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New technologies for plant food processing in the Gravettian

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ABSTRACT

"Plant Resources in the Palaeolithic" is a research project focused on the technologies for plant food processing as documented by use-wear traces and plant residue on grinding tools found in European sites. Many researchers have been involved in the project, which encompasses the fields of archaeology, botany and food processing technologies, within the context of the history of European Prehistoric societies.

The first study was carried out on use-wear traces and plant remains recovered from grinding tools from the sites of Bilancino (Italy), Kostienki 16 (Russia) and Pavlov VI (Czech Republic), dating to the Middle-Upper Palaeolithic (Gravettian and Gorotsovian) around 28,000–30,000 cal BP. The results demonstrated that vegetable food processing and the production of flour was a common practice across Europe from at least 30,000 years ago and that flour, a high-energy food, was a component of the food economy of mobile hunter gatherers. Flour production and consumption imply multi-step processing from harvesting to cooking to obtain a suitable and digestible food, and that this was part of an Upper Paleolithic behavioural package. This paper presents new data from two Gravettian pestles, found at Grotta Paglicci – level 23a (Southern Italy) and at Dolni Vestonice I (Czech Republic), which furnish further information about plant exploitation and the technologies related to plant food processing.

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1. Introduction

It has long been a widely-shared opinion that the principal source of food for hunter–gatherers was derived from game hunting and that meat, rich in energy and a valuable source of protein, was a vital component of their diet (Ströhle et al., 2010). Ethnographic data indicates that hunter–gatherers relied on the three main subsistence categories of hunting, fishing, and gathering plant foods. These categories do not appear to be affected by latitude, although plant food decreases significantly towards areas of more severe climate (>40° N or S). However, a combination of hunted and fished animal foods is a constant for hunter-gatherers living in low-to-moderate latitude regions. Significant correlations have been detected between latitude and subsistence dependence on gathered plant foods and fished animal foods, but not between latitude and dependence on hunted animal food (Cordain et al., 2000).

The most recent studies, reconsidering the history of the human diet from the very origins of the *Homo* genus from a multidisciplinary angle, including the study of palaeo-environments, comparative anatomy, biogeochemistry, archaeology, anthropology/ethnology, (patho)physiology and epidemiology, underscore the importance of gathering and of vegetable foodstuffs in the human diet. More specifically, the contribution of nutrients of vegetable origin to the diet of *Homo sapiens* can be estimated at around 60% (Kuipers et al., 2012).

Archaeozoological data, being over-represented in comparison to more perishable remains such as vegetal residues, have

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traditionally been taken to support high meat consumption. However, as a result of new lines of research, there is increasing evidence for other food sources, such as small game, fish, molluscs and plants. According to recently available data, even for Neanderthals, considered as top-level carnivores, evidence is emerging for some plant food consumption (Lev et al., 2005; Hardy, 2010; Henry et al., 2011, 2014; Hardy et al., 2012).

Promoted by the Istituto Italiano di Preistoria e Protostoria, and launched in 2007, the research project "Plant Resources in the Palaeolithic" began with the analysis of a grindstone and a pestle-grinder which were found in 1995–1996 during excavations in the Gravettian settlement of Bilancino, near Florence. The discovery on both grindstone and pestle-grinder of starch belonging to different plant species (most of which may be attributed to *Typha* spp., which has a starch-rich rhizome) represented the earliest evidence found to date of a technique used in the preparation of flour based on wild plants (Aranguren et al., 2007; Aranguren and Revedin, 2008; Aranguren et al., 2015).

Based on this evidence, it was decided to explore the possibility that flour grinding was not an occasional activity documented in the Bilancino seasonal camp, but may have been a widespread practice during the Upper Palaeolithic, hence long before the beginning of agriculture. This led to the launch of a project that would enable further examination of grinding stones from early UP contexts, searching for plant residues.

The research hypothesis is that high-energy plant resources were part of the food economy of Upper Palaeolithic mobile hunter-gatherers and that plant food processing and the production of flour was common practice across Europe from at least thirty thousand years ago. As a result of the first stage of this research, evidence has already been presented of starch granules from various wild plants found adhering to the surfaces of grinding tools from the sites of Bilancino, Kostienki 16 and Pavlov VI, and dating to the Upper Palaeolithic (Gravettian and Gorotsovian) at around 28,000–30,000 cal BC (Revedin et al., 2010).

