Paestum dietary habits during the Imperial period: archaeological records and stable isotope measurement

Paola Ricci1, Carmina Sirignano2, Simona Altieri1, Mariangela Pistillo3, Alfonso Santoriello3, Carmine Lubritto1

1Department of Environmental, Biological and Pharmaceutical Science and Technology, Second University of Naples, via Vivaldi 43, 81100 Caserta, Italy
2Department of Mathematics and Physics, Second University of Naples, via Vivaldi 43, 81100 Caserta, Italy
3Department of Science and Cultural Heritage, University of Salerno, I-84088, Fisciano, Salerno, Italy

ABSTRACT

In historical contexts, analyses of carbon and nitrogen stable isotopes can be useful to answer different questions on dietary behavior and to crosscheck information, drawn from texts and classical archaeological investigations. In this study the Isotope Ratio Mass Spectrometry (IRMS) facility installed at the IRMS-SUN Laboratory of the Second University of Naples is presented. Moreover, results coming from application of stable isotope analyses to bone collagen extracted from human remains of the necropolis of “Porta Sirena” in Paestum will be discussed. Finally, a combined analyses of archaeological and historical record and stable isotope measurements permits to expand our knowledge on diet in Roman Paestum.

1. INTRODUCTION

1.1. Isotopes definitions

Isotopes are nuclides of a single element that differ in their atomic weights (in particular in neutrons number). Stable isotopes are generally reported as the measured difference in the isotopic composition of the sample (s) and an accepted standard (std), in terms of “delta-notation” (δ-values) (1):

$$\delta_x (\%) = \frac{R_{isot} - R_{std}}{R_{std}} \times 1000$$

where R is the isotope ratio between the heavy isotope and the light one of the same element [1]. Standards used are internationally well defined: for carbon it is the PDB (Peedee Belemnite) and for nitrogen it is Air [1].

Isotopic fractionation is “the partitioning of a sample into two or more parts that have different ratios of heavy and light isotopes than the original ratio”; if one of these parts is “enriched” in the heavy isotope, the other must be “depleted” [1].

1.2. Paleodiet and stable isotopes

The paleodiet, the diet of ancient populations, can be investigated with the consolidated methodology using stable isotopes analysis of human bones collagen [2], [3]. De Niro and Epstein conducted first studies on animal feeding, indicating that stable isotopes ratios of carbon and nitrogen of whole body and specific tissues reflect that of the consumed food [4], [5]. Organic and inorganic constituents of bones represent a record of long-term diet [6] and, in specific, bone collagen carries diet information average of several years because of a turnover of ten years [7]. As the isotopic signature varies among different trophic chains (i.e. marine or terrestrial) and it propagates along a chain, it gives reliable indications to
distinguish whether or not an individual belongs to a certain food chain or to a certain level of it [8]-[11]. It must be considered that between diet and bone collagen there is a fractionation of +5 ‰ for carbon and +3 ‰ for nitrogen [12], [13]. About carbon, the δ¹³C signal in human bones reflects the consumption of C3 and C4 plants, that have a different metabolic pathway in the photosynthetic cycles [7], [14], [15], with an enrichment of about 14 ‰ for C4 one. Besides, the majority of marine or terrestrial foods provides changes in δ¹³C of human bones (higher signals for prevalence of marine foods) [7]. Concerning nitrogen isotopes, the majority of the variations in δ¹⁵N human collagen derive from trophic level of the food consumed: there is a consistent enrichment in δ¹⁵N of marine animals, because phytoplankton uses enriched nitrate dissolved in seawater and because larger marine carnivores, usually common food for humans, are in the higher trophic level [16]. For the same reason, small fishes belong to low trophic level and so do not provide great changes in δ¹⁵N signal of human bones. Instead, a big consumption of marine foods is detectable in collagen δ¹⁵N [17].

Therefore, it is possible to establish ranges of δ¹³C and δ¹⁵N human collagen that indicate the main consumption of terrestrial or marine foods: if marine protein were prevalent in the diet of ancient population, δ¹³C results between -12 and -14 ‰ and δ¹⁵N is between +12 and +22 ‰; if they fed more of terrestrial food, δ¹³C values are around -20 ‰ and δ¹⁵N is between +5 and +12 ‰ [13], [16], [18], [19].

