Ancient beer: multidisciplinary approaches for its identification in the archaeological record

A workshop in the context of ERC Project PLANTCULT

Workshop to be held at the University of Hohenheim, Germany

07-09 February 2019

Abstracts

PlantCult

INVESTIGATING THE FOOD CULTURES OF ANCIENT EUROPE:

Ancient beer: multidisciplinary approaches for its identification in the archaeological record

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Time frame:

08. & 09.02.2019 (07 & 10.02. for travelling), University of Hohenheim, Germany

Organizers:

Hans-Peter Stika, Elena Marinova, Marian Berihuete, Chryssa Petridou, Andreas Heiss, Ferran Antolin, Soultana-Maria Valamoti

Aim:

The proposed PLANTCULT-workshop aims to integrate archaeobotanical, chemical and experimental evidence on ancient beer remains in order to explore the potential and limitations for archaeological recognition of beer production in past societies. In order to achieve this the organisers have invited a broad variety of specialists dealing with archaeological finds and their experimental reproduction, archaeobotanical remains, anthropology, brewing technology, fermentation microbiology, diverse analytical approaches like residue analysis, ancient starch analyses.

Main topics that will be discussed in the context of the workshop

Archaeobotanical remains and beer making: from indications to evidence. Which are the reliable criteria for the description of possible beer components in archaeological context and their identification as such?

Architectural and artefactual evidence related with beer making. Which structures and tools are of importance for the identification of brewing activities?

The contribution of experimental and ethnographic evidence towards the identification of beer making and beer-making components in the archaeobotanical and archaeological record. How comparable are the archaeological finds with the experimentally obtained beer products?

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UNIVERSITÄT HOHENHEIM

Baden-Württemberg
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Neolithic beer production in the Iberian Peninsula? A revision of the available evidence in Can Sadurní Cave

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In 2008, the extraordinary results of microresidue analyses undertaken on grinding equipment and a ceramic sherd indicating beer production in the Poscardial layers of Can Sadurní cave, dated around 4500 cal. BC, were published (in Spanish) in the Proceedings of the Neolithic Conference of the Iberian Peninsula, celebrated in Alicante in 2006. Additionally, as reported in the same publication, beer might also have been produced at the site during the late Bronze Age. Since then, the impact of this find has been big in the Catalan media, it is well known in the Spanish scientific community and it has been quoted in some international journals. Moreover, a private craft beer company, Cerveza Artesana, developed a brand inspired on this find, called "Encantada", which has been relatively successful in the Barcelona province over the last few years and has helped to disseminate this discovery among the general public. We want to take this opportunity to present the results in front of a specialist audience, together with new research at the site, in order to discuss their validity and future lines of research.

Tapping into the Past: Experimental Brewing, Community Partnerships and Public Education

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Archaeologically and historically derived sources of evidence about the cultural evolutionary and socio-economic history of the production and consumption of ancient alcohol have been significantly increased recently by breakthroughs in various areas of scientific analysis. At the same time public interest in craft brews and other forms of culturally enriched alcohol in west-central Europe and the Americas has resulted in an unprecedented appetite for research-based information about the origins and cultural foundations of these beverages. This presents an opportunity for archaeologists and historians to partner with researchers in chemistry, agriculture, biology and other fields in developing outreach initiatives whose goals include educating the general public about the disciplines involved in the study of the science and culture of ancient alcohol. Pre-hops plant additives such as meadowsweet, anise hyssop, mugwort and bog myrtle that are attested in archaeological contexts and have been identified as possible flavorings/preservatives were grown in the UWM Hortus Academicus and used in experimental brewing and analysis. The potential of partnerships between universities and local businesses in the study of ancient alcohol is illustrated by a case study from Milwaukee, Wisconsin, historically known as Brew City, USA.

The magic of malt: making malt sugars and ale from grain using traditional techniques.

Merryn Dineley

The transformation of grain into ale is a three step process – malting, mashing and fermentation. Each step requires different conditions. Understanding these processes enables us to interpret the archaeological evidence for beer in Europe.

