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Beer for Men and Gods

Brewing in Egypt under the Ptolemies and the Principate (323 BC – 284 AD)

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I hereby declare that, in line with the Faculty of Arts' code of conduct for research integrity, the work submitted here is my own original work and that any additional sources of information have been duly cited.

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Proem

> *"And… and what is civilization if it isn't people talking to each other over a goddamned beer?" Fayez said, then lolled his head back over his shoulder. "Am I right?"*
> *"Fuckin' A," Amos called back.*
> *– Page 9, Chapter Twenty: Elvi,* Cibola Burn*, book 4* of The Expanse.[1]

Though this observant quote originates from a rather excellent science fiction novel rather than a great work of history, it attests to the significance of beer as a crucial part of the very fabric of society. As a key catalyst in the development of fledgling sedentary settlements and burgeoning empires alike, it brings people together and acts as a key driver of effervescent social interaction, whether it is in a small human colony on a fictional extraterrestrial planet named Ilus, that wretched epicenter of inebriated congregation named Fakbar Letteren or a village perched on the reed-covered banks of the winding river called the Nile.

No country's ancient history and society is more determined by the importance of beer than Egypt (see the map, figure 1). From the dawn of agriculture in the Nile Valley, beer was made from barley and emmer wheat as a staple of daily diet. Soon, as social complexity developed along with organized religion, it also became a critical object of ritual and funerary offerings. Through Egypt's entire pharaonic and Graeco-Roman history, beer was a cornerstone of culture and nourishment, unencumbered by the dominance of wine in the Ancient Near East from the Hellenistic era onward. As the oldest consistent economic product of the land of the pharaohs, its making deserves to be investigated from barley to packaging.

I hereby express my gratitude to all those who have supported me during the conjuration of this project, first and foremost my promotor, prof. dr. Katelijn Vandorpe, secondly Nico Dogaer for his kind suggestions on papyri and other texts pertaining to beer and its production and finally all other people who have aided in the process of and reviewed my thesis and pointed out its flaws. As such, any remaining imperfections and errors are mine. I'm also very grateful to my parents for their enduring support, as well as Fakbar Letteren for providing the necessary nocturnal leisure after the enduring crafting of this thesis. A penultimate word of gratitude goes out to the creators of Trismegistos, the Papyrological Navigator (PN or papyri.info) and Loeb Classical Library, three online databases and respositories which saved me an unfathomable amount of time in researching and analyzing papyri from Graeco-Roman Egypt. An honorable mention goes out to the prog rock and metal bands Rush, Dream Theater, Genesis, Symphony X, Circus Maximus and Haken amid many others for pulling me through the wasteland of research, writing and revising sessions.

[1] COREY, J. S. A., *Cibola Burn – Book 4 of* The Expanse, Croydon, 2015.

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Preamble

From the beginning of agriculture in the Ancient Near East, beer was the national drink in both Egypt and Mesopotamia and was consumed and brewed by all classes in society. Its significance is evidenced by a passage in the Qoheleth, one of the books of the Jewish Thora. For example, in Qoh. xi 1-2 Qoheleth beseeches the reader to:

> Throw your bread upon the face of the water,
> because in many days you will acquire it.
> Give a serving to seven and also to eight,
> because you do not know what evil will be upon

According to Homan, Qoheleth is recommending both beer production and consumption in perilous times.[2] Beer's popularity and importance in these regions was in part due to climactic and agricultural reasons, as grapes were more difficult to produce than cereals and could not easily be kept unless dried.[3] The brewing process, however, was a primary component of and came near the end of the whole cycle of cereal production and well-constructed breweries provide some of the earliest evidence in Egypt for communal organization within settlements[4] that marked the emergence of complex agricultural society. As such, beer is attested to in the earliest written records from Mesopotamia and Egypt[5] and likely predates the emergence of complex societies in the region.[6]

Content and structure

This master's thesis adresses the production of beer in the Roman province of Egypt under the Ptolemies and the Principate of the Roman Empire (305 BC – 284 AD)[7] in production sequence. First is the proem, followed by the table of contents, this preamble and the subdivided bibliography with each category being sorted alphabetically. The semantic prelude contains a brief history of the evolution of beer brewing in Egypt between the advent of agriculture in Egypt and the beginning of the Ptolemaic era, covering the Pre-Pharaonic origins of Egyptian beer and the Early Dynastic Period, the Old Kingdom, the First Intermediate Period and Middle Kingdom, the Second Intermediate Period and the New Kingdom and the Third Intermediate Period and Late Period. Properties and evolutions are demonstrated using concrete examples from archaeological excavations.

[2] HOMAN 2002, 275.
[3] HOMAN 2004, 85; SIGAUT 2005, 294.
[4] KEMP 2006, 172.
[5] SMITH 1995, 9 and SAMUEL 2000, 537 – 538.
[6] BRAIDWOOD et al. 1953, 515 – 526 and GELLER 1993, 255 – 267.
[7] All reign dates are according to SHAW 2000, 480 – 490.

The discussion of the production during the Ptolemaic era and the Principate begins with the places of brewing, followed by the identity of the beer-makers. The production facilities they used are then elaborated upon, including the layout of the brewery and the equipment they used to create the substance we call beer. Subsequently, I elaborate upon the process used to create beer out of barley and/or emmer wheat. This begins with the agriculture of the cereals used and their harvest before transportation to the breweries, followed by selected comparative cases of ancient and authentic contemporaneous cereal-based beers. Subsequently I address the ingredients of the process, including the basic ingredients, additives and intermediate products.

The discussion of the beer-making process proper starts with the discussion of a so-called baking process for beer, followed by a detailed step-by-step brewing process itself inside the beer-making facilities from germination through fermentation, informed by other ancient and authentic contemporaneous cereal-based beers. Penultimately, I address the brewing results, namely the general character, taste and nutritious value and alcohol content, leaving me to finish with the types and identification of beer containers and the preservation of beer. The conclusions, including a Dutch abstract at the end, summarize the plausible beer-making process from field cereal to casked beer with its end results and wrap up this thesis. Appended are the figures referred to in the text.

Sources and Literature

The chief primary sources for the brewing process during the Ptolemaic and Roman times are first and foremost written documents, namely papyri and ostraca from Egypt. The evidence from Egypt is very extensive because of two reasons: the large and widespread consumption of beer there and the extensive conservation of everyday type papyri and ostraca. The former generally either belong to the category of official documents involving the Ptolemaic or Roman government beer regulations and taxation of the production and sale of beer or references to beer or beer-makers in various types of texts.[8] Finally, depictions from Egyptian pharaonic temples and tombs depict the steps of beer production and the consumption itself, but as Hornsey rightfully notes, these depictions are rarely accompanied by any form of explanation. In many cases it is quite difficult to ascertain what is going on and in what order portrayed actions are being carried out. To complicate matters, artistic records cover a period of almost three millennia, during which time brewing techniques would undoubtedly have changed.[9]

[8] NELSON 2001, 16.
[9] HORNSEY 2003, 64 – 65.

Therefore, we cannot rely on artistic representations from pharaonic Egypt to inform us about the beer brewing process in the Graeco-Roman period.

Most notable are discarded accounts and receipts of government officials and from archives from the middle of the third century BC, like the Zenon archive, named after an official in Philadelphia who managed the estate of Ptolemaios II Philadelphos' finance minister Apollonios. Some of his letters deal with beer production, while others are useful for terminology.[10] The papyri are most often of a fiscal or legal nature, chiefly consisting of beer tax collection lists or agreements involving the lease or sale of breweries between the monopoly-holding state actors and private lessees. The most significant papyrus actually addressing the brewing process is P.Tebt. 2 401, a Tebtynis papyrus from 14 AD. This papyrus is a list of names followed by an amount of beer supplied to the person's house in the Arsinoite nome, with an evaluation and list of expenditures, in which the ingredients and processes of beer-making play a large part.[11] Another significant papyrus listing supplies to a beer-maker and -seller and varying quantities of beer to several individuals with Semitic (i.e. Hebrew names) is P.Bon. I.S.A. 3 *R e V* dating to the Late Ptolemaic or early Roman Period and of unknown provenance. [12][13] Ostraca concerning beer deliveries and payments during the Principate include O.Berl. 95 and 96 (2nd to 3rd century AD at Tebtynis)[14] and O. Fay. 11 (from Theadelphia (Arsinoites) dated November 27, 25 BC).[15] Other texts include varied cases such as reports to the police from the first and second centuries AD, such as P.Ryl. 2 127.[16]

Textual sources include the fourth century BC Greek writer and successor to Aristoteles Theophrastus, who wrote the *Περὶ φυτῶν ἱστορία* or *Historia Plantarum* or *Enquiry into Plants* and *Περὶ φυτῶν αἰτιων* or *De Causis Plantarum* or *Plant Aetiology* concerning plant physiology, the first century AD agricultural writer Columella, who writes about plant additives

[10] NELSON 2001, 16. Papyri: i. e. 'P.Cair. Zen. 2 59199', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59199). Accessed on 10 September 2018.

[11] 'P.Tebt. 2 401', *papyri.info* (http://papyri.info/ddbdp/p.tebt;2;401). Accessed on November 16, 2018.

[12] PASSONI DELL'ACQUA, A., 'P.Bon. I.S.A. 3 Recto e Verso: conto di distribuzione di birra ed altri beni con onomastica (tardo tolemaico/prima età romana)', B. PALME ed., *Akten des 23. Internationalen Papyrologenkongresses, Wien, 22.—28. Juli 2001* (Papyrologica Vindobonensia 1), Vienna, 2007, 513 – 524. Both P.Tebt. 2 401 and P.Bon. I.S.A. 3 *R e V* are lists of names of persons. They were drafted by the manufacturers (*ζυτοποιοί*) or beer sellers (*ζυτοπωλεία*) with the names and quantities of beer (*ζῦτος*/*ζῦθος*) sold or delivered constituted the official list for the payment of the beer tax (*ζυτηρά*) and secondly the per-capita consumption tax (*τό κατ' ἄνδρα*), the product was subject to state monopoly. Cf. WALLACE, S. L. R., *Taxation in Egypt from Augustus to Diocletian*, Princeton 1938, 187 – 188; NELSON, C. A., 'A Receipt for Beer Tax', *Chronique d'Égypte*, 51 (1976), 121 – 129, 128 (Euhemeria, May 19 155 A.D.); SCAIFE, A. R., 'Accounts for Taxes on Beer and Natron P.Austin inv. 34', *Zeitschrift für Papyrologie und Epihraphik*, 71 (1988), 105 – 109, 105 – 106 (footnote 6), (Late IIIrd century BC). See also HANSON, A. E., 'P.Mich. inv. 1434: Receipts for Syntaximon and Beer Tax', *Bulletin of the American Society of Papyrologists*, 19 (1982), 47 – 60 (Philadelpheia, 66/71 AD).

[14] 'O.Berl. 95', *papyri.info* (http://papyri.info/ddbdp/o.berl;;95). Accessed on November 18, 2018.
'O.Berl. 96', *papyri.info* (http://papyri.info/ddbdp/o.berl;;96). Accessed on November 18, 2018.

[15] 'O. Fay. 11', *papyri.info* (http://papyri.info/ddbdp/o.fay;;11). Accessed on November 18, 2018.

[16] See i. e. a report about a burglary by a beer-maker in 29 AD, 'P.Ryl. 2 127', *papyri.info* (http://papyri.info/ddbdp/p.ryl;2;127). Accessed on September 12, 2018.

to beer, the first century AD Greek physician Aretaeus Cappadox' *De causis et signis acutorum morborum*[17] and the fourth century AD Egyptian alchemist Zosimos of Panopolis, to whom a 'baking' method for making beer was attributed, in which heated malted bread is fermented in water.[18] As always, Athenaeus of Naukratis' early third century AD *Δειπνοσοφισταί* or *Deipnosophistae* or *The Learned Banqueters* provides passages concerning gastronomy which are only preserved in his compilation. He quotes first and foremost Theophrastus, who briefly describes the fermentation process in *De Causis Plantarum*,[19] but also Diphilus of Siphnos (physician of Siphnos in the third century BC) and Zeno of Kition (the late fourth century and early third century BC founder of the Stoic philosophical school).[20]

The most innovative aspect of the research is the use of comparative cases concerning archaeological sites outside of Egypt to address the missing parts and uncertainties regarding the equipment and brewing process in Egypt in Antiquity. Concerning equipment, one case of interest is an archaeological sample from a fifth century BC house at the Iron Age site of Roquepertuse in the French Mediterranean area of the Etang de Berre, which produced a concentration of carbonized barley (*Hordeum vulgare*) grain and most likely was used for beer-brewing activities.[21] Another is an ancient Wari (600 – 1000 AD) brewery identified on the summit of Cerro Baúl, a provincial administrative center of the Wari Empire in the Moquegua Valley of Southern Peru with a trapezoidal brewing structure with three separate brewing rooms.[22]

One contemporary case providing a solid image of household beer-making is the tribe of the Omotic-speaking Gamo who live in the highlands of south-western Ethiopia along the Rift Valley and produce beer for ceremonies and everyday subsistence. They use different types of grains depending on their ecological zone, which determines whether they subsist more on maize or barley and wheat.[23] The second comparative brewing process can be found in the Upper Volta River Delta region, where brewers are still mashing and fermenting sorghum in facilities that resembled those of 5,500 years ago at Hierakonpolis and other Upper Egyptian sites. Beer manufacturing likely arrived here at a very early date.[24] Thirdly, African Kaffir (Kaffircorn) beer, also known as Bantu beer and made from sorghum, is the traditional beverage of the Bantu tribes of South Africa. Other names are *utshwala* (Zulu) and *utywala*

[17] ARETAEUS CAPPADOX, *Des causes et des signes des Maladies aiguës et chroniques Arétée de Cappadoce* (Hautes études du monde gréco-romain, 27), ed. trad. R. T. H. LAENNEC, M. D. GRMEK and D. GOUREVITCH, Geneva, 2000.
[18] BERTHELOT and RUELLE 1888, 372.
[19] *De Causis Plantarum* 6.11.2.
[20] VAN MINNEN 1991, 167 – 168.
[21] BOUBY, BOISSINOT and MARINVAL 2011, 351.
[22] MOSELEY et al. 2005, 17264 – 17271; BIWER and VANDERWARKER 2015, 28 – 31.
[23] ARTHUR 2003, 519.
[24] MCGOVERN 2009, 256.

(Xhosa).[25] The fourth indigenous beer discussed whose process is well-known is *Talla* (*tella*), an Ethiopian home-processed beer with a smoky flavor and a tan to dark brown color, depending upon how long it has matured. Sorghum, millet, teff, barley, wheat and maize are all used and usually a variety of grains are combined.[26] Fifth is the Orton Hall Farm in East Anglia, where an agricultural site occupied and proved to have developed continuously from at least the middle of the first century AD to the early sixth century provides a possible contemporary parallel to Imperial breweries in Egypt during Roman times.[27] Finally, *bouza*, the modern Egyptian beer and descendent from the beer brewn since the earliest times of agriculture in Egypt, is also well-known for its unique brewing process.[28]

Countless studies have been conducted into beer production, consumption and funerary use and significance during the pharaonic era. Earlier works include the studies of Lutz,[29] Hartman and Oppenheim [30] and Darby, Ghalioungui and Grivetti. [31] Delwen Samuel has recently assembled the most comprehensive theory surrounding beer production in the Dynastic epoch based on chemical analyses and experimental brewing.[32] Another significant archaeologist is Jeremy Geller, who has been excavating the Pre-Dynastic fourth millennium BC site of Hierakonpolis since 1978.[33] Also noteworthy are the recent chemical analyses of yeast by Mukherjee et al. in 2017[34] and Aouizerat et al. in 2019[35], the latter in an archaeological context from Egyptian pharaonic breweries in Israel. These studies shed light on the nature of the yeast potentially used in the brewing process. Finally, Barry Kemp provides a context of socio-economic development in his *Anatomy of a Civilization* and a reconstruction of a brewery/bakery and its potential equipment.[36]

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[25] NOVELLIE 1963, 28 and NOVELLIE 1976, 73 – 77.
[26] STEINKRAUS 1996, 428.
[27] MACKRETH 1996, xi – xv.
[28] DARBY, GHALIOUNGUI and GRIVETTI 1977, 534; 541.
[29] LUTZ, H. F., *Viticulture and Brewing in the Ancient Orient*, New York, 1922.
[30] HARTMAN, L. H., and OPPENHEIM, A. L., *On beer and brewing techniques in ancient Mesopotamia* (Journal of the American Oriental Society suppl. 10), 1950.
[31] DARBY, W. J., GHALIOUNGUI, P. and GRIVETTI, L., *Food: The gift of Osiris*, New York, 1977.
[32] SAMUEL, D., 'A new look at bread and beer', *Egyptian Archaeology* 4 (1994), 9 – 11., SAMUEL, D. and BOLT, P., 'Rediscovering ancient Egyptian beer', *Brewers' Guardian*, 124 (1995), 26 – 31, SAMUEL, D., 'Archaeology of ancient Egyptian beer', *Journal of the American Society of Brewing Chemists*, 54 (1996), 3 – 12, SAMUEL, D., 'Investigation of Ancient Egyptian Baking and Brewing Methods by Correlative Microscopy', *Science*, 273 (1996), 488 – 490, SAMUEL, D., 'Bread Making and Social Interactions at the Amarna Workmen's Village, Egypt', *World Archaeology*, 31 (1999), 121 – 144, SAMUEL, D., 'Brewing and baking', in P. T. NICHOLSON and I. SHAW eds., *Ancient Egyptian materials and technology*, Cambridge, 2000, 537 – 576 and WILLIAMS, N., 'How the Ancient Egyptians Brewed Beer', *Science*, 273 (1996), 432.
[33] GELLER 1993, 255.
[34] MUKHERJEE, V., RADECKA, D., AERTS, G., VERSTREPEN, K. J., LIEVENS, B. and THEVELEIN, J.M., 'Phenotypic landscape of non-conventional yeast species for different stress tolerance traits desirable in bioethanol fermentation', *Biotechnology for Biofuels*, 10 (2017), 1 – 19. Accessed at https://doi.org/10.1186/S13068-017-0899-5 on 23 May 2019.
[35] AOUIZERAT, T. et al., 'Isolation and characterization of live yeast cells from ancient vessels as a tool in bioarchaeology', *mBio*, 10 (2019); 1 – 21.
[36] KEMP, B. J., *Anatomy of a Civilization*, 2nd edition, London, 2006.

Several authors have conducted research into brewing in Graeco-Roman Antiquity, though mostly not specifically focused on Egypt. Max Nelson has published an overview in 2001 concerning beer-production in Graeco-Roman Antiquity over the Mediterranean Basin as a whole.[37] Though covering beer-brewing across the globe, Ian Hornsey's monograph also deserves to be mentioned due to him being a brewer by profession, thus offering a refreshing craftsman perspective amid the panoply of publications by academic historians and archaeologists.[38] A modern historical overview of significant alcoholic beverages across the world from the earliest times onward is authored by Patrick McGovern, who spends some attention to *bouza*.[39] Finally, chemical analyses of residues by e.g. Samuel[40] and Morcos[41] help to precisely determine the ingredients of Egyptian beer and provide clues to the steps of the brewing process.[42]

[37] NELSON, M., *Beer in Greco-Roman Antiquity*, Ph.D. dissertation, The University of British Columbia, The Faculty of Graduate Studies, Department of Classical, Near Eastern, and Religious Studies, Vancouver, BC, 2001.
[38] HORNSEY, I. S., *A history of beer and brewing*, Cambridge, 2003.
[39] MCGOVERN, P. E., *Uncorking the Past: The Quest for Wine, Beer and Other Alcoholic Beverages*, London, 2009.
[40] SAMUEL, D., 'Investigation of Ancient Egyptian Baking and Brewing Methods by Correlative Microscopy', *Science*, 273 (1996), 488 – 490.
[41] MORCOS, S. R., HEGAZI, S. M. and EL-DAMHOUGY, S. T., 'Fermented Foods of Common Use in Egypt. II. The Chemical Composition of bouza and its Ingredients', *Journal of the Science of Food and Agriculture*, 24 (1973), 1157 – 1161.
[42] See i. e. for bouza (modern Egyptian beer descending from ancient Egyptian brews) MORCOS, S. R., HEGAZI, S. M. and EL-DAMHOUGY, S. T., 'Fermented Foods of Common Use in Egypt. II. The Chemical Composition of bouza and its Ingredients', *Journal of the Science of Food and Agriculture*, 24 (1973), 1157 – 1161.

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ḥnḳ.t: Brief overview of an Egyptian staple

Pre-Pharaonic Origins and Early Dynastic Period

From the beginning of agriculture in the Ancient Near East, beer was the favored drink in both Egypt and Mesopotamia and was consumed by all classes in society. Beer's popularity in these regions was in part due to climatic and agricultural reasons, as grapes were more difficult to produce than cereals and the wild grape did not grow in Egypt's arid climate.[43] Beer, made from barley (both *Hordeum distichum* and *H. vulgare*) and emmer wheat (*Triticum dicoccum*), was the most widely consumed alcoholic drink in the ancient Near East.[44] In Egypt, emmer wheat and barley were the most significant, with the former primarily used to bake bread, but also used for beer-making and the latter being chiefly used to produce beer.[45] Since bread and beer used the same cereals (wheat and barley) and partly the processes (see *infra*) to make them were inextricably linked with each other.

Geller has reassessed previously known materials from Abydos, Mahasna, Badari, Ballas and other sites and suggests that brewing was widespread in Naqada I–III Egypt.[46] An adjoining site which he interprets as a bakery would confirm the connections between baking and brewing from iconographical evidence.[47] The use of bread in beer production is known in both Egypt and Mesopotamia,[48] and Geller points to textual and iconographical evidence suggesting that brewing was done largely by women.[49]

A major site is Hierakonpolis, where a number of brewing and bakery sites have been excavated and additionally located through surface survey.[50] Vats from two sites at Hierakonpolis suggest the brewing of an emmer wheat-based beer.[51] Emmer wheat is known to be the main constituent of the so called 'Nekhen Beer'[52] as identified in the large vats of the brewery at locality HK24A, which were excavated by Jeremy Geller in 1988 – 1989.[53] The production of beer probably took place in kilns, consisting of two parallel rows of jars sunk into the ground whose contents were then heated to ferment emmer wheat,[54] as shown by finds at Cemetery D area of the Osiris temple at Predynastic el-Mahasna north of Abydos.[55]

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[43] HOMAN 2004, 85; MCGOVERN 2009, 166.
[44] GELLER 1992a, 127; GHALIOUNGUI 1979, 13.
[45] MURRAY 2000, 511 – 512.
[46] GELLER 1992b, 21 – 23; GELLER 1993, 262 – 263.
[47] DARBY, GHALIOUNGUI and GRIVETTI 1977, 501 – 550; GELLER 1993, 260; SAMUEL 1994, 9 – 11.
[48] HARTMAN and OPPENHEIM 1950, 11; CHAZAN and LEHNER 1990, 29.
[49] GELLER 1992b, 21.
[50] GELLER 1993, 264.
[51] GELLER 1989, 52; GELLER 1992b, 21 – 23.
[52] MAKSOUD, EL HADIDI and AMER 1994, 221.
[53] FRIEDMAN et al. 1999, 18, GELLER 1989, 41 – 52 and GELLER 1992b, 19 – 26.
[54] BARD 1994, 275; GELLER 1989, 47.
[55] PEET and LOAT 1913, 1 – 7.

The scale of beer and bread production indicated by the archaeological evidence is considerable. The six vats could produce up to 1,100 (Geller) or 2,500 (McGovern) liters per day.[56] This is well beyond the domestic or household level, leading to the conclusion that community production and provisioning were being undertaken. Geller has suggested that Hierakonpolis was the Predynastic Milwaukee or St. Louis, "with beer-making a dominant elite-building and maintaining industry".[57]

What remains a mystery is where and how other stages in the beer making process were carried out at any of these sites. For example, where were the malting facilities if the vats were used for mashing? How was the liquid wort separated from the spent grain? If separate vessels were used to ferment the wort after it had cooled, can they be identified in the excavation corpus? Most important, the telltale chemical evidence of barley beer fermentation — beerstone, or calcium oxalate, as was detected inside the Godin Tepe beer jug — has not yet been confirmed from any vessel at these Egyptian sites.[58] However, McGovern remarks that in the upper Volta River region, brewers are still mashing and fermenting sorghum in facilities that resembled those of 5,500 years ago at Hierakonpolis and other Upper Egyptian sites, indicating that beer manufacturing likely arrived at a very early date.[59] It should be noted that there is clear archaeological evidence that pre-Dynastic brewing was different to that of the New Kingdom. Neither is likely to have involved beer loaves as in Mesopotamia (see Baking, *infra*).[60]

Then there is the mystery of why grapes and dates would have been added to the mash. A bitter taste can't be the reason, since hops were not added to 'Bouza'.[61] Mixing barley and wheat malt together makes sense, because barley is a much richer source of diastase enzymes than wheat. Perhaps the fruit was also mixed in to provide yeast and an immediate dose of sugar that encouraged an initial fermentation, which marginally elevated the alcohol level and limited the growth of harmful microorganisms. The higher temperatures of mashing, however, would have killed the yeast, which cannot tolerate temperatures above 40°C. Another possibility, consistent with the way sorghum beer is made in the West African nation of Burkina Faso today (see Sorghum beer in the Upper Volta River Delta region, *infra*), is that the primary fermentation was carried out in the same jar as the mashing. After the wort had cooled down,

[56] GELLER 1993, 263; MCGOVERN 2009, 249 – 250.
[57] GELLER 1992b, 24.
[58] MCGOVERN 2009, 243.
[59] MCGOVERN 2009, 256.
[60] SAMUEL 2005, 294.
[61] MAKSOUD, EL HADIDI and AMER 1994, 219.

fruit was added to jumpstart the main fermentation, contribute flavors and increase the alcohol content.[62]

Throughout the later Predynastic or Naqada II and III periods local Egyptian elites made efforts toward self-definition, including increasing control over craft production and symbols.[63] However, working class burials at the HK43 cemetery in Hierakonpolis with only one (a bottle) or two pots (a bottle and a jar set) often contained beer in straw-tempered bottles,[64] indicating the basic nature of beer as a valued possession both in the real and the afterlife. Securing of copper resources and technology from the southern Levant was another goal,[65] as was eventually the maintenance of a small-scale colonial system in the southern Levant.[66] It is significant that vats associated with beer making have been found at several sites in this colonial system. Beer production and distribution played an important role in the official provisioning of the colonial system, a situation apparently paralleled in Uruk in Mesopotamia.[67] Most of the 40,000 First and Second Dynasty stone vessels that were discovered in the subterranean galleries VI and VII under the eastern side of the Step Pyramid at Saqqara had inscriptions mentioning bread and beer in conjunctions with ceremonies like the Sed-festival.[68]

The evidence of beer production should be coupled with that for bread production by the emergent state. The bread mold or *bedja* bowl has been recently discussed by Chazan and Lehner (1990) in terms of both its function and ubiquity in Early Dynastic and Old Kingdom contexts and its formal and functional similarities to the Uruk beveled-rim bowl. They note that with the rise of the state and the need for mobilizing and provisioning large labor forces "a technology which would have allowed the production of large quantities of bread would have been desirable".[69] They observe, for example, that bread molds comprise some 32% of the total sherd count from the excavations at the Giza Menkaura pyramid complex,[70] and large-scale bakeries have recently been discovered nearby. With the benefit of modern occupational safety consciousness one can imagine that a steady supply of bread and beer may have tempered the tedium of pyramid building while simultaneously increasing its hazards.[71] Therefore, the importance of beer only increased during the Old Kingdom.

[62] MCGOVERN 2009, 243.
[63] CIALOWICZ 1989; DAVIS 1983; DAVIS 1990.
[64] FRIEDMAN et al. 1999, 8 – 9.
[65] SEEHER 1990; SEEHER 1991, 313 – 318; ENDRÖDI 1991, 29.
[66] JOFFE 1993; DESSEL and JOFFE s. d.
[67] JOFFE 1998, 299.
[68] REGULSKI 2009, 262.
[69] CHAZAN and LEHNER 1990, 31.
[70] CHAZAN and LEHNER 1990, 26.
[71] JOFFE 1998, 299.

Old Kingdom

During the later 4th and throughout the 3rd millennium food, time and people became commodified and elaborate systems of valuation for both were established and maintained by proliferating administrative structures. Beer from the state helped accelerate the acceptance of these new structures and relationships.[72] As a divine gift, it was esteemed by the Egyptians as a necessity for the living and equally a necessity for the parched throats of the dead.[73] Wine had also spread to beer-drinking Egypt by the third millennium BC, despite the absence of native wild grapes in Egypt.[74] However, contrary to the general size increase of royal and private tombs during the third and fourth Dynasties of the Old Kingdom, massive prehistoric mashing facilities turned out to be short-lived and have been found only at late Prehistoric sites (unless Old Kingdom Giza represents a continuation of the tradition). Freestanding jars and relatively small, preheated bowls replaced them, to judge from later tomb artistic depictions and models.[75] Barley and wheat beer, however, remained the drink of choice for the masses, showing that the distinction between wine and beer was a common class marker in ancient Mesopotamia and Egypt.[76]

A precise reconstruction of the production process of beer in the Old Kingdom is offered by Delwen Samuel (see figure 2). According to Samuel, the brewer first gathered husked grains of barley and/or emmer wheat.[77] Emmer (and einkorn and bread wheats) were used sparingly throughout the ancient Near East because they are more difficult to ferment than barley.[78] The grains were laid out on mats, in shallow bins, or inside big jars turned on their sides. The cereals were exposed to moisture and allowed to sprout to produce amylases. After five to seven days for barley and six to eight days for emmer wheat, the grains were exposed to the sun, milled to create malt and then mixed with cold water. A second batch of barley and/or emmer wheat was prepared at the same time. This batch was made with milled grain (either sprouted or unaltered) that was cooked in water. Brewers then mixed the two batches together for a period to induce saccharification in the warm water. The mixture was rinsed with water and passed through a sieve. The dregs that were caught in the sieve were then squeezed to remove any remaining liquid. Water was sometimes added to the liquid in the jar at this point both to increase the quantity of beer brewed and to reduce its strength.[79]

[72] JOFFE 1998, 300.
[73] FORBES 1951, 282.
[74] DIETLER 2006, 233.
[75] MCGOVERN 2009, 250.
[76] DIETLER 2006, 233; 237; + DZIERZBICKA 2011, 1.
[77] SAMUEL 2000, 551 – 553.
[78] MCGOVERN et al. 2005, 293.
[79] SAMUEL 2000, 551 – 553.