Generally, in a defined historical context, information about foods commonly used in human nutrition is known from archaeological investigations and different models have been implemented in order to untangle the diet of an individual into its different food constituent [20]. But, it appears more difficult to obtain precise information about food consumption as among different social, age and gender groups, within a community or region as a whole. In this case, stable isotopes analysis can be useful to confirm the actual adoption of a certain kind of diet, known to be common at a time. In particular, historical records or textual references about food and diet during the Roman Imperial period explain that fish or certain kind of diet, known to be common at a time.

For the scope of this study, 23 of the 73 discovered graves have been sampled for paleodiet analysis. The choice fell on those graves where the human remains were better preserved, preferring those among them who by inhumation and grave

<table>
<thead>
<tr>
<th>Site description</th>
<th>Material and methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rome Casal Bertone (2nd-3rd centuries AD)</td>
<td>Site description</td>
</tr>
<tr>
<td>Rome Castellaccio Europeparco (1st-3rd centuries AD)</td>
<td>Material and methods</td>
</tr>
<tr>
<td>Isola Sacra (1st-3rd centuries)</td>
<td>Site description</td>
</tr>
<tr>
<td>Portus Romae</td>
<td>Material and methods</td>
</tr>
</tbody>
</table>

Stable isotope analysis was especially used to look into the diet of the population and how it varied as function of sex, age and status [21], [24] and it revealed that the population generally mixed terrestrial resources with marine food, consuming marine organisms of higher trophic level more than the famous garum, a fish sauce typical of the elite Roman diet. The nearby inland cemetery, named ANAS, was originally intended as reference site for terrestrial based diet. However, final evidences showed that it had been occupied by two different clusters of individuals, identified for their similarity to Isola Sacra individuals, as one group belonging to the inland site, and another one with individuals that possibly migrated from a coastal zone (ANAS 1 and ANAS 2, respectively for our reference) [21]. Craig et al. [27] moved their research southwards and they explored the dietary habits at the coastal sites of Velia. By means of cluster analysis, they revealed that the majority of the population from the Velia necropolis had a diet high in cereals and relatively lower in meat, but they found a group which had consumed more meat and also fish, especially high trophic level fish (Velia 1 and Velia 2, respectively for our reference). About 30 km to the north of Velia, during the excavations conducted in the area of “Porta Sirena” at Paestum (Salerno, Italy), graves belonging to the Roman Imperial Period came to light. The human remains were studied according to the standards of the funerary archaeology [28] and they have been processed for isotope analysis.

In this study, carbon and nitrogen isotope analyses applied to the human remains of the necropolis of “Porta Sirena” in Paestum are presented. Primarily, this investigation has aimed to verify the hypothesis of presence of fish in the diet at this shore site during the Roman Imperial time, especially by comparing coeval sites. Furthermore, since more studies on this topic have been invoked as desirable (see for example Killgrove et al. 2013 [22]), this work is expected to generally contribute to the knowledge on average lower class diet from this time, which is complex and variable in its distribution among different kind of people and different territories.

Anthropological assessments are not covered by this study and samples were collected only for paleodiet analysis. But for the purpose of the study itself, it is important to consider that the grave goods found in the site were in no case valuable or interesting, confirming the absence of any elite member of the community interred in this necropolis.

2. MATERIALS AND METHODS

2.1. Site description

The area of the excavation is located along North-South direction of “Porta Sirena” (Figure 1), while the eastern and western limits of the zone of operation are respectively represented by the modern road and the walls. The area has been divided into different sectors. The excavation of the necropolis, whose tombs are located at about 10-15 cm depth, have so far returned 73 burials, numbered from 21 to 95 (t21 to t95). According to their stratigraphy and the archaeological analysis of the grave goods, the interments have been attributed to a period spanning from the 2nd to the 4th centuries AD.

