




# Fermented beverage and food storage in 13,000y-old stone mortars at Raqefet Cave, Israel: Investigating Natufian ritual feasting

Li Liu <sup>a</sup> , Jiajing Wang <sup>a</sup>, Danny Rosenberg <sup>b</sup>, Hao Zhao <sup>c</sup>, György Lengyel <sup>d</sup>, Dani Nadel <sup>e</sup> 

[Show more](#) 

 Share  Cite

<https://doi.org/10.1016/j.jasrep.2018.08.008> 

[Get rights and content](#) 

## Abstract

Fermented and alcoholic beverages played a pivotal role in feastings and social events in past agricultural and urban societies across the globe, but the origins of the sophisticated relevant technologies remain elusive. It has long been speculated that the thirst for beer may have been the stimulus behind cereal domestication, which led to a major social-technological change in human history; but this hypothesis has been highly controversial. We report here of the earliest archaeological evidence for cereal-based beer brewing by a semi-sedentary, foraging people. The current project incorporates experimental study, contextual examination, and use-wear and residue analyses of three stone mortars from a Natufian burial site at Raqefet Cave, Israel (13,700–11,700 cal. BP). The results of the analyses indicate that the Natufians exploited at least seven plant taxa, including wheat or barley, oat, legumes and bast fibers (including flax). They packed plant-foods, including malted wheat/barley, in fiber-made containers and stored them in boulder mortars. They used bedrock mortars for pounding and cooking

plant-foods, including brewing wheat/barley-based beer likely served in ritual feasts ca. 13,000 years ago. These innovations predated the appearance of domesticated cereals by several millennia in the Near East.

---

## Introduction

The consumption of fermented and alcoholic beverages is one of the most prevalent human behaviors, but the time and cultural context of its origins remain unclear. Archaeological evidence for alcohol production and use is usually associated with fermenting domesticated species in agricultural societies, such as ancient Egypt, Mesopotamia, China, and South America (Goldstein, 2001; Jennings, et al., 2005; Katz and Voigt, 1986; McGovern, et al., 2004; Samuel, 1996; Wang, et al., 2016). It has long been speculated that humans' thirst for beer may have been the stimulus behind cereal domestication (Braidwood et al., 1953), and some scholars have attributed this invention to the Natufians in the Near East (ca. 15,000–11,500 Cal BP) (see Hayden, et al., 2013). The Natufians were innovative in many material and social realms, and paved the way to the establishment of the first sedentary Neolithic villages at about 11,500 cal BP (Bar-Yosef, 1998). To test the so far unsubstantiated “Natufian beer hypothesis” we examined three stone mortars from the first chamber at Raqefet Cave (13,700–11,700 cal. BP), a site with a long archaeological sequence (Lengyel, 2007), that also served as a Natufian burial place in Mt. Carmel, Israel (Fig. 1A; Fig. S1A) (Nadel, et al., 2013).

Excavations at Raqefet Cave between 2004 and 2011 revealed a radio-metrically dated Natufian graveyard with ca. 30 burials (Barzilai, et al., 2017; Lengyel, et al., 2013). Clear indications for burial-associated rituals include repetitive interments, floral grave lining in some of the burials (Nadel, et al., 2013), and animal bones in the graves representing punctuated funerary feasts (Yeshurun, et al., 2013). About 100 bedrock features (e.g. mortars and cupmarks hewn in the cave floor and the terrace) were found (Nadel and Lengyel, 2009), some directly associated with burials. Two deep

narrow boulder mortars (BM1 and BM2) were found in situ and juxtaposed to human remains. Thus, they were the focus of our contextual, use-wear and residue analyses. BM1 has a cylindrical shaft ca. 33 cm deep and a hole at the base; it is stored in the Laboratory for Ground Stone Tools Research, Zinman Institute of Archaeology, University of Haifa after the excavation in 2006. BM2, a funnel-shaped shaft ca. 35 cm deep, has remained inside Raqefet cave. A well-preserved bowl-like bedrock mortar (BM3), 18 cm deep and 27 cm in rim diameter, located in a cluster of bedrock features in the middle of the cave floor was included in the current study (Fig. 1B; Fig. S1B,C).

