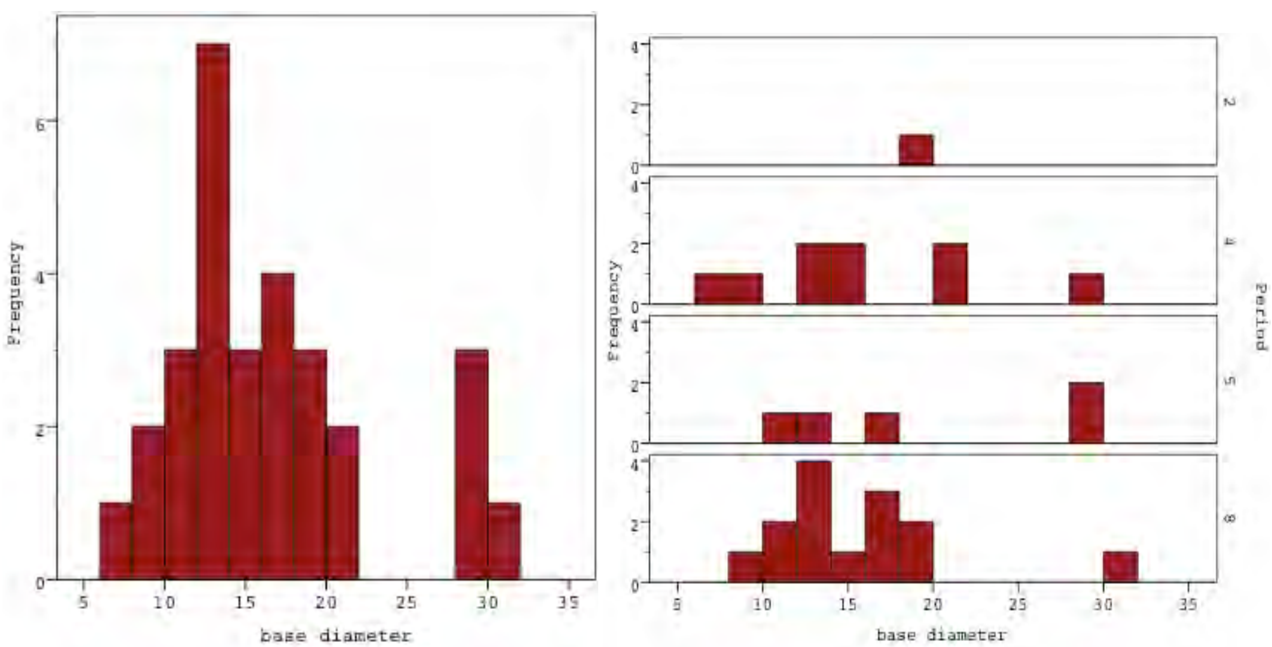

Figure 62. a) Diameters of bases of all internal red slip ware tegami; b) Bases divided by period

There is little variation in base angle, defined as the orientation at which the floor of these tegami attaches to the wall of the vessel. This is to be expected given the similarity of the

[654] This is determined using a Kruskal-Wallis test.

rim angles of these vessels. Base angles average from 130˚ to 137˚ by period, with medians from 120˚ to 140˚. There is also little variation in the thickness of the base wall or floor which each period medians being between 7.6 mm and 5.6 mm (Figure 63).

Figure 63. Base fragment of internal red slip tegame

Alteration: Blackening

Fire damage on internal red slip tegame bases appears mostly on the vessels' exterior. Of the 30 bases, 23 have exterior blackening (77%) and 8 have interior blackening (23%). All of the latter also have exterior blackening (Table 33).[655]

Table 33. Location of blackening on internal red slip tegame base fragments

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	1	-
3	Double patch on belly	-	1[656]
4	Around top of rim	1[657]	-
5	Around top of vessel, below rim	-	-
6	Around bottom of vessel and on base	-	4
7	Forming a ring on base	-	5
8	Completely covering base	2	8
9	Entirety of vessel not including lower wall and base[658]	-	2
10	Entirety of vessel[659]	2	3
11	Patch in center of base (inverse of 7)	1	2
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

[655] $\chi^2=3.32$ ($p=0.068$). This significance value is lowered by the fact that 7 fragments have no blackening at all.
[656] This is MUS 5572 from Period 8 (SU 635008), a tripod cooking pan which has patches of black only at the top of its legs.
[657] This is MUS 2049 from Period 8 (SU 511001) and is nearly whole. Only the tip of its rim is not preserved to create the whole profile.
[658] This is estimated/extrapolated in most of these circumstances, since the rim is not preserved to confirm that blackening goes all the way to the vessel opening.
[659] This is estimated/extrapolated in most of these circumstances, since the rim is not preserved to confirm that blackening goes all the way to the vessel opening.

With the exception of one fragment, all of the fragments (n=23) that have exterior blackening are blackened on their undersides, that is, on their exterior base floor. The seven fragments that do not have any exterior base floor sooting can be explained by preservation factors. Six have 1.5 cm or less of their base floor preserved, suggesting that the area in which they were blackened may not be present. They could be blackened in an off-center patch (location 2 or 3) or in location 11, in the center of the base exterior.[660]

There is no significant change over time in the type of blackening at Musarna. There is no correlation between vessel size or angle, and the presence of blackening. The only correlation between interior and exterior blackening on these bases is between location 8 on the interior and exterior. Only two examples are completely black on their interior floor are also completely black on their exterior. One, MUS 5519, has black powdery residue on its interior from burnt food while its exterior is classed with an opacity score of 4 "surface is totally opaque black, but no excess material." This suggests that the vessel was repeatedly used, and at least in its last few uses, it was placed above an overly-hot heat source (Figure 64). The other example, MUS 4919, has an interior of score 4 and a much lighter exterior of score 2 "obviously darkened, but vessel color still visible" (Figure 65).

Figure 64. Internal red slip tegame base with an interior opacity of 5, exterior opacity of 4 (MUS 5519)

[660] The seventh fragment, which does not show any exterior blackening at all, is quite anomalous. It is a large fragment (20 cm^2), with a lot of base floor preserved (4 cm), yet has no trace of abrasion or blackening. The vessel may never have been used, never used for cooking, or was placed directly in charcoal. This position, however, seems unlikely given the form of the vessel and the rest of the vessels in this sample.

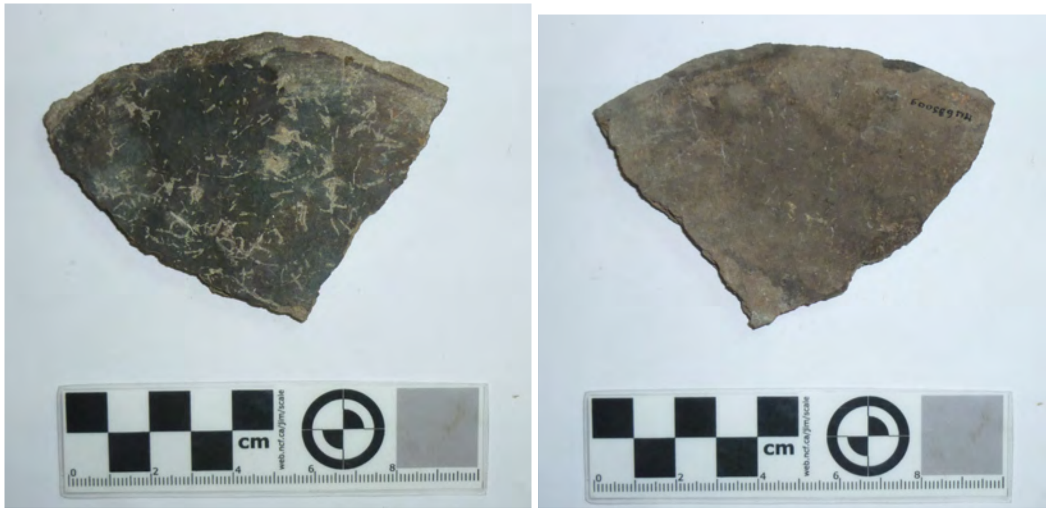

Figure 65. Internal red slip tegame base with an interior opacity of 4, exterior opacity of 2 (MUS 4919)

Alteration: Abrasion

Out of 30 internal red slip tegame bases, eight have abrasion on their interior and eight on their exterior (27% each). Only two examples have some form of abrasion on both their interior and their exterior (Table 34).

Table 34. Location of abrasion on tegame bases

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	7	8
Abrasion on wall	1	-
Abrasion on rim	-	-

Of the interior abrasion, four of eight are distinct chordal scratches, and two are radial scratches which cut through the internal red slip. The sample sizes here are too low to determine the correlations between any one type of scratch and its location on the vessel.

5.2.4.3. Semi-diagnostic fragments

Internal red slip tegami are a relatively easily-identifiable vessel form and, as we have seen, part of a standard category of Roman ceramics. This has meant that it is straightforward to identify the body sherds of this class and understand where in the vessel they originate. This is especially the case for flat base fragments since they are slipped only on their interior, and often their slip has a concentric ring quality which makes it possible to orient fragments within the vessel. As a result, I have additional fragments on which it is possible to apply alteration analysis.

There are 13 semi-diagnostic internal red slip base fragments. Diameters cannot be measured for any of them, since their diagnostic edges are not preserved; however, the average preserved surface area is 30 cm^2 and the median is 25 cm^2, so the fragments are substantial enough to allow alterations to be visible. One of these fragments has some blackening on its interior (a very faint off-center patch in location 11) and 54% (n=7) have black on their exterior (Table 35).

Table 35. Location of blackening of internal red slip semi-diagnostic bases

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	-	1[661]
3	Double patch on belly	-	-
4	Around top of rim	-	-
5	Around top of vessel, below rim	-	-
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	2
8	Completely covering base	-	3
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	-	-
11	Patch in center of base (inverse of 7)	1	2
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

These fragments emphasize further the elevation of internal red slip tegame over the fuel source by their prevalence of exterior floor blackening. The opacity of the exterior blackening is all between 2 and 3, suggesting moderate use.

None of these semi-diagnostic fragments have abrasion on their exterior, but nine out of 13 (69%) have some interior abrasion. Three of these have radial scratches, three have chordal scratches, one has concentric, and two have patches of removed slip, both of which are described in the database notes as pock marks in the slip all over the interior base floor. All of the fragments with linear abrasions have multiple scratches (two to four) of varying lengths, as little as 1 cm long, and as much as 4 cm long (Figure 66, Figure 67). These suggest brief repetitive strikes, rather than some sort of repeated cutting motion.

[661] This is not a patch "on belly" but it is too off-center and irregular to label it location 11.

Figure 66. Radial gouge in internal red slip base (MUS 2450)

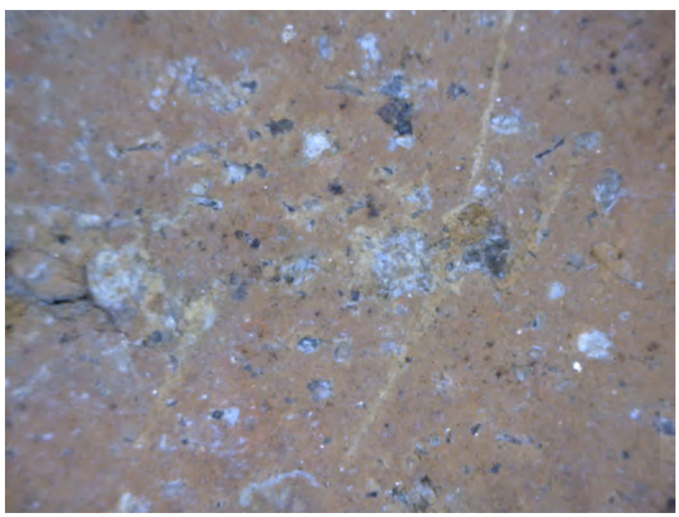

Figure 67. Four 2 cm long radial and chordal scratches at 50x magnification (MUS 3865)

5.2.4.4. Pentole

Morphology

There are 15 pentole fragments in internal red slip ware. These represent an MNV of 14.[662] This is a highly unusual form in this ware, currently unattested in the literature on internal red slip ware pottery. Its singular appearance in Period 4 and 5, and substantial appearance in Period 8, suggests that it was produced starting in the latter half of the 2nd century BCE (Table 36).[663] Three of these are rims with horizontal handles, 2 of which are almost certainly from the same vessel. They all have a spherical shape with probably a rounded bottom (Figure 68). Instead, the common form of the 13 remaining rims and one whole profile fragment has a flat bottom with lugs at its base, and a straight diagonal wall (sitting at 45˚) (Figure 69).