Fermentation was initiated through the yeasts in the unwashed jar or by the addition of beer from the last brew or ingredients such as fruits that contained a natural yeast bloom.[80] Although yeast cells have been identified in ancient residues, the specific varieties of yeast used remain unknown.[81] According to Lucas, the yeast was principally a previously unknown variety of wild yeast which Grüss named *Saccharomyces Winlocki* after Mr. H. E. Winlock, who supplied the material for examination from Meryet-Amun's Eighteenth Dynasty tomb.[82] In a few cases, large colonies of bacteria have also been found in residues. This discovery suggests possible parallel lactic acid fermentation in some cases (present-day lambic and gueuze beers go through an analogous process).[83] The mash, allowed to ferment in a large, wide-mouthed jar, formed a frothy scum on the surface. In order to prevent this from passing into the storage jars the vat was provided with a small spout which permitted the clear brew to be poured off first. In the Old Kingdom tomb of Ti at Sakkareh just such a vat is shown in use (see figure 4).[84] Having fermented for a few days, the beer was decanted into jars and sealed for storage or transport.[85] While jars were used in Egypt for fermentation, Mesopotamians may have used an apparatus that allowed the wort (the heated, saccharified malt) to trickle into a collector vat for fermentation.[86]

Samuel's reconstruction differs from other accounts in two critical ways. In most accounts, malted flour is mixed with flour and yeast and lightly baked. The bread, used instead of the malt in Samuel's reconstruction, was either used directly after baking, dried for a few days, or baked again for long-term storage.[87] In all cases, the operational chain dovetailed with Samuel's reconstruction after the bread was broken up, mixed with water and passed through a sieve.[88] Samuel argues against this interpretation because the morphology of the starches found in beer residues, at least in Egypt, seems to preclude baking as a step in the process.[89] The baking of beer loaves is, however, well-documented in Mesopotamian records.[90]

The second way in which Samuel's process differs from other accounts is in the addition of dates and other flavorings. According to most scholars, dates served as both an important flavoring and a provider of the sugars needed for the production of alcohol.[91] Other flavorings,

[80] SAMUEL 2000, 555; GELLER 1992b, 21.
[81] HORNSEY 2003, 71.
[82] LUCAS 1962, 23; GRÜSS 1929, 681 – 682 and WINLOCK 1932, 32 – 33.
[83] HORNSEY 2003, 71; SAMUEL 2000, 547.
[84] LANSING 1937, 286; STEINDORF 1913, pl. 83.
[85] SAMUEL 2000, 555 – 556.
[86] HORNSEY 2003, 90 – 91.
[87] DARBY, GHALIOUNGUI and GRIVETTI 1977, 538; KATZ and MAYTAG 1991, 27.
[88] DARBY, GHALIOUNGUI and GRIVETTI 1977, 541, LUTZ 1922,79, MONTET 1958, 87 and SAMUEL 1996a, 3.
[89] SAMUEL 2000, 555.
[90] CIVIL 1964, HARTMAN and OPPENHEIM 1950 and HORNSEY 2003, 83 – 91.
[91] DARBY, GHALIOUNGUI and GRIVETTI 1977, 543, HORNSEY 2003, 62 – 63, KATZ and MAYTAG 1991, 32, KEMP 2006, 123 – 124 and MONTET 1958, 87.

such as lupines, skirrets and radishes, are mentioned as having sometimes been added to the brew during fermentation.[92] No evidence for the use of dates or other additives has yet been found in beer residues, [93] however, and it is possible that these items were used only rarely for special brews.[94]

A relatively complete portrait of beer production comes from a 5th Dynasty painting in the tomb of Ti, an Egyptian official at Saqqara (see figure 4). Shown in the figure are the complete panel (left), close-ups of people heating the pottery (top left), baking and extracting bread in what appear to be vessels similar to beer bottles and flowerpots (top right) and pouring the beer into containers to be sealed (bottom).[95] Prototypes of bread molds were used in producing bread and beer throughout the Fertile Crescent from the beginning of history, with forms including the aforementioned Old Kingdom *bedja* bread molds.[96] This appears to resonate with Samuel's theory, though the tomb images offer a less extensive view.

First Intermediate Period and Middle Kingdom

The eventual bureaucratization of beer production, which came to fruition in the Middle Kingdom, has been well described by Barry Kemp, including the scribal intervention from the first harvest over the bread and beer-making to storage and shipment of the containers.[97] Thanks to the analysis of a bread crumb from the tomb of Mentuhotep II (2060 – 2010 BC), the first ruler of the Middle Kingdom, we now have a good idea of the process of beer-making in the early Middle Kingdom.[98] At the time of Mentuhotep and Princess Meryet-Amun, beer or *bouza* was made in Egypt by coarsely grinding a quantity of barley, kneading about three-quarters of it with water to form a stiff dough and lightly baking it with enough heat to partly gelatinize the starch but not enough to kill the enzymes in either the flour or the yeast.[99] The remainder of the barley was spread out in a warm place and kept damp for several hours-a primitive form of malting. The loaves of 'beer bread' were then broken into water. The rest of the barley and an amount of bouza from a previous batch were added and the entire mixture left to ferment. When finished, the *bouza* was separated from the mash by either careful decantation or by pressing through a coarse cloth. According to Swift, this indicates a high state of development of the brewers art. [100]

[92] DARBY, GHALIOUNGUI and GRIVETTI 1977, 543, KATZ and MAYTAG 1991, 30 and HORNSEY 2003, 62 – 63.
[93] SAMUEL 1996a, 10; SAMUEL 1996b, 488.
[94] SAMUEL 2000, 556.
[95] HOMAN 2004, 94.
[96] HOMAN 2004, 88.
[97] KEMP 2006, 171 – 172.
[98] See SWIFT 1966, 216 – 222.
[99] LARSEN 1936, 51 – 57.
[100] SWIFT 1966, 218 – 219.

The process itself has also been extensively elaborated upon by Barry Kemp based on a model from the 12th dynasty tomb of Meketra (figure 3). As in earlier times, baking and brewing were part of the cereal process and happened side-by-side. Beer relied upon malting, allowing the grains to begin to sprout and release their sugar and the critical mixing and blending of uncooked malt with cooked grain or malt. As the model illustrates, the making of bread and beer happened seemingly side by side. The room to the right of the vestibule was the brewery, divided from the bakery behind it by a low partition wall. In the brewery a man wielded a long wooden pestle to crush grain in one of the circular limestone mortars. This operation precedes the grinding, which loosened the husks that tautly encased the grain (his step is skipped with modern free-threshing wheat). Paired grindstones sat in quern emplacements. Large jars in a row against the partition wall were used for storing finished beer. Opposite them stood five large cylindrical tubs presumably made of pottery for sieving and malting.[101]

Beer mixes in the Middle Kingdom varied, with various grains involved (*bšꜣ*, *bdt*, *ỉt šmˁ*) as well as dates,[102] offering an elaboration upon Samuel's Old Kingdom process outlined *supra*. A Middle Kingdom texts states that ¾ hekat of *bšꜣ* (malt) went into the beer with an equivalent amount of dates:

Beer	*sty* jug	of 2 des *pew* 2	1 jug makes 3/4 hekat 3/4 hekat dates

This was an admixture of the cereal plus dates (or another liquid), which do not occur in the New Kingdom. These mixtures can also be noted in the P. Bulaq 18 and in the Illahun papyrus.[103] However, the fact that no evidence for the use of dates or other additives has yet been found in beer residues[104] while it is implied in Middle Kingdom texts may be explained by the thesis that these items were used only rarely for special brews.[105]

[101] KEMP 2006, 172 – 174.
[102] SPALINGER 1988, 268.
[103] SPALINGER 1988, 268 – 269.
[104] SAMUEL 1996a, 10; SAMUEL 1996b, 488.
[105] SAMUEL 2000, 556.

Second Intermediate Period and New Kingdom

During the New Kingdom, wages were usually paid in bread and beer which were baked and brewn at institutional bakeries and breweries.[106] However, despite the mature state of the New Kingdom economy or maybe because of it, elites coped with the production of surplus for feasting together with day-to-day consumption needs. Production methods may have been the same as for domestic production, differing only in scale.[107]

Bappir (beer bread) or manna bread, has long been hypothesized as an alternative for the mashing process.[108] This theory is based on interpretations of historical Sumerian and Egyptian texts, such as the Hymn to Ninkasi, cylinder seals and hieroglyphs including those found on pottery sherds and tomb walls.[109] Ground-malted grain was mixed with water and possibly adjuncts for flavor and formed into a loaf to create bappir. The loaf was then slow cooked to achieve temperatures suitable for the enzymes in the malted grain to break down the starches into sugars. The fire was used to bake the bread, which is then mixed with water, filtered and stored in jars that are sealed with a ceramic lid and mud/clay on the outside (see figure 5).[110]

Some archaeologists have argued that these loaves may have also been inoculated with a significant amount of yeast (a fungus within the *Eumycota* family), effectively producing a starter for a brew which could either be used immediately or stored for future use.[111] When it was required for brewing, the *bappir* likely would have been broken up, mixed with water and strained into a fermentation vessel.[112] Dineley has conducted a series of experiments which demonstrate the potential for this alternative to mashing, which effectively eliminates the need for a mash tun and the challenges of maintaining the temperatures necessary for the diastase to be effective. However, to date, the archaeological evidence has not been able to substantiate the process of using *bappir* and it is still the subject of some debate.[113]

Samuel has conducted extensive research into the analysis of starch residue in New Kingdom Egypt (ca. 1550 – 1069 BC), which demonstrated the morphological breakdown of cereal starches, particularly einkorn and barley, into sugars. Through his analysis, he has concluded that the process of using *bappir* was not a factor, at least in the domestic brewing

[106] JANSSEN 1975, 455.
[107] SAMUEL et al. 2005, 294.
[108] KATZ and MAYTAG 1991, 25 – 31, SAMUEL and BOLT 1995, 27 and JENNINGS et al. 2005, 280.
[109] KATZ and MAYTAG 1991, 25 – 31.
[110] HOMAN 2004, 92.
[111] SAMUEL and BOLT 1995, 27.
[112] DINELEY 2004, KATZ and MAYTAG 1991, 25 – 31 and JENNINGS et al. 2005, 280.
[113] DINELEY 2004 and HAYDEN, CANUEL and SHANSE 2013, 106 – 107.

process.[114]Also, brewing took place in smaller moveable pottery vessels, though this may have been the case before the New Kingdom.[115] For example, at Beth Shean, there is an interesting transition from flowerpots in the 18th Dynasty of Egypt to beer bottles in the 19th and 20th Dynasties. In Level IX (second half of the fifteenth to fourteenth centuries BC) there are only flowerpots on the site. In Level VIII-VI (thirteenth to twelfth centuries BC/Ramesside era) only beer bottles appear.[116] Finally, In the Middle Kingdom, an admixture of the cereal plus dates (or another liquid) has taken place. Why such products do not occur in the New Kingdom, which after all used dates, is anyone's guess. Perhaps tastes had altered between Dynasty XIII and XVIII. However, it is evident from the offering lists of the New Kingdom that these intricate calculations do not occur.[117]

[114] SAMUEL and BOLT 1995, 31.
[115] SAMUEL et al. 2005, 294.
[116] MULLINS 2002.
[117] SPALINGER 1988, 268 – 269.

Third Intermediate and Late Period

During the Third Intermediate Period (1069 BC – 664 BC) and particularly the Late Period (664 BC – 332 BC), Greek sources address Egyptian beer, which they often call 'wine'. The first Greek colonization efforts in the eight century BC mark the first encounter of Greeks with Egyptian beer.[118] Hecataeus of Miletus speaks of the Egyptians, saying that "they grind barley for a drink" (*τὰς κριθὰς ἐς τὸ πῶμα καταλέουσιν.*).[119] Similarly Aeschylus, who uses the term when presumably speaking of a Thracian, mentions Egyptians as "drinkers of the inebriant [made] from barley" (*πίνοντας ἐκ κριθῶν μέθυ.*).[120]

Herodotus too says that Egyptians "use wine made of barley":

> *οἴνῳ δὲ* ***ἐκ κριθέων πεποιημένῳ*** *διαχρέωνται· οὐ γάρ σφι εἰσὶ ἐν τῇ χώρῃ ἄμπελοι.* [121]
>
> For wine, they use a drink made from barley, for they have no vines in their country.

The *olyra* referenced by Herodotus is tetraploid emmer wheat (*Triticum dicoccum*).[122] In fact, Egyptian beer is first given its Greek term by Theophrastus, who calls it *ζύτος*[123] and otherwise still speaks of separate beers as "wines made from barley and wheat" (*τούς οἴνους ποιούντες ἐκ τών κριθών καί τών πυρών*),[124] again demonstrating the preeminence of wine in Greek literature and society.[125][126] This term was from Thracian origin, since the Greeks learned of beer-drinking from their north-eastern neighbors who became the model-drinkers of beer, a role which was overtaken by the Egyptians by the end of the fourth century BC,[127] though the term *ζύτος* persisted.[128] It also shows that the basic ingredients, barley and wheat, had remained unchanged since beer was first produced in Egypt some four millennia earlier. However, details concerning additional ingredients like yeast and the brewing process itself remain elusive, regrettably not allowing to define the nature and evolution of beers and their brewing process during the Third Intermediate and Late Periods.

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[118] NELSON 2001, 76.
[119] Hecat. FGrH 1 F323a (in Ath. Deipn. 10.447d), and slightly differently at FGrH 1F323b (in Ath. Deipn. 10.418e).
[120] Aesch. Suppl. 953.
[121] Hdt. 2.77.4.
[122] DIXON 1969 and DARBY, GHALIOUNGUI and GRIVETTI 1977, 461 – 479.
[123] This term is also used for Gaul barley beer, see Diod. 5.26.2.: "Furthermore, since temperateness of climate is destroyed by the excessive cold, the land produces neither wine nor oil, and as a consequence those Gauls who are deprived of these fruits make a drink out of barley which they call *zythos* or beer, …"
[124] NELSON 2001, 27.
[125] De caus. plant. 6.11.2.
[126] NELSON 2014, 34.
[127] NELSON 2001, 44.
[128] NELSON 2001, 34.

Beer brewing in Egypt Under the Ptolemies and Principate

Places of brewing

It is generally accepted that the word for a brewery in ancient Greek was *ζυτουργεῖον* (or *ζυτουργίον*), following the model of such terms as *ἐριουργεῖον* ('wool factory'), *καθαρουργεῖον* ('bakery'), *λινουργεῖον* ('linen factory'), *πλινθουργεῖον* ('brick factory'), or *ὑαλουργεῖον* ('glass factory'). However, *ζυτουργεῖον* is found in no ancient text and is a modern scholarly invention,[129] based on a restoration of *ζ* and *ζυ* in three Flinder Petrie papyri by Mahaffy and Smyly.[130] The proper word for a brewery, as far as we know, was *ζυτοπωλεῖον* (almost always found as *ζυτοπώλιον*), literally 'beer store', which was also a place of public importance.[131][132] Peremans and Van 't Dack have shown that in Ptolemaic Egypt the term *ζυτοπώλιον* could denote a brewery, citing two letters from Apollonios to Zenon, both dated to 254 BC. In the first, Apollonios speaks of twelve *artabai* of barley to be used to make beer daily at a *ζυτοπώλιον* in Philadelphia (see Scale of Brewing, *infra*).[133] In the second he mentions Amenneus the 'beer-maker' (*ζυτοποιός*)[134] at the same *ζυτοπώλιον*.[135] Therefore, one can assume that the *ζυτοποιοι* and *ζυτοπώλαι*, beer brewers and beer shop-keepers, were generally the same, beer brewing being very simple and requiring no special machinery.[136]

In another letter in the same series both the *ζυτοπώλιον* and the *ἐργαστήριον* are mentioned and both have also been restored in another papyrus of the archive from 254 BC (see figure 7):[137]

Ἀπολλώνιος Ζήνωνι χαίρειν. ἔγραψα[ς]
ἡμῖν ὅτ[ι] Πᾶις ὁ ζυτοποιὸς [ἔ]νδε̣κ̣[α ἀ]ρ[ταβῶν]
τὴν ἡμέραν φάσκοι συντετάχθαι
πρὸς ἡμᾶς. ἔψ[ε]υσται οὖν πρὸς σέ· δώδεκ[α] γ[ὰ]ρ
ἀρταβῶν ὑπέσ̣τ̣η καὶ ἐπὶ τούτοις ἀπ̣έστ̣α̣λ̣κ̣α
πρὸς ὑμᾶς. σύσχες οὖν αὐτὸν μέχρι ἂν
ἡμεῖς παραγενώμεθα καὶ σύνταξον
ἀντιγράφεσθαι τὸ ***ζυτοπώλιο****ν καὶ]*
παρακολουθεῖν πᾶσι τοῖς κατὰ τὸ
ἐργαστήριον.

(Recto); Apollonios to Zenon greeting. You wrote to us that Pais the brewer says that he has made an agreement with us for eleven artabas
a day. He has therefore lied to you; for he undertook to brew twelve artabai and it was on that understanding that I have sent him to you. Detain him then until
we arrive and order
your agent to check the accounts of the beer-shop and follow all the operations of the
brewery.

[129] NELSON 2001, 88.
[130] MAHAFFY and SMYLY 1905, 221.
[131] ROSTOVTZEFF 1922, 70; E. g. *ζυτοπωλείου Σαραπείου* in P.Lond. 3 1177, col. 3, l. 51., see 'P.Lond. 3 1177', *papyri.info* (http://papyri.info/ddbdp/p.lond;3;1177). Accessed on September 11, 2018. See figure 6.

[133] 'P.Cair. Zen. 2 59199', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59199). Accessed on 10 September 2018.
[134] P.Cair. Zen. 2 59202v, l. 5. See also HARRAUER 1987, 82 – 86.
[135] 'P.Cair. Zen. 2 59202', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59202). Accessed on 10 September 2018. See also PEREMANS and VAN'T DACK 1977, xxviii and 3.
[136] ROSTOVTZEFF 1922, 119.
[137] 'P.Mich. 1 36', *papyri.info* (http://www.papyri.info/ddbdp/p.mich;1;36). Accessed on September 12, 2018.

ἔρρωσο. (ἔτους) λα, Δύστρου [ζ, Φαμεν]ὼθ ιδ. Ζήν[νω]νι.	Farewell. Year 31, Dystros [7], Phamenoth 14. (Verso) To Zenon.[138]

There is further proof for this contention. In another Ptolemaic text from Tebtynis dated to 253 BC in which barley (*κρ(ιθῆς)*) is to be supplied for beer, it is sent to a *ζυτοπώλιον*:[139]

> *Ἀρχιτίμωι σύνταξον μετρ[ῆσαι εἰς τὸ ἐν -ca.?-]*
> ***ζυτοπώλιον κρ(ιθῆς)*** *ρ. [-ca.?-]*

Certainly, a simple beer store would have no need for cereal. Later instances could also be advanced. For instance, in 29 AD, Papontos, the former 'beer-maker' (*ζυτοποιός*), allegedly broke into a house in Dionysias from the *ζυτοπώλιον* next door, where he presumably had worked (and neglected to return the key).[140] However, it is uncertain whether a *ζυτοπώλιον* is always a proper 'beer store', one connected to a brewery or just the latter. Only the textual and, where available, archaeological context can determine the precise meaning of the term *ζυτοπώλιον*.

A significant question is how 'state' or 'royal breweries' in Egypt can be discerned from 'private' enterprises. This matter is complicated by the fact that the Ptolemies and the Roman officials regulated the production and sale of beer in Egypt differently, with the former taking a more centralized and planned approach.

As part of the Ptolemaic state monopoly, a fixed amount of cereals (*σύνταξις*) was delivered to beer-makers[141] in state-run or at least state-contracted factories to produce a determined amount of beer, whose production was subsequently taxed.[142]

The Roman officials did not regulate the beer production in Egypt as strictly, since they leased out concessions to private beer-making facilities and did not impose fixed amounts of cereals, allowing home-brewing to a certain extent even though the product was still subject to taxes.[143] Finally, it should be noted that these forms of control by the Ptolemies and Romans did not differ from their respective regulatory approaches to other industries, such as oil production.[144]

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[138] Translation in 'P.Mich. 1 36', *papyri.info* (http://www.papyri.info/ddbdp/p.mich;1;36). Accessed on September 12, 2018. Modified from original English translation in EVANS 2011, 218.

[139] P.Tebt. 3 701 V, col. III, l. 248 – 249., excerpted from 'P. Tebt. 3 701', *papyri.info* (http://papyri.info/ddbdp/p.tebt;3.1;701a). Accessed on September 12, 2018.

[140] 'P.Ryl. 2 127', *papyri.info* (http://papyri.info/ddbdp/p.ryl;2;127). Accessed on September 12, 2018.

[141] See i. e. P.Cair. Zen. 2 59199, discussed *infra*. 'P.Cair. Zen. 2 59199', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59199). Accessed on 10 September 2018.

[142] REIL 1913, 167 – 168, PRÉAUX 1939, 152 – 158, HEICHELHEIM 1933, 170 – 172, RÖMER and GAGOS 1996, 145 and TAUBENSCHLAG 1955, 669.

[143] REIL 1913, 168 – 169, WALLACE 1938, 187, TAUBENSCHLAG 1955, 669 – 670 and HEICHELHEIM 1933, 196.

[144] NELSON 2001, 226.

Despite the tight state control under the Ptolemies, the textual evidence does not provide a specific term for them since no *βασιλικόν ζυτουργεῖον* occurs in the texts, despite a claim by Grenfell, Hunt and Smyly to the contrary.[145] Certain terms may be indicative of large-scale brewing in a state-contracted or state-run brewery. In one papyrus from the Zenon Archive from Philadelphia in the spring of 253 BC, a woman named Haunchis (*Αὔγχις*) petitions Zenon for help to reclaim her daughter from an abductor while stating that she distributes beer every day *ἐκ τοῦ μεγάλου ζυτοπωλίου*.[146] Given that at least homebrewing was generally a woman's occupation (see Identity of the Brewers, *infra*), one can assume the mentioned facility was probably a large brewery rather than a beer wholesaler, as Nelson also believes.[147] This beer-making nature is further supported by the mention of *τὸ ἐργαστήριον* in line 12.[148]

Secondly, the scale of certain contracts demonstrates the stringent government control of the output of breweries. One example can be found in Philadelphia, which contracted with the government to brew beer daily from twelve artabas ((*ἀρταβῶν*) *ιβ*, perhaps about 480 pounds) of barley (*κριθῶν*), according to P. Cair. Zen. 2 59199, a letter from Philadephos' finance minister Apollonios to Zenon from 254 BC (see figure 8):

Ἀπολλώνιος Ζήν[ωνι χα]ίρειν. τῶν ἐκ τοῦ
[Ἀρσι]νοίτου ζυτοπ[οιῶν -ca.?-]. ε. . [-ca.?-]
[ὑφ]ίσταται τοῦ ζυτοπωλίου [το]ῦ [ἐν] Φιλαδελφεία[ι]
σύνταξιν \δώσειν εἰς τὸ βασιλι[κ]ὸν/ τὴν ἡμέραν ***κριθῶν (ἀρταβῶν)****(*)* ***ιβ***.
5συγγραψάμενος οὖν πρὸς αὐτὸν καὶ χειρογραφία[ν]
λαβὼν παράδος αὐτῶι τὸ ἐργαστήριον,
παρακατάστησον δὲ καὶ πιστολογευτὴν
ἀξιόπιστον τὸν ἐπακολουθήσοντα τῆι
ἐργασίαι. τὸν δὲ νῦν ζυτοποιοῦντα
10συνανάγκασον τὰ δίκαια ποιῆσαι ὧν χρόνων
πεπραγμάτευται.
ἔρρωσο. (ἔτους) λα, Περιτίου ἐμβολί(μου) κη, Φαμενὼθ ς

Ζήνωνι.
ζυτοπο[ιο]ῦ
Πάιτος[149]

Apollonios greets Zenon. You must know that X (the name is not preserved)
has

[145] GRENFELL, HUNT and SMYLY 1902, 49., based on P. Tebt. 1 5, l. 170 (γεω(ργοῦντας) βα(σιλικὴν)) from 'P. Tebt. 1 5', *papyri.info* (http://papyri.info/ddbdp/p.tebt;1;5). Accessed on November 23, 2018; NELSON 2001, 88 – 89.

[146] P.Lond. 7 1976, l. 2 – 4 from 'P.Lond. 7 1976', *papyri.info* (http://papyri.info/ddbdp/p.lond;7;1976). Accessed on November 23, 2018. See also ROWLANDSON 1998, 209, BAGNALL and CRIBIORE 2006, 102, BAGNALL and CRIBIORE 2008, A1.4, Nr. 4. and CLARYSSE and VANDORPE 1995, 98. Beer wholesaler: PESTMAN 1990, 77 – 78.

[147] NELSON 2001, 89.

[148] P.Lond. 7 1976, l. 12.

[149] 'P.Cair. Zen. 2 59199', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59199). Accessed on 10 September 2018.

rented the beer shop at Philadephia and
has assumed the obligation to pay to the treasury according to the daily output of beer made from 12 artabae of barley. Make a contract with him and
after having taken from him his sworn declaration let him have the beer shop.
Appoint also a trustworthy collector who will control the
business. The present brewer
shall fulfill his obligations for the time
he managed the business.

To Zenon.
Concerning the brewer Paitos.[150]

Due to the importance of beer as an offer for the dead since the early pharaonic era, it isn't surprising that breweries were also part of temple domains or endowments, which received deliveries of grain.[151] For example, there was a pious citizen of the Delta, who had already endowed a shrine of Aphrodite with a string of shops, desired to add a brewery to the endowment and decided to request tax exemption for a brewery devoted to such a holy cause.[152] Indeed, the idea of profit seems to have been the main reason for integrating the brewery as part of a sanctity's facilities aside from the proximity of the production facility's client. It appears that the temple of Soknopaios at Soknopaiou Nesos or in the Arsinoites (*ἀπὸ [κ]ώμης Σοκνοπαίου Νήσου*) in the second century BC (UPZ 1 110, col. V, from September 21, 164 BC) and 209 AD (BGU 1 2, see figure 9) owned and perhaps contained within its precinct a taxable brewery based on the mention of the beer-tax (*ζυτηρᾶι*) in the former and the sowing of grain (*κατασπορᾶς σιτικῶν*) in the latter:

κ[αὶ] πράγματος διαφορὰν εὑρεῖν, ὃς οὐδ' αὐτὸ τοῦτό
γε δυνήσεται συννοεῖν, ὅτι καὶ τοὺς ὑποτελεῖς
τῆι τε ἰχθυηρᾶι καὶ **ζυτηρᾶι** *καὶ ταῖς ἄλλαις ὠν-*
αῖς ἐν τοῖς σύνπασιν ἀνθρώποις καταριθμεῖ-
σθαι συμβέβηκε,[153]

and to find the disagreement of the affairs, who himself won't
be able to understand it
because he has also come to terms with counting the discharges
for the fish-tax and the **beer-tax** and the other
taxes among all the people[154]

Ἀπολλοφάνι(*) [τ]ῷ καὶ Σαραπάμμωνι στρ(ατηγῷ) Ἀρσι(νοΐτου) Ἡρ(ακλείδου)

[150] ROSTOVTZEFF 1922, 118.
[151] For the mention of grain deliveries to temples for the purpose of beer-making, see Ostracon nr. 4 (P 762), KAPLONY-HECKEL 1998, 214; 219 – 221. Beer-making for Hathor is more elaborately described in LEITZ 2017, 221 – 237.
[152] FORBES 1951, 283.
[153] UPZ 1 110, col. V, excerpted from 'UPZ 1 10', *papyri.info* (http://papyri.info/ddbdp/upz;1;110). Accessed on September 11, 2018.
[154] Adapted from WHITE 1986, 36.

μ[ε]ρίδος
παρὰ Ἐριεῦτος Τατᾶτος ***ἀπὸ [κ]ώμης Σοκνο-***
παίου Νήσου. *μετὰ τὸ ἐπιτελ[έσ]αι με τὰ προ-*
ήκοντα ἔργα μέχρι ***κατασπορᾶς σιτικῶν***
ἐδαφῶν ὄντων περὶ τὴ[ν] αὐτὴν κώμην
ἐν τόπῳ Τωα(...)[155]

To Apollophanis and Sarapammon, strategos of Arsinoites
Of the lot
From Erieus, son of Tatas**, from the village of Sokno-**
Paiou Nesos. With the discharge of the pro-
Ceding works as far as the sowing of the wheat
In the present soil about the village itself
In the place Tooa[156]

Wilcken observed that here was the earliest known predecessor of the mediaeval monastic breweries.[157] The brief window of consumption for most traditional alcoholic beverages is one reason that ancient breweries have been relatively rare archaeological finds and those that have been identified in Egypt,[158] are facilities for state-sponsored feasting at an adjacent location rather than for trade.[159]

Finally, since beer was usually made from products that were a common part of the household agrarian base, production was often a domestic activity.[160] The home-brewing of beer was common in Roman Egypt and the general beer tax on all consumers made sure that the government derived revenue even from cottage industry.[161] The scale of output of private breweries was probably low but sufficient for local needs of an extended family to village level. However, output may have been kept intentionally to a limited level to not draw attention from tax officials and avoid the general beer tax or *ζυτηρά* or *ζυτηρά κατ' ἄνδρα*, probably a poll tax on private consumption.[162][163] Concerning the total volume of brewing Nelson states that the production of beer in Egypt may well have exceeded that in Europe and the former's wider availability resulted in a cheaper cost.[164]

[155] 'BGU 1 2', *papyri.info* (http://www.papyri.info/hgv/8961). Accessed on September 11, 2018.
[156] Translation by Daan Smets.
[157] WILCKEN 1899, 369 – 371.
[158] GELLER 1993, 255 – 267.
[159] DIETLER 2006, 238.
[160] DIETLER 2006, 238.
[161] FORBES 1951, 283; WALLACE 1938, 187.
[162] See O.Oslo 12 from 211 AD for such a beer tax receipt from Tebtynis on an ostracon. 'O.Oslo 12', *papyri.info* (http://papyri.info/ddbdp/o.oslo;;12). Accessed on November 24, 2018.
[163] WALLACE 1938, 187 – 188; NELSON 1976, 126 – 129.
[164] NELSON 2001, 93.

Identity of the brewers

Firstly, the activity of the beer-maker was denoted by *ζυτοποιῶν* ('to make *zythos*') in a Zenon Archive Papyrus from April 29, 254 BC[165] and possibly *ζυτοποιία* ('the making of *zythos*') in a papyrus dated to June 13 62 AD,[166] with *παραζυτοποιία* attested in a papyrus from February 9, 61 AD and ostracon from 55 to 68 AD[167][168][169] and *παραζυγῆς* in a papyrus dated to March 26, 56 AD.[170][171] Brewers received special licences in the form of a special contract concluded by the brewer with the farmers of the beer industry and the state officials.[172]

Concerning the labor of beer production, the actual work of brewing did not appeal to the Greeks according to Forbes. The professional brewers were largely native Egyptians,[173] as evidenced by the names Taembes and Petosiris in P. Hib. 1 139.[174] However, a brewer (*ζυτοποιοῦ*) named Eutychas (*Εὐτυχᾶτι*) was presumably a Greek in P. Mich. 2 123, a tax register made up during the 6th year of the reign of Emperor Claudius, from Tebtynis (Arsinoites) dated September 3 to 25 October 25, 45 AD (recto) and November 9,45 to December 24, 46 AD (verso):

θ ***Εὐτυχᾶτι ζυτοποιῷ*** *εἰς χαρτη(ράν). (δραχμαὶ) δ*[175]	On the 9th. For Eutychas the brewer, for the paper tax (chartera): 4 drachmai.;
(δραχμαὶ) δ κ τιμῆ(ς) ζύτο(υ) ἀπὸ τοῦ Τριστόμο(υ) δρό(μου) **Εὐτυχᾶ(τος)** **ζυτοποιοῦ**. (πυροῦ ἀρτάβης) α γ´. ἀργ(υρίου) (δραχμαὶ) ις[176]	On the 20th. For the price of beer (bought) from Eutychas the brewer at the avenue of Tristomos: 1 5/6 artabai of wheat, (of the value) of 16 silver drachmai

[165] ζυτοπ[οιῶν -ca.?-] in P.Cair. Zen. 2 59199, l. 2 from 'P.Cair. Zen. 2 59199', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59199). Accessed on 10 September 2018.
[166] ζυτοπ(οιίας) or παραζυτ( ) in P. Stras. 6 501, l. 12 from 'P. Stras. 6 501', *papyri.info* (http://papyri.info/ddbdp/p.stras;6;501). Accessed on November 22, 2018.
[167] 'παραζυτοποιΐα', *TM Words* (https://www.trismegistos.org/words/detail.php?lemma=παραζυτοποιΐα&morph_type=noun). Accessed on December 23, 2018.
[168] παραζυτοποι(ίας) in P.Fay. 47, l. 5 from 'P.Fay. 47', *papyri.info* (http://papyri.info/ddbdp/p.fay;;47). Accessed on November 22, 2018.
[169] [παραζ]υτοπ(οιίας(?)) κατ' ἄνδ(ρα) in O.Fay. 10, l. 4 from 'O.Fay. 10', *papyri.info* (http://papyri.info/ddbdp/o.fay;;10/). Accessed on December 17, 2018.
[170] παραζυγῆς in P.Mil. 1 11v, l. 5 from 'P.Mil. 1 11v', *papyri.info* (http://papyri.info/ddbdp/p.mil;1;11). Accessed on November 22, 2018.
[171] In total, *papyri.info* has 50 attestation for *ζυτοποι* in Greek papyri. 'ζυτόποι', *papyrus.info* (http://papyri.info/search?STRING=(ζυτοποι)&no_caps=on&no_marks=on&target=text&DATE_MODE=LOOSE&DOCS_PER_PAGE=15). Accessed on December 17, 2018.
[172] ROSTOVTZEFF 1967, 119; PEREMANS, W. and VAN'T DACK, E., *Prosopographia Ptolemaica, vol. V*, Louvain, 1977.
[173] FORBES 1951, 283.
[174] 'P.Hib. 1 139', *papyri.info* (http://papyri.info/ddbdp/sb;12;10783). Accessed on September 12, 2018.
[175] P. Mich. 2 123 recto, col. 1 d, r. 8 – 9, excerpted from 'P.Mich. 2 123 R', *papyri.info* (http://papyri.info/ddbdp/p.mich;2;123). Accessed on September 11, 2018.
[176] P. Mich. 2 123 verso, col. 11, r. 25 – 27, excerpted from 'P.Mich. 2 123 V', *papyri.info* (http://papyri.info/ddbdp/p.mich;2;123). Accessed on September 11, 2018.