2.2. Paleodiet analysis

For the scope of this study, 23 of the 73 discovered graves have been sampled for paleodiet analysis. The choice fell on those graves where the human remains were better preserved, preferring those among them who by inhumation and grave
goods were more heterogeneous, in order to be as more representative as possible of the whole interred population of the cemetery. The graves in *amphora*, were excluded from this study, as they were usually used for very young corpses. Long bones, when available, have been preferred to the others, in order to obtain information about lifelong habits of the sampled individuals, and, when possible, the same skeletal element has been chosen for all the individuals, in order to minimize the influence arising from sampling different kind of bones. The classification of sampled bones is reported in Table 1, in addition to the age classification, C and N concentrations, C/N ratios, C and N isotopic ratios, collagen yield and presence of grave goods. Gaunal remains were rare and not properly preserved for classification, for reference purposes two teeth of two different herbivores (possibly a cow indicated as d1 and a goat as d2) have been collected at the site, being coeval with the human individuals under investigation.

### 2.3. Samples preparation

The samples for the analysis were processed to isolate the organic phase of the sample (collagen) adopting a modified procedure from Longin method (1971) [29]. A fragment of the sample was selected from each specimen. The bone surface was abraded to remove contaminants and it was pulverized. Each sample was then placed in polypropylene test tubes and demineralised in a sequence of acid attacks with hydrochloric acid (HCl) 0.6 M at ambient temperature (20-25 °C), interrupted by one alkali attack (NaOH 0.1 M) 30 minutes long. Several rinses with de-ionized water were done after each step, before finally oven-drying the samples. Finally, the gelatinization protocol was applied [29], [30].

### 2.4. Elemental analysis (EA) and Stable Isotopes Mass Spectrometry (IRMS)

The Isotope Ratio Mass Spectrometry (IRMS) is a methodology used for qualitative and quantitative analyses, measuring isotopic ratios of different element of various types of samples (solid, liquid or gas). It is based on the principle of separation of atoms or rather ions with different mass to measure their relative abundances [31].

For solid samples, it is coupled with an Elemental Analyzer (EA), where the sample is burned and transported by a carrier flow (He) to the IRMS, as showed in the schema of the instrumentation used at IRMS-SUN Laboratory (Figure 2).

For collagen quality test, C and N fractions of collagen dry

---

**Table 1. Samples classifications, isotopic values and collagen quality indicator of human’s bone and fauna’s teeth samples from the necropolis “Porta Sirena” of Paestum.**