---

## Section snippets

### Methods

We collected and examined microbotanical residues and use traces on the mortars in 2015. To test possible post-depositional contaminations in the residue samples, we obtained control sediment samples from various archaeological and natural contexts (see below)....

### Beer-brewing materiality and experimental studies

Ancient brewing processes had great regional variations (Hayden, et al., 2013; Jennings, et al., 2005; Samuel, 1996), but would have involved three basic stages. (1) Malting: grains are germinated in water, drained, dried, and then stored for use. (2) Mashing: the malt is coarsely ground or crushed in a container, mixed with water, and heated until the temperature reached to and maintained in the range of 65 °C -70 °C over a period of time around 30 min to 4 h. (3) Fermenting: yeast is added...

### Starch types

Among the 121 starch granules recovered from the Raqefet Cave residues, six types, corresponding to certain taxa, were identified (Table 1; Fig. 3).

Type I, Triticeae starches ( $n = 13$ ; 10% of the total), are lenticular in shape, with faint lamellae and occasionally scattered craters. The size range is 15.31–41.08  $\mu\text{m}$ . Triticeae starch granules possess a bimodal size distribution, involving the presence of both large granules oval to sub-round in 2D shape, lenticular in 3D (A-type) and small...

## Functional analyses of the Raqefet Cave mortars

Boulder mortars: On BM1, the rim area shows high-level polish with fine or furrow striations, while its interior surface exhibits medium-to-high level polish with long and very fine striations mostly running vertically. Similar use traces (very fine, vertical striations) were observed on the interior surface of BM2 (Fig. 7A–E). Based on our experimental study (Fig. 2), the rim area of BM1 is likely to have been in contact with various materials with different hardness, including stones, and...

## Discussion and conclusions

This multi-disciplinary research on a sample of the Raqefet Cave stone mortars sheds new light on Natufian ritual behavior. The Natufians at Raqefet Cave collected locally available plants, stored malted seeds, and made beer as a part of their mortuary rituals to venerate the dead and/or to enhance group cohesion among the living (Hayden, et al., 2013; Munro and Grosman, 2010; Nadel and Lengyel, 2009; Power, et al., 2014; Rosenberg and Nadel, 2014; Yeshurun, et al., 2013). They used stone...

## Acknowledgements

We thank D. Piperno for her suggestions on starch analysis, and E. Kvavadze for her advice on flax fiber identification. The research is supported by the Min Kwaan Archaeology Fund at Stanford Archaeology Center, Stanford University. Fieldwork at Raqefet Cave was carried out under license numbers G-2004/50, G-34/2006, G-64/2008, G-34/2010 and G-22/2011 of the Israel Antiquities Authority, and permits of the Israel Nature and Parks Authority. The Irene Levi-Sala CARE Archaeological Foundation,...

---

## References (71)

H. Barton *et al.*

Cooking up recipes for ancient starch: assessing current methodologies and looking to the future

J. Archaeol. Sci.(2015)

C. Bergfjord *et al.*

A procedure for identifying textile bast fibres using microscopy: flax, nettle/ramie, hemp and jute

Ultramicroscopy(2010)

A. Betts *et al.*

Early cotton in North Arabia

J. Archaeol. Sci.(1994)

A. Crowther *et al.*

Documenting contamination in ancient starch laboratories

J. Archaeol. Sci.(2014)

L. Dubreuil

Long-term trends in Natufian subsistence: a use-wear analysis of ground stone tools

J. Archaeol. Sci.(2004)

A.G. Henry *et al.*

Changes in starch grain morphologies from cooking

J. Archaeol. Sci.(2009)

J. Lamb *et al.*

Seeing red: the use of Congo red dye to identify cooked and damaged starch grains in archaeological residues

J. Archaeol. Sci.(2005)

E. Lev *et al.*

Ethnopharmacological survey of traditional drugs sold in Israel at the end of the 20th century

J. Ethnopharmacol.(2000)

L. Liu *et al.*

## Usewear and residue analyses of experimental harvesting stone tools for archaeological research

J. Archaeol. Sci. Rep.(2017)

C. Moulherat *et al.*

## First evidence of cotton at Neolithic Mehrgarh, Pakistan: analysis of mineralized fibres from a copper bead

J. Archaeol. Sci.(2002)

☐ View more references

---

Cited by (95)