Figure 68. Handled internal red slip pentola (MUS 4915)

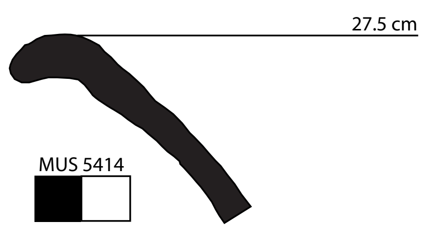

Figure 69. Typical internal red slip pentola at Musarna (MUS 5414)

[662] These fragments represent 3.49 EVEs.
[663] Strangely, it does not appear in the oft-referenced, but brief Leotta 2005. It may be produced only in the area around Musarna.

Table 36. Pentole rims and whole vessels in internal red slip

Period	Frequency	Percent	Mean (cm)	Median (cm)
4	1	6.7	21	21
5	1	6.7	25	25
8	13	86.7	25.62	24
Total	*15*	*100.0*	*25.27*	*24*

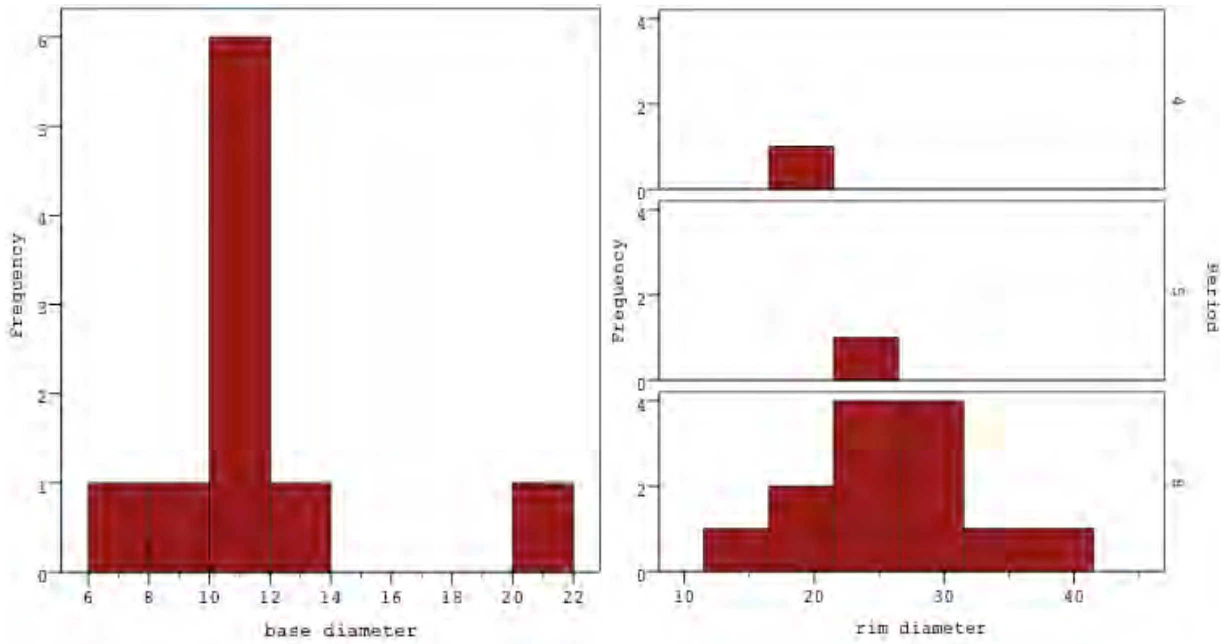

Figure 70. a) Diameters of internal red slip pentole rims; b) Diameters by period

Although the diameters of these vessels range in Period 8 from 14 cm to 37 cm, the majority are between 20 cm and 30 cm, with the mean and median at 25.6 cm and 24 cm, respectively (Figure 70). There is also little range in the angle of opening of these vessels, with the mean and median being 62˚ and 65˚, respectively. Similarly, the mean and median for the wall thickness just below the rim are both 8 mm. Three centimeters below they are both, 7.4 mm, and 6 cm below the rim, approximately 7.6 cm. This form is very homogeneous in Period 8.

Alteration: Blackening

Out of 15 examples, 7 have blackening on their interior, 6 on their exterior and 3 on both.

Table 37. Location of blackening on internal red slip pentole rims

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	1	-
2	Single patch on belly	2	1
3	Double patch on belly	-	-
4	Around top of rim	1	4
5	Around top of vessel, below rim	3	-
6	Around bottom of vessel and on base	-	2
7	Forming a ring on base	1	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	1	2
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

The samples sizes here are too low to understand a correlation between any two locations of blackening, or any connection between diameter and blackening.[664]

Alteration: Abrasion

Eight of the 15 penotle fragments have some abrasion on their interior, while 2 have some exterior abrasion and 1 has both.

Table 38. Abrasion on internal red slip pentole

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	2	-
Abrasion on wall	6	1
Abrasion on rim	4	1

The samples here are also too small to discern any association between the location of abrasion on these vessels. It is notable, like the examples of tegame above, that there is substantially more abrasion on the interior of the vessel than on the exterior. This is likely due to slip making scratches and pock marks more visible.

[664] Not to mention the homogeneity of the rim diameters.

5.1.4.5. Pentola Bases

Morphology

There are 10 bases of internal red slip pentole. Like the rims and whole vessels, they all come from Period 4 and Period 8 (Table 39).

Table 39. Base fragments from internal red slip pentole

Period	Frequency	Percent	Mean (cm)	Median (cm)
4	3	30	13.67	10
8	7	70	10.29	11
Total	*10*	*100*	*11.30*	*10.50*

All except one of these bases has a flat bottom and one to three lugs supports or stands at the edge of the base (Figure 71).

Figure 71. Internal red slip pentola bases with lugs

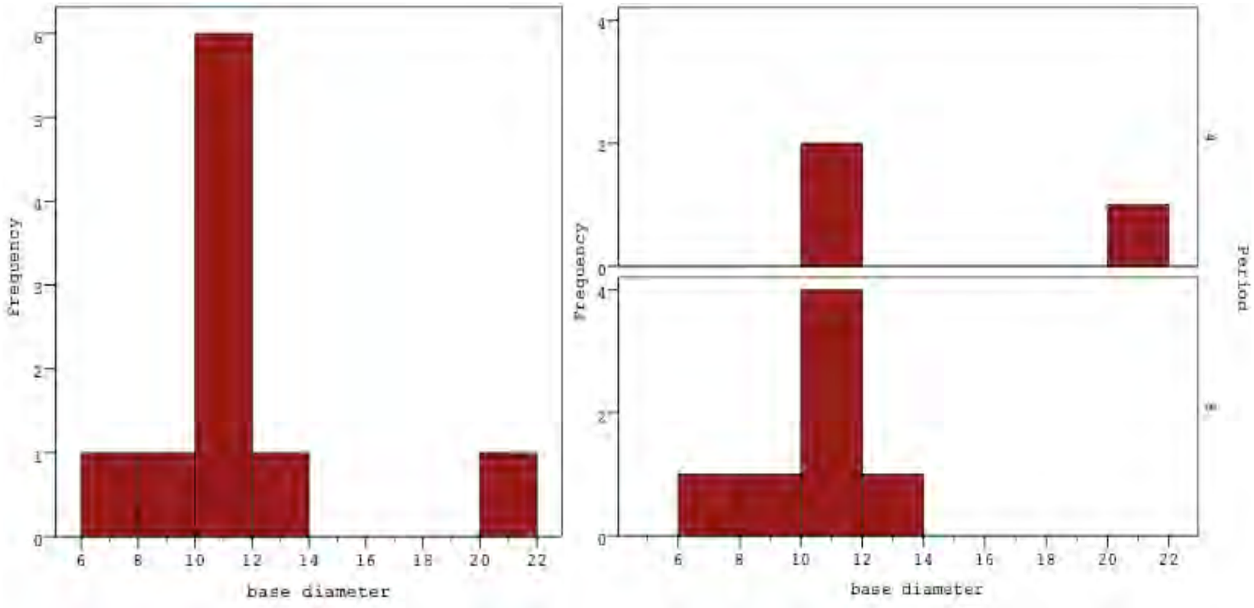

Figure 72. a) Diameters of internal red slip pentola bases; b) Pentola bases divided by period

There is little range in the other formal characteristics of these bases (Figure 72). Their angle of opening from their base floor ranges from 125˚ to 150˚, with the majority (n=7) being 130˚ to 140˚. The thickness of their vessel walls range from 6.4 cm to 10.8 cm, and their base floors range in thickness from 3 mm to 10 mm.

Alteration

There is no blackening or abrasion on the interior or exterior of these bases (Figure 73).

Figure 73. Internal red slip pentola bases MUS 5525 from Period 8; MUS 3866 from Period 4

5.2.5. Internal red slip observations

The data above illustrates several new findings about internal red slip wares. It is apparent that the tegame were elevated above the heat source and were sooted as a result. Elevation over a fuel source also explains the total exterior blackening of many of the rim and whole vessel fragments. The wide opening angle of this tegame form (from 115˚ to 160˚) and the vessels' low walls suggest that they would have easily become completely sooted.

The differences between these base floor blackening patterns (location 6, 7, 8, or 11 in my classification) may be a result of the height of the vessel over the heat source, as well as the type of device that raised the vessel. James Skibo's observations of the Kalinga's cooking methods in the Philippines noted that vessels elevated above the fire "especially if they have not been used many times" have distinct patches of exterior soot related to the structure of the cooking supports.[665] In his observations of vegetable and meat stewing pots placed on "three-stone" supports, soot was deposited in distinct patches along the lower sides of the vessel in between the supports and did not appear above the supports.[666] A sooting experiment, described in Appendix 3, I undertook helps to demonstrate the importance of cooking supports in producing exterior blackening patterns.[667]

Two examples from Musarna help illustrate how vessel stands my have been used in Roman cooking practices. The first, MUS 4975 (above), is a well-preserved tegame (80% of its 27 cm rim diameter intact) from Period 8. Its exterior is entirely opaque black (classed as score 4) but two or three faint rectangular patches are much lighter; they appear to have been not so consistently exposed to soot (Figure 74). They seem to be the shadows of a cooking stand of metal or ceramic.[668] It may have been U-shaped or had 2 or 3 separate supports.

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[665] Skibo 1992, 154.
[666] Skibo 1992, 154–155.
[667] Appendix 3: Experiment One, Test Two.
[668] See cooking stands of the 1st century CE, from Pompeii, for example: Dosi and Schnell 1986, 75; Stefani 2005, 85.

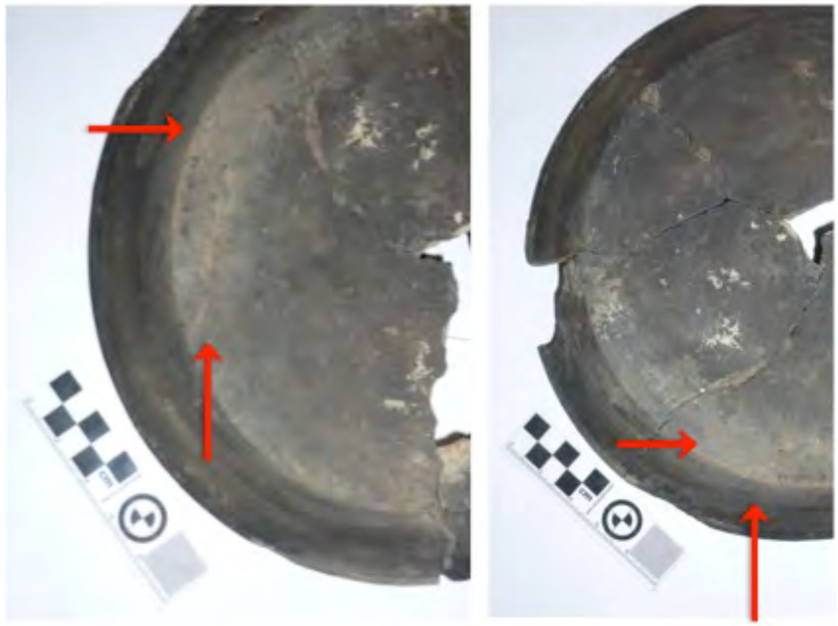

Figure 74. Internal red slip tegame (MUS 4975) with lighter patches of blackening on its base

Another singular example of possible cooking support evidence is seen on MUS 5054. The rim of this vessel is 13.5 cm in diameter and its rim together with its profile is 65% preserved. The tegame has a curved wall and horizontal everted rim. It has exterior blackening on its whole base and along its lower wall (location 6) and along the top its rim (location 4). On one side of its exterior wall, there is a 9 cm^2 rough patch where the vessel surface has been abraded. It is possible that this is the wear from a hanging device to elevate the pot above a cooking fire (Figure 75).

