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Biological perspectives on Hittite brewing

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ABSTRACT

This study examines biological properties of beer in ancient Anatolia. Discussion focuses on the Hittite site of Kuşaklı-Sarissa, where the remains of a brewery were excavated dating to the second millennium BC. While ancient brewing practices have often been investigated using archaeological and textual sources, relatively little scholarship has addressed the chemical constituents of this process. The following review makes use of a wider body of food science and medical literature in order to shed light on the sensory and nutritional characteristics of alcoholic beverages.

1. Introduction

It is widely acknowledged that brewing played an important part in the development of social complexity and the rise of the state in the ancient Near East (Joffe, 1998). Together with baking, it provided an impetus for agricultural production, and was a significant source of nutrition (Katz and Voigt, 1986; Braidwood et al., 1953). Beer was also the earliest form of payment for labour, and its consumption provided a focus for many communal gatherings (Milano, 1994). For the Hittite Empire, which ruled large areas of central Anatolia and north Syria during the mid to late second millennium BC, drinking beer (Hittite *siessar*) alongside other types of alcohol held a central role in many ceremonial and religious activities (Del Monte, 1995).

The baseline chemical analytical technique for identifying beer residues in the archaeological record is a spot test for oxalate ion (Fiegl, 1954). Calcium oxalate, otherwise known as 'beer-stone', forms when oxalic acid bonds with calcium in water, and falls out of solution during steeping, mashing, fermentation and storage of barely beer. While its identification is not strictly diagnostic, due to potential oxalate contamination from buried soil or the presence of cross-reacting compounds such as glycolic acids, when combined with contextual archaeological evidence, these results provide strong indication of brewing. Other spot tests, and related techniques including gas chromatography, can identify organic compounds such as tartaric acid indicative of wine, and beeswax associated with the fermentation of honey into mead (Michel et al., 1993; McGovern and Hall, 2015; Gregg, 2009; Heron, 1989). Most recently, ancient beer has been identified through starch (Wang et al., 2017).

Residue analyses of archaeological samples can reveal the content of ancient fermented beverages, but do not accurately reflect their proportional composition. This lack of information about the overall physical properties of ingredients presents a major challenge when attempting to assess their sensory and nutritional characteristics, or understand the brewing process. The aim of this study is to highlight the potential of archaeological, textual, and paleoenvironmental sources to address this evidentiary shortcoming, by examining the biological properties of ingredients and derivatives.

The focus of discussion is a temple brewery at the Hittite site of Kuşaklı-Sarissa in north-central Anatolia, which represents the most complete example of a brewing facility excavated anywhere in the ancient Near East (Müller-Karpe, 2005). Fragments of a very similar brew kit were also discovered in the central temple district of the Hittite capital at Boğazköy-Hattusa (Neve, 1999). Further south along the Euphrates valley, beer production is known through chemical analyses at the Hittite affiliated settlements of Tell Bazi (Zarnkow et al., 2006, 2008, 2011) and Tell Ahmar (Perini, 2015). Other closely related sites including Ugarit provide a rich corpus of supporting textual information (Sallaberger, 2012).

This review is divided into two parts; Sections 2 and 3 gives an overview of available sources concerning the production and basic composition of ancient Near Eastern beer during the second millennium BC, with particular reference to the brewery at Kuşaklı-Sarissa and other sites in the Hittite Empire; Sections 4 and 5 discusses the chemical properties of a proposed bittering adjunct (Polygonum), and biological characteristics of *S. cerevisiae* fermentation for ale-type beer.

2. Brewing equipment

The repertoire of ceramic vessels excavated at Kuşaklı-Sarissa permit a partial reconstruction of ancient brewing practices. Analysis

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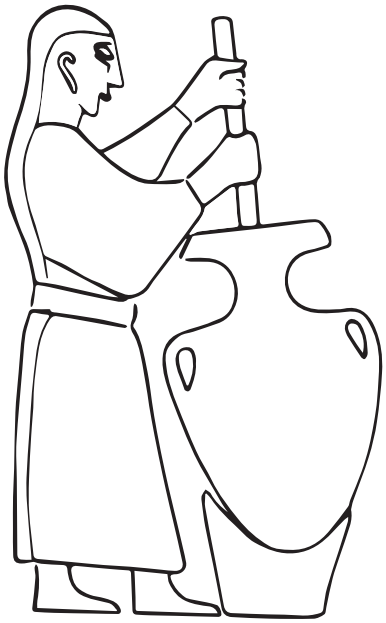

Fig. 1. Hittite brewer depicted on İnandıktepe vase (after Özgüç, 1988, 175 Fig. 64).

by Müller-Karpe (2005: 176–77) has determined that these represent two largely identical brew kits of standard size, comprised of six main vessels each with a shared collection receptacle. Mashing was most likely have carried out in large pithos. A lautering vessel is distinguished by the small hole in its base, and side handles that would have allowed for its suspension above a freestanding collection pot (Müller-Karpe, 2005: 178). Most of the remaining vessels are narrow-necked storage amphora for liquid. This shape is easily sealed with clay, thereby preventing bacterial contamination. While some beer was drunk 'green' through reed straws directly from fermentation vessels, other brews could have been laid aside for maturation and later consumption. Many of the vessels in the brewery have standardised volumes (Müller-Karpe, 2005: 179). Miscellaneous small shallow containers were likely used to measure out cereals and other dry additives, while small jugs could be for dispensing liquid including water, mead and/or for sampling beer. A figure who very likely represents a brewer, mashing the contents of a large vessel resting on a stand, is depicted as part of a Hittite festival scene on a 16th century BC vase from İnandıktepe (Fig. 1).