Another brewer (*ζυτοποιὸν*) with a Greek name, Herakles (*Ἡρακλῆ(ν)*), is mentioned in the very same papyrus on the verso:

(ὀβολοὶ) ε ὁμο(λογία) Νεφερῶτο(ς) καὶ ἄλλου πρὸ(ς) **Ἡρακλῆ(ν) ζυτοποιὸν** περὶ τοῦ κατ᾽ ἄνδρα.[177]	(Fee:) 5 obols.; Agreement from Nepheros and another to **Herakles, a brewer**, concerning the poll-tax.

According to P.Bon. I.S.A. 3 *R e V* dating to the Late Ptolemaic or early Roman Period, which is of unknown provenance and lists supplies to a beer-maker and -seller and varying quantities of beer to several individuals (see figure 10),[178] the recipients of the distributions and the goods given on credit were at least in large part (if not all) Jews, as evidenced by the names *Ἰοζη(που)* [R col. I l. 3] and *Ἰακουβ(ου)* [R col. I l. 5]. It could be the account of a brewer, in a village or in a neighbourhood inhabited by a good number of Jews and other Semitics and/or an account of distributions to persons not united by the place of residence but by the celebration of some perhaps religious festivals.[179] Here, we see them mentioned in the contexts of guilds of craftsmen.[180] Guilds of craftsmen and Jewish workers are attested[181] for Egypt also from Talmudic sources (at least for Alessandrian *τεχνίται*[182]), as well as by Philo[183], and especially for metalworking.[184] The Jews also excel as weavers and dyers.[185] They also distinguished themselves as traders: Philo complains about the cessation of business caused by the persecution of 38 AD[186].

The brewery and its tower or pylon is mentioned in R I 8 in the formula *ἐν τῶι πυλῶ(νι) το(ῦ) ζ(υτοπωλίου)*. Meanwhile, the son of the soldier Jacob, son of Ἀχιλλίων, relates to the *σύνοδος* of the brewers and the beer shop (*ἐν ζ(υτοπώλων)*) according to R I 5. Nothing prohibits that

[177] P. Mich. 2 123 verso, col. 15, r. 12 – 13, excerpted from 'P.Mich. 2 123 V', *papyri.info* (http://papyri.info/ddbdp/p.mich;2;123). Accessed on September 11, 2018.
[178] PASSONI DELL'ACQUA, A., 'P.Bon. I.S.A. 3 Recto e Verso: conto di distribuzione di birra ed altri beni con onomastica (tardo tolemaico/prima età romana)', B. PALME ed., *Akten des 23. Internationalen Papyrologenkongresses, Wien, 22.—28. Juli 2001* (Papyrologica Vindobonensia 1), Vienna, 2007, 513 – 524.
[179] PASSONI DELL'ACQUA 2007, 515.
[180] PASSONI DELL'ACQUA 2007, 522.
[181] JUSTER, J., *Les Juifs dans l'empire romain. Leur condition juridique, économique et sociale*, Paris, 1914, I, 485 – 487.
[182] JUSTER 1914, I, 486, note 2; APPLEBAUM, S., 'The Social and Economic Status of the Jews in the Diaspora,' S. SAFRAI, M. STERN, D. FLUSSER and W. C. VAN UNNIK eds., *The Jewish People in the First Century Historical Geography, Political History, Social, Cultural and Religious Life and Institutions*, I, Assen and Philadelphia, 1974, 701 – 727, 703. Talmud Babli, *Yôma'* 38a; *'Arakîn* 10b.
[183] In *In Flaccum* VIII 56 he speaks of the *ἐργαστηρια τῶν Ἰουδαίων* (cfr. COLSON, F. H., *Philo. With an English Translation*, vol. IX, Cambridge and London, 1954., 334).
[184] JUSTER 1914 (s. n. 64), II, 306 – 308 (and gloss); C. Pap. Jud. *Prolegomena* 16. We know that the rabbinical tradition has a special affection for arts and crafts. The observant Jews must learn, in addition to the intellectual work, a manual work. For the various categories of work and their respectability or not in the rabbinical tradition and on the work of the Rabbis cf. JEREMIAS, J. J., *Gerusalemme al tempo di Gesù*. (Ricerche di storia economica e sociale per il periodo neotestamentario) (trad. of *Jerusalem zur Zeit Jesu. Eine kulturgeschichtliche Untersuchung zur neutestamentlichen Zeitgeschichte*, Göttingen, 1962), Rome, 1989, 459 – 471.
[185] JUSTER 1914, (s. n. 64), II, 306–307; C.Pap. Jud., *Prolegomena* 17.
[186] C.Pap. Jud., *Prolegomena*, 48 – 49; *In Flaccum* 57.

they could work even for the production or sale of beer[187], as they think the Didymus of R I 12 and the Rebecca of V I 4 or that, as belonging to guilds of other workers made use of it, being a beverage not contrary to their food norms.[188] Monthly distributions of wheat to which the Jews participated since the times of Augustus are mentioned by Philo.[189] As far as barley beer (or fruit beer) is concerned, the drink is widespread in the ancient Near East (as mentioned *supra*), the Jews could use it and according to the rabbinical tradition the drink is *kašer*, so not only lawful, but even preferable to wine if this is not safe purity (*kašerut*) even during the celebration of festivities, excluding Easter (because beer is a fermented beverage). [190] Therefore, the presence of Jewish brewers seems certain.

Many of the brewers mentioned in the Graeco-Roman texts were also female, while winemaking was exclusively a man's occupation.[191] The best example is Taembes, a female brewer from Phebichis (Herakleopolis) from the Herakleopolitan nome in Middle Egypt. Her archive of 9 papyri dates from 247 BC to August 18, 244 BC[192] and concerns monthly payments made to the *logeuterion* (royal bank) at Phebichis, the main main center of the Koites toparchy of the Herakleopolite nome and range from 8 to 20 drachmai. The taxpayers are brewers and representatives of Taembes, who acted as a tax farmer[193] and apparently lived at Talae, a village of the same toparchy.[194] Taembes (*Ταμβέους*) is mentioned along with the special rent paid for the concession (*ζυτηρᾶς*)[195] in P. Hib. 1 139 from 246 BC (see figure 11):

[(ἔτους) Φα]ῶφι κζ. πέπτωκεν	Year. Phaophi 27. Petosiris, agent of Taembes
[ἐπὶ τὸ] ἐμ(*) Φεβίχει λο(γευτήριον) τοῦ	from Talae, in Phebichis of the
[Κωίτο]υ Ἡρακλείωι	Koite Toparchy to Heracleius,
[τραπεζ]ίτηι καὶ Νικο-	Banker and Niko-
[λάωι δοκ]ιμαστῆι παρὰ	laus, controller, has paid to the bank for
Πετοσίριος τοῦ παρὰ	the beer tax
Ταμβέους ἐκ Ταλάη	for the month of Phaophi,
ζυτηρᾶς εἰς τὸν Φαῶφιν χα(λκοῦ) [(δραχμὰς)]	nine drachmas of copper,
ἐννέα (γίνονται) θ.	that is, 9.

[187] For another case of Jews involved in the beer trade see CLARYSSE, W., 'The Financial Problems of the Beer-Seller Ameneus.', *Enchoria*, 16 (1988), 11 – 21, 18, P.Freib. inv. n. 130, Tholthi 30 June 230 B.C., r. 18 διὰ Δωροθέου. For the trades of Jews including beverage trade, cf. JUSTER 1914, (s. n. 64), II, 291 – 314, 298 – 300 (299 – 303 for Egypt), 300 (footnote 11). See Also the *judaici caupones* mentioned by Church Fathers as Ambrose (*De fide*, 3, 10, 65) and Gerolamo (*In amos* 2, 12).

[188] To avoid the distribution of food not allowed to the Jews they were replaced by cash correspondents: JUSTER 1914, (s. n. 64), I, 361; II, 236 – 238. The Egyptian *ζῦτος* was also exported to Palestine and the word appears transliterated also in Hebrew *zytws*. Cf. SCHÜRER, E., *History of the Jewish people at the time of Jesus Christ (175 BC – 135 A.D.)*, II, Edinburgh, 1986, 100 – 101, note 215.

[189] *De legibus* 23; cf. JUSTER 1914, (s. n. 64), II, 236. These distributions could also be postponed for a day if they fell on Saturdays.

[190] PASSONI DELL'ACQUA 2007, 523.

[191] MARCINIAK 1995, 242; PEREMANS, W. and VAN'T DACK, E., *Prosopographia Ptolemaica, vol. V: Le commerce et l'industrie; le transport sur terre et la flotte; la domesticité* (= Studia Hellenistica. Band 13), Louvain, 1963.

[192] 'Taembes beer brewer from Talae', *Trismegistos Archives* (https://www.trismegistos.org/archive/371). Accessed on September 12, 2018. The last papyrus is 'P. Hib. 1 107', *papyri.info* (http://papyri.info/ddbdp/p.hib;1;107). Accessed on November 14, 2018.

[193] CLARYSSE 2007, 90.

[194] CLARYSSE 2007, 89.

[195] SHUMAKER 1970, 42.

παρόντος Δωρίωνος Demotic 1 line[196]	In the presence of Dorion. 1 regel Demotisch[197]

According to Clarysse, the name Taembes is that of a woman and probably renders in Greek the Egyptian name *tɜ-ḥnb*. Heneb is a snake goddess who was venerated in the Herakleopolite nome and the name is typical of that nome.[198]

According to McGovern it is not surprising to find a woman being in charge of brewers or a brewer herself, since wine making which always had to be done on a rather large scale was probably from its very beginning a men's task, whereas until quite recent times beer making, like most other food preparation, was one of the many household chores and as such belonged to the sphere of women's activities, which seems to have been the case in New World cultures too.[199] This was particularly true in the case of alcohol production for work feasts.[200] It ought to be mentioned, however, that men performed the ritual brewing of beer.[201] This attribution of the brewing to the woman's household tasks in turn reveals the nature of the brewing equipment in private households.

Finally, there were other professions related to beer-brewing, such as yeast-making. This is seemingly demonstrated by the mention of *ζύμης 1/2|⟧ χό(ες) β* in the aforemention 14 AD P. Tebt. 2 401 (see figure 26):

> *ὁμ(οίως) διὰ αὐτοῦ ὅτε* συνο(ικίᾳ) Ἀντωνίας* ***ζύμης*** *1/2|⟧* ***χό(ες)*** *β 1/2 , ὁμ(οίως)*[202]
>
> *Similarly, in this place, now, in the store-room of Antonia* ***yeast*** *1/2]] yeast-pitchers 2 ½, similarly*[203]

ζύμης χό(ες) can literally be translated as 'pitchers of yeast', which proves that a leavened liquid substance was added to facilitate fermentation [204] and possibly points to the artificial cultivation of yeast in Graeco-Roman Egypt.[205] Additionally, Chantraine corroborates this by saying that *ζύμη* was used specifically to refer to beer yeast.[206] With four other papyri, of which are two from the second and third century AD, mentioning the profession of yeast-maker or

[196] 'P. Hib. 1 139', *papyri.info* (http://papyri.info/ddbdp/sb;12;10783). Accessed on September 12, 2018.
[197] SHUMAKER 1970, 42.
[198] CLARYSSE 2008, 158.
[199] MCGOVERN et al. 2005, 295; ORLOVE and SCHMIDT 1995, 276.
[200] DIETLER 2006, 238.
[201] JANSSEN 1980, 147, DRENKAHN 1976, 134 and CLÈRE 1975, 76.
[202] P. Tebt. 2 401, col. vii, l. 35.
[203] JOHNSON 1936, 382 – 383.
[204] NELSON 2001, 151.
[205] See also LUCAS and HARRIS 1962, 16.
[206] CHANTRAINE 1968, 401.

ζυμουργός five times,[207] it seems that at least from the first century AD onward there were individuals specialized in the breeding and cultivation of yeasts for both bread and beer.[208] Another Tebtynis papyrus (P. Tebt. 2 375) from September 8, 140 AD, does not mention *ζύμη* in the context of beer-selling or beer taxes, but seemingly confirms this by explicitly mentioning 'prepared leaven' or *ζύμης ἠρτυμένης* (see figure 27):

καὶ [δ]ώσω σοι καθ' ἔτος ***ζύμης ἠρτυ-***	*and I will pay you annually 2/3*
μένης *ἀρτάβης δίδυρον(*), σοῦ τ[.]ς ἀπολ. [. . . .]. [.]τω,*	*artabas of* ***prepared leaven*** *…*
καὶ μετὰ τὸν χρόνον παραδώσω πάσας τὰς ἀρούρας	*At the end of the period I will deliver up*
καθαρα(*) ἀπὸ θρύου καλάμου	*all the arouras free from rushes, reeds,*
δί[σ]ης(*) πάσης ὁμαλισμενα(*)[209]	*and dirt of all sorts and levelled*[210]

Equipment and layout of a brewery

As described under The First Intermediate Period and the Middle Kingdom, *supra*, brewing in pharaonic Egypt occurred parallel to and in conjunction with bread-making. Here, brewing vats serve to identify a brewery.[211] Since we know that beer brewing could have occurred as an ordinary domestic activity, it does not require specialized structures or implements in the case of private and non-commercial brewing.[212] At its most rudimentary form, all that is needed is an amount of grain, some water, containers (commonly pottery vessels) in which to soak the grain, a flat paved area - possibly the floor - to spread out and turn the grain during germination, an oven to dry it in order to stop germination, domestic grindstones to grind the malted grain, hearths and again separate containers for fermentation and storage. However, due to a lack of well-preserved Ptolemaic and Roman breweries from Egypt and the tax-related nature of almost all papyri concerning beer, we are forced to rely on pharaonic remains and carefully selected and analysed analogies in other pre-medieval grain-based beer-brewing cultures.

A first comparative case is to be found in the Moquegua Valley of Southern Peru, where archaeologists identified an ancient Wari (600 – 1000 AD) brewery on the summit of Cerro Baúl, a provincial administrative center of the Wari Empire.[213] This trapezoidal structure contains three separate rooms, each of which was identified as a distinct area for milling, boiling and fermentation, respectively (see figure 12). Other evidence that supports the

[207] 'ζυμουργός', *TM Words* (https://www.trismegistos.org/words/detail.php?lemma=ζυμουργός&morph_type=noun). Accessed on December 23, 2018; DARBY, GHALIOUNGUI and GRIVETTI 1977, 535 – 536.
[208] NELSON 2001, 151
[209] P.Tebt. 2 375, l. 27 – 30 from 'P.Tebt. 2 375', *papyri.info* (http://papyri.info/ddbdp/p.tebt;2;375). Accessed on November 16, 2018.
[210] GRENFELL, HUNT and GOODSPEED 1907, 217.
[211] GATES 1988, 74.
[212] ARTHUR 2003, 516 – 528 and LAUBENHEIMER, OUZOULIAS and VAN OSSEL 2003, 47 – 63.
[213] MOSELEY et al. 2005, 17264 – 17271.

interpretation that this space was a specialized chicha beer production area includes the presence of grinding slabs in the milling room, the remnants of large boiling/fermentation ceramic vats with a line of hearths lined paralleling the wall, the presence of stone pedestals used to support the vats in the boiling room and the remains of drinking cups (*keros*) recovered throughout the structure.[214] Meanwhile, among the Ethiopian Gamo, beer processing occurs within kitchens and storage buildings, where large jars are placed along the outer edge of the interior of the building (see figure 20).[215] The production of beer, however, is associated with the wealthy and high-caste Gamo households,[216] an important difference with the common household nature of Egyptian home-brewing.

Secondly, evidence for the aforementioned basic setup is also reported from the Iron Age Roquepertuse dwelling, where an interesting type of oven has been preserved.[217] In the Iron Age Roquepertuse dwelling in the Provence, an oven was discovered less than 2 m from the barley concentration. In brewing activity, an oven is often employed to stop germination at the desired level by drying or roasting malted grain.[218] The Roquepertuse oven (figure 14) would have been especially suitable for this operation. It is of an elaborate kind, typical of the French Mediterranean area during the Iron Age and particularly well-known in settlements from the Etang de Berre area.[219]

Such ovens are composed of three parts (figure 15): embers are contained in the lowest part while food can be cooked in the upper part by hot air circulating through the middle chamber. This would allow gentle air-drying which is perfectly suited to stop the germination process, as malt should not be overheated to avoid damaging the chemical properties of enzymes.[220] Archaeologists still regard the specific functions of these typical ovens as unknown and they could have been multi-functional. A particular function of the drying or roasting of cereals has often been assumed.[221] According to the Roquepertuse evidence, the drying of malt may well have been one of their specific functions.[222]

The multifunctional aspect of the Roquepertuse oven is intriguing, since we know that brewing and baking activities were often adjacent and sometimes shared the same facilities. In smaller households, such multi-functional facilities like ovens which used hot air to dry the grain and

[214] BIWER and VANDERWARKER 2015, 29.
[215] ARTHUR 2003, 523.
[216] ARTHUR 2003, 519.
[217] BOUBY, BOISSINOT and MARINVAL 2011, 356.
[218] VAN DER VEEN 1989, 302 – 319 and LAUBENHEIMER, OUZOULIAS and VAN OSSEL 2003, 47 – 63.
[219] PY 1993 and CHAUSSERIE-LAPRÉE 2005.
[220] LAUBENHEIMER, OUZOULIAS and VAN OSSEL 2003, 47 – 63.
[221] PY 1993 and CHAUSSERIE-LAPRÉE 2005.
[222] BOUBY, BOISSINOT and MARINVAL 2011, 356 – 357.

stop its germination may also have used the hot air to heat food or bake bread within the aforementioned multi-functional kitchens and storage rooms.

Thirdly, a brewery would need to be housed in water-tight and weatherproof buildings, just like at the Roman British Orton Hall Farm. The temperature and moisture of stored grain needed to be regulated and a steady germination rate depends upon the right temperatures. In winter, the drier was probably heated to encourage germination and careful temperature control would require the vents which are found in the better-preserved examples. Temperature control is also vital in the fermentation stage.[223]

It is likely that the Egyptian brewery required equipment similar to that found at Cerro Baúl. Textual support is provided by a list of items for beer brewers from the second century AD (P. Duk. inv. 975 R (b)) mentions key items needed for the configuration of such a room (see figure 13): old wheat (*sitos*) for the beer brewers(?), cutting(?) reed, sending(?) wheat (pyros), baked tiles and sawing beams(?).[224] *ζύμης χό(ες)*, literally translated as 'pitchers of yeast', contained a leavened liquid substance which was added to facilitate fermentation[225] and possibly points to the artificial cultivation of yeast in Graeco-Roman Egypt.[226] Professional brewers likely also had distinct rooms or areas for milling, boiling and fermentation of barley and wheat as at Cerro Baúl, though this may not have been the case for less affluent home-brewers. Meanwhile, small households likely processed beers within their kitchens and storage rooms like the Ethiopian Gamo did and still do, thus rendering them multi-functional places.

The technology of making beer was equally mundane and uncomplicated, even primitive, but extremely efficient. However, one last step is crucial to obtain a pleasantly consumable beverage. In order to achieve a clear and pure brew, without dregs and impurities which might cause problems for the drinkers, the Egyptians used filters, strainers and siphons either in production or in serving. Therefore, all three devices played an important role. These devices can be divided into three major groups:

1. the industrial group, used during production of the beverage,
2. the domestic group, used during drinking at social gatherings and parties.
3. the siphon group, used for siphoning and for drinking.[227]

[223] MACKRETH 1996, 230.
[224] 'P. Duk. inv. 975 R (b)', papyri.info (http://papyri.info/apis/duke.apis.33002334). Accessed on November 14, 2018.
[225] NELSON 2001, 151.
[226] See also LUCAS and HARRIS 1962, 16.
[227] MARCINIAK 1995, 242.

For beer production, only the first or industrial group matters. Group A consists mainly of rather crude strainers and filters. Two types exist within this industrial group.

The first type, a strainer, was used to separate the liquid beer from the mash. The mixture was heated at various intervals during the process of malting and brewing and then left to ferment. Beer made this way resembled gruel, unless decanted and strained.[228] The most popular strainer used during the process was a fiber basket placed on the top of a large jar (see upperleft corner of figure 24). Several representations of this process are known from tomb reliefs from the third Dynasty onwards (see figure 24).[229]

The second type of production strainer is far more sophisticated. It was made from bronze and set in a round piece of wood. A model of this straining device was found in the tomb of Tutankhamen.[230] This strainer was used the same way as the former one. It was usually placed over a large, tall vessel.[231]

Penultimately, natron (*νιτρική*) can be found in connection to beer in certain papyri, including P.Tebt. 1 40, a letter concerning protection of a tax-farmer from 117 BC.[232]

ἐλ(άβομεν) ἔτους νγ Τῦβι ιε. *(hand 2) Ἀμεννεῖ βασιλικῶι γραμματεῖ* *παρὰ Πνεφερῶτος τοῦ Παοῦτος* *τοῦ ἐξειληφότος τὴν* ***ζυτηρὰν*** *καὶ* ***νιτρικὴν*** *Κερκεοσίρεως τῆς* *Πολέμωνος μερίδος εἰς τὸ νγ (ἔτος).*[233]	(Docket of Menches) Received in the 53rd year, Tybi 15. (Letter) To Amenneus, basilikos grammateus, from Pnepheros son of Paous, contractor for the taxes on **beer** and **natron** at Kerkeosiris in the division of Polemon for the 53rd year.[234]

However, this is only only of eight instances in Greek papyri (dating from 250 BC to 117 BC) where we find *ζυτηρά* and *νιτρική* in the same text.[235][236] All those relate to the beer and nitron tax without further elaboration on their proximity, use or relation.

Finally, a statue of a patron goddess or other deity could be present. In pharaonic Egypt the goddess Hathor, 'the mistress of drunkenness', was the Egyptian equivalent of the Sumerian beer goddess, Ninkasi. She was closely associated with a lesser goddess 'who makes beer',

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[228] MARCINIAK 1995, 242.
[229] CARNARVON and CARTER 1912, 31; pl. 22.2 and PEET and WOOLLEY 1923, 74; pl. 22.2.
[230] CARTER 1933, 61; pl. 56A.
[231] MARCINIAK 1995, 242.
[232] BAGNALL and DEROW 2004, 158.
[233] 'P.Tebt. 1 40', *papyri.info* (http://papyri.info/ddbdp/p.tebt;1;40). Accessed on December 17, 2018.
[234] BAGNALL and DEROW 2004, 158.
[235] 'ζυτηρὰ AND νιτρικὴ', *papyri.info* (http://papyri.info/search?STRING1=ζυτηρὰ¤AND;νιτρικὴ&target1=TEXT&no_caps1=on&no_marks1=on). Accessed on December 17, 2018.
[236] *TM Words* registers 49 attestations of νιτρικὴ in all in declensions from the fourth to first centuries BC. 'νιτρικὴ', *TM Words* (https://www.trismegistos.org/words/detail.php?lemma=νιτρικὴ&morph_type=noun). Accessed on December 23, 2018.

Menqet.[237] If the Late Bronze era brewery (early 15th century BC) of Tell Hadidi in western Syria is an indication, where the basalt seated statue in the courtyard of the patron goddess of the brewing profession presided over the productivity of her devotees,[238] the cultic aspect might have had a presence in the brewery, which may have been more likely on temple domains.

[237] MCGOVERN 2009, 246.
[238] DORNEMANN 1981, 33; GATES 1988, 68.

The process of beer-making and brewing

Cultivation and harvest of cereals

Every beer in Egypt started with cereals. As mentioned earlier, wheat and barley were the most significant, with the former primarily used to bake bread, but also used for beer-making and the latter being chiefly used to produce beer.[239][240] However, the former was during Ptolemaic times not the *olyra* or tetraploid emmer wheat (*Triticum dicoccum*) referenced by Herodotus,[241] but rather the naked tetraploid wheat (*Triticum durum*), which was introduced to Egypt after the Greek conquest and soon completely supplanted the earlier emmer wheat.[242] Meanwhile, *olyra* continued to be grown but in decreasing quantities.[243]

Two harvests a year were possible in Egypt as attempts were made during the reign of Ptolemaios II Philadelphos (283 – 246) to augment cereal production by the introduction of a summer wheat crop in areas irrigated artificially.[244] For example, on 27 December 256 BC Apollonios wrote to Zenon in P. Cair. Zen. 2 59155 at Philadelphia (Arsinoites) [see figure 16]:

> *Ἀπολλώνιος Ζήνωνι χαίρειν. ὁ βασιλεὺς συνέτασσεν ἡμῖν*
> *δισπορῆσαι τὴν γῆν. ὡς ἂν οὖν ἐχθερίσηις τὸν πρώιον σῖτον,*
> *εὐθέως πότισον τὴν γῆν ἀπὸ χερός(*), ἐὰν δὲ μὴ δυνατὸν ἦι,*
> *κηλώνεια ἐπιστήσας πλεῖονα οὕτω πότιζε, μὴ πλείους δὲ*
> *πέντε ἡμερῶν σύσχηις τὸ ὕδωρ, καὶ καταψύξας εὐθέως*
> *κατάσπειρε τὸν τρίμηνον πυρόν. γράψον δὲ καὶ πρὸς ἡμᾶς*
> *πότε δύνασαι θερίζειν τὸν σῖτον.*
> *ἔρρωσο. (ἔτους) λ, Δίου ιγ, Ἀθὺρ γ.*
>
> *Ζήνωνι. [-ca.?-]σπόρου.*[245]
>
> Apollonios greets Zenon. The king [Ptolemaios II Philadelphos] has ordered us
> to sow the land twice. Therefore, as soon as you have harvested the early grain, immediately water the land by hand. And if this is not possible,
> set up a series of shadoofs [water-lifting devices consisting of a bucket and pole] and irrigate in this way. Do not keep
> the water on the land more than five days and as soon as it dries out
> sow the three-month wheat. And write to us
> when you are able to harvest it.
>
> To Zenon[246]

[239] MURRAY 2000, 511 – 512.
[240] A clear reference for the use of barley to start the malting process can be found in SB 16 12647, l. 1; 9, an account of barley distributed for the sowing in 211 AD. See 'SB 16 12647', *papyri.info* (http://papyri.info/ddbdp/sb;16;12647). Accessed on December 25, 2018.
[241] DIXON 1969 and DARBY, GHALIOUNGUI and GRIVETTI 1977, 461 – 479.
[242] CRAWFORD 1979, 140.
[243] SCHNEBEL 1925, 94.
[244] CRAWFORD 1979, 140 – 141.
[245] 'P. Cair. Zen. 2 59155', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59155). Accessed on 16 September 2018.
[246] Translation from CRAWFORD 1979, 141., with modifications.

Philadelphos ordered them to sow the land twice and, after the harvest of the early grain, use three-month wheat, which may have been the Syrian wheat first recorded under Philadelphos[247] and is probably to be identified as einkorn.[248] Other cereal strains were also introduced and other Zenon papers record a wide variety of cereals grown on the estate (e.g. Persian wheat (*κ Μηδικοῦ πυ(ροῦ) ις* ☐ /20th, of Median wheat 16½)[249] and native wheat and dark summer wheat (*ζ Ζωΐλωι μελαναιθέρος* ☐ *δ΄ἐπιχωρίου* ☐ *δ΄*/to Zoilos, dark summer wheat (*melanaither*), 3/4 (artaba); native (wheat) 3/4 (artaba))).[250]

The importance of a sufficient supply of barley and wheat to a flourishing beer trade is not to be underestimated, since in the fourth century AD beer disappears from the Egyptian menu, which suggests that barley had become so scarce that it was mainly used as animal fodder. Also, relatively more land had to be grown with wheat for human consumption than before.[251]

Good harvests depended on a good irrigation system. The effect of increasing control of the Nile flood, throughout history, has been to extend the area of cultivation, but also to develop land on the basis of security from natural summer flooding, encouraging the planting of cash crops.[252] Canal development was concerned primarily with promoting the flow of water into flood-basins, as is probably to be seen in both Middle Kingdom and early Ptolemaic developments in the Fayum. Perennial irrigation doubtless expanded slowly but continuously from a very small base in the earliest periods, but it was not widely used before the Roman period, associated with a major increase in the use of lifting machinery. In the early Ptolemaic period the development of the Fayum was marked by new crops, but most particularly by a large increase in the land under vines, to cater for the immigrant preference for wine over the native beer.[253] This trend was further reinforced by the gradual spread of the use of the water wheel (*saqia*) in the later Ptolemaic and Roman period.[254] The necessary capital investment, combined with the limited area a wheel can keep under perennial irrigation, meant that its primary use was in the relatively high value commercial development of orchards, particularly in the wine trade.[255]

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[247] THOMPSON 1930, 213.
[248] CRAWFORD 1979, 141.
[249] P. Ryl. 4 57, I. 4 from 'P. Ryl. 4 57', *papyri.info* (http://papyri.info/ddbdp/p.ryl;4;571). Accessed on 17 September 2018.
[250] P.Col. 4 69, l. 25 – 26 from = P. Cairo Zen. 4 59731, 'P.Col. 4 69', *papyri.info* (http://papyri.info/ddbdp/p.col;4;69). Accessed on 17 September 2018.
[251] VAN MINNEN 2000, 212.
[252] EYRE 1997, 370.
[253] EYRE 1997, 369 – 370.
[254] VENIT 1989, 219 – 222 and BONNEAU 1993, 105 – 115.
[255] BONNEAU 1970, 45 – 62, SAMUEL 1983, 48 – 50 and RATHBONE 1991, 33; 222 – 224.

Also, in the case of artificial irrigation of lands not subjected to the Nile's annual flooding, as described by P. Cair. Zen. 2 59155 *supra*, this required watering the land by hand immediately after the early harvest or by use of a series of *shadoofs*, water-lifting devices consisting of a bucket and pole. Water could not be kept on the land for more than five days before the sowing of the three-month wheat, requiring a swifter turnaround than during the single harvest year. Conversely, earlier orchard and wine production during the Pharaonic period was limited by the difficulty of hand or gravitational watering of plots protected from free flooding either by their high situation or by dyking.[256]

A predicament for beer production in Egypt, however, was that the irrigation system depended on high labour input. Labor inputs, however, differ from crop to crop: at the beginning of the nineteenth century wheat was reckoned to require about twice the number of man-hours as barley.[257] The system could easily break down in case the population decreased sharply, like what happened at Theadelphia at the end of the second and the beginning of the third century AD. The village was situtated at the end of a major canal and only an influential person such as Appianus could enforce the supply of water in case of problems higher up the canal.[258]

Finally, the harvested cereals, chiefly barley,[259] were transported to the brewery, either private, state-owned or endowed to a temple. Barley was purchased from government monopolies[260], at least by state-owned or -controlled breweries. Since the amount of payment depended upon the allotment of barley (*σύνταξις*) from the state which state-supplied brewers were required to make into beer,[261] we can assume that this type of brewers had no say in the origin, quantity or quality of the ingredients of their brews. Presumably, smaller private brewers drew from hand-picked local sources and could customize order size and quality.

