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"Drinking Beer in a Blissful Mood"

Alcohol Production, Operational Chains, and Feasting in the Ancient World[1]

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Feasts were important arenas of political action throughout much of the ancient world. Since alcoholic beverages were liberally consumed at many of these events, a sponsor often faced the daunting problem of assembling prodigious amounts of alcohol in the days preceding a feast. This paper considers traditional methods for making alcoholic beverages in certain regions and demonstrates how the details of each drink's manufacture, such as shelf life, plant maturation, and labor demand, offered challenges and opportunities to those who attempted to organize their mass production. Archaeological investigations of feasting have tended to focus on the political ramifications of the event itself, but the production struggles leading up to a feast are also important to our understanding of the political economies of past societies.

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May Ninkasi live together with you!
Let her pour for you beer (and) wine,
Let (the pouring) of the sweet liquor resound pleasantly for you!
In the . . . reed buckets there is sweet water
I will make cupbearers, boys, (and) brewers stand by,
While I turn around the abundance of beer,
While I feel wonderful, I feel wonderful,
Drinking beer in a blissful mood,
Drinking liquor, feeling exhilarated,
With joy in the heart (and) a happy liver—
While my heart full of joy,
(And my) happy liver I cover with a garment fit for a queen!

—"The Hymn of Ninkasi, the Mesopotamian Goddess of Brewing"

Over the past two decades, archaeologists have increasingly stressed that feasting—the communal consumption of food and drink at special events (after Dietler and Hayden 2001:3–4)—played an immensely important role in the social, economic, and political arenas of ancient cultures (Blitz 1993; Clark and Blake 1994; Dietler 1990, 1996, 2001; Edwards 1996; Gero 1992; Gumerman 1997; Hayden 1990, 1996, 2001; Joffe 1998; Junker 2001; Knight 2001; LeCount 2001; Schmandt-Bessarat 2001; Wiessner 2002). They recognize feasting as a "domain of political action" that was often critical to the development and maintenance of a wide variety of societies (Dietler 2001: 66). Feasts could be political tools for forming social alliances, fulfilling reciprocal obligations, creating social debt, collecting tribute, and advertising social differences (Hayden 2001:38). Leaders vied for power and elites sustained their power by sponsoring lavish banquets at which prodigious amounts of food and drink were consumed (Dietler 1996; 92–97; Earle 1991:3; Perodie 2001: 187).

Archaeologists have generally focused on finding the material correlates of feasts, distinguishing between different types of feasting patterns, identifying the various individuals involved, and investigating an event's wider political and economic implications (e.g., Bray 2003, Dietler and Hayden 2001, Dietler and Herbrich 2001). While this work is extremely valuable, its focus on the feasting event can obscure the labor and resources committed to growing, harvesting, and processing the food and drink that were consumed on these occasions (Adams 2004:56; Spielmann 2002:197). Investments in feasts could be dauntingly high—taking up a sizable portion of a region's resources, demanding many people's labor over the course of several weeks, months, or even years, and occasionally plunging individuals and communities into servitude and debt (Dietler 1990:361–62; 2001:81–82; Earle 1997:169–70; Kirch 1991:131). The material remains of a three-day feast, therefore, might represent the fruition of a community's three-year commitment to sponsoring a feast. Accordingly, an investigation into how an event's sponsor was able to marshal sufficient land, technology, and labor to underwrite a feast can potentially provide important insights into a society's political economy (Dietler 2001:80–81; Feinman 2001:159).

We argue that we can begin to understand the hurdles faced by leaders and elites by "engendering the *chaînes opératoires*" that brought goods to the festive table (Dobres 2000:173).

Operational chains are the technical stages by which classes of artifacts are manufactured and used. Embedding an artifact's life history within the social relations of its production and use engenders these chains. We argue that differences in the operational chains of food and beverages helped to shape feasting strategies by presenting both diverse processing challenges and unusual opportunities. We illustrate our argument by looking at how a few alcoholic beverages were made in the past. Alcohol, perhaps the most ancient, the most widely used, and the most versatile drug in the world (Dudley 2002; Heath 1976:41; Katz and Voigt 1986), has been commonly and liberally consumed at many feasts (e.g., Arthur 2003:521; Obayemi 1976:205; Taylor 1982:45–46). The ubiquity of alcoholic beverages and the diversity of ways in which ethanol is extracted from plants (Marshall 1979:2) provide an excellent opportunity to study the variable cost of producing different kinds of alcohol for a feast.