Figure 75. Internal red slip tegame with exterior abrasion possible evidence for cooking support (MUS 5054)

These tegami, made and used in two sizes throughout Musarna's republican history, do not exhibit much variation in their alteration. They seem to have been used in similar ways over time. The appearance of the unusual pentola form of the internal red slip vessel in the mid-2nd century has interesting implications for understanding cooking practices. The few examples (in the rim data set) of blackening seem to confirm that they did come into contact with fire. The infrequent blackening on the base of these vessels (there are only two examples which have exterior base blackening) suggest that they (like *ceramica da fuoco* ollae, and perhaps pentole) were set in a charcoal bed. The small lugs at the base of these pots do not seem to have an obvious functional purpose except possibly to aid in carrying the vessel when it was not hot. It may be then that the production and use of red slip pentole was a stylistic statement on the part of an innovative potter or consumer.

5.2.6. Conclusions

Over time, cooking wares at Musarna overall show a similarity of use but several changes in form. The results of the alteration analysis demonstrates that the methods of cooking with *ceramica da fuoco* vessels and internal red slip vessels remained consistent from the 3rd to the 1st centuries BCE. Ollae were typically placed in charcoal and often were lidded. Pentole and ollae were used to heat and cook foods. Jugs of *ceramica da fuoco* fabric bear no evidence for the heating of food; but rather, would have heated water. Internal slip ware tegami show evidence, though minor, of tool use by its internal abrasion on its slip. The frequent exterior blackening on the bases of tegami demonstrates that they were elevated over a heat source, either charcoal or an open fire. Both abrasion and blackening patterns suggest that tegami at Musarna were not used for baking in an oven. Although Michel Bats and others have understood this form to be a baking dish as well as a "*faitout*" or "stew-pot,"[669] the material from Musarna does not support baking. Though it has not been demonstrated experimentally, my anecdotal observation of traditional pizza baking in a wood-burning oven suggests that though a fine layer of soot may appear on the surface of the vessel on some unusual occasions, the exterior base of the vessel (or the bottom of the pizza) would not be sooted.[670] Instead, tegami of internal red slip seem to have been used for frying or sautéing foods over high heat. The low walls of this form mean that it was not appropriate for foods with a great deal of liquid content, like stews.

Despite this uniformity in cooking technology, the form of these vessels does change in small ways over time at Musarna suggesting a change in food preparation. Firstly, we have already considered some of the reasons for a shift towards a larger variety of ollae vessel sizes with an increase in larger sizes. There may have been an increased need to prepare large portions of food for larger groups or there was a shift in preparing more liquid foods, that is, stewed or boiled. This change should be understood in concert with internal red slip vessels. Internal red slip tegami, appearing in two size groups in each period, but with little alterations to distinguish these sizes, display a marked consistency in form and size. This may mean that there was not, in fact, a shift away from drier, non-stewed, foods as the ollae could suggest; rather, frying or sautéing occurred before and after ollae increased in size. The introduction of the internal red slip pentola at the same time as the increase in olla size, however, may suggest that there was a larger repertoire of stewed or liquid foods which required new or alternative cooking equipment leading to the addition of the pentola. The uniqueness of this pentola type to Musarna could be an indication of some local recipe; however, it is more likely that the role and function of the

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[669] Bats 1988, 67–69.
[670] Furthermore, this layer of soot would likely be what David Hally classes as "free carbon" and not likely to remain on the vessel in archaeological circumstances. See chapter 3.

internal red slip pentola was accomplished with a different, but similar open-form vessel elsewhere.

5.3. Populonia

The previous analyses will now be repeated based on the ceramics recovered from Populonia.

5.3.1. *Ceramica comune da fuoco*

Ceramica da fuoco vessels occur in Populonia in the same vessel forms as at Musarna: pentola, olla, tegame, and bowls as well as several types of lids and the cooking bell, the clibanus. As discussed in Chapter 4, I analyzed 777 total rim fragments from Populonia; these seem to represent a minimum number of 763 vessels and the equivalent of 35.34 vessels.

5.3.1.1. Pentole

Morphology

The collection of pentole consists of a rather small sample of 36 rims and no whole vessels. These represent 34 MNVs and a total of 2.9 EVEs. They only occur in Period 7 (150-100 BCE) and Period 9 (100-1 BCE). Rim diameters range between 11 cm and 33 cm, with an overall mean of 21.61 cm and median of 23.5 cm (Table 40, Figure 76). There is very little difference in the distribution of rim diameters in the two periods.

Table 40. *Ceramica da fuoco* pentole

Period	Frequency	Percent	Mean (cm)	Median (cm)
7	24	66.7	21.83	24.5
9	12	33.3	21.17	20
Total	*36*	*100.0*	*21.61*	*23.5*

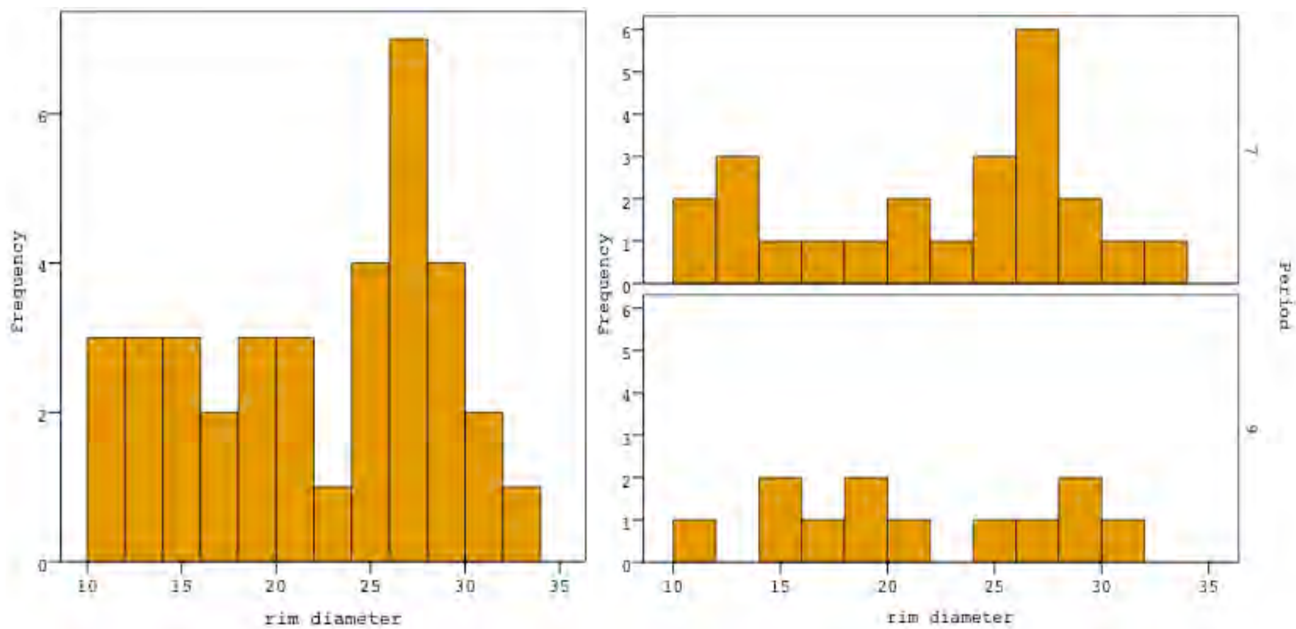

Figure 76. a) Diameters of all pentola rims at Populonia; b) Diameters of pentole by period

The wall thickness and wall angles of pentole also do not change significantly over time (Figure 77).

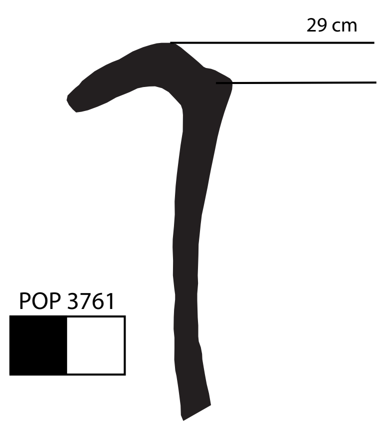

Figure 77. Typical pentola form at Populonia

Alteration: Blackening

Of the 36 pentola rims, 67% of the have interior blackening of some kind, 83% have blackening on their exterior, and 64% have both, demonstrating a strong relationship between interior and exterior blackening (Table 41).[671]

Table 41. Location of blackening on pentole from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	1
2	Single patch on belly	3	2
3	Double patch on belly	-	-
4	Around top of rim	10	17
5	Around top of vessel below rim	1	5
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	10	8
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

There is a strong relationship between the presence of blackening in several different locations on these pentole. Location 2 on the interior of the vessel is associated with the same location on the exterior.[672] Location 5 on the interior and the exterior are also strongly associated.[673]

[671] $\chi^2 = 8.1$ ($p<0.01$)
[672] $\chi^2 = 4.81$ ($p<0.05$)
[673] $\chi^2 = 6.38$ ($p<0.05$)

Figure 78. Pentole with exterior blackening in location 4 and 1 (POP 168)

The presence of blackening on the interior of the vessel is negatively correlated with vessel size or diameter. That is, for each centimeter that the diameter decreases, the likelihood of some type of interior blackening increases by 18%.[674] This might mean that smaller vessels have longer contact with fire or with a hotter fuel source which caused foodstuff contained in them to char. Such a correlation does not occur in the pentole at Musarna and suggests that Populonian pentole may have been used differently. Otherwise, there is no correlation between the appearance of blackening and other vessel qualities.

Examination of the opacity of blackening yields no differences over time. The opacity score of the interior of the vessels in both periods is centered on 2 "obviously darkened, but vessel color still visible." The opacity on the exterior of these pentole is mostly 3 "vessel color is barely discernible."

Alteration: Abrasion

Thirty-one percent (n=11) have abrasion on the interior, whereas only one has abrasion on its exterior, and none have both (Table 42).

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[674] Expβ=0.82 (p=0.014)

Table 42. Location of abrasion on pentole

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	-	-
Abrasion on wall	1	-
Abrasion on rim	10	1

A possible reason for the low amount of wall abrasion relative to rim is that 53% of these rim fragments are preserved to a height of 3 cm or less, thus they do not have a lot of wall to assess. The prevailing direction of abrasion is concentric, with interior rim abrasion having a strong association with concentric scratches.[675]

Interior abrasion is positively correlated with diameter. This means that as the rim diameter increases by 1 cm, the likelihood of abrasion on the interior increases by 18%.[676]

Likewise, interior abrasion is negatively correlated with rim angle: as angle decreases by 1 degree (that is, as the rim becomes more vertical), the likelihood of abrasion on the vessel interior increases by 3%.[677] This is a low enough percentage it may be meaningless.

5.3.1.2. Ollae

Morphology

There are 68 rims classed as ollae in the sample from Populonia. These represent an MNV of 64 and 8.52 EVEs (Table 43). They range in rim diameter from 6 cm to 26 cm (Figure 79). Their size is very consistent over time, since their diameters in each period cluster around 15 and 20 cm. There is also no significant change in the thickness of their walls.

Table 43. *Ceramica da fuoco* ollae at Populonia

Period	Frequency	Percent	Mean (cm)	Median (cm)
5	4	5.9	16.50	16.50
7	49	72.1	14.90	15
9	15	22.1	15.27	14

675 χ^2= 7 ($p<0.01$)
676 Expβ=1.182 ($p<0.05$). Given the prevalence of interior rim abrasion in particular, when we perform this calculation on just interior rim abrasion, it is also positively correlated with rim diameter: Expβ=1.17 ($p<0.05$).
677 Expβ=.970 ($p<0.05$). Given the prevalence of interior rim abrasion in particular, when we perform this calculation on just interior rim abrasion, it is also highly negatively correlated: Expβ=0.96 ($p=0.013$).