<table>
<thead>
<tr>
<th>Sample Classification</th>
<th>Age Classification</th>
<th>%N</th>
<th>%C</th>
<th>C/N</th>
<th>(\delta^{13}C) (‰VPPDB)</th>
<th>(\delta^{15}N) (‰AIR)</th>
<th>Collagen Yield</th>
<th>Presence of grave goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbivorous d1 Tooth</td>
<td>-</td>
<td>3.9</td>
<td>10.8</td>
<td>3.3</td>
<td>-21.9</td>
<td>4.7</td>
<td>3.1%</td>
<td></td>
</tr>
<tr>
<td>Herbivorous d2 Tooth</td>
<td>-</td>
<td>7.1</td>
<td>19.9</td>
<td>3.3</td>
<td>-22.1</td>
<td>5.1</td>
<td>1.9%</td>
<td></td>
</tr>
<tr>
<td>124 Radius sx Adult</td>
<td>14.1</td>
<td>37.1</td>
<td>3.1</td>
<td>-19.0</td>
<td>7.8</td>
<td>2.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>126 Radius sx Adult</td>
<td>16.1</td>
<td>41.1</td>
<td>3.0</td>
<td>-19.5</td>
<td>7.6</td>
<td>3.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>134 Tibia dx Adult</td>
<td>12.8</td>
<td>33.2</td>
<td>3.0</td>
<td>-19.3</td>
<td>8.5</td>
<td>2.7%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>138 Tibia dx Adult</td>
<td>12.8</td>
<td>33.8</td>
<td>3.1</td>
<td>-20.9</td>
<td>7.6</td>
<td>2.9%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>146 Femur dx Sub-adult</td>
<td>13.7</td>
<td>38.6</td>
<td>3.3</td>
<td>-20.5</td>
<td>7.1</td>
<td>1.6%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>147 Humerus sx Adult</td>
<td>14.9</td>
<td>38.3</td>
<td>3.0</td>
<td>-19.4</td>
<td>7.9</td>
<td>1.5%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>153 Femur dx Sub-adult</td>
<td>15.8</td>
<td>41.5</td>
<td>3.1</td>
<td>-19.1</td>
<td>7.8</td>
<td>2.6%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>158 Ulna Adult</td>
<td>15.7</td>
<td>40.7</td>
<td>3.0</td>
<td>-19.0</td>
<td>7.9</td>
<td>2.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>154 Ulna Adult</td>
<td>16.7</td>
<td>42.9</td>
<td>3.0</td>
<td>-18.5</td>
<td>8.2</td>
<td>4.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>155 Femur dx Sub-adult</td>
<td>15.5</td>
<td>41.2</td>
<td>3.1</td>
<td>-20.4</td>
<td>7.4</td>
<td>3.9%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>168 Humerus dx Adult</td>
<td>8.9</td>
<td>22.9</td>
<td>3.0</td>
<td>-18.5</td>
<td>9.4</td>
<td>3.9%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>169 Humerus dx Adult</td>
<td>15.8</td>
<td>41.5</td>
<td>3.1</td>
<td>-19.5</td>
<td>8.5</td>
<td>1.6%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>170 Tibia sx Adult</td>
<td>16.0</td>
<td>40.9</td>
<td>3.0</td>
<td>-18.8</td>
<td>8.1</td>
<td>3.1%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>172 Tibia sx Sub-adult</td>
<td>14.4</td>
<td>37.5</td>
<td>3.0</td>
<td>-19.4</td>
<td>7.9</td>
<td>1.2%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>176 Femur sx Adult</td>
<td>14.9</td>
<td>38.3</td>
<td>3.0</td>
<td>-20.1</td>
<td>7.6</td>
<td>2.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>177 Tibia dx Adult</td>
<td>14.2</td>
<td>36.5</td>
<td>3.0</td>
<td>-20.0</td>
<td>7.8</td>
<td>3.1%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>180 Humerus dx Adult</td>
<td>14.9</td>
<td>38.2</td>
<td>3.0</td>
<td>-19.0</td>
<td>7.5</td>
<td>1.0%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>181 Tibia sx Adult</td>
<td>14.0</td>
<td>37.1</td>
<td>3.1</td>
<td>-19.6</td>
<td>8.0</td>
<td>1.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>182 Humerus sx Adult</td>
<td>13.8</td>
<td>36.9</td>
<td>3.1</td>
<td>-20.3</td>
<td>8.2</td>
<td>1.0%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>183 Tibia sx Infant</td>
<td>11.3</td>
<td>29.8</td>
<td>3.1</td>
<td>-18.4</td>
<td>11.4</td>
<td>2.6%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>184 Humerus dx Adult</td>
<td>15.8</td>
<td>40.6</td>
<td>3.0</td>
<td>-19.9</td>
<td>8.8</td>
<td>3.2%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>185 Tibia dx Adult</td>
<td>15.4</td>
<td>40.0</td>
<td>3.0</td>
<td>-20.6</td>
<td>8.4</td>
<td>2.7%</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>186 Humerus dx Adult</td>
<td>16.3</td>
<td>41.6</td>
<td>3.0</td>
<td>-19.3</td>
<td>8.4</td>
<td>3.2%</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
mass (C, % and N, %) were measured with the Elemental Analyzer alone (CN Flash EA 1112 Series, Thermo Scientific, Finningan). In specific, each sample is weighed in a tin capsule (about 3 mg), placed in an auto-sampler and burned in the reaction column of the EA, by high temperature (1020 °C) and oxygen presence. Here, the sample derived gas is subjected to redox reactions, obtaining CO₂ and N₂ gases, subsequently separated in a chromatographic column, carried by the helium. Finally, the gases are captured by a detector; software allows the concentrations calculation, by means of a calibration curve obtained using a standard with certified concentrations. During the gases passage, water is removed by a hygroscopic trap (magnesium perchlorate).

The Elemental Analyzer, in our system, is connected to the IRMS (Delta V Advantage, Thermo Scientific) for isotopic ratios analysis (1 mg of samples), by an interface CONFLO III (in CONtinuous FLOW mode, Thermo Finningan), that modulates the passage of carrier flow and standard gases. In the IRMS, the gas sample is ionized by particles coming from a source, the resulting ions are accelerated in an electronic field to a magnetic field, where they have different trajectory depending on the mass/charge ratio.