We examine how maize beer, barley and emmer wheat beer, rice beer, agave wine, and grape wine were made in the past by certain cultures. Of the dozens of different plants from which alcohol can be made and the multiple ways in which each of these plants can be fermented (Atacador-Ramos et al. 1996, Joshi and Pandey 1999), we have chosen these particular recipes for three reasons. First, the operational chains that were used to make these five beverages in antiquity are well described and thus amenable to analysis. Second, we know that the drinks could be mass-produced in the past, since they were consumed at feasts in a number of unrelated cultures. Finally, there are significant differences between these recipes. By focusing on these beverages we can expose the wide variability in the operational chains of alcohol production. Other beverages, such as millet beer, sorghum beer, and honey wine, fit these criteria as well and could also have been discussed.

Our goal is *not* to provide definitive accounts of the making of these beverages across time and space. We do *not* describe their entire operational chains from the planting of the crops to the consumption of the drink, nor do we detail the specific links between particular operational chains and particular political economies. While these extremely important goals are part of our overall intellectual project (see Jennings n.d.), our goal in this work is to expose the substantial variation in manufacturing processes and suggest that this variation placed very different kinds of demands on individuals who sought to mass-produce these beverages for feasts. While other scholars have discussed the linkages between alcohol production, feasting, and political economy (e.g., Dietler 1990, Morris 1979, Joffe 1998, Vencl 1994), we suggest that richer reconstructions of engendered operational chains can build upon this previous work and deepen our understanding of how leaders and elites managed to create the "blissful mood" that was fundamental to feasting in many cultures.

Fermentation, Operational Chains, and Political Economy

Fermentation is a biological process that transforms a substance through the actions of microbial cells (Soni and Sandhu 1999:25). While fermentation occurs naturally, humans have long manipulated this process to enrich their diet, preserve surpluses, detoxify food, and decrease cooking times (Steinkraus 1996:3–4). The earliest use of fermentation by humans was probably the creation of alcohol (McGovern 2003:14–15), and the process of transforming a raw material into alcohol may have two phases. In the first phase, saccharification, nonfermentable starches are broken down into sugars by amylases and other enzymes. In the second phase, fermentation, a variety of bacteria, fungi, and molds convert the sugars into alcohol. Alcohol made from grains or other starchy substances, such as rice, millet, sorghum, beets, cassavas, and maize, must be saccharified before fermentation can occur. Alcohol made from honey, plums, grapes, and other substances composed of simple sugars, however, needs only to be fermented. Following Slavomil Vencl (1994:83), we define all beverages that go through both conversions as beer and those that only require fermentation as wine.

Although beer can be made from any carbohydrate that can be easily and economically broken down into sugars, grains and tubers are most often used because they are rich in amyloplasts, or starch grains—the main form of food reserves for plants (Simpson 1977:544–45). Starch is a complex sugar (polysaccharide) that comes in two main forms, amylopectin and amylose (Hornsey 1999:24). Amylopectin and amylose can be converted into sugars by the action of several enzymes, such as α-amylase, β-amylase, and starch phosphorylase (Goyal 1999:91), that are collectively known as diastase. While some of these enzymes, such as β-amylase, are latent in grains and tubers, most diastase must be introduced by saliva, fungus, or germination (Vencl 1994:83–84). Starches also need to be hydrolyzed, or exposed to water, before they can be broken down. Starch granules, however, are usually quite resistant to penetration by water at room temperatures. If the granules are heated in water, the hydrogen bonds within the starch molecules weaken, water is absorbed, the starches unwind, and the granules swell. The hydrolyzed starches can then be broken down into sugars by the diastase (Hornsey 1999:26–27).

The starch/water mixture, often called mash, is usually boiled after enzyme activity has converted most of the starches into simple sugars. Boiling terminates all enzyme activity, sterilizes the mash, and allows for the completion of chemical reactions that lower the liquid's pH. Sterile, slightly acidic malt provides an environment conducive to the growth of the microbes necessary for fermentation (Hornsey 1999:86; Soni and Sandhu 1999:38). While saccharification is an essential process in beermaking, fermentation is a necessary step in the production of both beer and wine. In anaerobic conditions, certain microbes (especially the yeasts found within the *Saccharomyces* species) convert glucose and often other monosaccharides into the biochemical energy that the microbe needs to survive and reproduce. One of the primary metabolic pathways used by these organisms produces ethanol (consumable alcohol) and carbon dioxide (Goyal 1999:116–18; Soni and Sandhu 1999:33–37).

After the mash cools (usually to less than 40° C), the microbes can be introduced. There is often a lag phase of a few hours as the microbe adjusts to the new medium. As the population expands, fermentation rates increase rapidly and lead to a release of CO_2, an increase in the concentration of ethanol, a lowering of pH, and a rise in temperature (Soni and Sandhu 1999:38–4l). These results of the fermentation process eventually inhibit and finally stop the growth of microbes because the organisms are tolerant of only a limited range of conditions. Most important, ethanol is toxic to these microbes at certain concentrations, but these concentrations vary considerably from organism to organism. For example, common brewer's yeast (*Saccharomyces cerevisiae* var. *carlsbergensis*) stops fermentation at about 6% ethanol by volume, while typical wine yeasts (*S. cerevisiae* var. *ellipsoideus*) stop fermentation at about 12% by volume (Soni and Sandhu 1999:40).