3. Cereals, malting and mashing

Two-row barley (*Hordeum v. distichon*) was by far the most common cereal at Kuşaklı-Sarissa, constituting 98% of the total seeds recovered (Pasternak, 2000: 351). Barley kernels found in the brewery were exceptionally large compared to those from other areas of the site, suggesting that they were specially selected for purpose (Dörfler et al., 2011: 107). At the time of the site's destruction by conflagration c. 1200 BCE, much of this barley had become swelled through soaking in water, which caused it to split in the fire. Approximately 50 examples of sprouted grains were also preserved (Pasternak, 2000: 350). These finds provide firm evidence for malting, and by extension brewing when viewed in combination with the above equipment (Section 2). Although present in relatively small quantities, three varieties of wheat suitable for brewing were also identified at Kuşaklı-Sarissa in separate contexts from the barley, with the most common being Emmer (*Triticum dicoccum*), suggesting that different types of beers were produced.

Neither archaeological nor textual evidence provides clear and detailed information regarding the composition of grain-bills for brewing, in terms of either the ratio of barley to other grains, or the proportion of malted to un-malted cereals. At a larger scale, it is possible to draw inferences regarding cereal use from the broader foodstuff assemblages of archaeological sites. Investigations at Boğazköy-Hattusa, the capital city of the Hittite Empire located in the north-central highlands of Anatolia, have revealed several grain silos, including a very large subterranean facility of the Old Hittite period with a storage capacity of c. 5880 t (Seeher, 2000). By far the most popular species represented were Barley (*Hordeum vulgare*) and Einkorn wheat (*Triticum monococcum*), which were found at a ratio of approximately 4 (Barley) to 1 (Einkorn) (Dörfler et al., 2011: 106–113). This implies that wheat probably formed the minority component in any derived foodstuffs including beer. Barley and wheat stored in silos at Boğazköy-Hattusa indicate that cereal ingredients were potentially available year-round. Whereas Barley is grown as a summer crop in temperate areas, Emmer and Einkorn wheat are primarily grown as a winter crop due to their frost resistance (Dörfler et al., 2011: 110).

A degree of variation in brewing practices throughout the Hittite Empire is apparent based on region. Whereas Emmer is the most common wheat species at Kuşaklı-Sarissa, Einkorn is more abundant at the capital site of Boğazköy-Hattusa (Dörfler et al., 2011: 107). Further to the east along the Euphrates valley, wheat is significantly more common in northern areas (Miller, 1997). This difference is likely due to the relative salt hardiness of barley, which made it more suitable for irrigation agriculture practiced south of the zone of rain-fed cultivation (Brown and Wilkinson, 2017: 156).[1]

Experimental reconstructions of malting technology at Tell Bazi, a Hittite affiliated settlement in northern Syria, highlight the diversity of techniques that could potentially have been applied. Grain was spread out over mats on the flat-roof of mud-brick buildings. Green malt was turned over twice per day, and germination was achieved within four days. Outside temperature highs in spring and summer (60 °C–45 °C) were sufficient to reduce the moisture content of barley below 14% for storage (Zarnkow et al., 2011: 51–52).

Another intriguing possibility raised through experimental research by Zarnkow et al. (2006, 2008, 2011) is that un-malted grains were mixed with malted grains in a cold mashing process. The principle reason for this appears to have been control over the alcoholic strength of beer, by limiting sugars available for fermentation. In practice, this would only have been possible to the extent that the diastatic power of enzymes in malted grains was still sufficient to allow for an acceptable degree of starch conversion. In other words, the un-malted cereal could only ever have formed a minority component of the grain-bill, if the intention was to brew a fermented beverage with appreciable alcoholic properties, which was not always the desired outcome. For a hot mashing process, an additional constraint would have been the potential for protein coagulation (or 'hot trub' formation), which can impede fermentation and cause undesirable off-flavours. This typically occurs

[1] Beyond the identification of cereal varietals and sprouted grains, gaps in the archaeological record mean that our understanding of malting and mashing technologies must rely on comparison with areas of the Near East in contact with the Hittite realm, where some degree of technology transfer is possible. At the Middle Bronze Age site of Kissonerga-Skalia in western Cyprus, a probable malting facility has been excavated dating to the first half of the second millennium BC (Crewe and Hill, 2012). This oven-like feature is interpreted as a kiln on the basis of the dried, but not charred, barley kernels found within. Dry environmental conditions in Egypt are unparalleled with respect to the preservation of organic remains. Examination of New Kingdom (16th–11th centuries BC) beer residues using scanning electron microscopy (SEM) has revealed pitted and channelled starch granules that are suggestive of enzymatic modification consistent with malting (Samuel, 1996, 2000). Although the possibility that these microstructures are diagenetic artefacts should be acknowledged, identification of significant quantities of unmodified starch within the same beer residues supports the hypothesis that malted and un-malted cereal were mixed together in grist. These analyses also confirm that both Barley and Emmer wheat were used for brewing. Based on the interpretation of brewing and baking model dioramas found in Egyptian tombs, malting inside a barrel-sized ceramic vessel placed on its side has been proposed (Wild, 1966: 101). Such vessels could have periodically been rolled to aerate the grain and prevent roots tangling, as well as placed upright and partially filled with water for steeping (Samuel, 2000: 552–553).