The grain or flour (and malt) of which beers are made can be stored for months, while conversely, grapes do not keep at all (unless dried, which is another story).[262] This allows for a certain flexibility in the allowance and provisioning of grain on the side of both the ingredient provider (i. e. the state monopoly or the private farmer) and the brewer, who can wait for the most economically advantageous moment to purchase his resources if he does not produce under a state contract.

[256] EYRE 1994, 57 – 80.
[257] MILLER 1991, 265 after RICHARDS 1982, 17, Table 2.1.
[258] VAN MINNEN 2000, 215.
[259] THOMPSON 1995, 316.
[260] SCAIFE 1988, 105 – 106.
[261] ELMAGHRABI 2013, 237.
[262] SIGAUT 2005, 294.

Comparative cases

The case for comparison

Firstly, beer-making in Egypt originated and developed in the context of and dialogue with beer and fermented beverage production in Africa, with the former influencing the other (see *infra*). The basic ingredients of fermented beverages in the 'homeland' of humanity included honey (especially in the Great Rift Valley), barley and wheat (especially in the Nile River Valley), sorghum and millet (especially in the Sahel and Sahara Desert), palm sap and many other fruits (e.g. Ziziphus), root crops and grasses.[263] Therefore, as might be expected, there are similarities among the opaque beers of Egypt (*bouza*), Sudan (*merissa*), Ethiopia (*talla*) and Kenya (*busaa*).[264] They contain, apart from the alcohol, important dietary supplements such as proteins, fats and carbohydrates. More importantly, the potency of the aminoacids and vitamins was increased during the fermentation process and this augmented enrichment might explain the popularity of the beverage within modem and ancient populations with inadequate and monotonous diets.[265] The first and the third are of specific interest to the brewing process (see Ethiopian Talla (Tella) and Back to the roots: Modern Egyptian bouza, both *infra*).

Secondly, it should be noted that ideas and technology about making fermented beverages (e.g. mashing installations for grains in Egypt and Burkina Faso) flowed between the Nile River and West Africa according to McGovern (see figure 17).[266] McGovern remarks that in the upper Volta River region, brewers are still mashing and fermenting sorghum in facilities resembling those of 5,500 years ago at Hierakonpolis and other Upper Egyptian sites, indicating that beer manufacturing likely arrived at a very early date. The technology had gone out of use in Egypt by the early Old Kingdom, so the transfer must have occurred earlier. Perhaps it made its way along the upper Nile into Nubia and Ethiopia. As the exploitation of sorghum spread across the Sahel, it might have been transmitted from one settlement to the next, eventually reaching West Africa. This scenario counters the widely held notion of very early independent domestication and cultural development in sub-Saharan Africa, divorced from any Afro-Asiatic migration or influence from Egypt. According to McGovern, it fits with a more nuanced version of diffusion in which the Neolithic period of the eastern Sahel was an epicenter of experimentalism, which had far-reaching consequences for the rest of Africa.[267]

[263] MCGOVERN 2009, 232.
[264] STEINKRAUS 1996, 407.
[265] GHALIOUNGUI 1979, 8-9, DARBY, GHALIOUNGUI and GRIVETTI 1977 and MORCOS, HEGAZI and EL-DAMHOUGY 1973, 1157.
[266] MCGOVERN 2009, 232.
[267] MCGOVERN 2009, 256 – 258.

Although the nature and extent of the flow of techniques and tools between sub-Saharan Africa remains elusive and McGovern rightfully notes that the authors have often relied on ethnographic and/or ethnohistorical accounts, while technologies, like cultures, have undergone significant changes over time,[268] he does raise an interesting point that merits further investigation by means of more detailed studies of the brewing processes amongst both contemporary and extinct tribes and peoples in particularly Africa and South America. After all, Geller states that the lifeways and material culture of provincial farmers still, to some degree, help to inform archaeological interpretation.[269]

The Gamo of south-western Ethiopia

One case are the Omotic-speaking Gamo who live in the highlands of south-western Ethiopia along the Rift Valley and produce beer for ceremonies and everyday subsistence (see figure 18).[270] Arthur spent two years (1996 – 1998) conducting an ethnoarchaeological study of Gamo pottery production, use and discard, focusing on 1,058 low-fired earthenware vessels from twenty households each in three villages (Zuza, Etello and Guyla). The Gamo produce beer by two different methods, though both involve the use of ceramic vessels. The highland Gamo produce beer by boiling water in a large ceramic cooking jar (*otto*) and then pouring the water over the flour and stirring it in a large serving bowl (*shele*), where it is left to cool. It is then poured into a beer jar (*batsa*) to ferment for five days. The second way to produce beer, which occurs in the lowland areas, is to combine and boil water and flour and then store this mixture in large beer jars for fermentation (see figure 19).[271]

Among the Gamo, beer processing occurs within kitchens and storage buildings, where large jars are placed along the outer edge of the interior of the building (see figure 20).[272] The production of beer is associated with the wealthy and high-caste Gamo households. They use different types of grains depending on their ecological zone, which determines whether they subsist more on maize or barley and wheat.[273] Just like in Egypt, the tradition of home-brewing of beer as a household activity is well cemented among the Gamo, as is the use of kitchens and storage buildings as multi-functional beer-rewing facilities.

[268] MCGOVERN et al. 1996, 293.
[269] GELLER 1993, 258.
[270] ARTHUR 2000.
[271] ARTHUR 2003, 519.
[272] ARTHUR 2003, 523.
[273] ARTHUR 2003, 519.

Sorghum beer in the Upper Volta River region

In the upper Volta River region brewers are still mashing and fermenting sorghum in facilities that resemble those of 5,500 years ago at Hierakonpolis and other Upper Egyptian sites. Therefore, beer manufacturing likely arrived at a very early date. In Burkina Faso today, only red sorghum goes into the brew and it generally yields a light, brownish-red beer with about 4 percent alcohol. Rarely, the alcohol is elevated by mixing in white sorghum, which contains more sugar, or boiling down the wort to half its volume before fermenting. According to tradition, only women make sorghum beer, which accounts for half of the caloric intake in Burkina Faso. In 1981, 700 million liters of beer were made, equivalent to 236 liters per person. As women and children consume much less than men, each male likely drinks an average of a liter or two every day.[274]

Rather than use a fermented dough as a starter, Burkina Faso beer makers first sprout the sorghum and make a malt. This procedure takes seven or eight days: the grain is submerged in water in large jars for two days, then allowed to sprout for another two or three days and finally sun dried for several days, depending on the season. Mashing takes place over two or three days in the large jars of the dedicated mashing facility. The resulting unfermented sweet wort is clarified by adding the bark of raisin bush (*Grewia flavescens*) and okra (*Abelmoschus esculentus*) and it is sometimes served to children, women and Muslims before fermentation. The remainder of the wort is cooled in the mashing jars and yeast gleaned from the jar bottoms of an earlier fermentation is added, recalling the bowls that were probably used to collect yeast from the Prehistoric Egyptian mashing vats. An initially pasty and milky substance is dried in the air and sun, yielding grayish crumbs of yeast. Fermentation takes place during a single night. Individual brewers have secret formulas of special ingredients, which might include bark of the whitethorn tree (*Acacia campylacantha*), the fruit of the soapberry tree (*Balanites aegyptica*), or grains of hallucinogenic jimson (*Datura stramonium*). Some groups add honey to the beer presented at funerals to bring the alcohol content up to 10 percent. [275]

Even with such a long, highly conservative history of beer making in ancient Egypt, one might still harbor doubts about whether the installations at late Prehistoric Hierakonpolis, Abydos and the other Upper Egyptian sites were containers for mashing grain (mash tuns). McGovern was assuaged by a photograph of a very similar modern-day facility: a sorghum-mashing facility in Burkina Faso. There were the large (80- to 100-liter) wide-mouthed jars clustered together, supported by firebricks and a firing chamber enclosed by packing mud up to and

[274] MCGOVERN 2009, 256 - 257.
[275] MCGOVERN 2009, 256 - 257.

around the vessel mouths. [276]

How the Upper Egyptian mashing techniques of 3500 BC reached the upper Volta region (Burkina Faso) is still an enigma. The technology had gone out of use in Egypt by the early Old Kingdom, so the transfer must have occurred earlier. Perhaps it made its way along the upper Nile into Nubia and Ethiopia. As the exploitation of sorghum spread across the Sahel, it might have been transmitted from one settlement to the next, eventually reaching West Africa.[277]

Another possibility, consistent with the way sorghum beer is made in the West African nation of Burkina Faso today (see *infra*), is that the primary fermentation was carried out in the same jar as the mashing. After the wort had cooled down, fruit was added to jumpstart the main fermentation, contribute flavors and increase the alcohol content.[278]

African kaffir (kaffircorn) sorghum beer

Kaffir beer, slso known as Bantu beer, is the traditional beverage of the Bantu tribes of South Africa. Other names are *utshwala* (Zulu) and *utywala* (Xhosa). It is an alcoholic, effervescent, pinkish-brown beverage with a sour flavor resembling yogurt, the consistency of a thin gruel and an opaque appearance due to its content of undigested starch residues, yeasts and other microorganisms. The beer is not hopped or pasteurized and is consumed while still actively fermenting.[279] Although based on a different grain, its production process, which is largely identical in both household and industry contexts, remains largely close to its traditional manner of making.

Preparation of production

The major part of the sorghum crop (*Sorghum caffrorum* or *S. vulgare*) is malted and used for brewing beer. Maize is frequently substituted for sorghum depending upon the relative cost.[280] The millets, *Eleusine coracana* and *Pennisetum typhoides*, are also malted and used in place of sorghum. Because of the small size of the millet seed, however, it is not malted by modern plants. Even cassava and plantains maybe used in beer brewing.[281] The essential steps in brewing are malting, mashing, souring, boiling, conversion, straining and alcoholic fermentation.[282]

[276] MCGOVERN 2009, 247; 249.
[277] MCGOVERN 2009, 257 - 258.
[278] MCGOVERN 2009, 243.
[279] NOVELLIE 1963, 28 and NOVELLIE 1976, 73 – 77.
[280] SCHWARTZ 1956, 101 – 105.
[281] PLATT 1964, 662 – 670.
[282] SCHWARTZ 1956, 101 – 105.

In the traditional village processes (see figure 21), kaffir beers are made in large drumlike pots in 115 to 180-liter batches. Each liter of beer requires 180 to 360 g of grain. Sorghum malt is produced by soaking the grain in water for one to two days, draining and then allowing the seed to germinate for a few days. The sprouted grain is sun-dried and allowed to mature for several months. Next, the malt is pulverized, slurried to a thin gruel, boiled and cooled and a small amount of fresh, uncooked malt is added, probably both for its amylolytic action and as a source of microorganisms. The mixture is held 1 day during which a lactic acid fermentation occurs. On the second day, it is boiled in the cooking pot and returned to the brewing pot for the alcoholic fermentation. On the third and fourth days more pulverized uncooked malt is added and on the fifth day the brew is strained through a coarse basket to remove the husks. The beer is then ready to drink.[283]

About equal quantities of malted and unmalted grains are mashed in cold and boiled water, respectively, at the time they are combined so that the temperature of the mixture turns out to be 37°C ±1°C. Platt and Webb concluded that the major saccharification was not due to malt amylases but to molds growing on the grain.[284] Novellie concluded, however, that the ability of the malt to produce enough diastatic power is the most critical factor in brewing kaffir beer.[285] He distinguishes native trade malts and malt for municipal beer brewing, but both are made by similar processes. Grain is steeped 8 to 24 h (frequently 16 to 18 h). Germination proceeds for 5 to 7 days. Municipal malts are more thoroughly precleaned and carefully washed and watered during germination.[286] Sorghum requires a warm temperature (25 to 30°C) for optimum production of amylases in a reasonable length of time. For optimum malting, the grains must be kept moist and aerated and turned to prevent overheating. The plumules should be 2.5 to 5.0 cm in length following germination. Gentle drying in the sun or in hot air at 50 to 60°C preserves the enzymes.[287]

Brewing on a large scale

The municipal brewing process involves two distinct fermentations (see figure 22),[288] a lactic acid and an alcoholic fermentation. Souring (lactic acid production) is achieved by holding a mixture of sorghum malt and water at 48 to 50°C for 8 to 16 h until the proper degree of acidity is attained. This 'sour' is about one-third the final volume of beer. The souring step controls the course of the remaining fermentation, mashing, body and alcoholic content of the beer; thus, it is very important. Although pure culture inoculation of lactic acid bacteria is not used,

[283] PLATT 1964, 662 – 670.
[284] PLATT en WEBB 1946, 132 – 140.
[285] NOVELLIE 1968, 17 – 29.
[286] NOVELLIE 1962, 115 – 120.
[287] NOVELLIE 1968, 17 – 29.
[288] NOVELLIE 1966a, 27 – 31 and NOVELLIE 1966, 354 – 361.

about 10% of each batch of sour is used to inoculate the next batch.[289] The pH at the end of souring should be 3.0 to 3.3 and total acidity should be 0.3 to 1.6% (average 0.8%) as lactic acid.[290]

The soured malt mixture is pumped to the cooker and diluted with 2 volumes of water. An adjunct (usually maize grits) is added and the whole mixture is boiled for 2 h. Most boiling is carried out at atmospheric pressure, but slight pressure cooking may be used at high altitudes where boiling temperature is low. High-pressure, high-temperature cooking produces a beer with too low a viscosity. The thick, cooked sour mash is cooled to 60°C. A small amount of malt may be added when the temperature reaches 75 to 80°C to reduce the viscosity. At 60°C, the conversion malt is added and the temperature is held for 1.5 to 2 h. The mash is now thinner and sweet. It is cooled to 30°C and pitched (inoculated) with a top-fermenting yeast strain of *S. cerevisiae*. The yeast is produced locally and distributed as a dry yeast which is slurried before pitching. No yeast is recovered because it is sold as part of the beer.[291]

The pitched mash is passed through coarse strainers to remove husks. Both screw presses and basket centrifuges are used. The wort then goes to fermentation tanks for 8- to 24-hour fermentation at 30°C. Fermentation continues in the cartons in which it is distributed.[292]

Microbiology

van der Walt (1956) described the microbiology of kaffir beer fermentation. Souring is caused by lactic acid bacteria.[293] No pure inoculum is used but previously soured maltlwater slurry is used to inoculate new suspensions. An incubation temperature of 50°C is favorable to development of the particular lactic acid bacteria desired. In traditional fermentations, the yeasts for the alcoholic fermentation are introduced with the malt. In municipal breweries, special strains of *S. cerevisiae* are distributed and used in the dry form, which is inoculated into the mash following slurrying.[294]

Biochemical Changes

Malting results in the formation of amylases and proteases important in solubilizing the starches and proteins of the grains and making them susceptible to fermentation. Malting also results in a marked improvement in flavor. The polyphenol content of sorghum strains

[289] VAN DER WALT 1956, 105 – 113.
[290] STEINKRAUS 1996, 410.
[291] STEINKRAUS 1996, 410.
[292] STEINKRAUS 1996, 410.
[293] VAN DER WALT 1956, 105 – 113.
[294] STEINKRAUS 1996, 410 – 411.

considered "birdproof" because the birds do not eat them is reduced; a high polyphenol content also inhibits lactic acid bacteria and souring.[295] Therefore, malting enhances acidification. During malting both α- to β-amylase from sorghum varies from 2:1 to 3:1 in contrast to barley malt, which is richest in β-amylase.[296] Amylases of sorghum malt may be soluble, partially soluble, or insoluble depending upon the polyphenol content. Insoluble amylases are obviously of no value in brewing.[297] Maltase is present in ungerminated sorghum grain and does not increase during malting.[298] Both the amylases and maltase function well at pH 4.0.[299]

Lactic acid is a major fermentation product which gives a sharp, refreshing flavor to the beer that appeals to the Bantu palate. The low pH has a preservative effect. Many undesirable microorganisms cannot develop at a pH of 3.0 to 3.3, but the pH is favorable to yeast fermentation. The lactic acid softens the protein enclosing the starch granules, aids cooking and increases viscosity; it also inhibits amylolytic action during mashing.[300] Starch is a very important component in Bantu beer. The beer contains a considerable amount of both gelatinized and ungelatinized starch.[301] The gelatinized starch helps keep the ungelatinized starch in suspension, makes the beer creamy and adds body. The starches provide calories to the consumer during the day, when kaffir beer is a major dietary component.[302]

Most of the amylolytic breakdown occurs when the mash is in the, or pH range 3.7 to 4.0.[303] With the lower pH, the mash never becomes very fluid, much starch remains, sugar content is low and final alcoholic content remains low. At higher pHs, the mash is thinner and alcohol production is higher. Sorghum amylases, however, are much more active at acid pH than barley malts.[304] Amylolytic hydrolysis occurs simultaneously with souring. The optimum temperature for saccharification is 60°C. Although the mash must be thinned, complete starch hydrolysis must be avoided. Inhibition of α-amylase by the low pH helps in this objective. Amylolytic hydrolysis continues even during the alcoholic fermentation.[305]

The absence of a cooking stage following mashing, when all the ingredients would be sterilized, is a serious disadvantage of the kaffir beer brewing process. The boil following souring does lower the microbial load of the mixture, but it is reinfected by fresh malt. This contributes to

[295] WATSON 1975, 133 – 142.
[296] NOVELLIE 1960b, 457 – 471 and DYER and NOVELLIE 1966, 449 – 456.
[297] DAIBER 1975, 1399 – 1411.
[298] WATSON and NOVELLIE 1974, 1037 – 1041.
[299] STEINKRAUS 1996, 412.
[300] STEINKRAUS 1996, 412.
[301] NOVELLIE 1966b, 354 – 361 and NOVELLIE and SCHUTTE 1961, 552 – 559.
[302] STEINKRAUS 1996, 412.
[303] NOVELLIE 1966b, 354 – 361.
[304] NOVELLIE 1966b, 354 – 361.
[305] STEINKRAUS 1996, 412.

poor keeping quality of kaffir beer despite the low pH. Traditional kaffir beers contain 2 to 4% w/v ethanol, 0.3 to 0.6% acid (as lactic) and 4 to 10% total solids. The final pH is generally between 3.3 and 3.5, making for a very sour beer.[306] In municipial beer the pH ranges from 3.2 to 3.7 with an average of 3.4. Total solids range from 3.0 to 8.0% with an average of 5.4%; alcohol ranges from 1.8 to 3.9% w/v with an average of 3.0%; and total acidity (as lactic acid) ranges from 0.16 to .25% with an average of 0.21%.[307]

Ethiopian Talla (Tella)

Talla (*tella*) is an Ethiopian home-processed beer with a smoky flavor and a tan to dark brown color, depending upon how long it has matured. *Amhara* talla is hopped and concentrated. Gurage talla is delicately aromatized with a variety of spices. *Oromo (galla)* talla is unhopped, thick and sweet. Talla is served on holidays and at wedding ceremonies in the homes of the country people as well as wealthier urban dwellers. It is frequently used as a medicineand also serves as a solvent for tapeworm medicine and other drugs. [308] The talla dregs are used as a dressing for wounds and as a cure for amoebic dysentery. Talla is also used to treat cattle that have eaten poisonous weeds.[309]

Steps in Preparation

Sorghum, millet, teff, barley, wheat and maize are all used and usually a variety of grains are combined. Barley or wheat malt is used for conversion of the starch to fermentable sugars. Hops (*Rhamunus prionoides*) called geisho is added as a flavoring agent (see figure 23). The smoky flavor is obtained by scrubbing the fermentation container and talla collection pots with various leaves and twigs and inverting them over smouldering olive wood. Talla also obtains some smoke flavor from the toasted, milled and boiled cereal grains. During the toasting, the grains are browned until they begin to smoke slightly. Sometimes they become charcoal black in color. In addition, the flat cereal bread used to make talla is baked to a crisp coal black on the outside before it is broken into pieces and added to the brew. Malt for talla is made by cleaning barley or wheat, soaking the grains overnight, draining and allowing the moist grains to germinate 3 days. They are then sun-dried and pulverized.[310]

[306] STEINKRAUS 1996, 412 – 413.
[307] NOVELLIE 1968, 17 – 29.
[308] TEGEGNE 1957,
[309] STEINKRAUS 1996, 428.
[310] STEINKRAUS 1996, 428; VOGEL and GOBEZIE 1977,

Microbiology and Biochemical and Nutritional Changes

No microbiological studies of talla have been reported. Due to its higher total solids, gurage talla is higher in carbohydrate, protein and most vitamins and minerals than regular talla. On a dry basis, it is higher only in carbohydrate and fiber. Talla contains 0.3% protein and gurage talla contains 2.9% protein, as well as a small amount of riboflavin and larger amounts of niacin-nutrients essential to the Ethiopian consumer. Basically, the methods of producing talla lead to substantial destruction of protein quality by the severe toasting (burning) of the cereals as they are processed to talla. However, since the Ethiopians prefer the burnt, smoked flavor, it is unlikely that they would accept talla produced with lesser heat treatment.[311]

Beer in Roman Britain: Orton Hall farm

Summary of the Site

Occupation on the site, apart from the periphery of a Neolithic-Bronze Age enclosure system, ran from the first to the sixth century AD. In Period 1 (Mid-first century – circa 175 AD), the stripped area lay to the south-east of an unexcavated nucleus and only contained elements of enclosures with some evidence for domestic occupation. The enclosure system developed through the second century AD until, towards the end of that and marking the initiation of Period 2 (c.175 – 225/250 AD), a new enclosure incorporating two barns was laid out. In Period 3 (c.225/250 – 300/325 AD), one barn was used as one side of a small walled yard and a house was built along the opposite side. A new barn, bringing the number to three, was built on the south side of the Period 2 enclosure which now was provided with a new south boundary. There is evidence for an increase in the number of animals from the site and for the conversion of one barn into a brewery. In Period 4 (c.300/325 – c.375 AD), more buildings were added and one barn resited. There is evidence that one of the new buildings had been a millhouse and it is possible that the building next to it was used to house farm-workers in a kind of barracks. In Period 5 (c.375 – early sixth century AD), the Roman site became degraded with some buildings being reduced in size, although brewing on a large scale continued.[312] Our interest, however, is in the converted barn from period 3.

[311] STEINKRAUS 1996, 428.
[312] MACKRETH 1996, xv.

The brewing process

The basic brewing process is both simple and unlikely to have altered very much over the centuries. The only major alterations would have been governed by changing tastes, refinements designed to produce cleaner or purer brews of differing types and by the need to mass-produce to satisfy large urban communities. Only three materials, at base, are involved: grain (usually barley), water and yeast. There are only three basic types of equipment needed: a device to finish the malt, a vat or vats and vessels for fermentation. The first stage is to prepare the malt. This is done by steeping the grain to soften it and begin the germination process; the grain is then heaped or spread to allow germination to continue. When this has been judged to have gone far enough, the grain is heated to stop further growth. The grain is transferred to a vat which is then filled with water and heated so that the sugars converted from the starch during malting can dissolve into the water. At the sametime the flavour of the malt is taken up by the water to form the basis of the taste of the drink. The water was probably heated to boiling point to aid the process. When this stage has finished, the cooled liquor is transferred to a fermentation vessel and yeast added. After four to six days, the beer is ready. There may have been refinements such as the rootlets of the sprouting grain being removed, the malt being slightly crushed or 'cracked' and fining of the finished product.[313]

Equipment and places of brewing

The frequency of driers and their sturdy construction suits an activity carried out through the year. A brewery would need to be housed in water-tight and weatherproof buildings. The temperature and moisture ofstored grain need to be regulated and a steady germination rate depends upon the right temperatures. In winter, the drier was probably heated to encourage germination and careful temperature control would require the vents which are found in the better preserved examples.[314] Temperature control is also vital in the fermentation stage: in at least one monastic house there were directions for keeping watch during the early stages, laying straw around the barrels and the lighting offires if need be in winter and closing windows in summer.[315]

Applying these different activities to what survived at Orton Hall Farm, Barns 2 and 4 were provided with three different facilities. Each contained driers and these, in Periods 3 and 5, were associated with what are described as vat bases. Both barns were given a water supply from a well placed as close to the main entrance as possible. The absence of a vat base in Period

[313] BOSTON 1976, 43 – 53.
[314] MACKRETH 1996, 230.
[315] CLARK 1897, 185.

4 is neither here nor thereas the areain which the driers of that period lay was very heavily cut about and degraded in Period 5. The simplest brewing process using these elements could have been to steep the grain in the vat in the first place, put it on the floor of the drier for germination to continue and then to stop it by the simple expedient of raising the heat ofthe drier. The quality of the malt would have been tested by empirical means, like every other stage of the process. The malt would then be put back into the vat, water added and the whole of that heated up. The liquor would then be drawn off and fermented with yeast. The spent malt would almost certainly have been used as a supplementary animal feed. No evidence for fermentation vessels was found, but these were almost certainly barrels and there is no good reason to suppose that they would have left any trace beyond, perhaps, fragments of hoops, if any had been in iron.[316]

Brewing capacity

A fully functioning brewery at Orton Hall Farm would only have been of a substantial nature if there was a big enough call for its output. The remains do not allow a satisfactory estimate of brewing capacity, but a rough idea of the degree of likely demand can be given. As a guide, we can look at what was the standard issue to servants and boarders in that other great ale-drinking period, the Middle Ages. Whether there was a basic uniformity in practice is uncertain, but it appears that one loaf of bread and a gallon of beer per day was fairly average.[317] This quantity given to twenty people at Orton Hall Farm would have needed nearly three hogsheads a week. If brewing took place once a week, six barrels at the least is not unreasonable as there would be the three being drunk and three being fermented. There may have been more if spares were kept or if there was an obligatory space of time before reuse.[318]

One brewing of this quantity would need one vat of 630 litres capacity which, when looking at the only large metal vessels known from Roman Britain, lead vats, is a sizeable amount. The capacity of those which can be measured is between 114 and 360 litres.[319] They have no known function but if their relative quantity matches the number of breweries represented by most driers, they could have been used as brewing vats, unless it is thought that the Christian symbols found on some renders them unfit for such a use. There is no objection to the use of lead as that was also commonly used for brewing and other industrial uses in the Middle Ages.[320]

[316] MACKRETH 1996, 229.
[317] CLARK 1897, 217, SALZMANN 1967, 477, HART and LYONS 1884, 57-85 and HART and LYONS 1886, 134.
[318] MACKRETH 1996, 230.
[319] GUY 1981, 275.
[320] e.g. SALZMANN 1967, 552.

Back to the roots: Modern Egyptian bouza

The direct descendent of ancient Egyptian beer is the aforementioned *bouza*. Bouza, a fermented wheat product of common use in Egypt, was known since the pharaohs. People consuming bouza nowadays are those of the lower socio-economic sector, living mostly in towns. The religious view, regarding bouza as an alcoholic drink, prevents most Muslims from consuming it. Modern bouza is a thick liquid, pale yellow in colour with a characteristic alcoholic odour and agreeable taste producing a sensation of heat. It has an acidic reaction.[321]

Preparation

Bouza is now prepared in Egypt from wheat grains, *Triticum vulgaris*, while pharaonic beer was made from barley (both *Hordeum distichum* and *H. vulgare*) and emmer wheat (*Triticum dicoccum*).[322] Coarsely grated wheat grains are placed in large wooden basins and kneaded with water into a dough. The dough is cut into thick loaves, which are baked very lightly. Some of the wheat grains, about a quarter of the total amount of wheat used, is moistened with water and left to germinate for 3 to 5 days, then dried in the sun and coarsely ground. They were mixed with the bread loaves and soaked in water in a wooden barrel. Some *bouza* from a previous brewing is added, left to ferment for 24 h at room temperature. After this period, the mixture is passed through a sieve to remove the solid materials. The liquor is made to the required dilution with water and becomes ready for use (first day or 24-hour *bouza*).[323]

Since the bulk of bouza produced in Egypt is consumed in the form of beer, the nutritive value of this beverage and the changes that occur during its preparation are of particular interest.[324] Nour Eldin reported that bouza can correct the vitamin deficiencies of certain diets.[325] Comparing bouza with its ingredients, results showed that during preparation of bouza, its fibre content increased, this may be due to the growth of micro-organisms involved in the process of fermentation.[326] Total sugars of germinated wheat were higher than that of the grains, this may be due to the action of α- and β-amylases which developed during germination.[327] In support of this Jorgensen showed that α-glucosidase activity was higher in the germinated than the ungerminated barley.[328] The increase in reducing sugars after baking is caused by hydrolysis of the dough starch by the heat and moisture to dextrins and reducing sugars. Summing up the data on changes that occurred in the total carbohydrates, starch,

[321] MORCOS, HEGAZI and EL-DAMHOUGY 1973, 1157.
[322] GELLER 1992a, 127; GHALIOUNGUI 1979, 13.
[323] MORCOS, HEGAZI and EL-DAMHOUGY 1973, 1157.
[324] MORCOS, HEGAZI and EL-DAMHOUGY 1973, 1160.
[325] NOUR ELDIN 1947.
[326] MURATA, IKEHATA and MIYAMOTO 1967, 580.
[327] NOVELLIE 1960, 408.
[328] JØRGENSEN 1965, 1014.

reducing and non-reducing sugars, it is seen that on the first day of fermentation, the breakdown of starches by the malt amylases was relatively high. The starch content decreased, the total and reducing sugars were increased. These increasing values of both the total and reducing sugars in the first day *bouza* is an indication of the activity of malt amylase "expressed as the diastatic power".

The decrease in the total reducing sugars as fermentation progressed could be due to the breakdown of sugars by the zymases of the micro-organisms produced leading to formation of alcohol, carbon dioxide and other products. Also, with the increased acidity of *bouza* on the second and third days which is due to the proteolytic action of the mould,[329] there is a weak activity of the malt amylases resulting in lowering the amounts of total and reducing sugars. Such results agree quite well with that previously reported by Steinkraus, Van Veen and Thiebeau.[330] Finally, it should be noted that the vat residue samples 3H and 4H were fermentation products of cereal grains and fruit material. The fermentation products now are of a similar character to those known from the *bouza* that had been brewn Egypt since early history.[331] The process of using bread loaves warrants a brief paragraph on the 'baking' manner.

[329] NOVELLIE 1966b, 354.
[330] STEINKRAUS, VAN VEEN and THIEBEAU 1967, 110.
[331] MAKSOUD, EL HADIDI and AMER 1994, 221.

Ingredients

Basic Ingredients

Ancient beer requires only three basic ingredients: grain (in Egypt usually barley or a mix dominated by barley), water and yeast, as we have also seen at Orton Hall Farm, *supra*. Barley and grain cultivation I have already discussed under Cultivation and harvest of cereals, *supra*. Sweet water was an abundant resource in the Nile Valley and oases in the desert like Kharga and boiling it a trivial task using big pots and wood-powered fires. Yeast was the final of three essential components of beer in Antiquity and merits more elaboration here.