Total	*68*	*100.0*	*15.07*	*15*

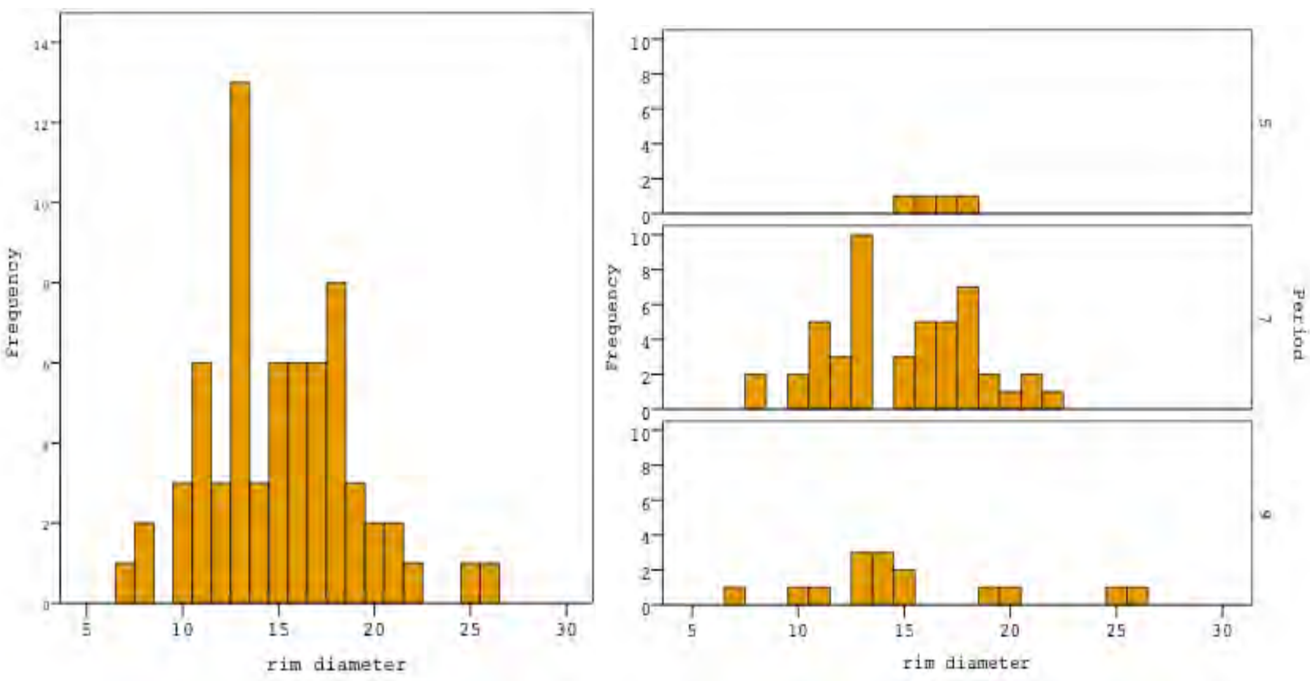

Figure 79. a) Diameters of all olla rims at Populonia; b) Diameters of ollae by period

Despite the relatively low sample size from each period which may account for the perceived consistency in the measurements above, there is statistically significant change in the angle of opening of ollae at Populonia. Their rims are much more vertical in Period 5 (200-100 BCE) than in Period 7 (150-100 BCE) or Period 9 (100-1 BCE).[678] The median rim angle for Period 5 is 70˚; whereas in Period 7 and 9 it is 50˚. This result makes sense given what archaeologists have observed about pre-Roman olla forms. The two pots in Period 5 which have rim angles of 80˚ (POP 3596 and 3597) are ollae with large almond rims and have precedents in deposits of archaic Etruria and Latium (Figure 80).[679]

[678] Between Period 5 and Period 8, χ^2= 8.78, p<0.01. Between Period 5 and Period 9, χ^2= 6.38, p=0.012. This is determined using a Kruskal-Wallis test.
[679] Olcese 2003, 38.

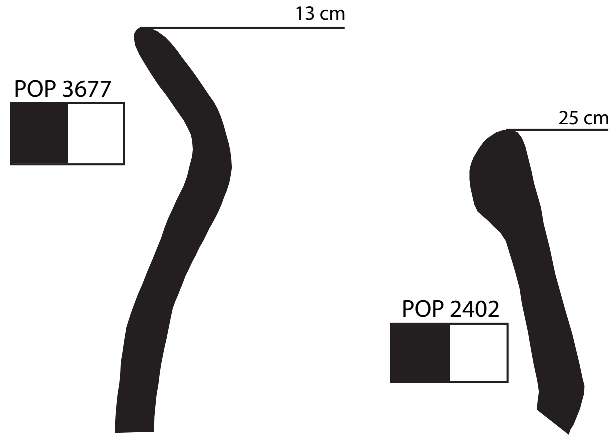

Figure 80. Variations in olla rims at Populonia

Alteration: Blackening

Eighty one percent of the ollae are blackened in some manner on their interior, while 84% are blackened on their exterior (Table 44). This means that 76% have blackening on their interior and exterior revealing a strong correlation between the two locations.[680]

Table 44. Location of blackening on ollae rims from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	3	2
2	Single patch on belly	5	6
3	Double patch on belly	-	-
4	Around top of rim	18	12
5	Around top of vessel below rim	18	11
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	20	28
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

The high frequency of blackening on olla rims is reflected in the strong relationship between several locations of blackening on these vessels. There is a significant relationship between blackening in location 2, a single patch on the vessel, on both its interior and its

[680] χ^2= 24.39, $p<0.01$

exterior.[681] Similarly, there is a relationship between location 4, along the rim, on the interior and the exterior, and between location 4 on the interior and the entire exterior blackened (Figure 81).[682] There is also a strong relationship between blackening in location 5 on the interior and entirely blackened on the exterior (Figure 82).[683] The size of the sample is insufficient to isolate individual periods and test for differences in the location of blackening between them.

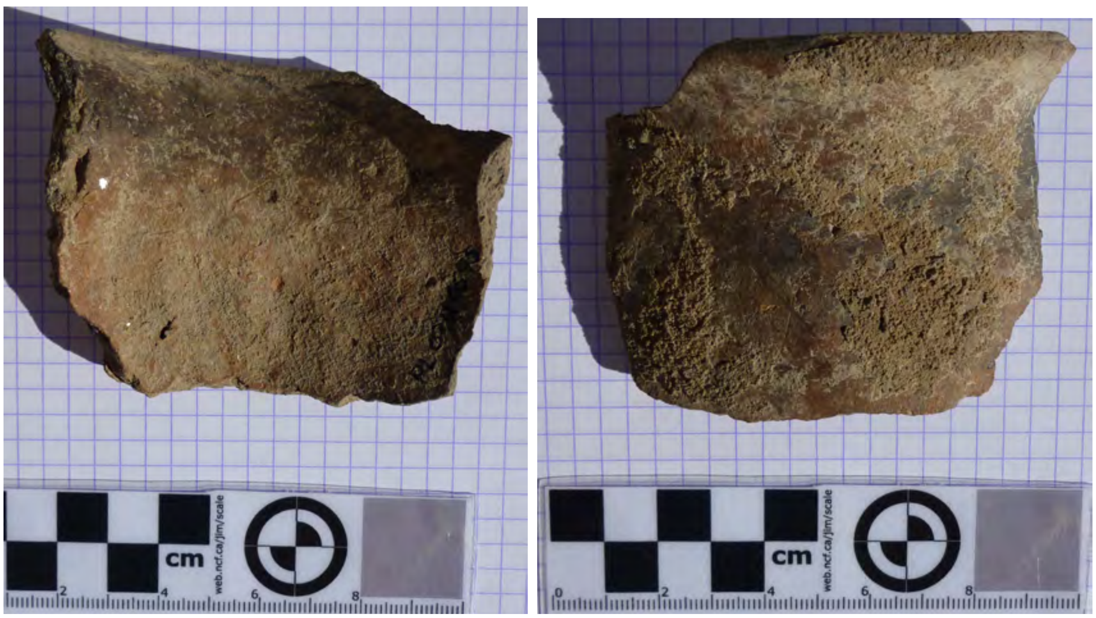

Figure 81. Olla blackened in interior location 4 and exterior locations 4 and 1 (POP 179)

[681] χ^2=6.52 (p=0.011)

[682] For location 4 interior and 4 exterior, χ^2=4.15 ($p<0.05$). For location 4 interior and location 10 exterior, χ^2=4.25 ($p<0.05$)

[683] χ^2=4.24 ($p<0.05$)

Figure 82. Olla with exterior blackening in location 10 (POP 3608)

There is a strong negative correlation between the diameter size of the ollae and the likelihood of blackening. It is a negative correlation. As the diameter of the vessel decreases by 1 cm, the likelihood that it will have blackening on its exterior increases by 15%.[684] Recall that this is a similar result to that observed on the pentole from Populonia. There is no correlation between the angle of the vessel opening and the appearance of blackening.

Regarding the opacity of the blackening, there is a significant difference in the opacity on the interior of the vessels between Period 5 and Period 9 and between Period 7 and Period 9, suggesting a gradual darkening over time (Figure 83).[685] This suggests that foodstuff were burnt more in the later periods. There is no difference in the distribution of opacity on the exterior of the vessels.

[684] The exponential β value is 0.85 and ($p>0.05$). This correlation exists even when I remove the high number of fragments with blackening on their entire exterior (location 10): Expβ=0.830 ($p=0.058$).
[685] Between Period 5 and Period 9, $\chi^2=9.624$ ($p<0.01$). Between Period 8 and Period 9, $\chi^2=4.66$ ($p<0.05$).

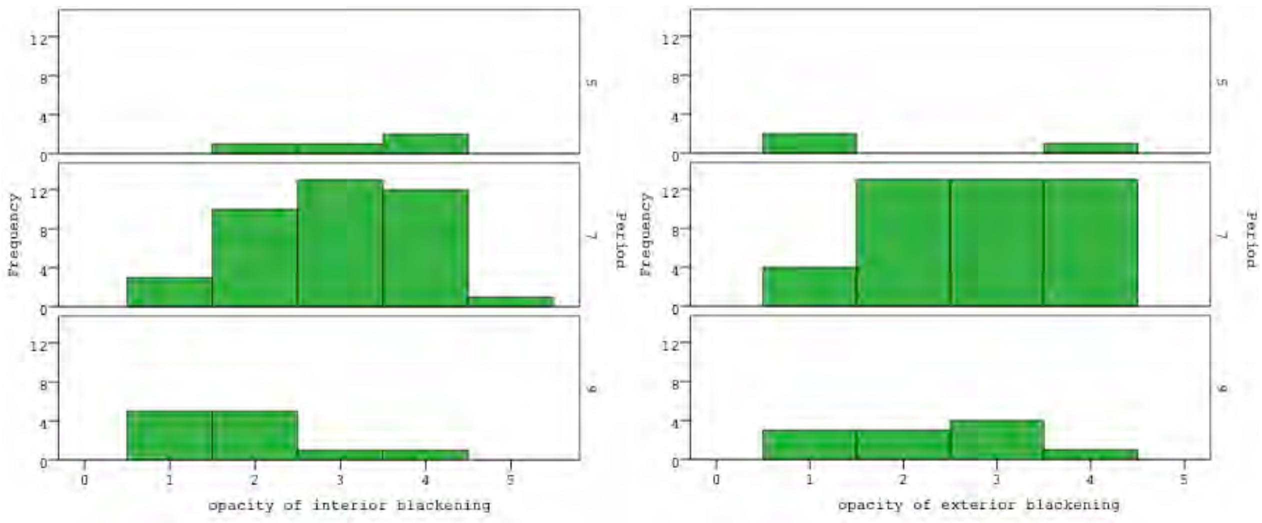

Figure 83. a) Interior opacity of blackening of ollae; b) Exterior opacity of ollae

Alteration: Abrasion

Turning to abrasion, only 4% of ollae have any sign of abrasion on their interiors, whereas 18% of them are abraded on their exterior; therefore, there is a low likelihood of either (Table 45).[686] This low frequency of abrasion observed may be due to the relatively high degree of mineral encrustation on these sherds. Sixty-three percent have some encrustation, 22% of these on the exterior are 30% to 90% covered. Forty-two percent of the fragments have crust on their interior which covers 30% to 70%. This heavy amount of mineral encrustation may be hiding some abrasion and makes the following observations inconclusive.

Table 45. Locations of abrasion on ollae at Populonia

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	-	-
Abrasion on wall	3	1
Abrasion on rim	-	11

The direction of all of the rim abrasion is concentric. There is no correlation between the appearance of abrasion and the size or dimension of ollae.

686 χ^2=68 ($p<0.01$)

5.3.1.3. Lids

Morphology

Sixty-five lid fragments from Populonia are either rim sherds or fragments of knob handles. Of these, only 54 have rims preserved more than 4% (Table 46). Comparing the distribution of rim diameters, Period 9 lids are significantly larger than Period 7 lids.[687] The mean and median in Period 7 are 24.70 cm and 24.50 cm; whereas in Period 9, the mean and median are 36.61 cm and 31 cm (Figure 84).