This presentation considers ancient brewing techniques from a practical, technical and scientific point of view. Brewing has become increasingly sophisticated since the Industrial Revolution with the introduction of roasted malts, malt extract and dried malt extract. Traditional malting floors disappeared from Britain, being replaced by Saladin boxes and later by Germinating Kilning Vessels. A malting floor may not be essential. In Norway, for example, malt is germinated on wooden trays in a small building, as brewing historian Lars Garshol discovered in his research into farmhouse brewing in Europe. Both techniques produce the same thing - partially germinated grain.

Mashing is usually done in a mash tun, where crushed malt and hot water are mixed together to make sugars. In parts of Lithuania, Estonia and Russia, crushed malt is mixed with hot water, then heated in an oven. This is 'keptinis'. It could be similar to ancient Egyptian techniques of making beer bread in an oven. Keptinis is a rare survival of an ancient brewing tradition.

We have investigated mashing techniques. Crushed malt was mixed with water and heated on a hot stone beside a fire to make 'bappir' or sweet barley cakes. We also mashed in earthenware bowls sealed with beeswax or fats. Hot rocks are ideal as a heat source instead of fire. We have mashed in stone troughs, wooden troughs and tubs. When recreating an ancient ale it is important and necessary to use appropriate techniques, ingredients and materials.

Strategic Drinking: The Shelf-Life and Socio-Political Importance of Early Iron Age West-Central European Beer

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This presentation examines key assumptions about the durability of prehistoric beer in order to investigate how the production and consumption of alcohol was entangled with social organization and political practice in Iron Age west-central Europe. An experimental archaeological approach was used to test the terminal shelf-life of prehistoric-style beer stored in a variety of vessels, which included modern equipment with known oxygen permeability rates, low-fired coil ceramics sealed with either beeswax or brewer's pitch, and oak barrels. I will discuss the role of archaeological, ethnographic, and historic evidence in determining likely parameters for brewing a prehistoric-style beer and then examine methods for testing beer's shelf-life. Preliminary results indicate a need to rethink assumptions about the durability of prehistoric beer and consider the possibility that it could have been stored for months or even years. These results are compared to ethnographic and historic models relating beverage shelf-life to politically motivated feasting events and social structure. Hypotheses about Iron Age beer's entanglement with social organization are compared to archaeological data from early Iron Age south-west Germany in particular and west-central European sites more broadly. This presentation reveals the need to reconsider the relationship between indigenous beverages, like beer, and foreign imported Mediterranean wine as strategic resources for status display and the creation of social obligation.

Grain or Malt? "Deviant" cereal components in Late Neolithic cereal preparations from the bnks of Lake Constance

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Since the first excavations of lakeshore dwellings around the Alps, finds of more or less intact (supposed or actual) charred "bread loaves" have been extensively documented, as have charred lumps containing cereal remains. Within the scope of European Research Council funded project "PLANTCULT" (ERC-CoG-2015, Grant Agreement No. 682529, PI Soultana Maria Valamoti) we are studying several of these objects in a structured approach with the goal of identifying both their components and the *chaînes opératoires* involved in their production. The methods used are primarily light and scanning electron microscopy of the artefacts in combination with imagery of experimentally charred cereals and cereal preparations. Imaging methods such as µCT and photogrammetry are being tested for structure analysis and documentation.

Aside from other late Neolithic lakeshore settlements such as Mondsee and Attersee (both Upper Austria), Zürichsee and Bielersee (both Switzerland), also finds from the two Lake Constance settlements of Hornstaad-Hörnle 1A and Sipplingen-Osthafen are under investigation. Analysis of their components resulted in *Triticum* species and *Hordeum vulgare* in varying degrees of processing, which shall be briefly presented. Some samples from both lakeshore settlements do not only share very unusual hollow shapes, but under the SEM they also display deviant aleurone tissue patches of the *Hordeum* type: Their cell walls are papery thin, in contrast to the regular thick-walled appearanceof cereal aleurone. Literature research and comparison to experimentally charred material suggest that the most probable process behind the thinning of aleurone cell walls in cereals is germination, and therefore possibly malting. Scenarios for the possible nature and purpose of the analysed artefacts shall be put up for discussion.