Yeast is a uni-cellular plant belonging to the fungus family and is distributed abundantly throughout the world, being found wild on many plants (particularly on ripe fruits) and in the air. There are many varieties, two of the principal useful ones being the cultivated beer yeast (*Saccharomyces cerevisiae*) and the wild yeast (*Saccharomyces ellipsoidetis*) which occurs on grapes and brings about vinous fermentation.[332] It has even been suggested that yeast was possibly cultivated before grain[333] and may be the oldest domesticated 'plant'.[334] This is seemingly backed up by the mention of yeast in conjunction with a beer shop (*ζυτοπολίῳ*) in P.Mich. 2 123v, col. 2,a, l. 4 – 7 from November 9, 45 – December 24, 46 AD:[335]

> *ὁμο(ίως) [. . . .] **ἐν ζυτοπολίῳ**(*) θέμα παρ' ἐαυτοῦ [-ca.?-]*
> *. . [. . . . .]ος Παανούφις χο( ) ρε( )*
> *[-ca.?-]ωνο( ) Παύσιος **ζύμη(ς)** κυερ( ) λ[-ca.?-]*
> *[-ca.?-]νο( ) Ὀννόφριο(ς) Ταορσεῦ(τος) **ζύμ(ης)** . . [-ca.?-]*[336]
>
> Similarly, [for him(?)], for his account **at the beer shop** [- - -].;
> [- - -] Paanouphis . . .;
> [- - -] son(?) of Pausis, for **yeast** . . . [- - -];
> [- - -] Onnophris, son of Taorseus, for **yeast** [- - -][337]

Indeed, cultivated yeasts have been carefully developed, cultivated and used as good for payments[338] and is almost always a species of *Saccharomyces*, usually *Saccharomyces cerevisiae* as the top-fermenting yeast for ales and *Saccharomyces Carlsbergensis* or *uvarum*

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[332] LUCAS 1962, 23.
[333] LAMBERT 1997, 134 – 136.
[334] BRAIDWOOD 1953, 515 – 526.
[335] Other evidence includes the gift of leaven as part of a payment in an application from 96 AD concerning a renewal for five years of a (sub?) lease of one or more parcels of (public?) land. See SB 14 11431, l. 4, from the papyrus 'SB 14 11431', *papyri.info* (http://papyri.info/ddbdp/sb;14;11431). Accessed on December 25, 2018.
[336] P.Mich. 2 123 verso, col. 2,a, l. 4 – 7, from 'P.Mich. 2 123 V', *papyri.info* (http://papyri.info/ddbdp/p.mich;2;123). Accessed on December 25, 2018.
[337] BOAK 1933.
[338] This is proven by the mention of 'prepared leaven' or *ζύμης ἠρτυμένης* in a Tebtynis papyrus (P. Tebt. 2 375, l. 27 – 28) from September 8, 140 AD concerning the leasing of catoecic land and in papyrus PSI 15 1531, l. 22 from possibly 195 AD about the renting of land. See 'P.Tebt. 2 375', *papyri.info* (http://papyri.info/ddbdp/p.tebt;2;375). Accessed on November 16, 2018. See also 'PSI 15 1531', *papyri.info* (http://papyri.info/ddbdp/psi;15;1531). Accessed on December 25, 2018.

as the bottom-fermenting yeast for lagers.[339] A wide variety of *S. cerevisiae* strains exist,[340] with differences in kinds of yeast recognized as early as 1550 BC, as demonstrated by the various yeasts types mentioned in the New Kingdom Ebers Papyrus: wine yeast, beer yeast and mesta-yeast, growing yeast, bottom yeast, yeast juice and yeast water.[341] Used for thousands of years in both baking and the production of alcoholic beverages[342][343] with evidence for this found in material collected from Egyptian wine jars dating back to approximately 3150 BC,[344] it is certain that the process of the conversion of sugar into alcohol by yeast was not properly understood. For the noun *ζύμη* there are 13 attestations in eight papyri and one inscription from 14 through 700 AD.[345] In Graeco-Roman Egypt, the beer yeast of *S. cerevisiae* was used. Many other yeasts are known, but as some of them produce a bitter flavor, a repugnant taste or a persistent turbidity in the fermented liquid, these are avoided in modern brewing.[346]

The occupation of a yeast-maker or *ζύμουργός* existed in Graeco-Roman Egypt (see Identity of the brewers, *supra*) and possibly points to the artificial cultivation of yeast in Graeco-Roman Egypt.[347] Additionally, Chantraine corroborates this by saying that *ζύμη* was used specifically to refer to beer yeast.[348] With four other papyri, of which are two from the second and third century AD, mentioning the profession of yeast-maker or *ζύμουργός* five times,[349] it seems that at least from the first century AD onward there were individuals specialized in the breeding and cultivation of yeasts for both bread and beer.[350]

However, as Aouizerat et al. note in their analysis of isolated yeast remains from Egyptian pharaonic breweries in modern-day Israel, aromatic beer can also be produced also by wild yeasts as mentioned *supra* and even pathogenic yeasts such as *C. parapsilosis*.[351] They also note that yeast strains that have experienced the selection pressures of alcoholic fermentation and beverage production environments continued to reproduce over the ages in microenvironments within the ceramic matrices of the ancient beverage vessels.[352] Therefore,

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339 GILLILAND 1971, 108 – 128, TUBB 1987 and JOHNSTON 1990, 55 – 104.
340 LEGRAS et al. 2007, 2091 – 2102.
341 PARTINGTON 1935, 197 – 198.
342 CAVALIERI et al. 2003, 226 – 232.
343 Yeast was also used in a pharmaceutic context, if P. Michael. Gr. 36, two pieces of a pharamcist's list from the fourth through seventh centuries, is to be believed. See P. Michael. Gr. 36, l. 8, from 'P. Michael. 36', *papyri.info* (http://papyri.info/ddbdp/p.michael;;36). Accessed on December 25, 2018.
344 RASMUSSEN 2014, 13.
345 'ζύμη', *TM Words* (https://www.trismegistos.org/words/detail.php?lemma=ζύμη&morph_type=noun). Accessed on December 23, 2018.
346 LUCAS 1962, 23.
347 See also LUCAS and HARRIS 1962, 16.
348 CHANTRAINE 1968, 401.
349 'ζυμουργός', *TM Words* (https://www.trismegistos.org/words/detail.php?lemma=ζυμουργός&morph_type=noun). Accessed on December 23, 2018.; DARBY, GHALIOUNGUI and GRIVETTI 1977, 535 – 536.
350 NELSON 2001, 151
351 MUKHERJEE et al. 2017, 16; AOUIZERAT et al. 2019, 12.
352 AOUIZERAT et al. 2019, 14 – 15.

experimental beer production *per se* cannot validate the thesis that the cultivated beer yeast of *S. cerevisiae* was always used, though the textual sources quoted *supra* seem to support the use of cultivated beer yeast.

Additives

Due to a lack of taste to plain beer brewed using the basic ingredient mentioned in the previous paragraph, additives have possibly been added to beer during the brewing process in Egypt since the beginning of brewing. Although dates have already been mentioned as an additive under First Intermediate Period and Middle Kingdom, *supra*, other taste agents were possibly added during Graeco-Roman times including sedges and possibly grapes, lupine and safflower.[353]

First, the addition of dates seems like a logical element of continuity in beer production given its apparent addition in classical pharaonic times. However, they are never explicitly connected to the beer-making process in Graeco-Roman sources, despite sources like Hecataeus and Herodotus mentioning the basic ingredients of Egyptian beer during the late Archaic and early Classical eras. Given its previous prominent appearance in Egyptian texts of varying nature, both Lucas and Harris and Darby, Ghalioungui and Grivetti argue in favor of the use of dates in the Graeco-Roman era, with the former arguing for use as a sweetener rather than an aromatic additive, while Darby et al. propose that it was mainly used to produce a beer with a higher alcohol level.[354] Finally, it is certain dates were used in the production of beer in Neo-Babylonian times,[355] but if this extends to Graeco-Roman Egypt is unproven.

The addition of sedge or galinage or common *Cyperus* is seemingly only mentioned by Theophrastus under the name *μαλιναθάλλη*. However, its use as an appetizer is noted in the *Deipnosophists*:

> *᾽Οτι εἰς τὸ πρόπομα καὶ ταῦτα ἐνεβάλλοντο, πέπερι, φυλλίς, σμύρνα,* ***κύπειρον****, μύρον Αἰγυπτιον.*[356]
>
> Into the appetizer these ingredients were also put: pepper, a salad leaf, myrrh, **sedge** and Egyptian perfume.

Theophrastus describes *μαλιναθάλλη*, a plant growing in sandy regions in Egypt, as follows in his *Historia plantarum*:

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[353] NELSON 2001, 148.
[354] LUCAS and HARRIS 1962, 15 and DARBY, GHALIOUNGUI and GRIVETTI 1977, 543 – 547.
[355] STOL 1994, 155 – 183.
[356] Deipn. 2.66.

> *Ἐν δὲ τοῖς ἀμμώδεσι χωρίοις, ἃ ἐστιν οὐ πόρρω τοῦ ποταμοῦ, φύεται κατὰ γῆς ὃ καλεῖται μαλιναθάλλη, στρογγύλον τῷ σχήματι μέγεθος δὲ ἡλίκον μέσπιλον ἀπύρηνον δὲ ἄφλοιον· φύλλα δὲ ἀφίησιν ἀπ᾽ αὐτοῦ ὅμοια κυπείρῳ· ταῦτα συνάγοντες οἱ κατὰ τὴν χώραν ἕψουσιν ἐν βρυτῷ τῷ ἀπὸ τῶν κριθῶν καὶ γίνεται γλυκέα σφόδρα· χρῶνται δὲ πάντες ὥσπερ τραγήμασι.*[357]
>
> "In sandy places which are not9 far from the river, there grows under ground the thing called malinathalle; this is round in shape and as large as a medlar but has no stone and no bark. It sends out leaves like those of galingale. These the people of the country collect and boil in beer made from barley and they become extremely sweet and all men use them as sweetmeats."

Despite a lack of contemporary or later medieval and modern evidence for sedge being used in beer, it could have been used to sweeten it.

The combination of grapes (*Vitis vinifera*) and cereals to create an alcoholic drink is not unprecented, if we are to read the first century AD Greek physician Aretaeus Cappadox' *De causis et signis acutorum morborum* literally:

> *… ποτόν παχύ, ὕδωρ μέν ὁ Νείλος, δριμύ δέ τό ἀπό τῶν κριυέων καί τό τῶν βρυτέων πόμα.*[358]
>
> "… Thick drink: the water of the Nile and the pungent drink made from from barley and that from grapes."

According to Nelson, it makes more sense that Aretaeus mentions two distinct drinks here rather than one.[359] However, according to Laennec and Grmek, who authored an annotated edition of Aretaeus' *De causis et signis acutorum morborum*, this could have been a grape beer. [360] This is seemingly supported by an archaeobotanical analysis of beer from Hierakonpolis dated to 3500 to 3400 BC (Predynastic Period) showing grape pips in beer residues.[361] However, this assessment had been put into doubt by Samuel two years later.[362] Honey grape beers, on the other hand, have been recently detected in goblets and concical cups from the Minoan Cretan cemetery of Armenoi and Phrygian cups from Midas' tomb in Gordion. However, this drink could also have been a mix of wine, beer and mead.[363] Let's return to Herodotus' original words on beer in Egypt:

> *οἴνῳ δὲ ἐκ κριθέων πεποιημένῳ διαχρέωνται· οὐ γάρ σφι εἰσὶ ἐν τῇ χώρῃ ἄμπελοι.* [364]
>
> For wine, they use a drink made from barley, for they have no vines in their country.

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[357] Hist. Plant. 4.8.12.
[358] De causis et signis acutorum morborum 1.9.4.
[359] NELSON 2001, 307.
[360] LAENNEC and GRMEK 2000, 27.
[361] MAKSOUD, EL HADIDI and AMER 1994, 221.
[362] SAMUEL 1996a, 10.
[363] Crete: PAIN 1999, 56 and TZEDAKIS and MARTLEW 1999, 166. Phrygia: MCGOVERN et al. 1999, 863 – 864 and GLASER 2001, 31.
[364] Hdt. 2.77.4.

Although his words apply to Persian Period Egypt (27th Dynasty), the limited occurrence of vines in the country along with the scarce and seemingly non-existent unambiguous literary evidence for 'grape beers' seems to make the addition of grapes in the brewing process more wishful thinking than reality.

Based on a dubious passage of the first century AD agricultural writer Columella, it has been proposed that lupine or lupin (*lupinus termis*), a type of edible leguminous herb, like skirwort or skirret (*sium sisarum* or *siser* in Latin), a liquorice-flavored plant and a certain Assyrian root (*radix Assyrius*) were used in Egyptian beer:

> *iam siser, Assyrioque venit quae semine radix,*
> *sectaque praebetur madido sociata lupino,*
> *ut* ***Pelusiaci*** *proriret pocula zythi.*[365]
>
> Now skirwort and the root which came from an Assyrian seed
> is sliced and served along with soaked lupines,
> to provoke the thirst for a cup of Pelusian *zythum* (or *zythus*).

There are two different interpretations: the plants are beer additives or are snacks to be eaten with the beer.[366] Peck assumes that the Assyrian root was used to add fragrance to the beer and lupines to increase bitterness like hops.[367] Van Minnen notes that Pelusian products in sources from Antiquity refer to objects originating from Egypt, with Pelusium being an important point of export. According to him, this passage indicates that lupines and probably liquorice were added to make the beer 'tasteful'. He also states that lupines were soaked before being placed into the beer, as Columella mentions, "to soften the bitter taste" as based on Athenaeus, himself quoting the fourth century BC sophist Theophrastus. The former said (without mentioning beer) that the 'lupine' (*θέρμος*) is 'very bitter' (*πικρότατος*), but becomes 'sweet' (*γλυκύς*) and 'very mild' (*προσηνέστατος*) once steeped:[368]

> *Θεόφραστος δέ ἱστορεί ἐν αἰτίοις φυτικοίς ὁτι "θέρμος καί ὀροβος καί ἐρεβινθος μόνα οὐ ζωιούται τών χεδροπών διά τήν δριμύτητα καί πικρότητα."*
>
> Theophrastus records, in *Plant Aetiology* (CP 4.2.2), that 'the lupine, bitter vetch and chick-pea are the only leguminous plants which do not breed worms, on account of their bitterness and sourness.'[369]
>
> *Δίφιλος δ' ὁ Σίφνιος τοὺς θέρμους φησὶν εἶναι σμηκτικοὺς καὶ πολυτρόφους, μάλιστα δὲ τοὺς ἐπὶ πλεῖον ἀπεγλυκασμένους.*

[365] Rei rusticae scriptores 10.114 – 116.
[366] NELSON 2001, 145.
[367] PECK 1965, 321.
[368] VAN MINNEN 1991, 167 – 168.
[369] Deipn. 2.55e.

> Diphilus of Siphnos says that lupines are purgative and nutritious, especially those that have been treated for a while to make them sweet.
>
> *ἔλεγε τὸ αὐτὸ τοῖς θέρμοις πάσχειν καί γάρ ἐκείνους πρίν διαβραχήναι πικρότατους εἶναι, ποτισθέντας δέ γλυκεῖς καί προσηνεστάτους*
>
> He (Zeno of Citium) [fr. 285, SVF i.65] answered that he underwent the same process as the lupine, for they too are very sour before they are soaked, but when steeped they become very sweet and mild.[370]

Athenaeus, however, is speaking of eating lupines and suggests that Columella's soaked lupines are to be eaten rather than drunk as beer.[371] It seems that a proper understanding of Columella relies on the correct translation of *praebetur … ut … proriret*, being literally 'is served/supplied … to provoke thirst'. Therefore, it seems to Nelson that lupines served as snacks to evoke a desire of drinking rather than being ingredients of beer.[372]

Finally, safflower (*Cathamus tinctorius*), a plant found throughout Europe and known for its use as a dye,[373] is one Hebrew chronicle mentioned as having been used to make Egyptian beer. Quoted in the Babylonian Talmud, Rabbi Joseph and Pappa say:

> וזיתום המצרי וכו׳ :מאי זיתום המצרי
>
> It is stated in the mishna that Egyptian zitom is considered leavened food. The Gemara asks: What is Egyptian zitom?
>
> תנא רב יוסף תלתא שערי תלתא קורטמי ותלתא מלחא
>
> Rav Yosef taught from a baraita: It is one-third barley, one-third safflower and one-third salt.
>
> רב פפא מפיק שערי ומעייל חיטי וסימניך סיסני
>
> Rav Pappa removes barley from the list of ingredients and includes wheat; he maintains that Egyptian zitom was made with wheat rather than barley. [374]

However, the uniqueness of this evidence makes this a doubtful hypothesis. Of all the discussed additives, safflower has the least ambiguous textual evidence to support its addition to Egyptian beer along with a remarkable absence in all other geographical areas of the Roman Empire.[375] Ghalioungui attempts to solve this matter by proposing that when Greeks and

[370] Deipn. 2.55f.
[371] NELSON 2001, 145 – 146.
[372] NELSON 2001, 146.
[373] GRIEVE 1959, II, 698 and LUST 1974, 340 – 341.
[374] Pesachim 42b, 10 – 11.
[375] NELSON 2001, 148.

Romans mentioned beer flavoring, they intended to mean 'medicated' beer as a medicine.[376] It also remains a fact that no evidence for the use of dates or other additives has yet been found in beer residues, [377] however, and it is possible that these items were used only rarely for special brews.[378]

Intermediate products

An indispensable intermediate product of the process before fermentation is malt. Malting, with *βυνοκοπία* meaning 'beer-malting' according to Preisigke,[379] is here simply germination as a means of converting starch to sugar to sweeten cereal grains, with sprouted grains milled to create malt.[380] The (modern) Greek name for malt, *βύνη*, is found in the aforementioned P. Tebt. 2 401[381] and in the unpublished sixth-century AD 10th book of Aëtius of Amidena, Emperor Justinianus I's physician.[382] The alternative term *βύνις* appears in the ostracon O.Did. 443 from the second century AD from Didymoi in the Eastern Desert as *βύνις*[383] and 3 other papyri from the 2nd and 3rd centuries AD (150 – 212).[384] For us, P. Tebt. 2 401 in particular is relevant as it uniquely describes a number of beer ingredients and processes relevant to a beer seller and mentions the word *βυνοκ( )* in line 30,[385] which Nelson completes to *βυνοκοπία*, a crucial part of the beer-making process which I elaborate upon in the next paragraph.

Finally, in the production of fermented beverages carbon dioxide is a significant by-product from ethanol, the primary product of fermentation. In the case of beer, the dissolved gas gives it carbonation and creates the head or froth on the beer. This additionally assists in preservation as a sealed cask retained under the pressure of carbon dioxide keeps air and microbes out of the empty portion of the cask.[386] The method described above allowed for good beer due to the natural constitution of the air in the location of the brewery and/or the reuse of properly contaminated vessels. According to Nelson, this was the probably most-used

[376] GHALIOUNGUI 1979, 8.
[377] SAMUEL 1996a, 10; SAMUEL 1996b, 488.
[378] SAMUEL 2000, 556.
[379] PREISIGKE 1925, I, 280.
[380] SAMUEL 2000, 551 – 553.
[381] P. Tebt. 2 401, col. vii, l. 30.
[382] NELSON 2001, 119.
[383] O.Did. 443, l. 6, from 'O.Did. 443', *papyri.info* (http://papyri.info/ddbdp/o.did;;443). Accessed on December 24, 2018.
[384] 'βύνις', *TM Words* (https://www.trismegistos.org/words/detail.php?lemma=βύνις&morph_type=noun). Accessed on December 24, 2018.
[385] This abbreviation of this word occurs in only one Greek text, namely the aforementioned P.Tebt. 2 401. See 'βυνοκ', *papyri.info* (http://papyri.info/search?STRING=(%CE%B2%CF%85%CE%BD%CE%BF%CE%BA)&no_caps=on&no_marks=on&target=text&DATE_MODE=LOOSE&DOCS_PER_PAGE=15). Accessed on December 25, 2018.
[386] LAMBERT 1997, 134 – 136.

method for the production, including the fermentation, of beer,[387] which is now the time to elaborate upon.

The baking process

The brewing process proper came and still comes near the end of the whole cycle of cereal production.[388] Although the word 'brewing' has been used, this term must not necessarily indicate a process in the modern sense of the word. Nelson, though he translates *ζυτοπωλεῖον* as 'brewery' and not 'beer-producing facility' out of convenience, gives *ζυτοποιός* the meaning 'beer-maker' rather than 'brewer' based on the recipe preserved in the works of Zosimos of Panopolis (around 300 AD)[389] in which heated malted bread is fermented in water.[390]

As mentioned *supra*, one very significant recipe detailing the alleged Egyptian baking method is attributed to the hand of the fourth century AD Egyptian alchemist Zosimos of Panopolis. However, the author of the recipe is most likely an anonymous imposter imitating Zosimos' style, who later added this recipe to the work of Zosimos.[391] The text is titled *De zythorum confectione* as published in the *Collection des anciens alchimistes grecs* 2.372 of Berthelot and Ruelle:

> περὶ ζύθων ποιήσεως·
> λαβὼν κριθὴν λευκὴν, καθαρίαν, καλὴν, βρέξον ἡμέραν α′, καὶ ἀνάσπασον ἢ καὶ κοίτασον ἐν ἀνειμέμῳ τόπῳ ἕως πρωΐ· καὶ πάλιν βρέξον ὥρας ε′· ἐπίβαλε εἰς βραχιώνιον ἀγγεῖον ἠθμοειδὲς, καὶ βρέχε. προαναξήρανε ἕως οὗ γένηται ὡς τύλη· καὶ ὅτε γένηται, ψῦξον ἐν ἡλίῳ ἕως οὗ πέσῃ· τὸ μαλίον γὰρ πικρόν. λοιπὸν ἄλεσον καὶ ποίησον ἄρτους προσβάλλων ζύμην ὥσπερ ἄρτου· καὶ ὅπτα ὠμότερον· καὶ ὁτ' ἂν ἐπανθῶσιν, διάλυε ὕδατι γλυκεῖ καὶ ἤθμιζε διὰ ἠθμοῦ ἢ κοσκίνου λεπτοῦ. ἄλλοι δὲ ὀπτῶντες ἄρτους βάλλουσιν εἰς κλουβὸν μετὰ ὕδατος, καὶ ἑψοῦσι μικρὸν, ἵνα μὴ κοχλάσῃ, μήτε ᾖ χλιαρὸν, καὶ ἀνασπῶσι καὶ ἠθμίζουσιν· καὶ περισκεπάσαντες, θερμαίνουσι καὶ ἀνακλίνουσιν.
>
> ἀνειμέμῳ Olck 1899: 459, ἀνηνέμῳ cod.; ζύμην ὥσπερ ἄρτου cod., ζύμην ὥσπερ <πρὸς> ἄρτον Olck; περισκεπάσαντες cod., περισκευάσαντες Lesart in Olck; ἀνακλίνουσιν Olck, ἀνακρίνουσιν cod.
>
> "On the making of zuthoi:
> "Take nice, clean, white barley, soak [it in water] for one day, take [it] up [out of the water] and lay it out in a windless place until early [the following day] and soak it again for five hours. Throw it into a shallow, strainer-like bowl, soak [it in water], making it dry up before until it becomes like a lump and, being so, dry it in the sunlight until it falls apart, since the little hairs are bitter. Grind the remainder and make [it] into loaves, adding yeast as that for bread. Heat [the loaves] more strongly [than bread] and when they rise, crumble them into fresh water and strain them through a strainer or fine sieve. Others bake the loaves and cast them in a vat with water and they heat it slightly, so that it does not boil nor become lukewarm,

[387] NELSON 2001, 149.
[388] KEMP 2006, 172.
[389] NELSON 2001, 722 – 723.
[390] BERTHELOT and RUELLE 1888, 372.
[391] NELSON 2001, 317.

then take up [the loaves from the water] and strain [the water] and they cover [it] around, heat [it] and lay [it] out."

The process can be summarized as follows:

1. Soaking, germination and drying of the barley.
    a. Nice, clean and white barley (*κριθήν*) is soaked in water for one day.
    b. Germination takes place.
    c. The germinated barley is laid out in a windless place the following day, ostensibly to dry it. Before soaking it again for five hours, placing it a shallow bowl for straining.
    d. It is soaked for the third time and dried before it becomes a lump.

With "dry it (the soaked cereal) in the sunlight until it falls apart, since the little hairs are bitter", the author perhaps alludes to germination, since the falling apart of the cereal could be a reference to this process along with the little hairs to the rootlets (often three) which grow out of the sprouting grain.[392]

2. Making and processing of the loaves.
    a. The remainder of the barley is ground.
    b. Loaves (*ἄρτους*) are made.
    c. Yeast (*ζύμην*) is added.
    d. The loaves are heated to a temperature higher than that of bread.
    e. When the loaves have risen, they are crumbled into fresh (γλυκεὶ) water.
        i. Alternatively, the loaves are baked and cast in a vat with water heated to a temperature between lukewarm and boiling.
    f. They are strained through a strainer (*ὑθμού*) or fine sieve (*κοσκίνου λεπτού*).
3. [At this stage, the liquid can ferment from yeast naturally present in the air or possibly from added, cultivated yeast, as elaborated upon in Basic Ingredients, *supra*.][393]
4. The liquid is poured through a strainer or a fine sieve and covered about, heated and laid out.

It has usually been assumed that Pseudo-Zosimos was elaborating upon the classic Egyptian way of beer production, by soaking malted loaves.[394] This is has been based on the fact that the same process is apparently shown in several Egyptian tomb paintings and wooden models from

[392] NELSON 2001, 117.
[393] NELSON 2001, 125.
[394] NELSON 2001, 126.

the official Meketra from the Middle Kingdom[395] (as discussed under Second Intermediate Period and New Kingdom, *supra*) and still used in modern Egypt to make *bouza*.[396] One of two[397] lone references in papyri in support of this method may be found in P. Tebt. 2 401, an account from a beer-seller from 14 AD from Tebtynis:

> *κζ. βροχῆς (ἀρτάβαι) β,* ***φυράμ(ατος)*** *(ἀρτάβαι) ε, δαπά(νης) χό(ες) λα, ποτισμ(οῦ) χό(ες) ις, πίσ(τεως) χό(ες) σγ δ΄,*
> *ἐμβολ(ῆς(?)) (ὀβολοὶ) {οβο} τλη (δραχμαὶ) νβ, (ἀφ᾽ ὧν) ὀψονί(ου)(*) Πανεβτ(ύνει) Ạ . [.]ης (ὀβολοὶ) δ, τιμ(ῆς)*[398]

It mentions dough or *φυράμα* in line 27 of column vii. If it is somehow connected to the yeast pitchers (*ζύμης χό(ες)*) mentioned in line 35 of the same column, this could point to the baking method being in use. The 5th century AD Greek Grammarian Hesychius even equates *ζύμη* and *φυράμα* in his compilation of obscure Greek words named the *Synagōgē pasōn lexeōn kata stoicheion* or 'Alphabetical collection of all words', also known as *Lexicon*.[399] Another mention of *φυράμα* is in P.Bon. ISA 3 from the Late Ptolemaic to Early Roman Period and a text of the same genre as P.Tebt. 2 401, as mentioned *supra*. Col. II, line 4 of the R (of which only the beginnings of 5 – 6 letters of each line remain) has *φυρ(άματος)* with an indication of expenditure (?), for a figure exceeding a bronze talent, of genres such as *ἀρτων*, with quantities expressed in units, or *φυράμα* ('leavened dough', possibly expressed in *artabai*), or, again, of payments of *ὀψώνιον* indicated in σtaters (for an amount of 1560). In these lists, perhaps of daily expenses, as the indications of the days 19 and 20 in R II 1 – 2 would suggest (?), there is also a rather characteristic entry, namely *βροχή*, which could indicate the wet paste to help the fermentation, therefore possibly referring to operations related to the manufacture of beer, although, the mention of *ἀρ(των)* in R II 7 and *ἀρτω(ν)* in V II 7 seems to point to the use of *φυράμα* for the production of bread, which, just like beer, were the subject of distributions in kind.[400]

However, the connection of *φυράμα* to the beer-making process is not certain given that dough was also used for the baking of bread and in Egypt breweries and bakeries were traditionally adjacent one another or sharing the same building.[401] Secondly, a 1965 chemical analysis by Freeman Swift from a bread crumb of bread from the first king of the Middle Kingdom

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[395] LUTZ 1922, 78 – 81, DARBY, GHALIOUNGUI and GRIVETTI 1977, 537 – 541, OLCK 1899, 459 – 460 and KEMP 2006, 173.
[396] DARBY, GHALIOUNGUI and GRIVETTI 1977, 534; 541.
[397] 'φυράμ', *papyri.info* (http://papyri.info/search?STRING=(%CF%86%CF%85%CF%81%CE%AC%CE%BC)&no_caps=on&no_marks=on&target=text&DATE_MODE=LOOSE&DOCS_PER_PAGE=15). Accessed on 21 May 2019.
[398] 'P. Tebt. 2 401', *papyri.info* (http://papyri.info/ddbdp/p.tebt;2;401). Accessed on November 16, 2018.
[399] NELSON 2001, 153.
[400] PASSONI DELL'ACQUA 2007, 514.
[401] See the early Middle Kingdom model bakery/brewery from the tomb of Meketra at Thebes from the 11th Dynasty in KEMP 2006, 173.

Mentuhotep II's tomb (2060 – 2010 BC) shows that the dough had been allowed to work out almost all of its available sugar (sugar being crucial to allow for the production of alcohol) before being baked, seemingly ruling out any idea that these loaves may have been baked as so-called 'beer bread.'[402] Finally, Delwen Samuel has argued in 1996 from an analysis of the morphology of starch granules from surviving ancient Egyptian beer residue that there is no certain evidence for the use of this method.[403] These reasons have demoted the baking process as being the primary way of beer production in Egypt and therefore, the focus will be on the 'brewing' method.

Egyptian Brewing during Antiquity step by step

Germination through straining

The essential steps in the two-part brewing process of coarsely ground, well-heated malt or grain and unheated malt[404] are firstly malting, mashing, souring, boiling, conversion, straining and secondly alcoholic fermentation (see figure 28).[405] This section deals with all those steps through straining. As at the Roman-Anglo-Saxon Orton Hall Farm in East Anglia, the basic brewing process is both simple and unlikely to have altered very much over the centuries. The only major alterations would have been governed by changing tastes, refinements designed to produce cleaner or purer brews of differing types and by the need to produce large quantities to satisfy large urban communities.[406] The process starts off at base with only three basic ingredients: grain (in Egypt usually barley or a mix dominated by barley), water and yeast as we have also seen at Orton Hall Farm, *supra*.

Malting, with *βυνοκοπία* meaning 'beer-malting' according to Preisigke,[407] is here simply germination as a means of converting starch to sugar to sweeten cereal grains and was most likely discovered soon after man started harvesting and storing grain. Emmer (and einkorn and bread wheats) were used sparingly throughout the ancient Near East because they are more difficult to ferment than barley.[408] This part of the process was probably largely like the one described by Samuel (see Old Kingdom, *supra*). First, the brewer gathered husked grains of barley and/or emmer wheat. The grains were laid out on mats, in shallow bins, or inside big jars turned on their sides. The cereals were exposed to moisture and allowed to sprout to produce amylases as a natural malting step. After five to seven days for barley (as is the case

[402] SWIFT 1966, 216 – 218.
[403] SAMUEL 1996a, 3 – 12.
[404] SAMUEL 1996b, 489.
[405] SCHWARTZ 1956, 101 – 105.
[406] For Orton Hall Farm, see MACKRETH 1996, 229 – 230.
[407] PREISIGKE 1925, I, 280.
[408] MCGOVERN et al. 2005, 293.

with the sorghum used for African Kaffir (Kaffircorn) Sorghum Beer) and six to eight days for emmer wheat, the grains were exposed to the sun or gently air-dried at a maximum of 50° to 60° C (as with African Kaffir (Kaffircorn) Sorghum Beer, *supra*) in a possibly multi-functional oven (as at Roquepertuse, *supra*) to stop the germination process, as malt should not be overheated to avoid damaging the chemical properties of amylase and other enzymes.[409] Thereafter, it was milled to create malt and then mixed with cold water.[410]

A second batch of barley and/or emmer wheat was prepared at the same time. This batch was made with milled grain (either sprouted or unaltered) that was cooked in water. Brewers then mixed the two batches together for a period to induce saccharification in the warm water. The mixture was rinsed with water. At this point, the mix was a gruel-like substance which was subsequently passed through a rather crude strainer in the form of a fiber basket or a more advanced metal or stone sieve, both placed on the top of a large jar.