Table 46. Lids in *ceramica da fuoco* from Populonia

Period	Frequency	Percent	Mean (cm)	Median (cm)
5	1	1.9	32	32
7	30	55.6	24.7	24.5
9	23	42.6	36.61	31
Total	*54*	*100.0*	*29.93*	*28.50*

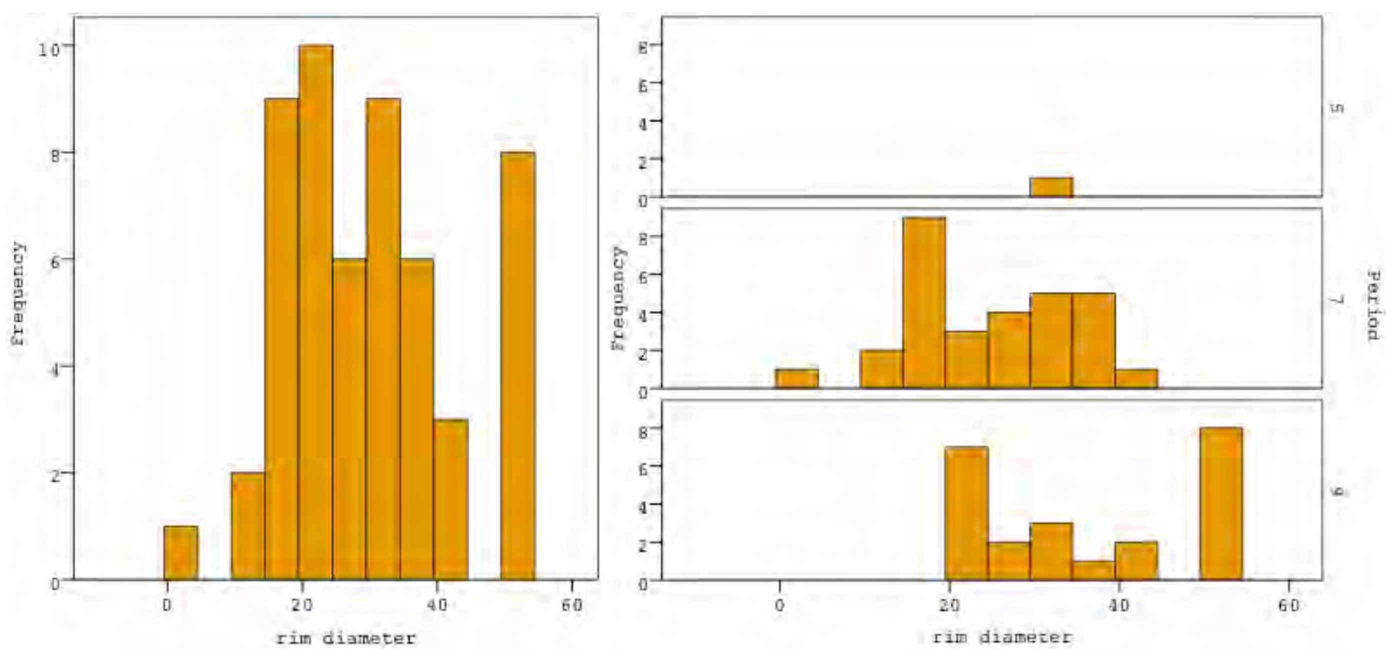

Figure 84. a) Diameters of lids in *ceramica da fuoco* at Populonia; b) Diameters of lids by period

The diameter size of these lids is well within the range of rim diameters for pentole and ollae at Populonia. There is no significant difference in the wall thickness or angle of recovered lids over time.

687 χ^2=9.44 ($p<0.01$)

Alteration

Fifty-seven percent (n=31) of these lids have blackening on their interior; whereas 59% (n=32) have blackening on their exterior and 50% (n=27) have both. This represents a very strong likelihood that if the lid is blackened on one side it will be blackened on the other.[688]

Table 47. Location of blackening on lids from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	5	5
3	Double patch on belly	-	-
4	Around top of rim	12	13
5	Around top of vessel below rim	5	7
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	-
8	Completely covering base	-	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	11	9
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

There are several strong associations between locations of blackening on lids. There is a strong likelihood that lids with location 2, a single patch, blackened on their interior with have location 2 blackened on their exterior.[689] Similarly, location 4 on the interior and exterior has a statistical relationship (Figure 85).[690] The opacity of the blackening on these lids is identical on the interior and exterior in each period with most given an opacity score of 2 “obviously darkened, but vessel color still visible.”

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[688] χ^2=23.36 ($p<0.01$)
[689] χ^2=16.86 ($p<0.01$)
[690] χ^2=21.89 ($p<0.01$)

Figure 85. Lid with blackening in location 4 on interior and exterior (not shown) (POP 3529)

Very few of these lid fragments have traces of abrasion visible. There are only nine examples of rim abrasion, three of which are concentric and the rest radial. Four lids have abrasion on their inner wall, two of which is concentric and the other chordal. Finally, there are five examples with abrasion on their exterior rim, all of which are concentric scratches.

5.3.1.4. Bases

Alteration: Morphology

As with the material from Musarna, it is not feasible to distinguish between bases of ollae and those of pentole, so they are treated here together (Figure 86). I recorded 65 base fragments from Populonia (Table 48).

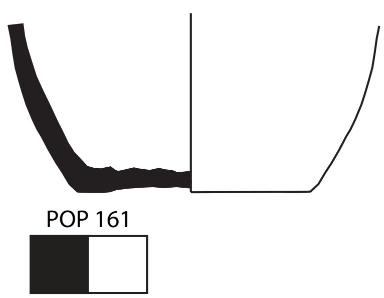

Figure 86. Base in *ceramica da fuoco* at Populonia

There is very little variability in the distribution of diameters of bases or their wall thickness over the different periods of interest at Populonia (Figure 87). There is likewise no significant difference between the angle of the wall of bases between different periods.

Table 48. *Ceramica da fuoco* bases at Populonia

Period	Frequency	Percent	Mean (cm)	Median (cm)
5	2	3.1	22	22
7	41	63.1	11.88	10
9	22	33.8	13.23	10
Total	*65*	*100.0*	*12.68*	*10*

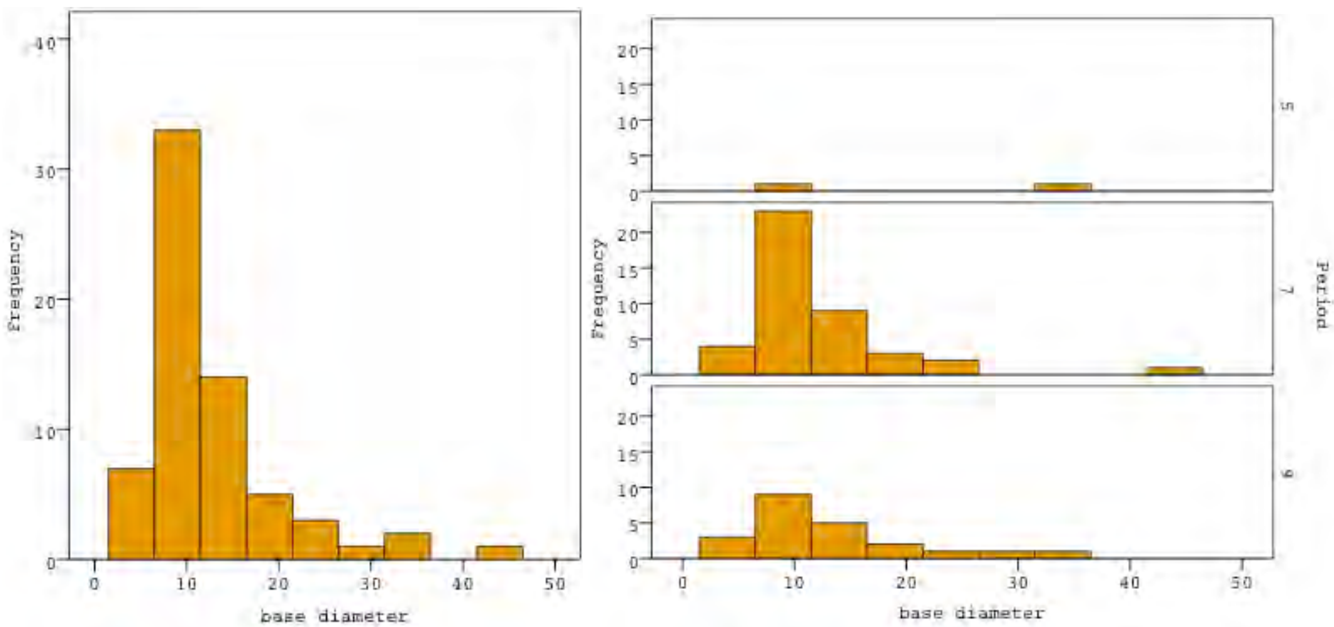

Figure 87. a) Diameters of all *ceramica da fuoco* bases at Populonia; b) Diameters of bases by period

Alteration: Blackening

Sixty-eight percent of these bases are blackened on their interior, 83% on their exterior, and 61% on both.[691] This is likely because these bases are a mix of olla and pentola bases, which seem to have different base blackening patterns from each other.[692]

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[691] χ^2=3.143 (p=0.079). This does not quite represent a strong relationship between the two.
[692] See 5.1.2. Discussion above.

Table 49. Location of blackening on *ceramica da fuoco* bases from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	2	1
2	Single patch on belly	4	8
3	Double patch on belly	-	-
4	Around top of rim	-	-
5	Around top of vessel below rim	-	-
6	Around bottom of vessel and on base	-	7
7	Forming a ring on base	6	6
8	Completely covering base	9	9
9	Entirety of vessel not including lower wall and base[693]	2	2
10	Entirety of vessel[694]	25	17
11	Patch in center of base (inverse of 7)	1	4
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

There is a strong relationship between several locations of blackening on the vessel bases (Table 49). Location 1 on the interior is strongly associated with location 1 on the exterior and with location 9 on the exterior.[695] Location 9 on the interior is similarly associated with location 9 on the exterior and with location 1 on the exterior, demonstrating a high frequency of bases with no blackening on their interior or exterior floors.[696] Location 7 on the interior, that is, a ring of black, has a strong relationship with location 7 on the exterior.[697] Location 8 on the interior is also strongly associated with location 6 on the exterior.[698] Finally, location 11 on the interior, that is, a central patch of black on the vessel floor, has a strong association with location 2 on the exterior.[699]

Several trends in the locations of blackening in different periods are noteworthy. Significantly more fragments are completely covered in black on their interior (location 10) in Period 7, than in Period 9.[700] There are also significantly more examples of blackening in

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693 This is estimated/extrapolated in most of these circumstances, since the rim is not preserved to confirm that blackening goes all the way to the vessel opening.
694 This is estimated/extrapolated in most of these circumstances, since the rim is not preserved to confirm that blackening goes all the way to the vessel opening.
695 Location 1 interior and Location 1 exterior, $\chi^2=31.92$ ($p<0.01$). Location 1 interior and Location 9 exterior, $\chi^2=15.24$ ($p<0.01$)
696 Location 9 interior and Location 9 exterior, $\chi^2=15.24$ ($p<0.01$). Location 9 interior and Location 1 exterior, $\chi^2=31.99$ ($p<0.01$).
697 $\chi^2=13.11$ ($p<0.01$)
698 $\chi^2=5.54$ ($p<0.05$)
699 $\chi^2=7.24$ ($p<0.01$)
700 $\chi^2=4.06$ ($p<0.05$)

location 8 (completely blackened base) in Period 9 than in Period 7.[701] Otherwise, locations of blackening are relatively evenly-distributed throughout all the periods.

No correlation occurs between the size or shape of these bases and the likelihood on blackening.

Though the opacity of interior blackening is relatively similar in each period, exterior blackening varies in several periods. There is significantly darker blackening in Period 7 (a concentration of score 3, especially, and including score 5) than in Period 9 (where score 1 is much more frequent).[702]

Alteration: Abrasion

Only 5% of the bases have abrasion on their interior, whereas 43% show exterior abrasion (Table 50).[703] These vessels have little mineral encrustation and a high proportion of sharp edges; therefore, there is little interference with or masking of alterations in this sample.

Table 50. Location of abrasion on *ceramica da fuoco* bases from Populonia

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	2	27
Abrasion on wall	-	-
Abrasion on rim	-	-

Though the numbers are not statistically significant, there are several notable trends in the direction of abrasion on these bases. Thirteen out of 27 of the bases with abrasion on their exterior are classed as having concentric abrasion. A few of these examples are abraded in a concentric fashion on the edge of their feet (fig. POP 3701), but most are flat-bottomed vessels with abrasion on their external edges where the base floor meets the vessel wall. An additional 13 out of 27 bases have abrasion classified as a "patch" which range from 1 to 100 cm^2, but whose median is 4 cm^2 and mean is 15.38 cm^2. These are all flat-bottomed vessels whose external base floor is rough. The two examples with interior abrasion are patches, 4 cm^2 in size. Both seem to be pedestalled, meaning their inclusions protrude from

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701 $\chi^2=4.66$ ($p<0.05$)
702 $\chi^2=11.88$ ($p<0.05$)
703 Only 3% of these bases have both interior and exterior abrasion.

a worn down clay matrix. This suggests that their interior bases sustained repetitive rubbing likely from a stirring utensil like a spoon (Figure 88).