Dominance and origin of the wine and beer yeast *Saccharomyces cerevisiae*

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The conversion of sugar to alcohol as it occurs in the production of alcoholic beverages, like wine and beer, is mainly brought about by the yeast *Saccharomyces cerevisiae*. There is evidence from the examination of wine jars from Egypt that this yeast was already the principal microorganism during wine fermentations in ancient times. *S. cerevisiae* dominates alcoholic fermentations. Although cell numbers are low at the beginning of fermentation, it takes over fermentation after 2-3 days and suppresses the growth of other microorganisms.

Traditionally the dominance of *S. cerevisiae* has been attributed to its high fermentative power and its perfect adaptation to the harsh conditions in fermenting mashes, like high levels of ethanol, high osmolarity, lack of oxygen, poor nutrient availability and low pH. But, through recent work, it has become clear that cell-cell contact between *S. cerevisiae* and non-*Saccharomyces* yeasts and antimicrobial peptides play an important role in keeping these other microbial species at bay. In my talk, I will review recent literature on this topic.

Also, I will dwell on the question of how yeast enters fermentation. Insect vectors like *Drosophila* seem to play a central role in this process.

Ancient beer remains from Hierakonpolis, Egypt: analytical approaches for proving fermentation processes

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The current paper will present archaeobotanical evidence of beer from locality HK11C of Predynastic Hierakonpolis, Upper Egypt, and, in particular, the observations on plant remains possibly related with brewing and similar processing. The excavations at this locality have revealed industrial food production activities dating to the Naqada II period (c. 3600-3200 cal BCE). From one structure (Operation B) archaeobotanical evidence was found in-situ in installation where large ceramic vats were preserved containing charred residues. Close examination of the charred residue revealed remnants of emmer most probably processed for food. Whole grains, as well as fragmented grains were distinguishable under low magnification (10-40x). Although no longer recognisable, without magnification, the presence of ground grains was proven by numerous cereal pericarp fragments and aleurone cell layers visible under higher magnification (100-400x). Charred starchy endosperm, without any distinguishing features, starch grains with perforations, some structure resembling yeasts, all observed under Scanning Electron Microscope (SEM) indicate the possibility that fermentation had taken place. This processing, with subsequent heating, must have resulted in a more or less homogenous mass suggesting that this matter was wet when charred. It may represent dough for bread making or - more probably considering the archaeological context - for starting beer production. Other samples found inside the vats and their surroundings also indicate processed emmer processed probably for beer production.

Beer residues from Predynastic (c. 3700–3500 BC, Naqada IIB–C) brewing installations in Tell el-Farkha, Estern Delta in Egypt.

Lucy Kubiak-Martens[a]

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The importance of two cereal products - bread and beer - to ancient Egyptian society is well known. Both bread and beer made a major contribution to diet and ritual practice. Despite the evidence for the importance of beer to ancient Egyptians and a great deal of scholarly debate about ancient brewing techniques, there is no clear answer to the question how the ancient beer was made. In Predynastic Tell el-Farkha, in the Eastern Delta, charred beer residue was preserved in one of the vats in brewing installations. It was encrusted on the bottom of the vat, which was placed in situ on the socket construction. There was also mineralized organic material, possible waste from beer production, found within the brewing installations. The vat content and the mineralized material were subjected to (SEM) archeobotanical and chemical analyses. Surprisingly, emmer, and not barley, was the main ingredient used for brewing at Tell el-Farkha. The beer was not flavoured or sweetened with extra ingredients. A two-part process is suggested as the Predynastic brewing method. The results of archaeobotanical and chemical studies will be presented in more details during the workshop.

Malting in the Hochdorf brewery: Reconstruction of the malting processes and the possible taste of the beer in comparison with the archaeological finds

Herman Kretschmer[a]

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General remarks on malting technology:

- Steeping.
- Germination.
- Kilning (drying)

Reconstruction trial of celtic beer from Hochdorf:

- Malting: Induction of germination by rising humidity in barley germination, kilning / drying on open fire (smoke)
- Brewing: coarsely grinding, mashing until saccharification (either in metal caldron or by hot stones), lautering by sedimentation of solid matter on a sieve or hay/straw/brushwood and extraction of the wort by sedimentation filtration , boiling of wort not known, but done in trial
- Additives: no hop was used in brewing (no hop was found in Hochdorf), maybe other bitter compounds were used (Mugwort [*Artemisia vulgare*]) fermentation with yeast [and probably lactobacteria (and others?)]