Finally, the dregs that were caught in the sieve were then squeezed to remove any remaining liquid. Water was sometimes added to the liquid in the jar at this point both to increase the quantity of beer brewed and to reduce its strength.[411] The large quantities of starch remaining are evidence of the relative inefficiency of the process, but such spent grains may have been re-used to make weaker beer according to Delwen Samuel (see Alcohol Content, *infra*).[412]

Fermentation

Alcoholic fermentation, also referred to as ethanol fermentation, is a biological process in which yeasts obtain energy via the conversion of various sugars (see figure 25) into ethanol and carbon dioxide. Yeasts are eukaryotic microorganisms classified in the kingdom Fungi and are estimated to be approximately one percent of all fungal species.[413] There are two basic ways of fermenting beer using yeast, without which beer cannot be made, namely spontaneously and artificially. The term for yeast is *ζύμη* in Greek and *fermentum* in Latin. Almost certainly *Saccharomyces cerevisiae* was used as the top-fermenting yeast for ales and *Saccharomyces Carlsbergensis* or *uvarum* as the bottom-fermenting yeast for lagers.[414] A wide variety of *S. cerevisiae* strains exist,[415] but here the beer yeast of *S. cerevisiae* was used. Because of the ubiquity of yeast, fermentation is a natural process and when solutions containing certain kinds of sugar are exposed to the air, after a short time they begin to ferment.[416] However, the

[409] LAUBENHEIMER, OUZOULIAS and VAN OSSEL 2003, 47 – 63.
[410] SAMUEL 2000, 551 – 553.
[411] SAMUEL 2000, 551 – 553.
[412] SAMUEL 1996b, 490.
[413] RASMUSSEN 2014, 13.
[414] GILLILAND 1971, 108 – 128, TUBB 1987 and JOHNSTON 1990, 55 – 104.
[415] LEGRAS et al. 2007, 2091 – 2102.
[416] LUCAS 1962, 23.

mention of *ζύμης χό(ες)*, literally translated as 'pitchers of yeast', proves that a leavened liquid substance was added to facilitate fermentation according to Nelson.[417] However, in my opinion it more probably points to the artificial cultivation of yeast in Graeco-Roman Egypt by so-called yeast-makers.[418]

Firstly, fermentation was initiated in the rinsed sugar- and starch-rich liquid obtained after straining out the bulk of the cereal husk.[419] The malted grain in free water would subsequently be fermented by potentially cultivated yeasts added from yeast pitchers. Since the process of malting is basically a sprouting and killing of grains, the process of fermentation was therefore seen as a subsequent decomposition of the cereal. Theophrastus states in his *De Causis Plantarum*:

> *τοὺς δὲ καὶ ἐξιστάντες τῆς φύσεως καὶ ὑποσήποντες εἰς χυλοὺς ἄγουσι ποτίμους (οἷον ὡς οἱ τοὺς οἴνους ποιοῦντες ἐκ τῶν κριθῶν καὶ τῶν πυρῶν, καὶ τὸ ἐν Αἰγύπτῳ καλούμενον ζῦθος).*[420]
>
> They even make some depart from their nature by inducing partial decomposition and thus turn them into juices that we can drink, as do the makers of wines from barley and wheat and of the so-called *zûthos* in Egypt.

It was apparently believed that beer had to decompose, while wine was not subject to the same process for the ancients.[421] Concretely in the case of beer, the brewer would leaven the water in which the cooled mix of water and malt (also called mash) was submerged, a process known as pitching yeast.[422] However, the leavening probably did not take place here in the fermentation process. After the addition of yeast, there was the subsequent potential yet unproven addition of flavorings like dates to sweeten the brew and raise the alcohol content.

Finally, in the fermentation phase of the production of fermented beverages, ethanol is the primary product with carbon dioxide (CO_2) as a significant by-product of the conversion of the malt sugars by the yeast. In the case of beer, the dissolved gas gives it carbonation and creates the head or froth on the beer. This additionally assists in preservation as a sealed cask that is retained under the pressure of carbon dioxide (CO_2) keeps air and microbes out of the empty portion of the cask.[423] Storage in sealed casks and pots allowed for preservation for a couple of days (no longer than one week).[424] This method allowed for good beer due to the natural constitution of the air in the location of the brewery and/or the reuse of properly contaminated

[417] NELSON 2001, 151.
[418] See also LUCAS and HARRIS 1962, 16.
[419] SAMUEL 1996b, 488 – 490 and SAMUEL 2000, 537 – 576.
[420] De Causis Plantarum 6.11.2.
[421] NELSON 2001, 152 – 153.
[422] NELSON 2001, 151.
[423] LAMBERT 1997, 134 – 136.
[424] JENNINGS et al. 2005, 281.

vessels. According to Nelson, this was the probably most-used method for the fermentation of beer.[425]

However, the archaeological record does not always record the presence of yeast. In the case of Delwen Samuel's study of the beer residue at Deir el-Medina on the west bank of the Nile and the Workmen's Village of Amarna, both dating back to the New Kingdom, nearly all of the large cereal-based contents of whole jars revealed no traces of yeast, but large pieces of chaff and coarse fragments of grain. The high proportion of chaff and lack of yeast were attributed to the contents consisting of spent grain (i.e. residues after rinsing sugars, dextrins and starch from processed malt). From this Samuel proposed that fermentation was initiated in the rinsed sugar- and starch-rich liquid obtained after straining out the bulk of the cereal husk.[426] However, it remains uncertain if the basic procedure of the New Kingdom was still applied in Graeco-Roman Egypt and the mention of yeast-pitchers in a brewing context point to their use.

Results of the brewing process

General character

First, it can be assumed that the results were fermentation products of cereal grains and possibly fruit material which were consumed by the majority of the Egyptian population. The potency of the aminoacids and vitamins was increased during the fermentation process and this augmented enrichment might explain the popularity of the beverage within modem and ancient populations with inadequate and monotonous diets.[427] Secondly, as noted earlier (Back to the roots: Modern Egyptian bouza, *supra*), the fermentation products were of a similar character to those known from vat residue samples 3H and 4H at the Pre-Dynastic mid-fourth millennium BC brewery complex at the HK24A locality at Hierakonpolis and the local beer 'Bouza' which has been known in Egypt since early history.[428] Thirdly, recovered whole seeds of emmer and barley do not show signs of high temperature treatments (e.g. dark colour and shrivelled embryos) and so there is a question mark as to how dark beers, which we know existed, were produced.[429]

[425] NELSON 2001, 149.
[426] SAMUEL 1996b, 488 – 490 and SAMUEL 2000, 537 – 576.
[427] GHALIOUNGUI 1979, 8-9, DARBY, GHALIOUNGUI and GRIVETTI 1977 and MORCOS, HEGAZI and EL-DAMHOUGY 1973, 1157.
[428] MAKSOUD, EL HADIDI and AMER 1994, 221.
[429] HORNSEY 2003, 70.

Taste and nutritious value

Modern beers are typically flavored with hops, a practice originating in the Western European Middle-Ages. Thus, ancient beers taste quite different than modern varieties, though not surprisingly, ancient beers taste like water and malted barley and/or emmer wheat, depending on which cereal or cereal mix one chooses,[430] with some froth on top. Although not bereft of a certain sweetness resulting from the malting process itself, this taste could be spiced or sweetened with additives as mentioned under Additives, *supra*. According to most scholars, dates served as both an important flavoring and a provider of the sugars needed to produce alcohol.[431] Other flavorings, such as lupines, skirrets and radishes, are mentioned as having sometimes been added to the brew during fermentation.[432]

No evidence for the use of dates or other additives has yet been found in beer residues,[433] however and it is possible that these items were used only rarely for special brews.[434] This could be due to the fact that the consumer would note the added sweetness resulting from the malting process itself and would likely attempt to repeat the process. The effect of the alcoholic beer on the primitive human psyche very likely led the early discoverers of malting and brewing to believe that a miracle had occurred and that the 'spirit' of the grain had been released.[435]

However, flavoring was used to create a more pleasantly tasting beer. Using emmer wheat and coriander and juniper flavoring, which were also widely available at the time, the team led by James Merrington at the Scottish and Newcastle brewery in Newcastle, one of the sponsors of the research, followed Samuel's process and came up with a beer that was delicious with a long, complex aftertaste according to Samuel.[436]

Finally, it should be noted that beer traditionally was a nutritious food in its own right as an indispensable part of the daily diet, as opposed to our drinking of brewed beverages for refreshment. As such, brewing focused on providing a high nutritious value, including an increased fibre content. Nour Eldin in this light reported that Egyptian *bouza* can correct the vitamin deficiencies of certain diets.[437] Comparing *bouza* with its ingredients, results showed that during preparation of bouza, its fibre content increased, this may be due to the growth of

[430] HOMAN 2004, 91.
[431] DARBY, GHALIOUNGUI and GRIVETTI 1977, 543, HORNSEY 2003, 62 – 63, KATZ and MAYTAG 1991, 32, KEMP 2006, 123 – 124 and MONTET 1958, 87.
[432] DARBY, GHALIOUNGUI and GRIVETTI 1977, 543, KATZ and MAYTAG 1991, 30 and HORNSEY 2003, 62 – 63.
[433] SAMUEL 1996a, 10; SAMUEL 1996b, 488.
[434] SAMUEL 2000, 556.
[435] STEINKRAUS 1996, 407.
[436] WILLIAMS 1996, 432.
[437] NOUR ELDIN 1947.

micro-organisms involved in the process of fermentation.[438] Total sugars of germinated wheat were higher than that of the grains, this may be due to the action of α- and β-amylases which developed during germination.[439] Also, this is today still true of the Kaffircorn (Sorghum) beer from southern Africa. Starch is a very important component there in Bantu beer. The beer contains a considerable amount of both gelatinized and ungelatinized starch.[440] The gelatinized starch helps keep the ungelatinized starch in suspension, makes the beer creamy and adds body. The starches provide calories to the consumer during the day, when kaffir beer is a major dietary component.[441] This was probably also the case with Egyptian beer, though the creamy effect may have been less profound.

Alcohol content

The alcohol content of ancient brews was between two to three percent, compared with most modern beers at five percent alcohol or higher, as observed in a modern recreation of an ancient brewing process by Homan.[442] Kemp and Samuel peg the range of alcohol content at 3–6%.[443] For comparison, the amount of alcohol present in *bouza* varied from 6.2 per cent to 8.1 per cent by volume, with a mean of 7.1 per cent.[444] However, moderation in the consumption of beer was urged as early as the late New Kingdom around 1200 BC by the teacher named Ani in his 13th Maxim:

> "Do not get heated in the house where intoxicating liquor is being drunk. Your legs will become paralyzed, and you will fall; no one will lend you a hand; your boon companions will drink and will leave, saying, 'Go home, for you have drunk your fill.' You are needed for managing your own private affairs; and you will be found lying helplessly on the ground like a small child."[445]

Whether this advice was headed or not, it was possible to brew weaker beer by reusing the spent grains or the large quantities of starch that remained.[446] The end result may have been a more palpable table beer suitable for younger consumers.

[438] MURATA, IKEHATA and MIYAMOTO 1967, 580.
[439] NOVELLIE 1960, 408.
[440] NOVELLIE 1966b, 354 – 361 and NOVELLIE and SCHUTTE 1961, 552 – 559.
[441] STEINKRAUS 1996, 412.
[442] HOMAN 2004, 91.
[443] KEMP 2006, 120; SAMUEL 2000, 553.
[444] LUCAS 1962, 17.
[445] NEUBURGER 1930, 103.
[446] SAMUEL 1996b, 490.

Beer storage and distribution

Types and identification of containers

Beer was difficult to store and a deep concern over the storage and spoilage of beer is found in earlier Egyptian funerary texts.[447] The foremost container of beer were jars. After fermentation was complete, the jars were stopped with a disk of clay and a lump of mud plaster and the inside may have smeared with clay or bitumen for impermeability.[448] Despite these attempts at creating anaerobic conditions, beer would keep only "for a very short time," primarily because of its low alcohol content and likely exposure to bacteria that quickly converted the ethanol to acetic and lactic acid.[449] While in Gaul wooden barrels were common for beer storage and transport due to their light weight and easy transportation by rolling and were possibly even invented in the Gallic world before the arrival,[450] the first unambiguous evidence for wooden beer barrels as we know them dates to the seventh century AD[451] and were therefore probably not used in Egypt during Graeco-Roman Antiquity.

Secondly, beer storage vessels are not easily identified. One problem with determining the nature of a storage vessel is by separating them from fermentation containers. One particular compound settles out from the liquid during the processing and storing of barley beer. Calcium oxalate, known as beerstone by brewers, is the simplest of organic acid salts, combined with ionic calcium. It's a very bitter, potentially poisonous compound, so it is a good thing to eliminate it from the brew. The pores in the pottery helped do this by removing the calcium oxalate from the brew while it helped to preserve the compound for our extraction and analysis thousands of years later. Beerstone can be identified down to the one part per million level using a standard chemical spot test developed by Fritz Feigl.[452] The Graeco-Roman papyri from Egypt mention several types of beer containers, representing varying liquid measures. A 'Rhodian' (*῾Ροδίον*)[453] is said to be equal to half a jar or *κεράμιον,* which was commonly mentioned in conjunction with wine.[454][455] Meanwhile, the pitcher or *χούς* mentioned notably

[447] DARBY, GHALIOUNGUI and GRIVETTI 1977, 532.
[448] DARBY, GHALIOUNGUI and GRIVETTI 1977, 547, LUTZ 1922, 81 and MONTET 1958, 88.
[449] DARBY, GHALIOUNGUI and GRIVETTI 1977, 547, KATZ and MAYTAG 1991, 33 and MONTET 1958, 88.
[450] FORBES 1956, 136; NELSON 2001, 155.
[451] NELSON 2001, 157.
[452] MCGOVERN 2009, 67.
[453] P. Tebt. 3 2 894, fr. 5, l. 13 (ζὺτου Ῥοδίου) and fr. 6v. (Ῥοδίου) from 'P. Tebt. 3 2 894', *papyri.info* (http://papyri.info/ddbdp/p.tebt;3.2;894). Accessed on November 18, 2018.
[454] For the word jar, see i. e. O. Fay. 11, l. 4 (ζὺ(του) κερά(μιον)) from 'O. Fay. 11', *papyri.info* (http://papyri.info/ddbdp/o.fay;;11). Accessed on November 18, 2018.
[455] 108 out of 216 mentions of *κεράμιον* are connected to wine. See 'κεράμιον', *papyri.info* (http://papyri.info/search?STRING1=%CE%BA%CE%B5%CF%81%CE%AC%CE%BC%CE%B9%CE%BF%CE%BD&target1=TEXT&no_caps1=on&no_marks1=on). Accessed on November 18, 2018. See also 'κεράμιον AND οἴνου', *papyri.info* (http://papyri.info/search?STRING=(οἴνου)&no_caps=on&no_marks=on&target=text&DATE_MODE=LOOSE&DOCS_PER_PAGE=15&STRING1=κεράμιον&target1=TEXT&no_caps1=on&no_marks1=on). Accessed on November 18, 2018.

in P. Tebt. 2 401 from 14 AD fits eight times within a *δίχωρον*, a measure mentioned from the late first century AD onward. It was also used for the transport of wine.[456][457]

Preservation of beer

Bouza, a beer made in Egypt today using a similar process described *supra*, tends to sour and spoil in a few days.[458] It is likely that ancient Near Eastern beer lasted no longer than a week.[459][460] However, McGovern rightfully notes that the authors have often relied on ethnographic and/or ethnohistorical accounts, while technologies, like cultures, have undergone significant changes over time.[461] Therefore, *bouza* may not be a good analogue for Graeco-Roman Egyptian beers. However, the brief window of consumption for most traditional alcoholic beverages is one reason that ancient breweries have been relatively rare archaeological finds.[462] This also implies that consumption was in immediate proximity and just after production, possibly after primary fermentation had finished,[463] as evidenced by finds from Bronze Age at Tell Hadidi in western Syria on the Euphrates.[464] The Hadidi Tablet Building, containing 17 cuneiform tablets with sealings which date the building comfortably to the Late Bronze IB period (early 15th century BC)[465] contains pierced vessels, smaller jars for storage and shipping,[466] tankards to fill them[467] and perhaps even kraters for consumption on the spot.[468] However, it is also known that the ancient Egyptians knew how to brew beer that possessed an extended shelf-life according to Hornsey. How this was realized is unknown, but it was certainly necessary for funerary beers to be long-lasting.[469]

Since primitive beers, of whatever kind of grain they happen to be made (maize, barley, millet, rice, etc.), do not keep more than a few days, they must be made on demand. They can be produced on demand because the grain or flour (and malt) of which they are made can be stored for months, while conversely, grapes do not keep at all unless dried and therefore wine

[456] O. Berl. 95, l. 3 (ζὐτον δἰχωρα), 96, l. 3 (ζὐτ(ον) δἰ(χωρα)) and SB XIV 11561, l. 3 (ζὐτ(ου) δἰχ(ωρα)).
[457] ‘δἰχωρα’, *papyri.info* (http://papyri.info/search?STRING1=%CE%B4%CE%AF%CF%87%CF%89%CF%81%CE%B1&target1=TEXT&no_caps1=on&no_marks1=on&page=1). Accessed on November 18, 2018. For wine (οἴνου δἰχω(ρον)), see i. e. P.Laur. 1 17. ‘P.Laur. 1 17’, *papyri.info* (http://papyri.info/ddbdp/p.laur;1;17). Accessed on November 18, 2018.
[458] ATACADOR-RAMOS 1996, 421 - 425 and GELLER 1992a, 125 – 126.
[459] JENNINGS et al. 2005, 281.
[460] Spanish beer supposedly held longer, according to Pliny the Elder in his *Naturalis Historia*: “Hispaniae iam et vetustatem ferre ea genera docuerunt./The Spanish provinces have by this time even taught us that these liquors will bear being kept a long time” (Nat. Hist. 14.29.149).
[461] MCGOVERN et al. 2005, 293.
[462] DIETLER 2006, 238.
[463] HORNSEY 2003, 37.
[464] GATES 1988, 66.
[465] DORNEMANN 1981, 42; 59. Carbon-14 dates between 1540 – 1510 and 1450 – 1400.
[466] DORNEMANN 1981, fig. 6: 2 – 6.
[467] DORNEMANN 1981, fig. 4: 7 – 10.
[468] GATES 1988, 68.
[469] HORNSEY 2003, 37.

must be made immediately following the grape harvest and stored as such.[470] Due to these limitations, beer, like most traditional indigenous forms of alcohol, could not be traded over great distances or stockpiled: production and consumption were usually spatially and temporally proximate. These drinks necessitated control of a large labor force for hosting a significant consumption event and they were of limited value as trade goods.[471]

[470] SIGAUT et al. 2005, 294.
[471] DIETLER 2006, 238.

Conclusions

Beer production in Greco-Roman Egypt is a process that builds on millennia of tradition starting with the emergence of agriculture and the development of a hierarchical society in the Nile Valley. Female and male brewers produced beer in both domestic kitchens and industrial breweries with their own grinding and fermentation rooms using fermentation jars, storage jars and yeast jugs.

Through chemical analyzes of beer residues from the Old Empire by Delwen Samuel, the comparison with contemporary parallels based on archaeobotanical and chemical research of other hopeless brewed beers and information from papyri and fragments of ancient authors makes it possible to record a possible brewing process. A beer in Greco-Roman Egypt needed only three ingredients: grain (barley or a mix dominated by barley), water and yeast, a single-celled plant whose cultivated Saccharomyces cerevisiae strain was cultivated delivered in yeast jugs. The essential steps in the two-part grain brewing process are, first, sprouting, crushing, acidifying, cooking, conversion and filtering, and, secondly, alcoholic fermentation. First, the brewer collected shelled grains. They were spread and exposed to moisture to make them sprout to produce amylases. After 5 to 7 days, the barley grains were exposed to the sun or gently dried (50 to 60 ° C) by hot air in an oven to end the germination process. It was then ground to make malt and mixed with cold water. At the same time, a second heap of barley was prepared. This was prepared with ground grain (sprouted or shelled grain) boiled in water. The two groups were then mixed to cause saccharification. This mix was rinsed with water and then the slurry mixture was pressed through a woven basket or a more advanced metal or stone sieve, both placed on a large pot. Finally, the residual lees in the screen were squeezed out to remove any remaining liquid.

Alcoholic fermentation was the last and most crucial step in the brewing process. In this biological process, yeast obtains energy through the conversion of sugars into ethanol and the by-product carbon dioxide (CO_2). First, fermentation was initiated in the flushed sugar and starchy liquid. The malted grain in freestanding water was then fermented by possibly cultivated yeast from yeast jugs, possibly followed by the unproven addition of flavorings such as dates. Here the decomposed gas gives the beer its carbonization and it creates the head on the beer. This process also contributes to the storage (a few days to a maximum of 1 week) since the pressure ofCO_2 air and microorganisms from the jar. After the fermentation was completed, the vessels were sealed with a clay disc and mud plaster and the inside was possibly smeared for impermeability.

The slightly sweet brew tasted like malted barley, with sometimes hints of emmer wheat, and possibly coriander and juniper to enhance the taste. The alcohol percentage was between that of table beer and the stronger abbey beer. Probably it had a lower strength (2 - 3%) for daily use. The color was a rather dark blond with a creamy head, although thunder beers were also made of which the recipe is unknown. As part of the daily and possibly poor diet, it was rich in fiber.

Samenvatting voor een breed publiek

Bierproductie in Grieks-Romeins Egypte is een proces dat bouwt op millennia van traditie beginnend met het ontstaan van landbouw en de ontwikkeling van een hiërarchische samenleving in de Nijlvallei. Vrouwelijke en mannelijke brouwers produceerden bier in zowel huishoudelijke keukens als industriële brouwerijen met eigen maal- en fermentatieruimtes met behulp van fermentatiekruiken, opslagpotten en gistkannen. Door chemische analyses van bierresten uit het Oude Rijk door Delwen Samuel, de vergelijking met contemporaine parallellen gebaseerd op archeobotanisch en chemisch onderzoek van andere hoploze gebrouwen bieren en informatie uit papyri en fragmenten van antieke auteurs is het mogelijk om een mogelijk brouwproces vast te leggen. Een bier in Grieks-Romeins Egypte had slechts drie ingrediënten nodig: graan (gerst of een mix gedomineerd door gerst), water en gist, een eencellige plant waarvan de gecultiveerde *Saccharomyces cerevisiae*-stam gecultiveerd geleverd werd in gistkannen.

De essentiële stappen in het tweedelige brouwproces van graan zijn ten eerste het ontspruiten, fijnstampen, verzuren, koken, conversie en filtreren en ten tweede alcoholische fermentatie. Eerst verzamelde de brouwer gedopte graantjes. Die werden uitgespreid en blootgesteld aan vocht om hen te laten ontspruiten om amylases te produceren. Na 5 tot 7 dagen werden de gerstgraantjes blootgesteld aan de zon of voorzichtig gedroogd (50 tot 60° C) door warme lucht in een oven om het germinatieproces te beëindigen. Daarna werd het gemalen om mout te maken en gemengd met koud water.

Tegelijkertijd maakte men een tweede hoop gerst klaar. Deze was bereid met gemalen graan (ontspruit of gepeld graan) gekookt in water. Daarna vermengde men de twee groepen om saccharificatie te veroorzaken. Deze mix werd gespoeld met water en daarna perste men het brijachtige mengsel door een geweven mand of een meer geavanceerde metalen of stenen zeef, beiden geplaatst op een grote pot. Tot slot perste men het achtergebleven droesem in de zeef uit om achterblijvende vloeistof eruit te halen.

Alcoholische fermentatie was de laatste en meest cruciale stap in het brouwproces. In dit biologisch proces verkrijgt gist energie door de omzetting van suikers in ethanol en het bijproduct koolstofdioxide (CO_2). Eerst werd fermentatie geïnitieerd in de gespoelde suiker- and zetmeelrijke vloeistof. Het gemoute graan in vrijstaand water werd vervolgens gefermenteerd door mogelijk gecultiveerde gist uit gistkannen, eventueel gevolgd door de onbewezen toevoeging van smaakstoffen zoals dadels.

Hier geeft het ontbonden gas het bier zijn carbonisatie en het creeërt de schuimkraag op het bier. Dit proces draagt eveneens bij aan de bewaring (enkele dagen tot maximaal 1 week) aangezien de druk van CO_2 lucht en micro-organismen uit de kruik houdt. Nadat de fermentatie voltooid was, werden de vaten afgesloten met een kleischijf en modderpleister en de binnenkant werd mogelijk ingesmeerd voor ondoorlaatbaarheid.

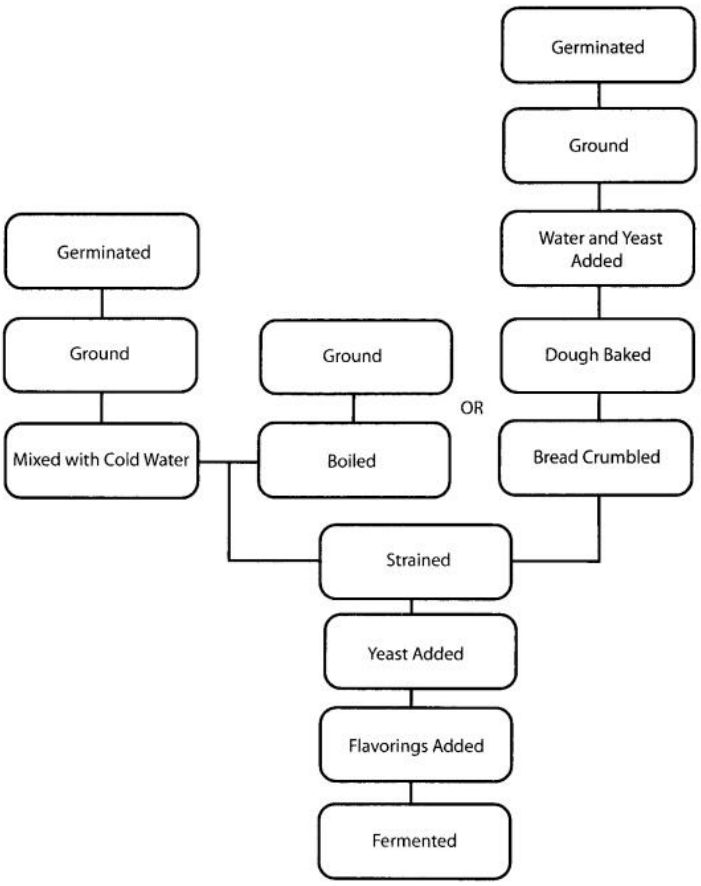
Het licht zoete brouwsel smaakte naar gemout gerst, met soms hints van emmerkoren, en mogelijk koriander en jeneverbes om de smaak te versterken. Het alcoholpercentage lag tussen dat van tafelbier en het stevigere abdijbier. Waarschijnlijk had het een lagere sterkte (2 – 3%) voor dagelijks gebruik. De kleur was eerder donkerblond met een romige schuimkraag, al maakte men ook dondere bieren waarvan het recept onbekend is. Als deel van het dagelijkse en mogelijk te arme eetpatroon was het rijk aan vezels.

Figures

Figure 1: Map of Egypt with the most important archaeological sites in the country:[472]

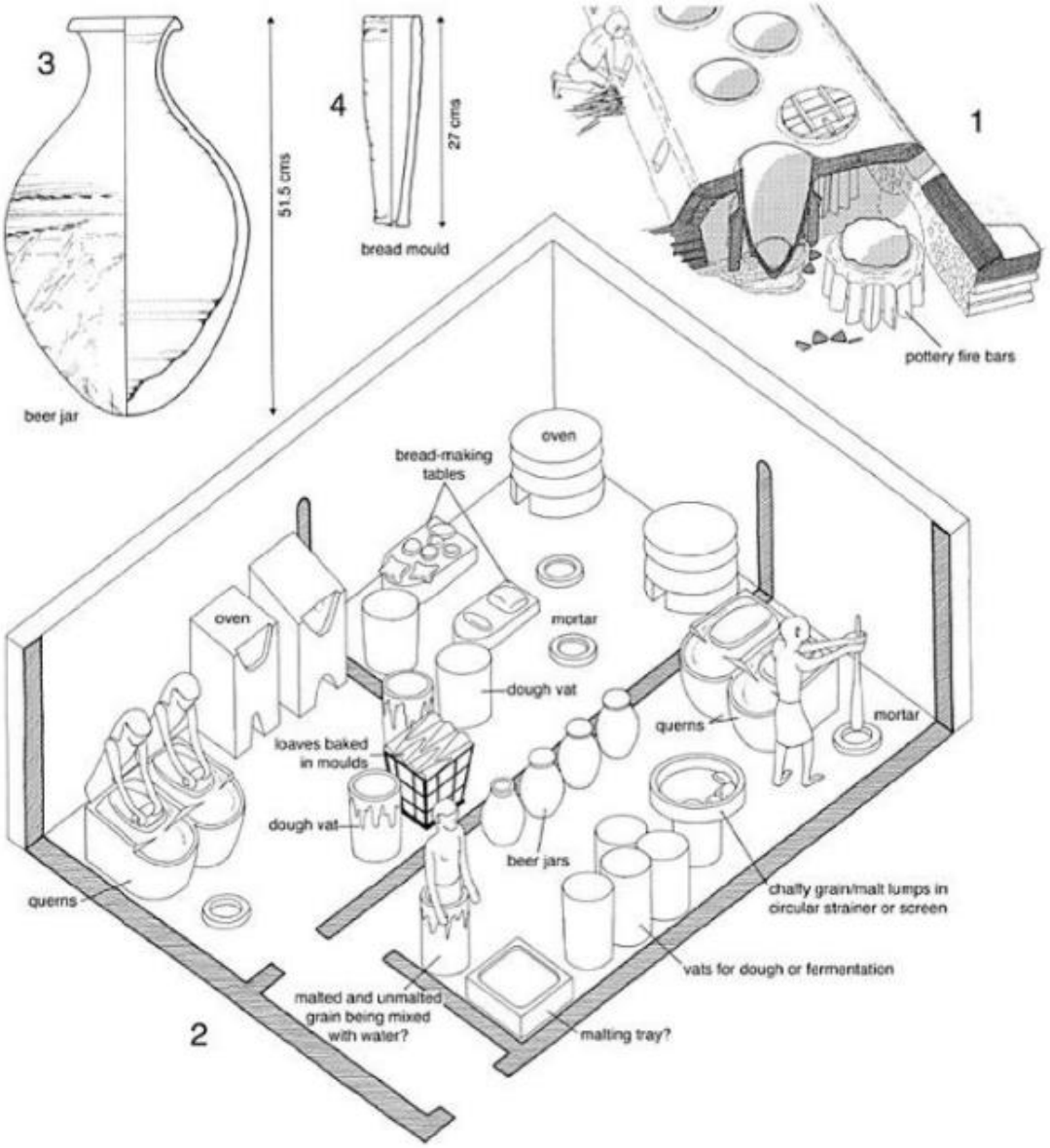
[472] 'Ancient Near East Site Maps', *Computer Laboratory - The Oriental Institute* (https://oi.uchicago.edu/sites/oi.uchicago.edu/files/uploads/shared/images/archive/Egypt_Site_300dpi.gif) . Accessed on 25 May 2019.

Figure 2: operational chain of the beer-making process in the Middle Kingdom according to Delwen Samuel:[473]



[473] JENNINGS et al. 2005, 280.