The research also comprises the identification of new plant species used in the human diet and the chemical-nutritional characterisation of the processed plants (Marconi et al., 2011). A reconstruction of Palaeolithic nutrition that includes a broader and more precise evaluation of the plant food contribution, through the chemical-nutritional characterisation of processed plants, could also have important implications for the current human diet (Hockett and Haws, 2003; Lindeberg et al., 2007; Frassetto et al., 2009; Eaton et al., 2010; Strőhle et al., 2010; Delluc, 2012). The idea is gaining ground that a diet and lifestyle in keeping with human evolution may be important in the prevention and treatment of the so-called "diseases of civilization" (Haywood and Proietto, 2012; Kuipers et al., 2012; Ruiz-Núñez et al., 2013), and for healthy ageing (Fontana et al., 2012).

This paper is mainly focused on the technologies used in plant food processing. The attempt is to identify different technologies in sites from a wide geographical range, through analysis of the settlement context and the artefacts. The aim is to establish a relationship between grinding stone morphology, use-wear trace characteristics and distribution and types of residue (plant species).

New data from two Gravettian pestles, from Grotta Paglicci – level 23a – in Southern Italy, and Dolni Vestonice I in the Czech Republic respectively, offer evidence regarding the role of vegetable food and the technologies related to its processing in the human diet. The study will also present the qualitative evaluation of the protein fraction (biological value) and the starch fraction (amylose, amylopectin, digestibility of the starch) from two of the wild plants, *Typha* (cattail) and *Quercus* (oak) among those possibly identified on Gravettian grinding tools.

2. Methods

The study of the stone tools involved in plant processing is carried out through microscopic analyses for both microwear analysis and starch analysis. The analytic techniques used are described in Revedin et al. (2010) and Aranguren et al. (2011). In addition to gas-chromatography, these include mass-spectrometry and Raman spectrometry in order to assess the nutritional characterisation of the starch.

2.1. Use-wear and residue identification

The identification and description of use-wear traces was carried out by means of Low Power Approach (LPA) and High Power Approach (HPA) through the application to wear-trace analysis of the combined potential of the Digital Microscope (Hirox KH-7700). The Hirox KH-7700 has a multi-viewer function that permits easy inspection at various angles. The device is furnished with two different optics: macro MX-G 5040Z working at lower magnification and OL −140 II working as a microscopy (up to 7000×). A fully-focused image can be constructed instantaneously by compiling a small number of images from different focus positions, building a 3D model that enables versatile observation of surface shape. This device has proved a very effective tool for distinguishing the worn granules embedded in the matrix of the slab.

2.2. Residue extraction and identification

For the starch granule analysis, small surfaces of each stone were selected based on the macroscopic wear traces, and were sampled using running distilled water to remove the adhering sediment containing the residue. The analysis was performed on the entire surface of the artefacts which had already been washed. The residue was treated according to Barton et al. (1998), using zinc chloride for the heavy liquid separation. Starch granules were observed under light microscope and polarizing microscope. Identification, based on morphology (shape, dimensions, characteristics of the hilum, possible presence of lamellae), was performed with the assistance of literature (Tateoka, 1962; Seidemann, 1966; Henry et al., 2009, 2011; Madella et al., 2013) and modern reference material.

2.3. Nutritional data

The nutritional data come from different methods of analysis including gas-chromatography.

Fatty Acids Analysis: lipids were extracted from flours using acid hydrolysis (Approved Method 30-10, AOAC, 2000; Iafelice et al., 2008).

Amino acid analysis:

1 – *Protein hydrolysis.* Traditional protein hydrolysis was carried out using the procedure reported by Spackman et al. (1958).

2 – Chromatographic determination.

The amino acid content was determined by High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection (HPAEC–PAD). Quantitative determination was carried out according to Messia et al., 2008. Single amino acid identification was carried out using external amino acid standards.

3. New evidence and analysis

The research is now focusing on the study of new tools from a wider range of sites and periods that may have been involved in plant processing (for both nutritional and medicinal purposes),

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