Drinking practices in Early Iron Age: looking for molecular biomarkers that could trace beer consumption in pottery from the Heuneburg and Mont Lassois

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Consumption practices, especially in feasting contexts, played a major role in Early Celtic life, as evidenced by a rich corpus of feasting vessels in settlements and graves. To contribute to current knowledge on Early Iron Age societies north of the Alps, we integrate drinking practices as an additional marker. For this purpose, we investigate Mediterranean imported and local vessels from two Early Celtic key sites, Vix-mont Lassois and the Heuneburg, through organic residue analysis.

However, the identification of alcoholic drinks is still a great challenge for organic residue analysis. Indeed, fermented beverages comprise mainly ethanol and fast-decaying polysaccharides which are unlikely to survive over archaeological timescales. Tartaric acid is nowadays accepted as a specific marker of grape product and indirectly wine, however biomarkers for other fermented beverages are still controversial.

To shed light on cereal beer consumption, it is essential to integrate multidiscplinary approaches which include bimolecular archaeology, archaeobotany, experimental archaeology as well as use wear analysis and the techno-typological studies of the vessels. Here we present first results of our integrated approach. At Vix-mont-Lassois and the Heuneburg, we identified several markers which suggest the consumption and possible production of cereal beer. We also discuss the limitations posed by this interpretation and the biomarkers which have traditionally been used to characterize archaeological beer.

Mush and mash: beer in Near Eastern and European prehistory

Eva Rosenstock[a]

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Beers can be classified according to materials used, ways of saccharification, as well as fermentation processes. These suggestions follow Maurizio's Geschichte der gegorenen Getränke (1933) and are based on a rather broad definition of beer as viscous to liquid foods and drinks that are produced by microbial fermentation of enzymatically saccharized starches. This definition considers not only malt-based beers such as lagers, ales, merissa and chicha, but also traditional raw-fruit or bread based fermented cereal beverages such as boza and kwass. Together, they can serve as a framework for interpreting the evidence for beer in prehistoric Southwest Asia and Europe known to date outlined together with that for breads as closely related foodstuffs. Evidence for beer is extremely patchy before the 5th millennium BC, when first malt finds and later pictorial and written evidence appear. As the evidence currently allows only for educated guesses about the development of beer brewing, the paper tries to outline related issues that might have the potential to contribute. Here, among others, the genetics of alcohol tolerance in humans, the genetics of sugar metabolism in yeasts and lactic acid bacteria as well as possible spill-over effects between other fermented drinks and foods such as wines and dairy products might enable us to sketch a more coherent picture of early beer production.

Archaeology of brewing in New Kingdom Egypt

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Beer was a dietary staple for ancient Egyptians. Tomb art includes abundant depictions of food processing, and the artistic record has traditionally been the main source of information about beer production. The archaeological record, however, has considerable potential to expand the data set on brewing. Surviving organic materials are an outstanding source, thanks to the arid Egyptian climate. I will present evidence from scanning electron microscopy of desiccated beer residues dating to the 18th Dynasty (c. 1550-1300 BC) to suggest a model for ancient brewing. This model is both consistent with the art, and indicates that Egyptian brewing was more sophisticated than previously thought. The new evidence allows us to consider how we can expand our understanding of ancient Egyptian nutrition, physical anthropology and the food-related economy.

Are germinated cereal finds proof enough for ancient beer brewing?

Hans Peter Stika[a]

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Beer has been known as the drink of the big civilisations of the Near East, Sumerians and Egyptians, with many artefactual, pictorial and textual evidence confirming the widespread practice of beer making. From Pre- and Protohistoric Central Europe we do not have such evidence, in some cases e.g. beer of early Celts we have written sources from the ancient Greek and Roman authors. Another indication for beer making lies among finds of sprouted cereal grains, as an indication for malt production, i.e. the first step in beer brewing. Of course, one cannot be certain that the sprouted grains are always the outcome of malting for making beer. Intentional malting of a larger amount of pure thoroughly cleaned cereal grains in combination with special installations, findings and finds indication beer production (e.g. flavouring agents, residue analyses of crusts) and consumption (e.g. special drinking vessels) can confirm the evidence of ancient beer.