Figure 3: Brewing and baking: an early conjoined industry. (1) Reconstruction of a Predynastic brewery based on an example found well preserved at Abydos. (2) The model bakery/brewery from the tomb of Meketra at Thebes, 11th Dynasty. The two pots (3) and (4) are from the mortuary temple town of Amenemhat III at Dahshur:[474]

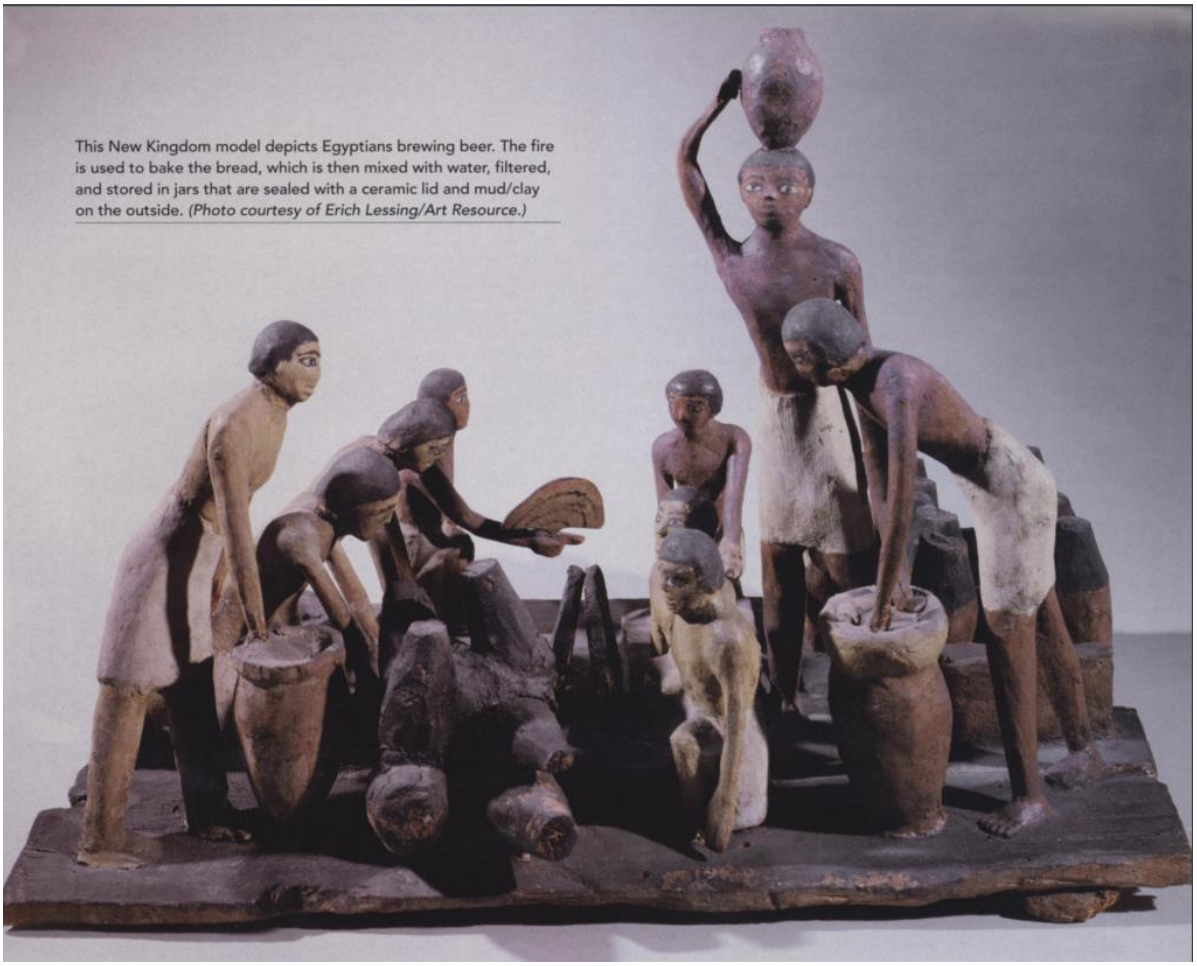


[474] KEMP 2006, 173.

Figure 4: detailed beer-brewing process on the walls of the 5th Dynasty tomb of Ti in Saqqara (Photos courtesy of T. Benderitter.):[475]

[475] HOMAN 2004, 94.

Figure 5: New Kingdom model depicting Egyptians brewing beer (Photo courtesy of Erich Lessing/Art Resource.):[476]



[476] HOMAN 2004, 92.

Figure 6: P.Lond. 3 1177 from August 30, 131 AD - August 28, 132 AD, mentioning the ubiquitous term *ζυτοπωλείου* for beer shop/brewery:[477]

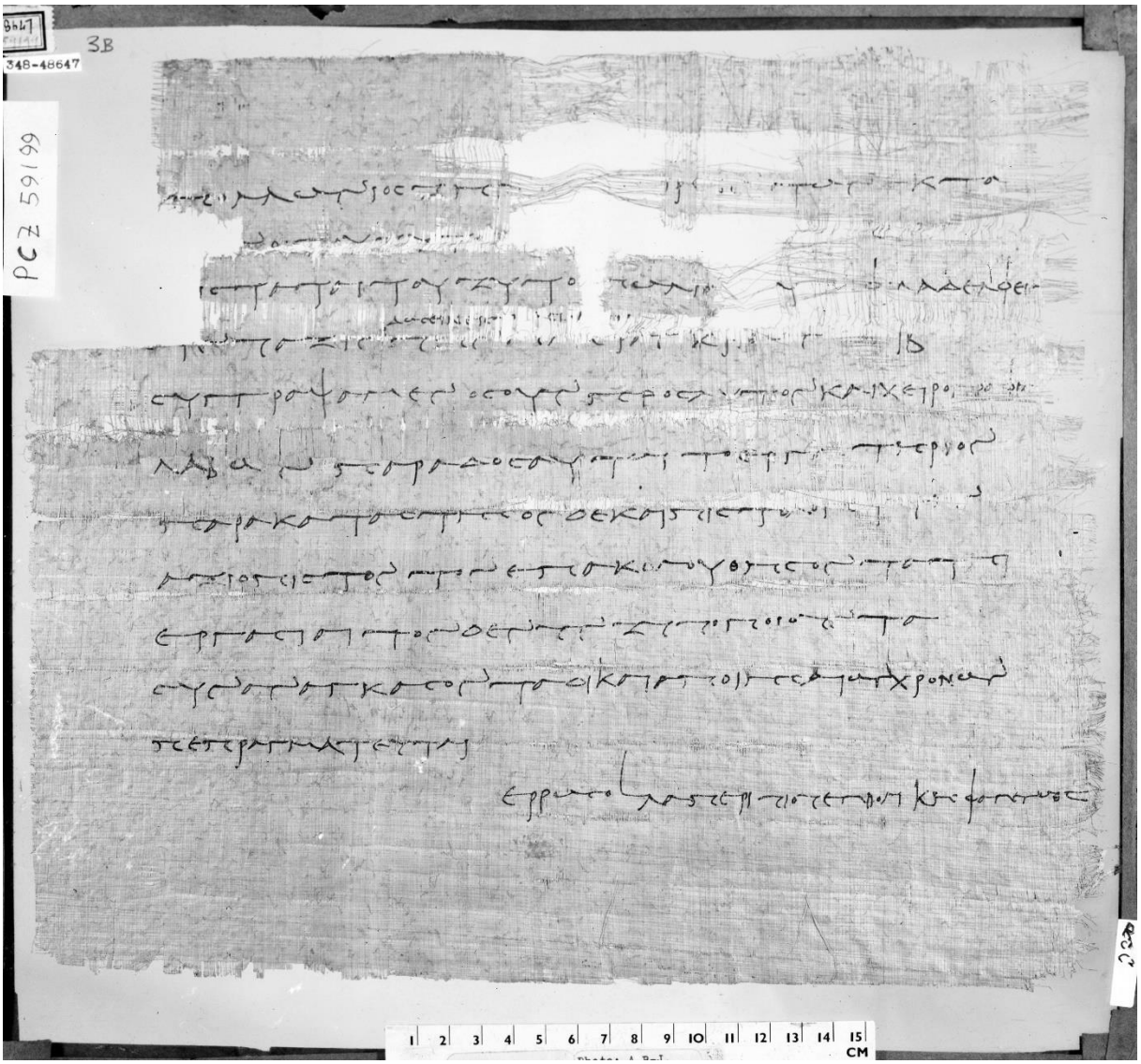
κζ αἱ αἱροῦσαι [(δραχμαὶ)] λ[γ (ὀβολοὶ) δ,] Μεσορὴ (δραχμαὶ) λς (ὀβολοὶ) θ καὶ
3
ὑπὲρ Ἐπαγομένων ε ὀβ(ολοὶ) με (γίνονται) ἐπὶ τὸ α(ὐτὸ) (δραχμαὶ) ρμα (ὀβολοὶ) ος.
/ κρήνης Μακεδόνων ὁμοίως ἡμερησίων (ὀβολοὶ) θ
Παχὼν (δραχμαὶ) λς (ὀβολοὶ) θ, Παῦνι (δραχμαὶ) λς (ὀβολοὶ) θ, Ἐπεὶφ
ms
/ ζ̣ή̣(τει) Θὼθ Φαῶ̣(φι)
ctr
ὁμοίως (δραχμαὶ) λς (ὀβολοὶ) θ, Μεσορὴ (δραχμαὶ) λς (ὀβολοὶ) θ, Ἐπαγο(μένων) ε
ὀβ(ολοὶ) με
(γίνονται) (δραχμαὶ) ρνβ (ὀβολοὶ) ιδ.
/ κρήνης Κλεοπατρίου(*) ὁμοίως ἡμερησίων (ὀβολοὶ) θ
Παχὼν (δραχμαὶ) λς (ὀβολοὶ) θ, Παῦνι (δραχμαὶ) λς (ὀβολοὶ) θ, Ἐπεὶφ (δραχμαὶ) λς
(ὀβολοὶ) θ,
ms
/ ἐπέχε(τε)
ctr
Μεσορὴ (δραχμαὶ) κ καὶ αἱ πλείω βληθεῖσαι βαλανείου Σευηριανοῦ(*)
ἐπὶ τοῦ α(ὐτοῦ) μηνὸς (δραχμαὶ) ιδ (ὀβολοὶ) ε
Ἐπαγομένων ἡμερῶν δ (δραχμαὶ) ε
ιζ (ἔτους) Θὼθ̣ [. . .] Θὼθ ἡμερῶν κθ (δραχμαὶ) λς διὰ τὸ τὴν μίαν
ms
/ διὰ τί
ctr
ἡμέραν μὴ κεχορηγῆσθαι, Φαῶφι (δραχμαὶ) λς (ὀβολοὶ) θ (γίνονται) (δραχμαὶ) σε
(ὀβολοὶ) λς.
/ ζυτοπωλείου Σαραπείου ἡμερησίων (ὀβολοὶ) ιγ
Παχὼν (δραχμαὶ) νβ (ὀβολοὶ) ιγ, Παῦνι (δραχμαὶ) νβ (ὀβολοὶ) ιγ, Ἐπεὶφ (δραχμαὶ) νβ
(ὀβολοὶ) ιγ, Μεσορὴ ἀπὸ
(δραχμῶν) νβ (ὀβολῶν) ιγ (δραχμαὶ) νβ (πεντώβολον) διὰ τὸ τοὺς λοιπ(οὺς) ὀβολ(οὺς) η
ἐκκεκρουκέναι
ὑπὲρ μ̣ε̣[τα]φ̣ο̣ρᾶς ὑδάτους ἑαυτῷ̣ χορηγήσαντο(ς), ἐπαγομ(ένων)
ὑπὲρ ἡμερῶν ε (δραχμαὶ) θ, ιζ (ἔτους) Θὼθ (δραχμαὶ) νβ (ὀβολοὶ) ιγ, Φαῶφι

[477] 'P.Lond. 3 1177', *papyri.info* (http://papyri.info/ddbdp/p.lond;3;1177). Accessed on September 11, 2018.

Figure 7: Letter from Apollonios to Zenon dated May 7, 254 BC, concerning Pais the brewer, who had agreed to take over the brewery in Philadelpheia for a certain amount, but pretended to Zenon that the amount was lower than the one agreed with Apollonios: the dioiketes tells to Zenon to detain Pais by force and to check the accounts of the beer-house:[478]

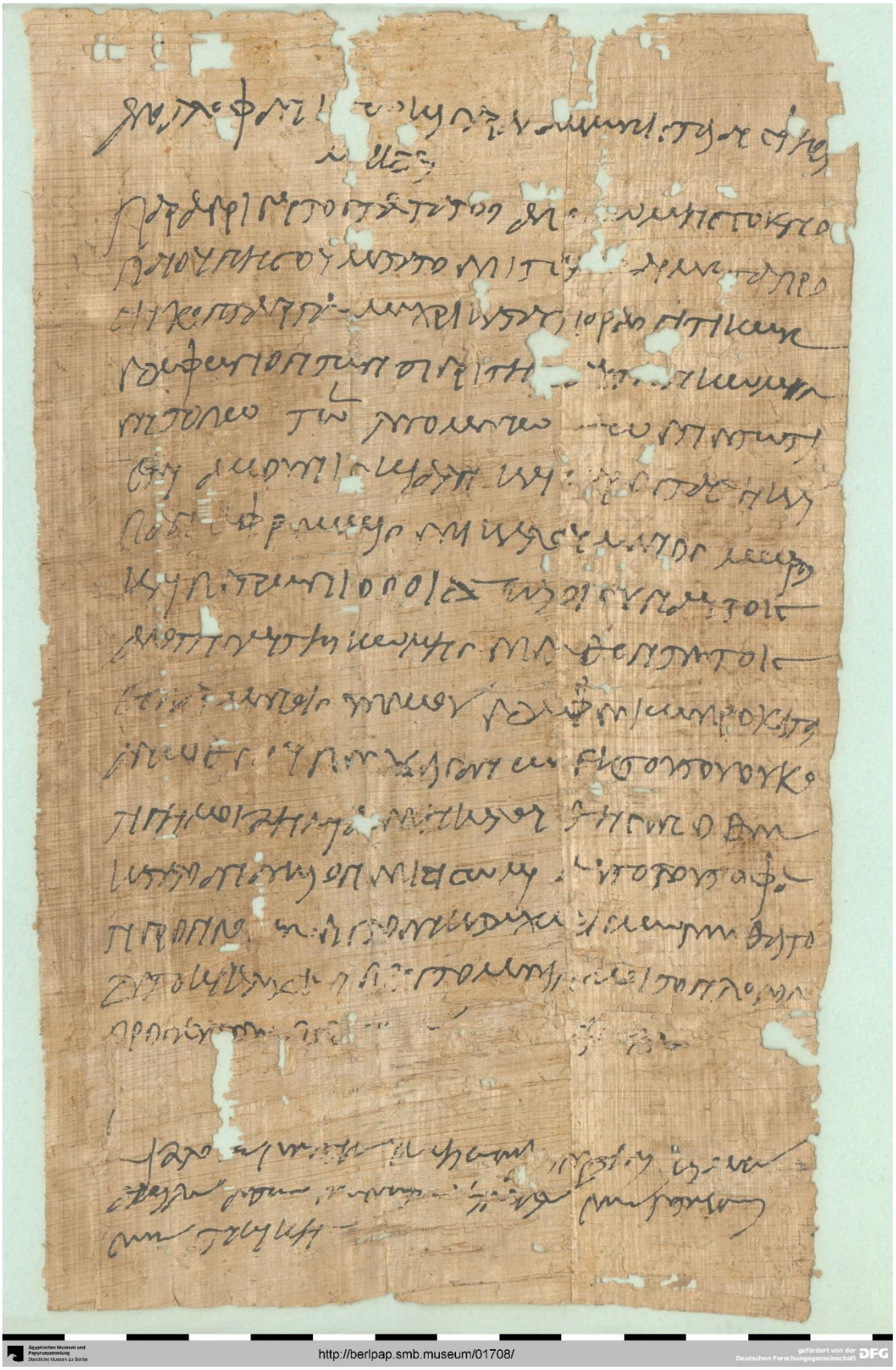
[478] 'P.Mich. 1 36', *papyri.info* (http://www.papyri.info/ddbdp/p.mich;1;36). Accessed on September 12, 2018.

Figure 8: P. Cair. Zen. 2 59199, a letter from Apollonios to Zenon from 254 BC:[479]



[479] 'P.Cair. Zen. 2 59199', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59199). Accessed on 10 September 2018.

Figure 9: Input from Herieus to the strategist Apollophanes (Egyptian name: Sarapammon) concerning an already sown field that was dug up on January 23, 209 AD:[480]



[480] 'BGU 1 2', *papyri.info* (http://www.papyri.info/hgv/8961). Accessed on September 11, 2018.

Figure 10: P.Bon. I.S.A. 3 *R e V* dating to the Late Ptolemaic or early Roman Period, of unknown provenance and listing supplies to a beer-maker and -seller and beer deliveries in varying quantities to several individuals, similar to P. Tebt. 2 401 (14 AD):[481]

Recto

[481] PASSONI DELL'ACQUA, A., 'P.Bon. I.S.A. 3 Recto e Verso: conto di distribuzione di birra ed altri beni con onomastica (tardo tolemaico/prima età romana)', B. PALME ed., *Akten des 23. Internationalen Papyrologenkongresses, Wien, 22.—28. Juli 2001* (Papyrologica Vindobonensia 1), Vienna, 2007, 513 – 524. Figures of recto and verso on pages 516 and 517, respectively.

Verso

Figure 11: Beer-tax collection from brewers and representatives by Taembes, a female beer brewer from Talae in the Herakleopolite nome from 246 BC:[482]

[482] 'P. Hib. 1 139', papyri.info (http://papyri.info/ddbdp/sb;12;10783). Accessed on September 12, 2018.

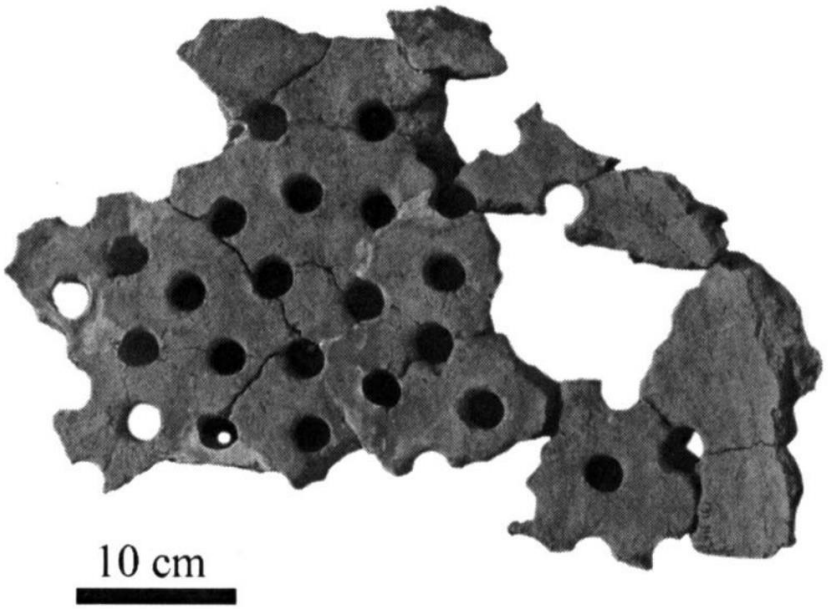
Figure 12: The boiling room of the Brewery excavated on the top of Cerro Baúl, Moquegua, Peru (photo courtesy of Patrick Ryan Williams).[483]

[483] BIWER and VANDERWARKER 2015, 29.

Figure 13: a list of items for beer brewers from the second century AD mentioning key items needed for the configuration of a brewery room (see figure 3, *supra*): old wheat (sitos) for the beer brewers(?), cutting(?) reed, sending(?) wheat (pyros), baked tiles and sawing beams(?):[484]

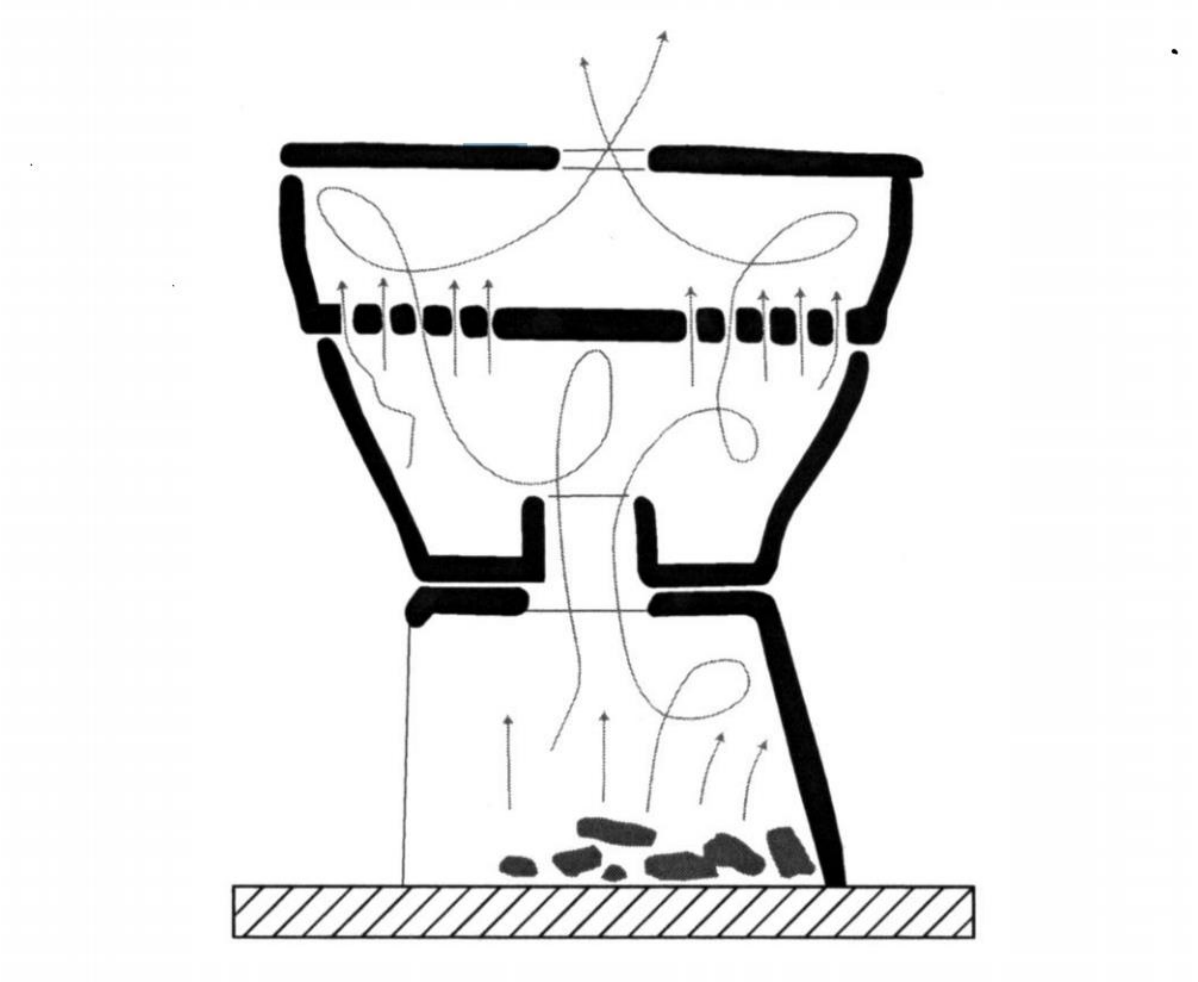
[484] 'P. Duk. inv. 975 R (b)', papyri.info (http://papyri.info/apis/duke.apis.33002334). Accessed on November 14, 2018.

Figure 14: Combined fragments of the oven retrieved in Roquepertuse, close to the concentration of carbonized barley grains:[485]



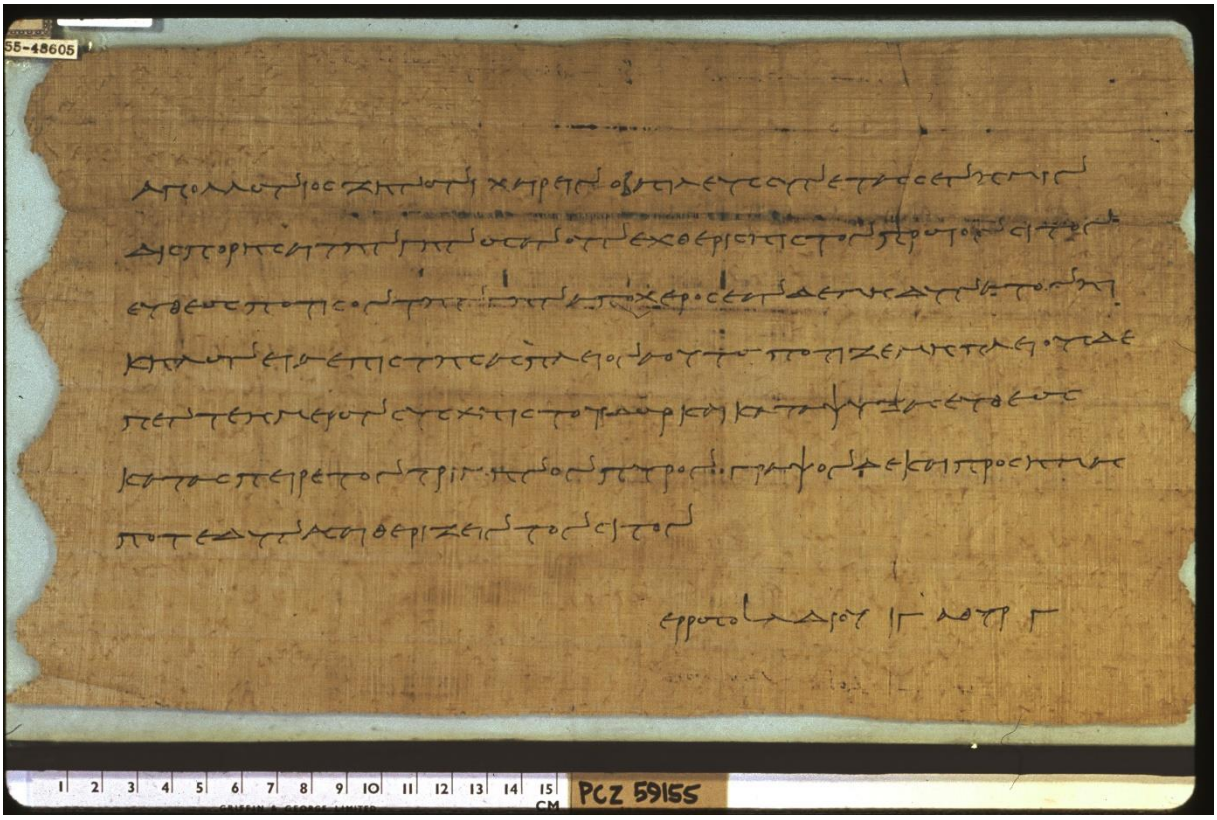
[485] BOUBY, BOISSINOT and MARINVAL 2011, 357.

Figure 15: Schematic representation of the type of elaborated oven identified in Roquepertuse (approximate height 1 meter):[486]



[486] BOUBY, BOISSINOT and MARINVAL 2011, 357.

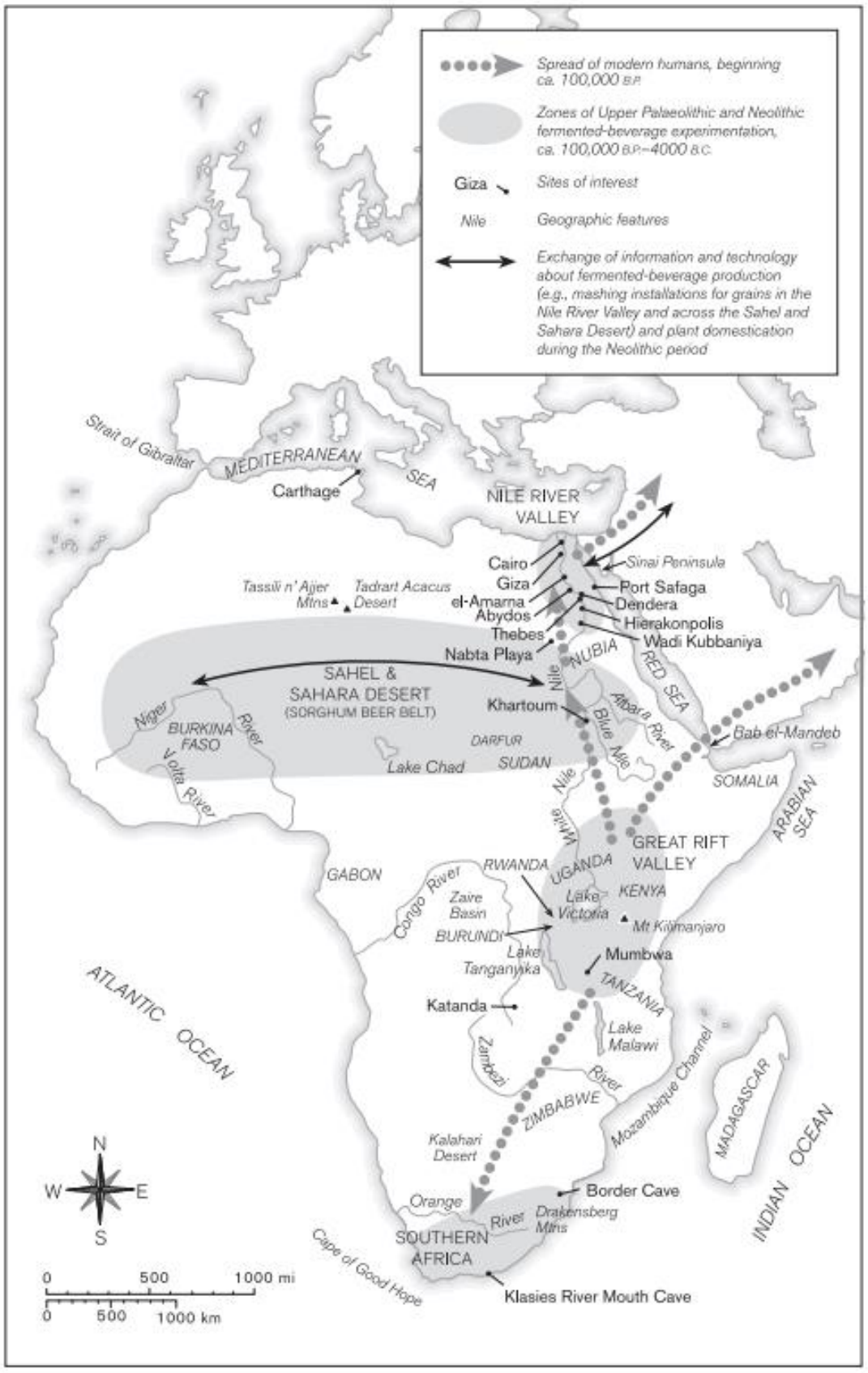
Figure 16: Letter from Apollonios to Zenon on 27 December 256 BC in P. Cair. Zen. 2 59155 at Philadelphia concerning the royal order to sow the land twice with the three-month wheat and the process involved (recto and verso):[487]



[487] 'P. Cair. Zen. 2 59155', *papyri.info* (http://papyri.info/ddbdp/p.cair.zen;2;59155). Accessed on 16 September 2018.