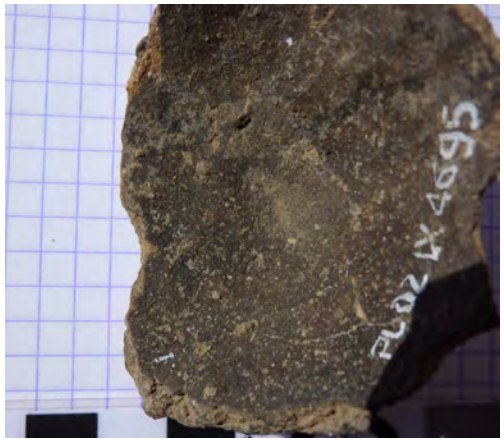

Figure 88. Interior pedestalling of base (POP 161)

5.3.1.5. Clibani

There is only one fragment of clibanus, or cooking bell, from Populonia. This has been identified by its flange, the only element of the vessel preserved. The flange suggests that the vessel is 30 cm in diameter, so it is within the range of clibani recovered from Musarna. In terms of alteration, like the examples from Musarna, this clibanus example has been given an opacity score of 1 "barely discernible darkening." This suggests minimal sooting of the exterior consistent with being covered directly with charcoal (Figure 89).

Figure 89. One clibanus from Populonia (POP 3712)

5.3.1.6. Tegami

Morphology

Only four tegame in *ceramica da fuoco* are preserved more than 4% of their diameter. Three are rim fragments, and one is a whole profile (Table 51, Figure 90). There are, however, an additional five sherds of different vessels which are preserved under 5%. These are bifid tegame, that is, they have a notch indented in the tops of their lip, and appear to be quite large in diameter (typically over 26 cm wide) (Figure 91). The following analysis, according to the convention adopted in this dissertation, will include only the four examples with 5% or more of the circumference preserved even while acknowledging that this sample size makes statistical testing inconclusive.

Table 51. *Ceramica da fuoco* tegami at Populonia

Period	**Frequency**	**Percent**	**Mean (cm)**	**Median (cm)**
5	1	25	27	27
7	2	50	20.5	20.5
9	1	25	25	25
Total	*4*	*100*	*23.5*	*26.5*

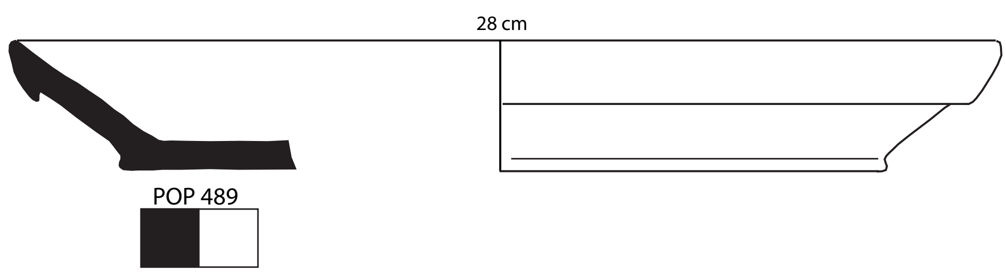

Figure 90. Tegame of *ceramica comune da fuoco* with its whole profile intact

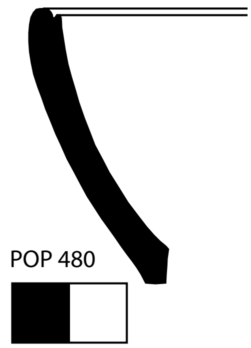

Figure 91. Bifid tegame of *ceramica comune da fuoco*, preserved less than 5%

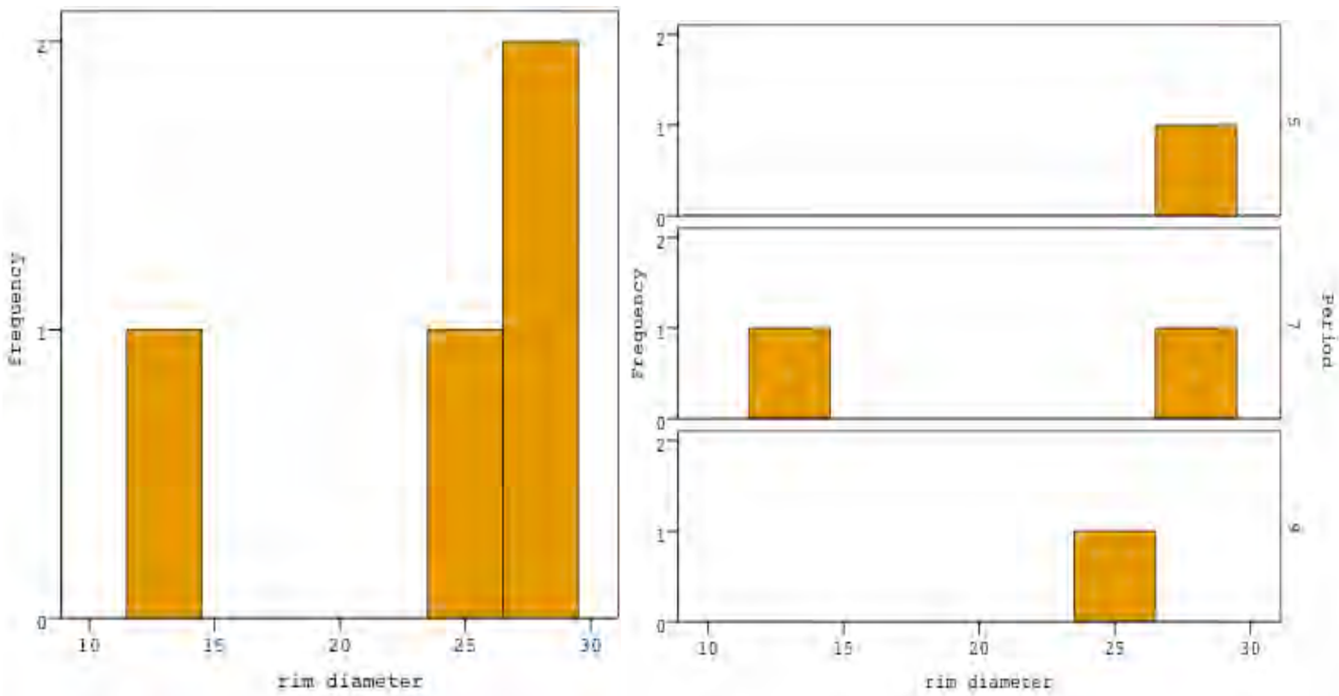

Figure 92. a) Diameters of *ceramica da fuoco* tegami; b) Diameters of tegami by period

Three of the four fragments range from from 25 cm to 30 cm (Figure 92). One example is much smaller – 13 cm (POP 157); however, its wall height is so poorly preserved (at 4 cm tall) that its identification as a tegame is questionable.

Tegame wall thickness appears to decrease over time, but this cannot be verified statistically. The angle of the walls of these tegame has a small range of 40˚ to 45˚ except one example from Period 7 which is substantially more vertical, at 75˚.

Alteration: Blackening

Again, the sample size precludes useful statistical analysis, but we can observe that 2 out of 4 fragments have interior blackening and all fragments have blackening on their exterior (Table 52).

Table 52. Location of blackening on tegame rims from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	-	-
3	Double patch on belly	-	-
4	Around top of rim	1	1
5	Around top of vessel below rim	-	1
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	1
8	Completely covering base	-	1
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	1	1
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

There are an insufficient number of tegami of ceramica da fuoco to see any further correlations between locations of blackening or vessel size or shape.

Alteration: Abrasion

There is only one abraded fragment which has concentric scratches on its exterior rim.

5.3.2. *Ceramica da fuoco* observations

The pentole and ollae from Populonia show similar trends in their blackening and abrasion as the same forms from Musarna, though a higher degree of masking from post-depositional factors may distort these numbers. There is a clear association between abrasion and pentola size at Populonia. As pentola rims become larger, they are more likely to have interior abrasion. This may be for similar reasons as those discussed for ollae at Musarna. Foodstuffs cooked in larger vessels, and therefore likely in larger quantity, seem to have called for more frequent or more vigorous stirring which left visible scratches. While the form of olla and the cooking of *puls* has been connected before because of Cato's evocation of the word "*aula*" in his recipe there is no need to associate what modern scholars call an olla with Cato's imagination, nor is it appropriate to consider Cato's designated pot an absolute requirement for cooking *puls* in an ancient Italian kitchen.[704] It is certainly possible that a porridge which required stirring was cooked in pentole at Populonia.

Interior blackening (but not exterior blackening) on pentole is negatively correlated with their size. This means that on larger pentole, soot was not rising high enough to mar the interior rim and food was not being charred on the vessels' interior walls. A possible explanation for this is that larger pentole are not used in as hot a fire. This is not to say that people in Populonia could measure the temperature of their wood or charcoal fires, but rather, the pentole were perhaps elevated away from the flame so as not to receive as much heat.

It is also worth restating the negative correlation between olla size and the appearance of exterior blackening. This may suggest that larger ollae were not consistently used for cooking, despite their "cooking fabric." Also worth noting is the change in opacity levels on the interior of ollae from Period 5 and 7 to Period 9. The darkening of blackening may suggest more frequent or long-term use, or indeed poorer cooking skill, since interior blackening results from charring of foodstuffs.

In terms of change over the periods of study, there is more consistency at Populonia than at Musarna. Ollae are consistent in size, though their rim angle changes slightly between Period 5 and Period 9: they become more horizontal or open. Though the change is statistically significant, the actual diferences are relatively minor; there is a 20° difference between the medians. It is not clear that this would be enough to make a functional difference in terms of stirring or access to the inner contents of the vessel. I do not posit, therefore, that such a change reflects a change in foodways.

The number of lids at Populonia is interesting. When we compare them to the number of *ceramica da fuoco* vessels (36 pentole, 68 ollae, and more than 4 tegami), the proportion of vessels to lids is about 2:1. In contrast, the proportion of vessels to lids at Musarna is about 5.4:1. Again, we might recall that a disproportionately lower number of lids than vessels on Roman sites is commonplace. It is possible that ceramic lids were more

[704] The problems of assigning ceramic names used in ancient cooking texts to specific archaeological forms and to limited cooking techniques is illuminated in Donnelly Forthcoming.

frequently employed for cooking at Populonia than at Musarna; however, the prevalence of location 4 blackening (a ribbon around the top of the rim) on the interior of vessels from both sites is indirect evidence for frequent lid use at both sites. The lower frequency of lids preserved from Musarna may simply be a matter of happenstance.

5.3.3. Internal red slip ware

5.3.3.1. Tegami

Morphology

At Populonia, vessels in internal red slip ware occur in the standard tegame form. Many have a heavy almond-shaped rim. These are very similar to examples from deposits in Bolsena of the early 1st century BCE.[705] There are 18 fragments in total in my sample: four have their whole profile preserved. This represents an MNV of 18 and 1.69 EVEs (Table 53). In Period 5 and Period 7, they seem to form two distinct size groups (Figure 93). The smaller group, at smaller than about 24 cm, corresponds to two relatively thin-walled forms, one a bifid vessel, and one a vessel with a small flange. The larger diameter group corresponds to the heavy almond rim form (Figure 94).

Table 53. Internal red slip tegame rims and whole profiles

Period	Frequency	Percent	Mean (cm)	Median (cm)
5	1	5.6	19	19
7	7	38.9	22	21
9	10	55.6	43.8	44
Total	*18*	*100.0*	*33.94*	*36.50*

[705] Specifically, Goudineau 1970, plate I, n.2, and plate VII, zone B, couche 3, n. 7 and n. 8.