Finds of malt occur at the Early La Tène settlement site (5th-4th cent. BC) of Hochdorf/Enz, distr. Ludwigsburg, close to Stuttgart, South-Western Germany, and at 5th-cent. BC (2nd Iron Age in France) Roquepertuse, Velaux, dépt. Bouches-du-Rhône, in South-Eastern France. There, not only malt was found, but additionally features were unearthed that could have been used as drying-kilns indicating a large scale beer production.

Detecting steps in ancient beer making in the archaeobotanical record with the aid of experimentation and Scanning Electron Microscopy: the case of Archondiko Giannitson

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Wine-consumption in the prehistoric Aegean is considered an essential element of communities inhabiting the area, especially from the Bronze Age onwards. This assumption is based on various lines of evidence including archaeobotanical and textual evidence (Linear B texts, ancient texts) as well as ceramic vessels and residue analyses. Indeed there is ample information to suggest that wine was the main drink prepared and consumed, possibly relying on some form of incipient cultivation of the grape-vine since the 5th millennium B.C. There is, however, hardly any comparable evidence to point towards other alcoholic beverages, mead and beer. Recent archaeobotanical finds from Archondiko Giannitson have put forward the hypothesis that during the Bronze Age a cereal-based alcoholic beverage might have been prepared at the site and possibly other sites in the regions of Macedonia and Thessaly. Here we present the archaeobotanical remains from Archondiko, together with other lines of evidence from the same site, that might point towards the preparation of some form of beer. We integrate artefactual, archaeobotanical and experimental material generated from different steps of beer preparation and we attempt to interpret some intriguing finds of ground cereal fragments that might have been used for beer preparation. We explore whether these fragments correspond to ground malt and suggest criteria for detecting ground malt in the archaeobotanical record.

Reconstruction of an ancient beer – on the basis of Tall Bazi 1350 BC

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Tall Bazi ist ein archäologischer Siedlungshügel (Tall) im Gouvernement ar-Raqqa im Norden von Syrien. Es wurde eine Stadtanlage aus der zweiten Hälfte des 1. Jahrtausends v. Chr. freigelegt. Gefunden wurden in der sogenannten Weststadt in etwa 50 uniformen Häusern sehr ähnliche Gefäße. Eines davon war größtenteils in den Boden eingelassen, mit einer großen Öffnung und an einer Stelle mit gutem Durchzug. Ein weiteres Lochbodengefäß war mobil und fasste die Hälfte des Volumens des anderen Gefäßes. In beiden wurden Oxalatkristalle gefunden. Oxalat entsteht über den Mälzungs- und Brauprozess. Kann aber auch von Pflanzen in das Erdreich mit eingetragen werden. Aufgrund dieser Befunde und weiterer Studien bezüglich des Textmaterials und klimatischen sowie botanischen Betrachtungen wurden technologische Versuche gefahren, die es ermöglichten eine wahrscheinliche Herstellungsweise dieses bronzezeitlichen Bieres zu rekonstruieren. Dabei war ein Hauptaugenmerk die Verwendung von unvermälztem Getreide und deren Zweck sowie die Rolle von Sauerteigbrot. Beide Rohmaterialien wurden nach alten Keilschriftexten zu jeweils einem Drittel verwendet. Warum diese Verhältnisse? Es zeigte sich, dass das die idealen Verhältnisse sind, die eine lang andauernde und damit stabile Gärung verursachen. Eine Art Naturformel, die sich auch in der Herführung für den Sauerteig zeigte. Ein Zehntel von dem alten Teig wird zum Ansetzen des neuen verwendet. Die Rekonstruktion ist seit Jahren (sie wird zweimal pro Jahr für die Studierenden in Weihenstephan angesetzt) stabil und wird immer sensorisch gut bewertet.

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AN INTERDISCIPLINARY INVESTIGATION OF PLANT INGREDIENTS, CULINARY TRANSFORMATION AND EVOLUTION THROUGH TIME

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