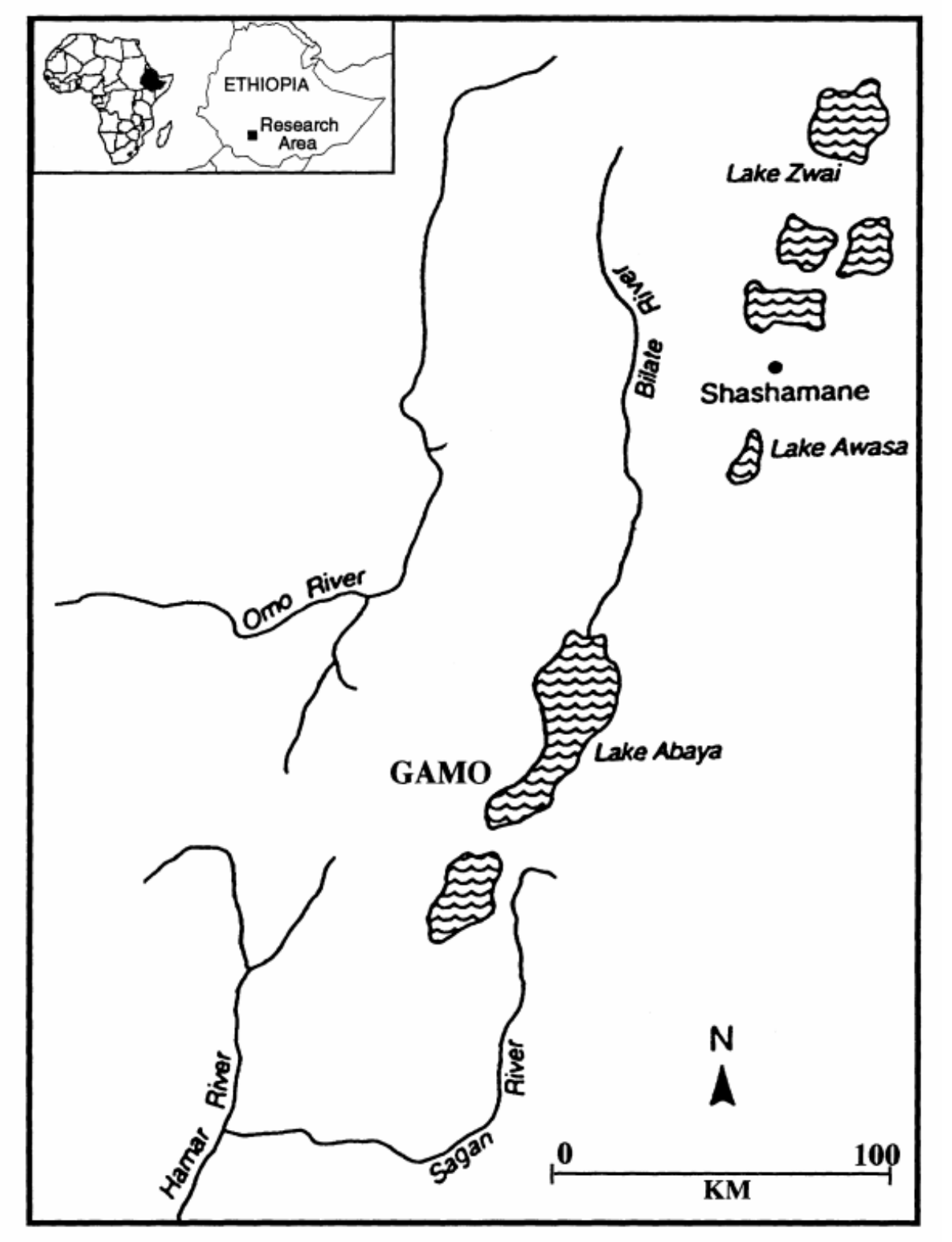

PCZ
59155
GRIFFIN & GEORGE LIMITED
MADE IN ENGLAND
CM
PCZ 59155

Figure 17: Map of Africa showing the major beer-producing areas on the continent.[488]



[488] MCGOVERN 2009, 232 – 233.

Figure 18: Map of the Gamo region within Ethiopia and Africa:[489]



[489] ARTHUR 2003, 520.

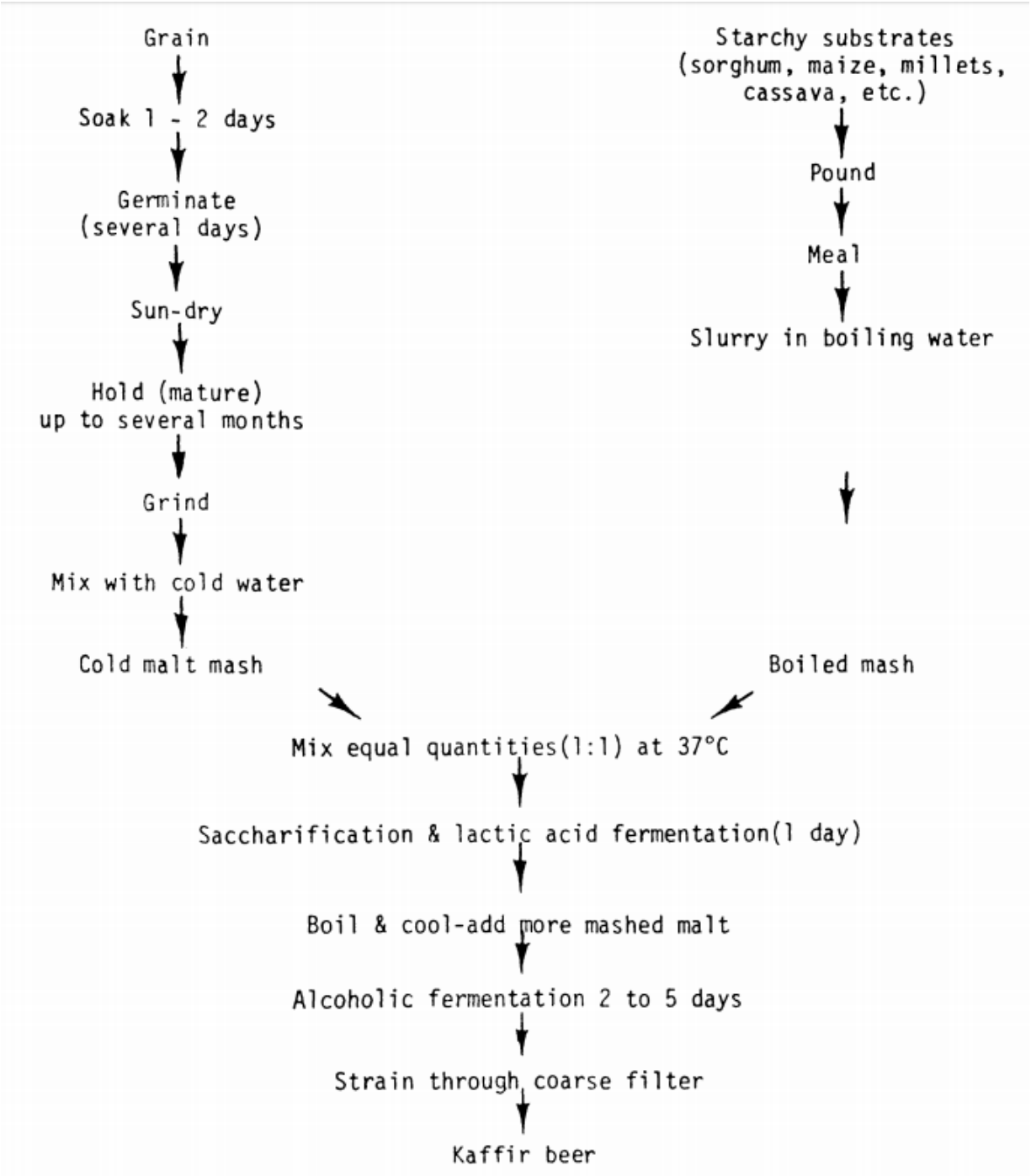
Figure 19: A Gamo woman making beer by putting beer dough into a jar to boil with water:[490]

[490] ARTHUR 2003, 521.

Figure 20: Storage of large jars along the wall in a Gamo house for the purpose of fermenting beer:[491]

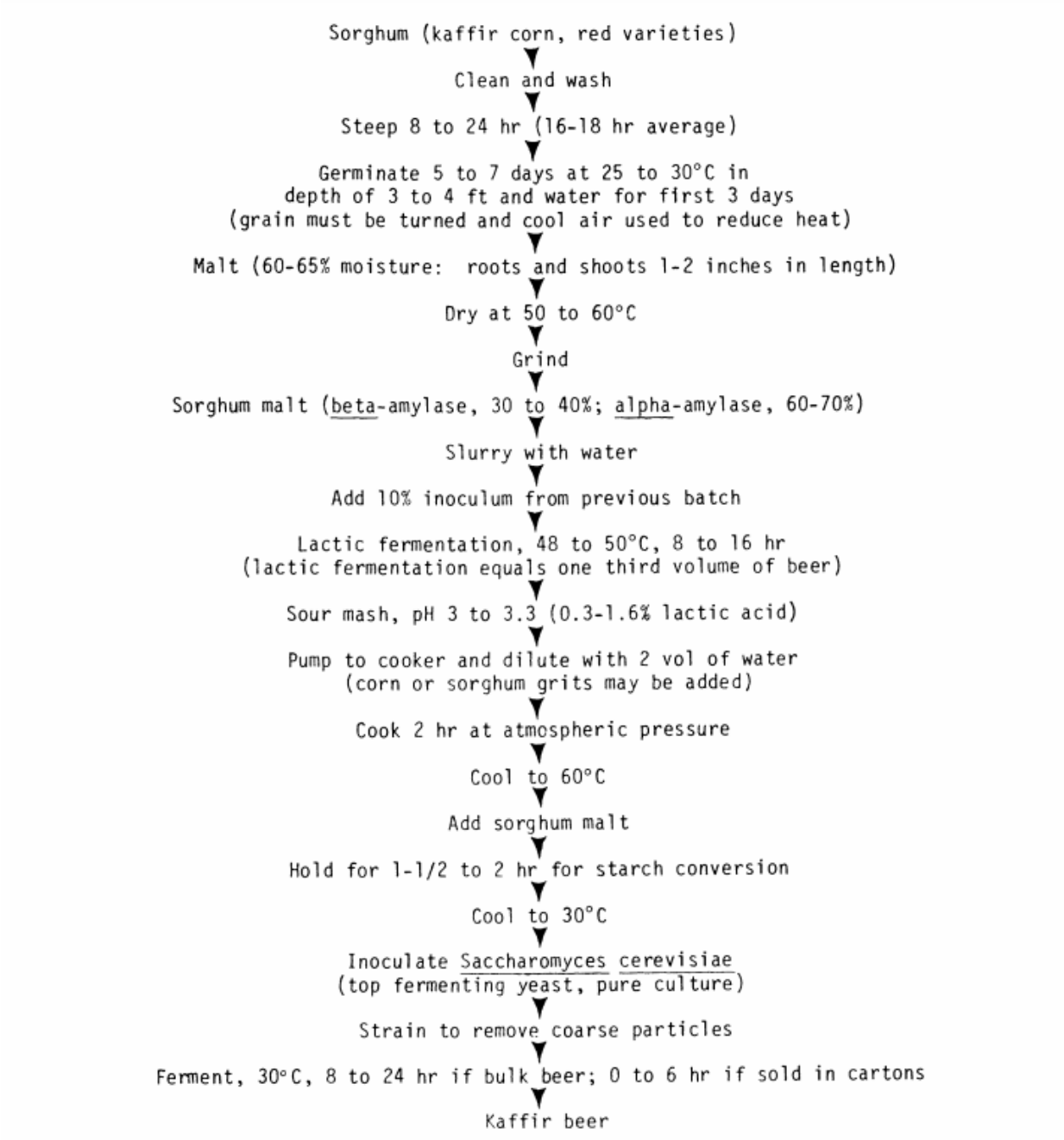
[491] ARTHUR 2003, 523.

Figure 21: Flow sheet: Traditional production flow of African kaffir(corn) beer:[492][493]



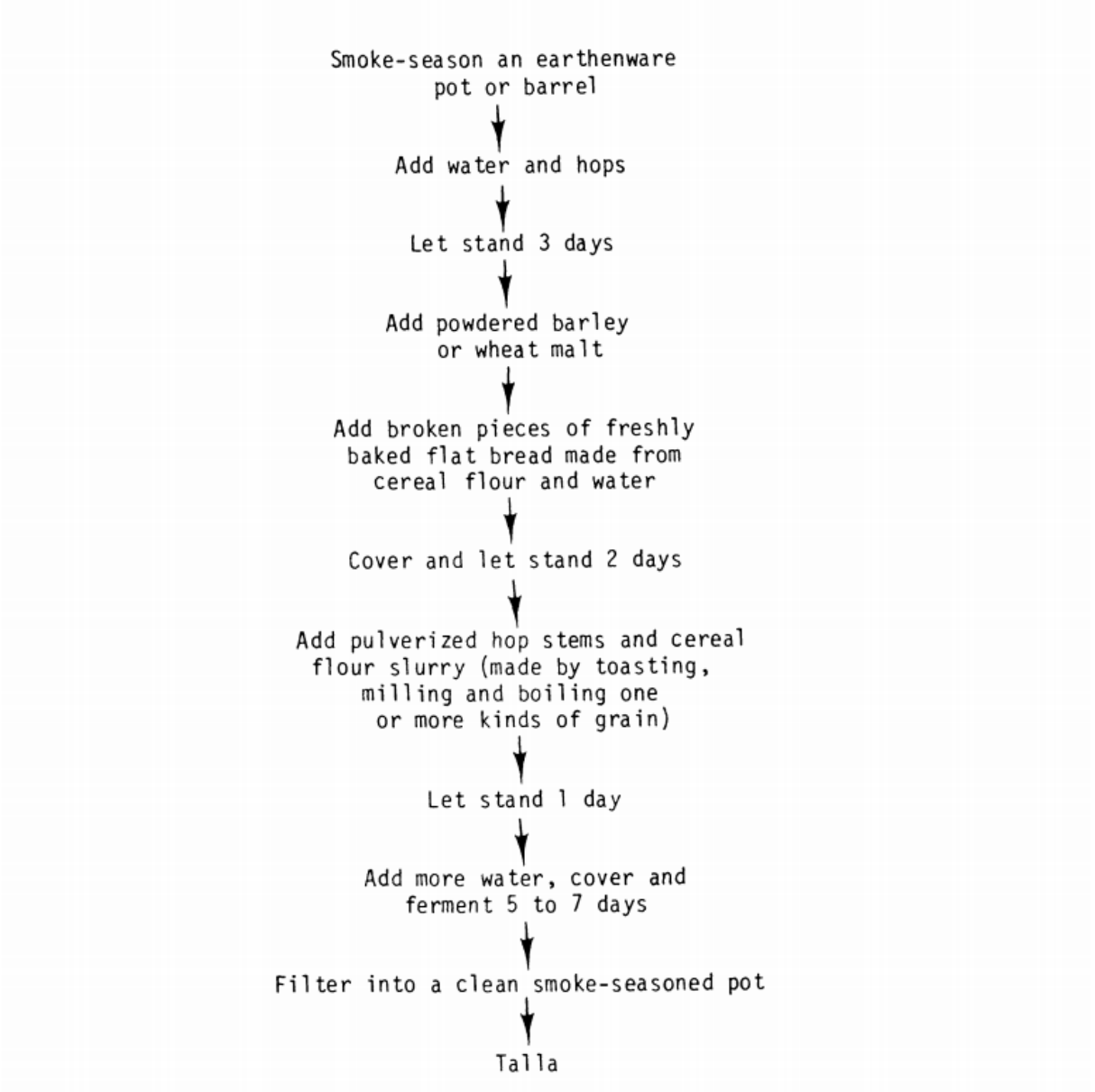
[492] STEINKRAUS 1996, 409.
[493] Adapted from PLATT 1964.

Figure 22: Flow sheet schematizing municipal kaffir beer fermentation. (Adapted from Novellie, 1968 and Hesseltine, 1979):[494]



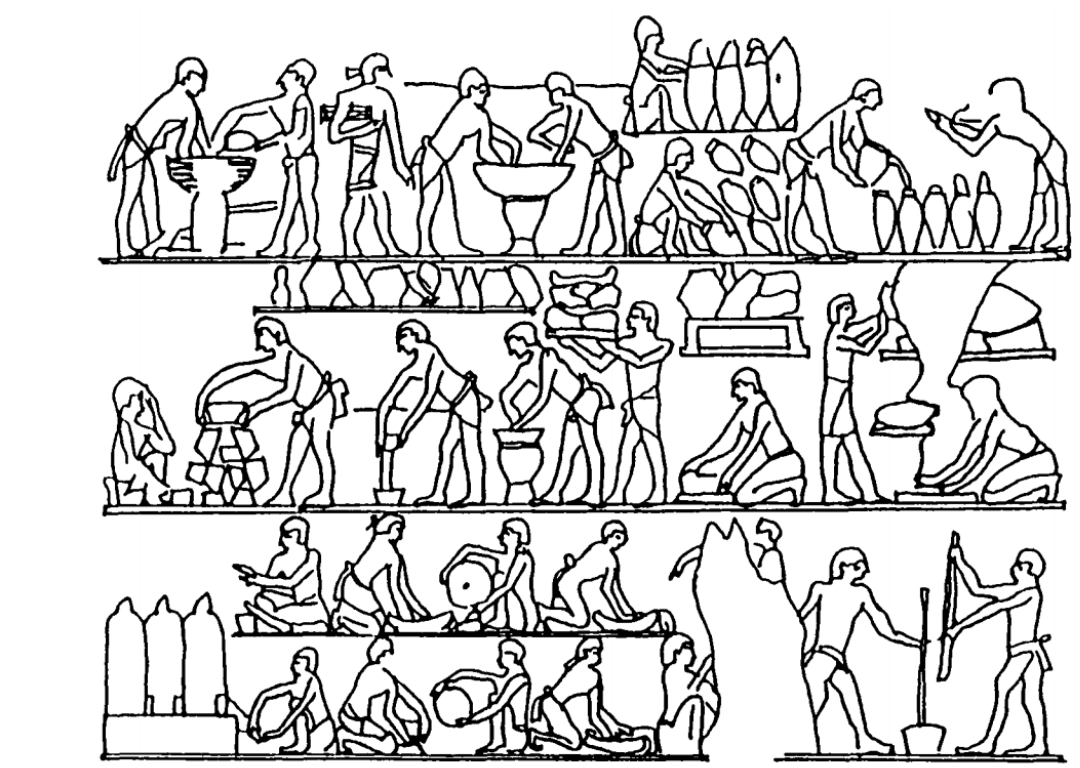
[494] STEINKRAUS 1996, 411.

Figure 23: Flow sheet: Production of Ethiopian talla:[495]



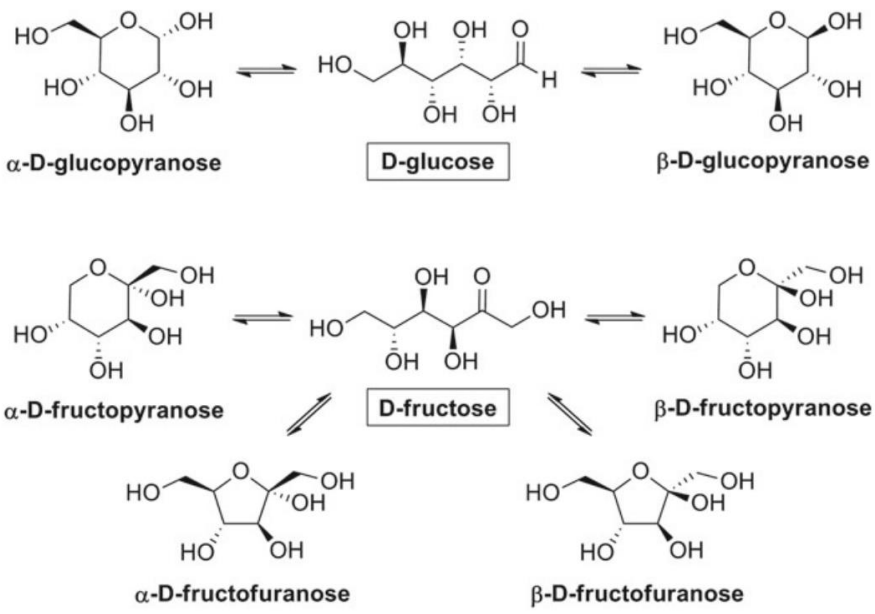
[495] STEINKRAUS 1996, 429.

Figure 24: Relief number 60 from the third Dynasty tomb of Ti at Saqqara depicting the beer-making process, including filtration (far left, top row):[496]



[496] MARCINIAK 1995, 243.

Figure 25: A chemical breakdown of the fermentation process. The sugars D-glucose and D-fructose in the linear form, as well as the various cyclic hemiacetal isomers that predominate in solution:[497]

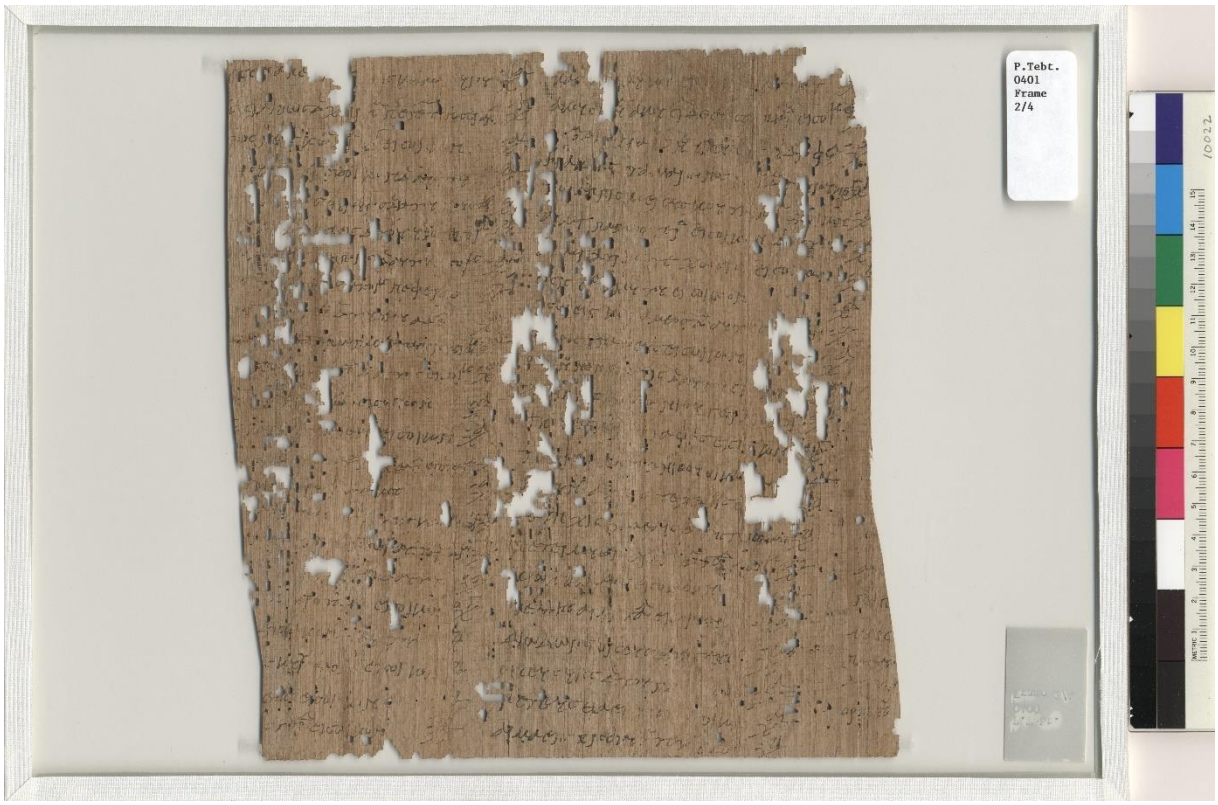


[497] RASMUSSEN 2014, 15.

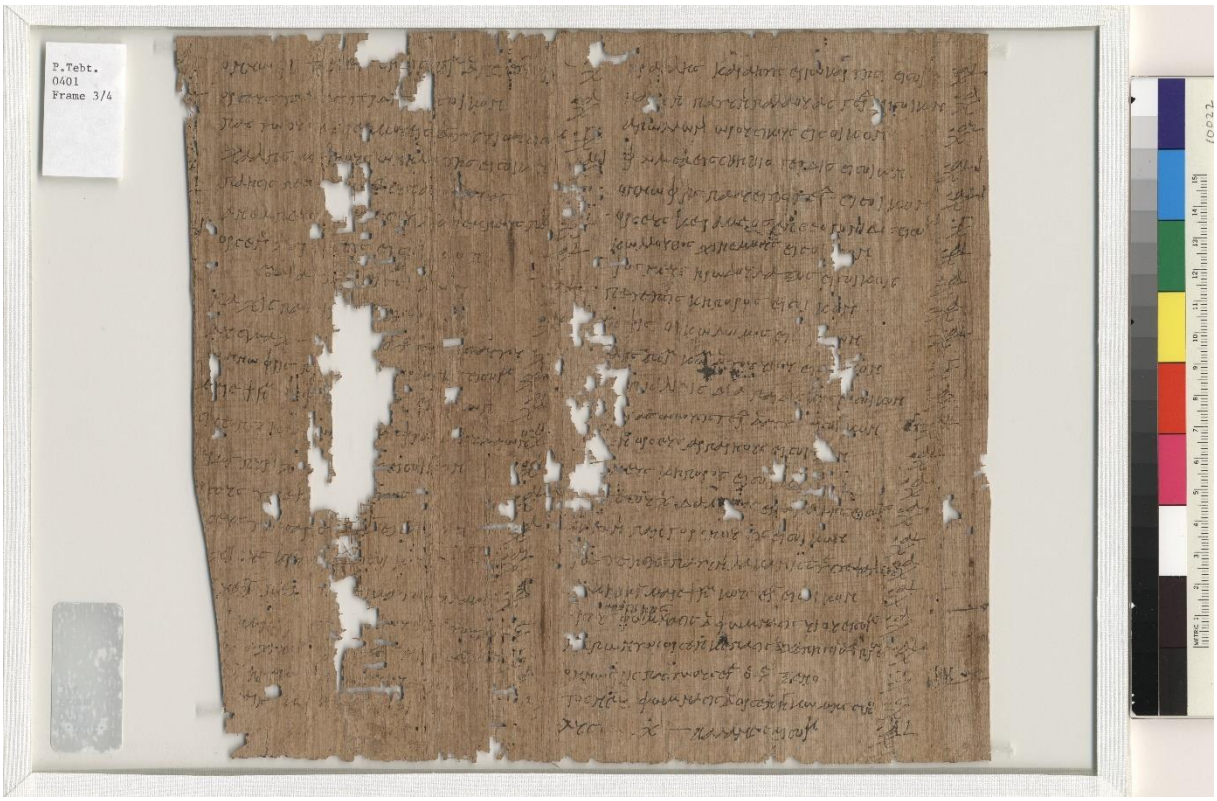
Figure 26: P.Tebt. 2 401, a 14 AD papyrus from a beer-seller, found in Tebtynis. Entitled 'Account of a beer-seller', it contains a list of names followed by an amount of beer supplied to the person's house, with an evaluation and list of expenditures, in which the ingredients and processes of beer-making play a large part.[498] Verso, frame 1 of 4:

[498] 'P.Tebt. 2 401', *papyri.info* (http://papyri.info/ddbdp/p.tebt;2;401). Accessed on November 16, 2018.

Verso, frame 2 of 4:



Verso, frame 3 of 4:



Verso, frame 4 of 4:

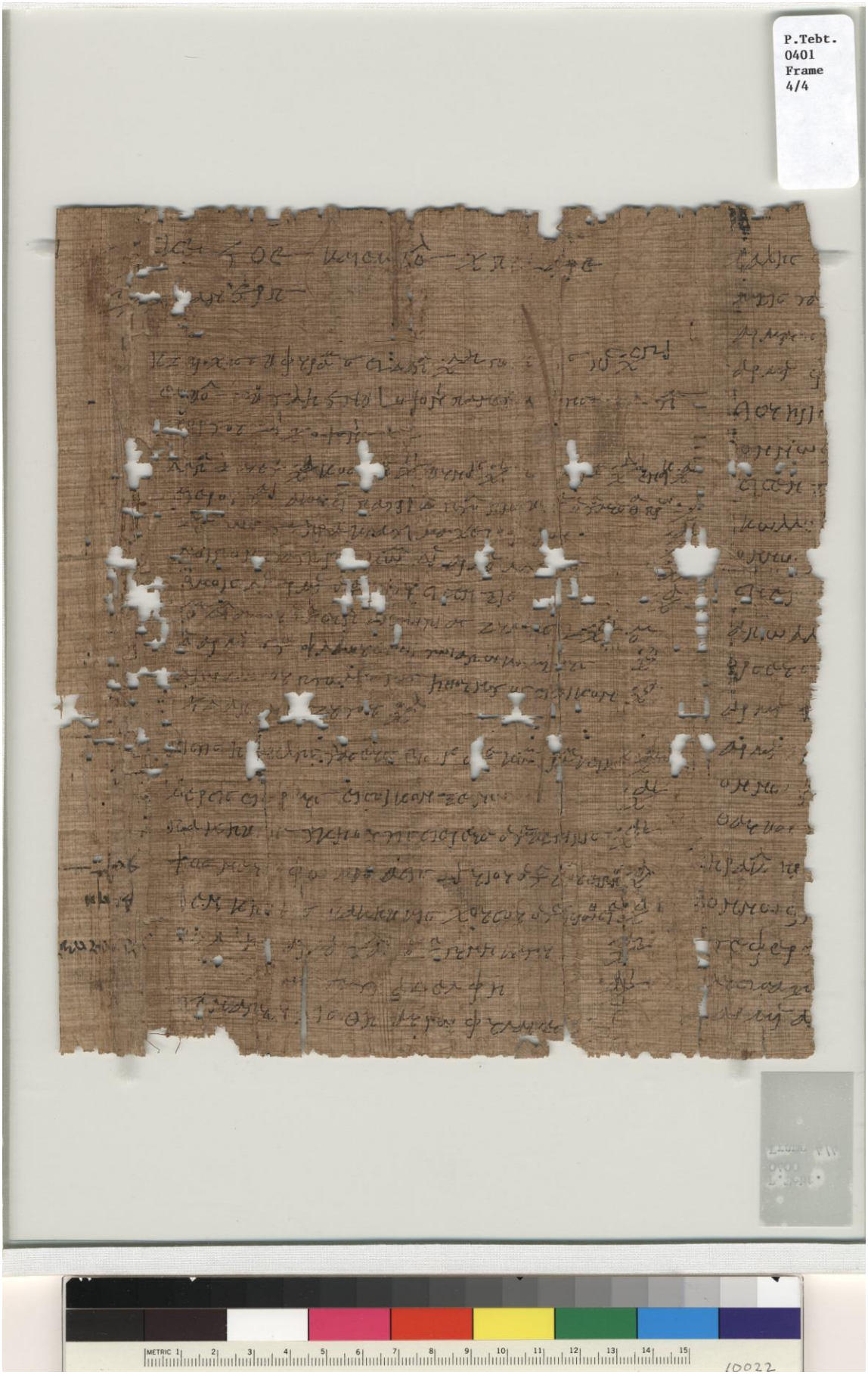


Figure 27: *ζύμη* or yeast mentioned in a proposal (P. Tebt. 2 375) from Ptolemais Eugergetis from September 8, 140 AD for a lease of 10 1/2 arourae of catoecic land for two years, by Herakleides, the lessor, from Ision, at Berenicis Thesmophori and Ibion Argaei. Recto:[499]

[499] 'P.Tebt. 2 375', *papyri.info* (http://papyri.info/ddbdp/p.tebt;2;375). Accessed on November 16, 2018.

Verso:

Figure 28: Schematic representation of a probable brewing process of beer used in Graeco-Roman Egypt based on barley or a grain mix with predominantly barley and using cultivated yeast:[500]

[500] Original diagram created by Daan Smets on 6 – 7 January 2019. Modified on 23 January 2019.