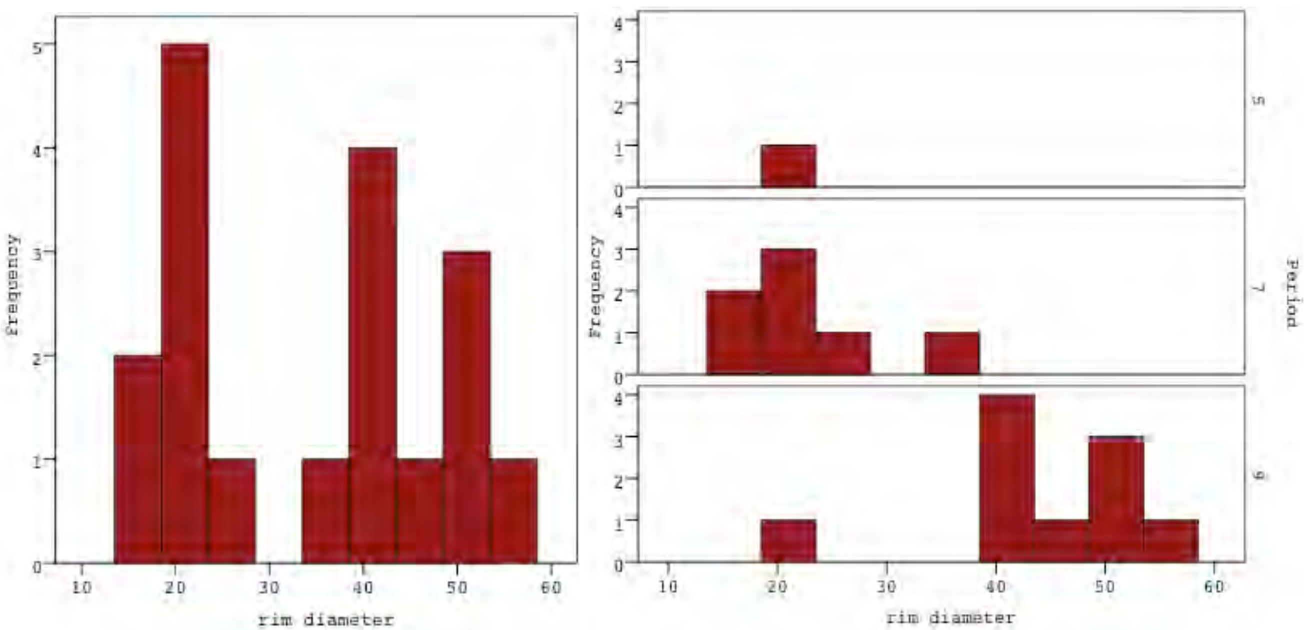

Figure 93. a) Diameters of internal red slip ware tegami; b) Diameters divided by period

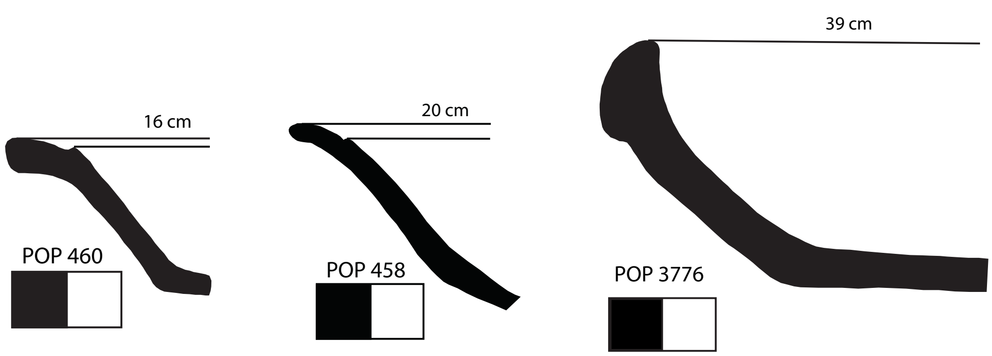

Figure 94. Internal red slip tegami at Populonia

There is a significant change in the diameter of these vessels over time since by Period 9 only larger-sized vessels were made.[706] Similarly for wall thickness, though two groups are still discernible in the size graph in Period 7 and Period 9, Period 9 tends towards thicker walls.[707] The angle of opening of these vessels is fairly regular across time.

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706 $\chi^2=5.91$ ($p=0.015$)
707 $\chi^2=10.49$ ($p<0.01$)

Alteration: Blackening

These tegami have significant evidence of post-depositional disturbance which likely masks a great deal of use alteration. Specifically, the accretion of large amounts of mineral encrustation which is probably anthropogenic, from mortar and plaster. Many of these fragments were re-used as wall covering, while several have holes drilled into them to affix them to a flat surface (Figure 95). Sixty-seven percent of these fragments are encrusted. On the interior, the majority are more than 40% covered in a thick accretional layer.[708] Meanwhile, 33% of the fragments have edges classed a "slightly rounded" and the rest are "sharp." The following analysis proceeds with this interference in mind, acknowledging that the large amount of encrustation may make the results unreliable.

Figure 95. Internal red slip tegame with plaster and hole drilled in for use as wall facing (POP 3741)

[708] On the interior of the fragments, the median percent covered in 50% and the mean is 46.67%. On the exterior, the median percentage covered is 70% and the mean 63.5%.

Twenty-two percent (n=4) of these vessels have discernible blackening on their interior, while 33% (n=6) have blackening on their exterior and interior (Table 54).[709]

Table 54. Location of blackening on internal red slip ware tegami from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	2	1
3	Double patch on belly	-	-
4	Around top of rim	2	2
5	Around top of vessel below rim	-	-
6	Around bottom of vessel and on base	-	-
7	Forming a ring on base	-	-
8	Completely covering base	1	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	-	4
11	Patch in center of base (inverse of 7)	-	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

There is a strong relationship between the appearance of blackening in location 2 on the interior and exterior as well as location 4 on the interior and exterior.[710] There is also a relatively strong relationship between blackening in location 8 on the interior, and the entire exterior being blackened (location 10), but not quite to a statistically significant degree.[711]

There is no discernible difference in the opacity of the blackening in any period (Figure 96).

[709] $\chi^2=10.29$ ($p<0.01$)
[710] For location 2, $\chi^2=8.47$ ($p<0.01$). For location 4, $\chi^2=18$ ($p<0.01$)
[711] $\chi^2=3.7$ ($p=0.054$)

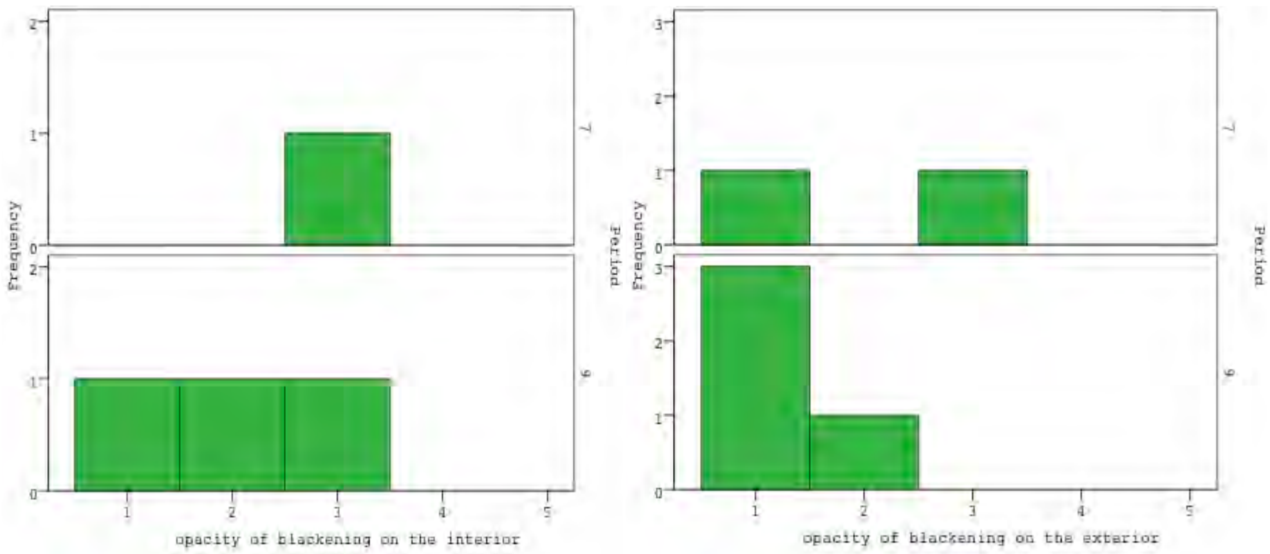

Figure 96. a) Interior opacity of internal red slip ware tegami; b) Exterior opacity of tegami

The sample size is to be too small to make any solid observations about the correlations between vessel size or shape and blackening.

Alteration: Abrasion

With the problematic state of the post-depositional circumstances of these fragments kept in mind, we can observe that 17% have abrasion on their interior. Eleven percent have abrasion on their exterior and only 5% (n=1) have both (Table 55).

Table 55. Location of abrasion on internal red slip ware tegami from Populonia

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	-	-
Abrasion on wall	5	-
Abrasion on rim	10	2

There is no evidence for an association between different locations of abrasion, though different locations of abrasion do seem to have strong relationships with directions of abrasion. For example, interior rim abrasion is associated with concentric scratches.[712] Conversely, interior wall abrasion is associated with concentric scratches and chordal scratches (Figure 97).[713] There is only one example of an interior wall with a radial scratch through the slip of the vessel (Figure 98).

[712] $\chi^2=8.78$, $p<0.01$
[713] concentric scratches, $\chi^2=6.24$ ($p=0.012$) and chordal scratches, $\chi^2=3.78$ ($p=0.052$)

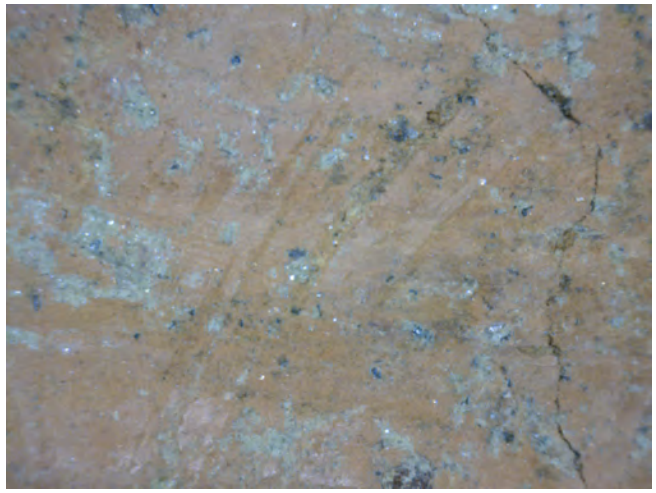

Figure 97. Chordal scratches on interior wall of internal red slip tegame at 50x magnification (POP 3568)

Figure 98. Radial scratches on interior wall of internal red slip tegame at 20x magnification in different light conditions (POP 3707)

Otherwise, no discernible difference in the abrasion of different periods emerges, nor is there a correlation between vessel size or shape and abrasion.

5.3.3.2. Tegame bases

Morphology

There are only four examples of red slip tegame bases, identifiable by their flat floor and wall angle (Table 56). Though there is no statistically significant difference in the diameter of these bases, it is notable that the three larger ones (23, 24, and 45 cm) come from Period 7, while the smaller one (12 cm) is in Period 5 (Figure 99). Similarly, no significant change in the wall thickness or angle of these vessels is evident; however the outlier falls in Period 5. The fragment from Period 5 is narrower than the other three and has a larger angle (150˚) compared to the Period 7 examples (which range from 120˚ to 135˚); however a single example from this period cannot represent all vessels in the period.