## Differential behavior of *Lactobacillus helveticus* B1929 and ATCC 15009 on the hydrolysis and angiotensin-I-converting enzyme inhibition activity of fermented ultra-high-temperature milk and nonfat dried milk powder

2023, Journal of Dairy Science

Show abstract ▾

## Pounding, grinding, transitioning. A use-wear perspective

2023, Journal of Archaeological Science: Reports

Show abstract ▾

## Characterization of liquor remains in Beibaie site, central China during the 8th century BCE

2022, Microchemical Journal

*Citation Excerpt :*

...However, culturally, liquor (alcoholic beverages) made from intentional fermentation of sugary substances such as grains, fruits, honey, etc. appeared later[16]. Up to now, the earliest evidence of artificial brewing come from the Mesolithic Age (11000 BCE) in the Near East and the Early Neolithic Age (7000 BCE) in East Asia[17,18]. Most regions in the world have gradually mastered liquor-making technology in the Neolithic Age[19]....

Show abstract ▾

## An initial key of starch grains from edible plants of the Eastern Mediterranean for use in identifying archaeological starches

2022, Journal of Archaeological Science: Reports

*Citation Excerpt :*

...They have also been recovered in calculus on teeth (e.g., Hardy et al., 2016; Henry and Piperno, 2008). In many of these studies, starches are the only preserved record of plant use, and have often provided evidence for novel processing techniques [e.g., brewing (Liu et al., 2018)] or early spread of domesticated plants [e.g., maize (Piperno et al., 2009)]. The identification of starches relies on matching the morphological features of archaeological starches to those from modern plants....

[Show abstract](#) ▾

## Introduction: Alcohol, rituals, and politics in the ancient world

2022, Journal of Anthropological Archaeology

[Show abstract](#) ▾

## Fermented maize beverages as ritual offerings: Investigating elite drinking during Classic Maya period at Copan, Honduras

2022, Journal of Anthropological Archaeology

*Citation Excerpt :*

...Alcohol not only has a long history but is also widespread. Archaeological evidence of alcohol fermented from different kinds of plant materials has been discovered in many parts of the world, including ancient Egypt, Mesopotamia, China, and South America (Liu, 2021; Liu et al., 2018b; McGovern et al., 2004; Wang et al., 2016; McGovern, 2009). The role of alcohol relates to a wide range of perspectives in human societies....

[Show abstract](#) ▾

[↗](#) [View all citing articles on Scopus](#)

---

## Recommended articles (6)

Research article

## Assessing the effects of severe weather events through remote sensing on Samothrace, Greece: applications for the management of cultural resources

Journal of Archaeological Science: Reports, Volume 21, 2018, pp. 810-820

[Show abstract](#) ∨

Research article

## The stable isotope ecology of early (3100 B.P.) hunter-gatherers/farmers from Tula, Tamaulipas, Mexico. Isotopic evidence in bone and teeth

Journal of Archaeological Science: Reports, Volume 21, 2018, pp. 794-809

[Show abstract](#) ∨

Research article

## Natufian collective burial practice and cranial pigmentation: A reconstruction from Azraq 18 (Jordan)

Journal of Archaeological Science: Reports, Volume 10, 2016, pp. 693-702

[Show abstract](#) ∨

Research article

## Revealing invisible brews: A new approach to the chemical identification of ancient beer

Journal of Archaeological Science, Volume 100, 2018, pp. 176-190

[Show abstract](#) ∨

Research article

## Charred wood remains in the natufian sequence of el-Wad terrace (Israel): New insights into the climatic, environmental and cultural changes at the end of the Pleistocene

Quaternary Science Reviews, Volume 131, Part A, 2016, pp. 20-32

[Show abstract](#) ∨

Research article

# Starch taphonomy, equifinality and the importance of context: Some notes on the identification of food processing through starch grain analysis

Journal of Archaeological Science, Volume 124, 2020, Article 105267

[Show abstract](#) ▾

---

[View full text](#)

© 2018 Elsevier Ltd. All rights reserved.



Copyright © 2023 Elsevier B.V. or its licensors or contributors.  
ScienceDirect® is a registered trademark of Elsevier B.V.

 RELX™