Trajectories of lighter and heavier isotope ions are deflected in different ways, following the relation (2): 

\[ \frac{m}{q} = \frac{e^2}{2VB^2}, \]  

(2)

where \(m\) is the mass, \(q\) the charge, \(r\) is the radius of curvature of ions beam trajectory, \(V\) the potential differences and \(B\) the magnetic field.

Ions beams are collected by Faraday cups (collectors), which are able to measure current intensity generated by incident beam. A mass spectrum is derived, where each line corresponds to a fragment of specific \(m/q\). Molecular peak (more intense) is made from molecular ion, that is a non fragmented molecule with a positive charge (for a lost electron). Peak position is related to a specific mass value (qualitative analyses), peak intensity is proportional to relative abundance of each fragment (quantitative analyses).

Samples were retained for isotope analyses when extracted collagen achieved a yield higher than 1% and an atomic C:N ratio between 2.9 and 3.6 [30]-[34]. For \(\delta^{15}N\) and \(\delta^{13}C\) analyses, samples were analysed according to the method used by Preston and Ovens 1985 [35].

The isotopic measurements were calibrated based on the measurement of standards, aiming to set their values on internationally referenced scales (VPDB for C and Air for N) [36]. The analyses were conducted in blocks of 12 samples, maximum. Between one block and the next one, three different reference materials were measured: two used to calibrate the measurement, and the last one used to evaluate the proper conduct of the analysis (target) and the repeatability of the measurement itself. The reference materials used for \(\delta^{15}N\) analysis calibration were IAEA-N-2 (ammonium sulphate, \(\delta^{15}N_{IAEA} = 20.3 \pm 0.2 \text{‰}\)) and IAEA-N-1 (ammonium sulphate, \(\delta^{15}N_{IAEA} = 0.4 \pm 0.2 \text{‰}\)) [37]. The reference materials used for \(\delta^{13}C\) analysis were IAEA-CH6 (sucrose, \(\delta^{13}C_{V\text{PDB}} = -0.45 \pm 0.03 \text{‰}\)) and IAEA-CH3 (cellulose, \(\delta^{13}C_{V\text{PDB}} = -24.72 \pm 0.04 \text{‰}\)) [38]. Typical analytical precision evaluated from repeated measurements of the standard, used as target, is 0.1‰ for \(\delta^{13}C\) and 0.2‰ for \(\delta^{15}N\).

3. RESULTS AND DISCUSSION

The results of the isotopic analysis are shown in Table 1 (\(\delta^{13}C\) and \(\delta^{15}N\), together with collagen quality indicators (C/N, collagen yield). The general state of preservation of the sampled bones has been acceptable. Testing the quality of collagen extracted assures the absence of potential contamination effects. From the results obtained, all the samples were retained for analysis, presenting yields above 1% and C/N values spanning from 3.0 to 3.3 [31]-[34].

Figure 3 represents the \(\delta^{13}C\) and \(\delta^{15}N\) bi-variate plot which finally allows considerations on the dietary habits. All the results from the necropolis of “Porta Sirena” in Paestum are plotted as compared to the faunal remains, the ones found at the same site (triangles) and the fauna collected at the coeval sites of Vela (diamonds) [27] and Isola Sacra (circles) [21], in particular pigs and herbivores. The isotopic composition of the two fauna samples from Paestum falls well within the variability shown by the coeval fauna from the other sites, both Isola Sacra and Vela.

Regarding to the humans, the collagen extracted from the bone sampled in the tomb t83 has given delta values clearly very different from those found for other samples. The bone fragments extracted from tomb t83 have been attributed to an individual younger than 1 year, an infant, i.e. a breast-feeding baby. Breastfeeding individuals can be considered “consumers” of their mother’s tissues, therefore occupying a higher trophic level than the adults and the weaned children. A \(^{15}N\)
enrichment of about +2 and +3 ‰ and a δ13C enrichment of about 1 ‰ are typical for this trophic shift [39], [40]. This δ13C and δ15N offset pattern is consistent with what we find for this individual t83. Being t83 a child early in life, it is very likely that the individual laying in the same grave (t82) might have been his/her mother. They differ from each other of 1.9 ‰ on the δ13C scale and of 3.2 ‰ on the δ15N scale, which is a result that could indicate the trophic shift mother-baby. But this could only be confirmed in response to anthropological analysis (i.e. individuals sex).