Table 56. Internal red slip tegame bases

Period	Frequency	Percent	Mean (cm)	Median (cm)
5	1	25.0	12	12
7	3	75.0	30.67	24
Total	*4*	*100.0*	*26*	*23.5*

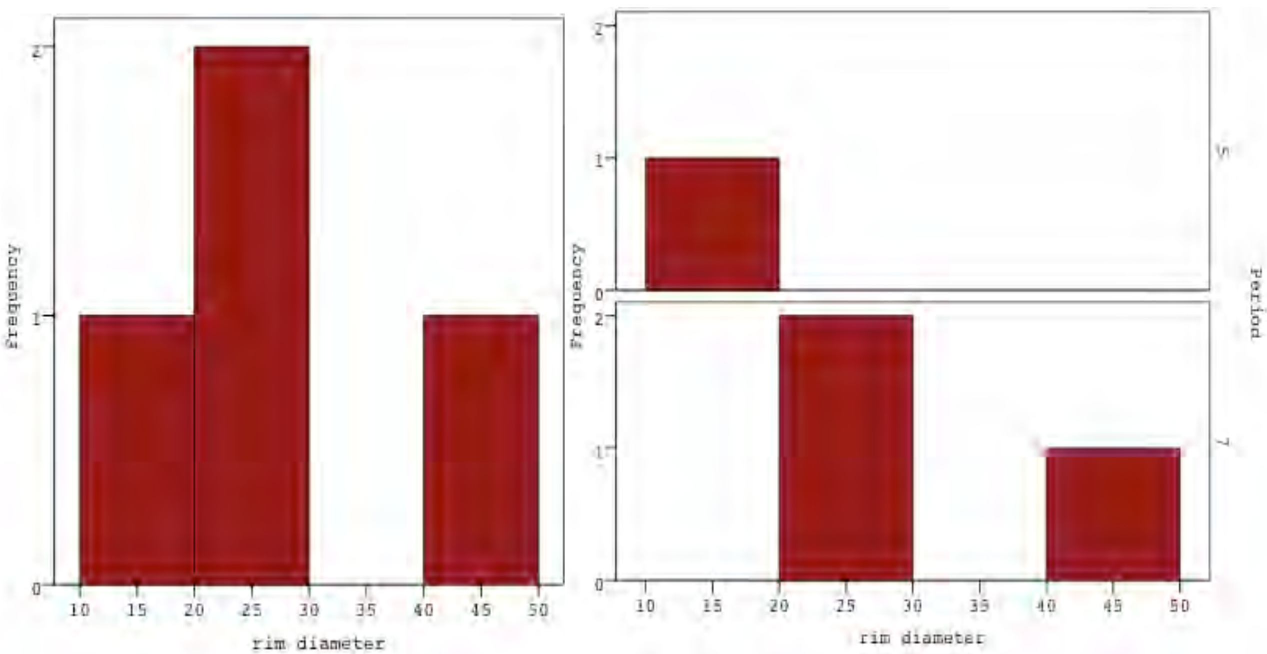

Figure 99. a) Diameters of internal red slip ware tegame bases; b) Diameters of bases by period

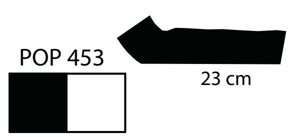

Figure 100. Small fragment of an internal red slip base

Alteration: Blackening

Unlike the rim and whole profile examples of internal red slip ware described above, the base fragments have little evidence of re-use or post-depositional disturbance;

therefore they are appropriate candidates for use alteration analysis.[714] None have interior blackening though they all have exterior blackening. This is consistent with the sample of similar vessels from Musarna (Table 57).

Table 57. Location of blackening on internal red slip tegame bases from Populonia

Type	Location of blackening	Count (int)	Count (ext)
1	Around belly of vessel	-	-
2	Single patch on belly	-	-
3	Double patch on belly	-	-
4	Around top of rim	-	-
5	Around top of vessel below rim	-	-
6	Around bottom of vessel and on base	1	-
7	Forming a ring on base	-	-
8	Completely covering base	1	-
9	Entirety of vessel not including lower wall and base	-	-
10	Entirety of vessel	1[715]	-
11	Patch in center of base (inverse of 7)	1	-
12	Everything blackened except a strip just below the rim (inverse of 5)	-	-

The base blackening appears in slightly different locations (location 6, 8, 10 which are extremely similar, and 11); however, they all indicate that these vessels were elevated over a fuel source. Location 11, a single patch in the center of the vessel floor, may be indicative of the vessel being elevated enough to only receive soot and flame contact in its very center. Since every fragment is blackened, there is no change over time and no correlation between the likelihood of blackening and vessel shape and size.

Alteration: Abrasion

Two out of four fragments have abrasion on their interior, of which one has exterior abrasion (Table 58).

Table 58. Location of abrasion on internal red slip tegame bases from Populonia

Location of abrasion	Count (int)	Count (ext)
Abrasion on base	2	-
Abrasion on wall	-	1
Abrasion on rim	-	-

[714] Although all 4 fragments have some mineral encrustation, they are all under 30% covered on the interior and exterior.

[715] This has an opacity score of 1.

The interior abrasion on the base floor is a chordal scratch in one case (Figure 101) and the other is a 4 cm^2 patch of slip removed. The fragment with exterior abrasion has 2 radial scratches.

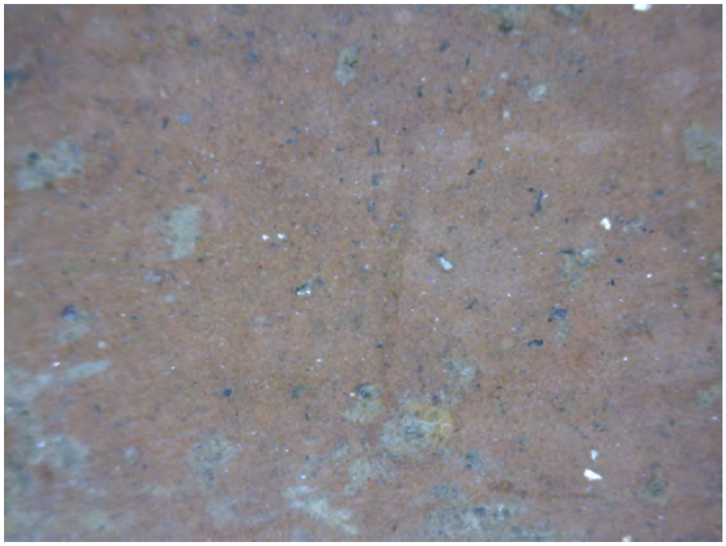

Figure 101. Chordal scratches on internal red slip tegame base at 50x magnification (POP 3477)

5.3.4. Conclusions

Cooking wares at Populonia suggest a similarity of vessel use over time, as demonstrated by the alteration analysis as well as a consistency of form and size. Though the lack of significant changes may be the result of small samples sizes (in comparison to Musarna), the few significant changes which are present suggest that the lack of evidence for change is a result of the samples' homogeneity, rather than its size. The exception to this homogeneity is in the internal red slip tegami which, like at Musarna, form two size groups in Period 5 and Period 7 until the average size shifts substantially towards a larger diameter in Period 9 (100 to 1 BCE). Tegami with larger rim diameters, naturally have greater surface areas of their vessel floor which means that the larger tegame size represents more cooking space for flat, fry-able foods on a slipped surface.[716] Thus, in Period 9 cooks in Populonia may have been cooking exclusively large pieces of meat or vegetation or a greater number of portions than in earlier times when there were two size options available.

[716] See Appendix 1 on volume calculation for further demonstration of the linear correlation between tegame rim diameter and its other dimensions.

5.4. Chapter discussion

My observations of abrasion disagree with Susan Rotroff's contention that abrasion from use is not common on pottery from the Hellenistic Mediterranean because it is high-fired.[717] Depending on the ware, fragment size and location, and vessel form, the ceramics from Musarna and Populonia demonstrate that abrasion attributable to use is common. Even more illustrative are the patterns of blackening produced by cooking. Sooting and charring produce patches and swaths of blackening to different degrees which have meaningful statistical relationships and demonstrate repetitive cooking behaviors.

When we compare the data on cooking vessels from Musarna and Populonia we see a number of common trends. Overall, the average diameters and the range of sizes of vessel categories in each period are very similar at both sites. The one exception is internal red slip tegami. Though there is no difference in tegame size between Musarna and Populonia in the middle of the 2nd century, the Period 9 tegami from Populonia are significantly larger on average than those from Period 8 in Musarna, just as they are when compared to Period 7 materials at Populonia.[718] This suggests that were we to have later materials from Musarna, this size change would also be evident there.

When we examine the whole assemblage of cooking vessels at Musarna and Populonia in each period, the perspective is similar (Figure 102). There is no significant change between the proportions of forms present in each period.

[717] Rotroff 2006, 59, n. 7.

[718] There are 46 tegami rims from Musarna in Period 8 and 10 rims from Populonia in Period 9. When we compared averages, $t=10.01$ ($p<0.01$). If we do not assume a normal distribution of the variables and use a Kruskal-Wallis test, $\chi^2=20.79$ ($p<0.01$).

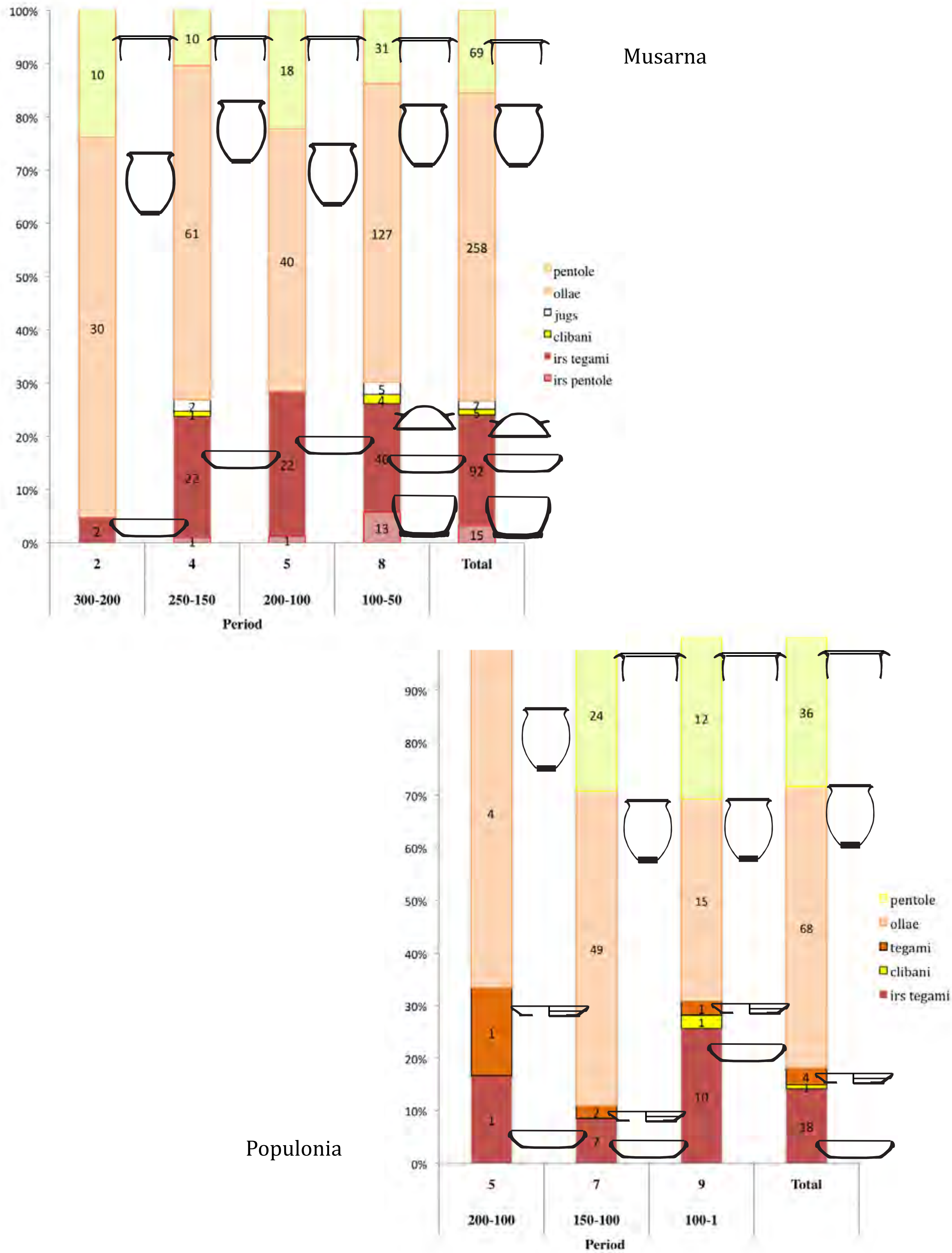

Figure 102. Relative proportions of cooking vessel forms at each site by period

Both assemblages are dominated by ollae of *ceramica comune da fuoco* in every period suggesting boiled or stewed foods form a large part of the diet at both sites. Since ollae have a more restrictive rim opening than pentole, their prevalence may mean that the foods they contained were not meant to evaporate quickly from wide surface area and that they were not accessed often with a utensil. As demonstrated with the abrasion patterns on the interior of ollae at Musarna, this scenario of ideal use was not always the case. At Populonia, the next most prevalent vessels are pentole of *ceramica comune da fuoco*, whereas at Musarna, internal red slip tegami are the second-most common in each period. Both sites have few tegami of *ceramica comune da fuoco* and few clibani, suggesting that covering food and cooking through conduction was not a common method.[719]

The vessels which pertain to cooking food should not be examined in isolation from preparing or serving vessels, and so the patterns observed in this chapter will be complemented by the findings of the next two chapters.

[719] Despite the relatively abundant amount of scholarship on this form, its lack of frequency at both sites and many others suggests that this was not a common way to cook bread. The attention the clibanus has received may simply be due to its novel form.