If we exclude the sample belonging to the tomb t83 all the δ13C and δ15N values are included respectively in the ranges [-20.9 ‰, -18.5 ‰] and [+7.1 ‰, +9.4 ‰]. According to these results one can say that the diet of the Paestum population buried at the necropolis of “Porta Sirena” was based on agricultural-pastoral foods, confirming the indications known from independent archaeological studies [28]. The values obtained, in fact, are consistent with a diet based on the consumption of C3 plants, characteristics of temperate climates, with addition of meat as confirmed by the fact that the average consumption of C3 plants, characteristics of temperate climates, corresponds to 2.4 ‰ and of 3.1 ‰ higher than herbivores samples on the δ13C and the δ15N scale, respectively. However, this analysis has the limitation of not being able to identify the possible consumption of small fish [17], as explained following in this paragraph.

Figure 4 and Table 2 compare the results from Paestum with those from the coeval sites from the central and south of Italy shown for their location on the map of Figure 1. Velia is the closest site and it has been the largest investigated site together with Isola Sacra, in term of analyzed individuals. In their extensive investigations Craig et al. (2009) [27] for Velia (diamonds) and Prowse et al. (2004) [21] for Isola Sacra (triangles) have been able to distinguish among groups of the population, which had different consume of meat and, especially, of fish in their diet. Here we refer to these categories to further interpret the results of the smaller population sampled at Paestum. The groups which very likely introduced fish in their diets have been here defined for simplicity “fish eaters” (Isola Sacra, ANAS 2 and Velia 2), the others have been named “non fish eaters” (Velia 1, ANAS 1). Fish eaters at Velia belongs to a small group of 17 individuals (Velia 2, empty symbols), while all individuals from Isola Sacra are thought to introduce to some extent marine food in their diets. In the original study, Isola Sacra samples were compared with individuals buried in a nearby inland place named ANAS (triangle). In the ANAS cemetery just a subset of inhumed individuals was identified with a terrestrial diet (ANAS 1, full symbols), the rest was formed by costal immigrant or seafarers (ANAS 2, full symbols). The δ13C and δ15N of human individuals found at the necropolis of “Porta Sirena” in Paestum averaged (excluding t83) -19.6 ‰ (s=0.7 ‰, n=22) and +8.0 ‰ (s=0.5 ‰, n=22), respectively. On the one hand, the mean δ13C of the fish eaters group is -18.9 ‰ (s=0.4 ‰, n=126) and the mean δ15N is +10.9 ‰ (s=1.2 ‰, n=125). These values are significantly higher than the values found at Paestum (two-sample t-test, p < 0.001; t=4.7 for the difference in δ13C, t=18.9 for the difference in δ15N). On the other hand, the human individuals found at the necropolis of “Porta Sirena” in Paestum show unequivocal analogy with the group identified as non fish eaters, mainly coming from Velia, whose mean δ13C is -19.5 ‰ (s=0.2 ‰, n=106) and δ15N is +8.2 ‰ (s=0.7 ‰, n=106), suggesting that these individuals had a negligible or no use of sea food in their diets (two-sample t-test, p < 0.001; t=0.6 for the difference in δ13C, t=1.3 for the difference in δ15N).

However, as mentioned before, it remains the hypothesis that “Porto Sirena” population could eat fish in a minor amount respect to other food, because marine protein could represent up to 20 % of total dietary protein without any appreciable change in δ13C values and consuming low trophic level marine resources (e.g. garum) could not change significantly δ15N signal [21].

Table 2. Isotopic average values and standard deviations (s) of isotopic results from different sites (see references), where n is the number of samples.

<table>
<thead>
<tr>
<th>Site</th>
<th>δ13C (%VPDB)</th>
<th>s</th>
<th>δ15N (%AIR)</th>
<th>s</th>
<th>n</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paestum</td>
<td>-19.6</td>
<td>±0.7</td>
<td>8.0</td>
<td>±0.5</td>
<td>22</td>
<td>this work</td>
</tr>
<tr>
<td>Rome Casal Bertone</td>
<td>-18.3</td>
<td>±0.6</td>
<td>10.1</td>
<td>±1.5</td>
<td>32</td>
<td>Killgrove et al., 2013</td>
</tr>
<tr>
<td>Rome Castellaccio Europarco</td>
<td>-18.5</td>
<td>±0.6</td>
<td>9.5</td>
<td>±1.3</td>
<td>12</td>
<td>Killgrove et al., 2014</td>
</tr>
<tr>
<td>Rome St. Callixtus</td>
<td>-19.7</td>
<td>±0.4</td>
<td>10.6</td>
<td>±0.5</td>
<td>22</td>
<td>Rutgers et al., 2009</td>
</tr>
<tr>
<td>Isola Sacra</td>
<td>-18.8</td>
<td>±0.3</td>
<td>10.8</td>
<td>±1.2</td>
<td>105</td>
<td>Craig et al., 2009</td>
</tr>
<tr>
<td>ANAS 1</td>
<td>-19.7</td>
<td>±0.2</td>
<td>7.9</td>
<td>±0.7</td>
<td>7</td>
<td>Craig et al., 2009</td>
</tr>
<tr>
<td>ANAS 2</td>
<td>-19.1</td>
<td>±0.2</td>
<td>11.1</td>
<td>±0.2</td>
<td>7</td>
<td>Craig et al., 2009</td>
</tr>
<tr>
<td>Velia</td>
<td>-19.4</td>
<td>±0.3</td>
<td>8.7</td>
<td>±1.3</td>
<td>117</td>
<td>Prowse et al., 2004</td>
</tr>
<tr>
<td>Velia 1</td>
<td>-19.5</td>
<td>±0.2</td>
<td>8.2</td>
<td>±0.7</td>
<td>100</td>
<td>Prowse et al., 2004</td>
</tr>
<tr>
<td>Velia 2</td>
<td>-19.3</td>
<td>±0.3</td>
<td>11.18</td>
<td>±1.3</td>
<td>17</td>
<td>Prowse et al., 2004</td>
</tr>
</tbody>
</table>
A third subset of three sites belongs to the city of Rome: two cemeteries just outside the urban walls, Rome-Casal Bertone (2nd-3rd centuries AD) and Rome-Castellaccio Europarco (1st-3rd centuries AD) and the Early Christian cemetery of St. Callistus (3rd to 5th centuries AD). Results of the dietary analysis from periurban Casal Bertone and suburban Castellaccio Europarco showed evidences as individuals living closer to the city of Rome were consuming some aquatic resources, those in the suburbium made greater use of millet as related to freshwater fish consumption. Beyond this, there is to be noted that the intra-site and inter-site variability existed in the diet of the common people during the Roman Imperial period, Paestum population, however, does not show signs of this complexity, appearing as a simple rural community, in accordance with the classical paradigm that fish or terrestrial animal meat was reserved to elite people, even when sea resources were so close in space. However, we could not bring any evidences of variability of the dietary behavior according to any hierarchical or social status in Paestum. In addition, no particular status distinction among the inhumed individuals was found at the site, as testified, for example, by the kind of tombs and the simple grave goods found in that.

4. CONCLUSIONS

This work has confirmed that isotopic measurements can integrate classical archaeological investigations to improve the knowledge of diet in Imperial Roman Paestum. As matter of fact, archaeological study allows to place the site chronologically, identifying analogies with the contemporary and vicinal necropolis of Velia, especially with respect to homogeneity in the poverty of the materials and rituals of burial. The isotopic analysis outlines uniformity even in the diet, identifying a typical agricultural-pastoral diet, we can therefore assume a homogeneous social structure, based on a predominantly rural economy, where, despite its proximity, the sea seems not regarded as a source of food, maybe because it was still not easily accessible. While showing analogies with the coeval and close by site of Velia, isotope analysis revealed many differences with the city of Rome and its nearby coast.

ACKNOWLEDGEMENT

The excavation of the necropolis is part of a project originally aiming to cataloguing and restoring the stone elements placed along the east side of the city walls of Paestum. This European-funded project, sponsored by the Archaeological Superintendence of Salerno, was done in collaboration with the University of Salerno, in particular with the archaeological laboratory of Mario Napoli, belonging to the department of Cultural Heritage.

REFERENCES