Beer and wine tend to spoil largely because of exposure to bacteria (especially from the *Acetobacter* genus) that convert the ethanol to acetic and lactic acid and also produce other flavors and odors that are unacceptable to consumers (Adams 1985:1; Haggblade and Holzapfel 1989:247; Jackson 1999:618; 2003:252–53). Spoilage can often occur within a few days but can be inhibited significantly by high acidity, low sugar content, high alcohol content, low storage temperatures, and the absence of air (Joshi, Sandhu, and Thakur 1999:721–26). A properly stored dry, red wine, for example, might be palatable after decades. One way that a beverage's shelf life can be extended is through heat pasteurization. Alcohol is pasteurized after fermentation by slowly raising the temperature of the liquid to about 60° and then lowering the temperature (Hornsey 1999:168–69). This action kills the major spoilage microbes, while usually sterilizing the fermenting microbes without destroying them. Unfortunately, pasteurization is not feasible for many alcoholic beverages because the process leads to unacceptable changes in taste, effervescence, and viscosity (Haggblade and Holzapfel 1989:247).

The process of alcohol production can be conceived of as an operational chain through which raw materials are transformed into a finished product (e.g., Leroi-Gourhan 1943, 1945). Each phase of production is a technical sequence—a bundle of actions, instruments, and agents that produce a particular result (Narotzky 1997:19; Miracle 2002:67). Operational sequences are constrained by the properties of the material being processed (Edmonds 1990:57; Mahias 1993:162; Narotzky 1997:19). In the case of alcohol production, the biochemical requirements of converting starches into sugar, sugar into alcohol, and alcohol into vinegar dictate many of the steps in the manufacturing process. Millet, for example, can be converted into alcohol only by wetting the grains, adding or generating diastase, heating the mash, cooling the mash, and adding a fermenting microbe.

The operational chains for making alcohol and other goods, however, are also formed by knowledgeable actors who design and use technology to achieve particular aims (Lemonnier 1993:2–3; Narotzky 1997:18). As Pierre Lemonnier notes, while the material sets constraints on what can be done, it is actors who make the "technological choices on which the development of a technical system is *de facto* based, although usually in an unconscious and unintentional way" (1993:6). How diastase is brought into the mash, how the mash is heated, and what kind of fermenting microbe to introduce or encourage are all technological choices. To paraphrase (and perhaps bastardize) Marx, humans make their own alcohol, but they do not make it just as they please; they make it not under circumstances chosen by themselves but under circumstances directly encountered, given, and transmitted from the raw materials (Marx 1977:300). It is the interaction between various humans and objects that shapes the operational chain (Bray 1986, Latour 1996).

Archaeological concerns with detailing production sequences stem largely from the development of the *Techniques et Culture* school in France (Lemonnier 1983, but also from behavioral archaeology [Schiffer 2002]). Drawing on the work of Marcel Mauss (1935) and Andre Leroi-Gourhan (1943, 1945), scholars of this school argued that technology was a socialized action and, therefore, the reconstruction of a prehistoric operational chain could ultimately uncover the conceptual template of the maker of the object. Since this structuralist project tended to focus on the individual, the social relations within which these sequences were embedded were often left unexplored (Dobres 2000:169). We suggest that engendering operational chains can capture the social dynamics of manufacture. When an operational chain is engendered, the social relations of production, value systems, economic relations, and political negotiations that are articulated within it can be explored (Cobb 1990, Dobres 2000, Edmonds 1990). Marcia-Ann Dobres, who coined the phrase "engendering the *chaîne opératoire*," investigates these relations through the lens of practice theory (e.g., Bourdieu 1977, Giddens 1979). While her concerns with embodiment and agency are important, we focus on Marxist concerns regarding the organization of production and its relationship to the political economy (e.g., Roseberry 1988, Wolf 1982).

Since feasts were important arenas of political action in ancient civilizations, differences in the operational chains of drinks would have been of critical political importance. Humans have long consumed ethanol (Dudley 2002), and alcohol production is part of daily household routine in many societies. The drinking of alcoholic beverages at small-scale feasts is common and helps to lubricate labor exchanges, ritual acts, family negotiations, and other activities. To meet their political needs, however, leaders and elites in early complex societies often needed to host much larger events where much more alcohol was consumed. Power in these societies, therefore, was based in part on overcoming the material, temporal, organizational, and labor obstacles to creating, controlling, and capturing sufficient amounts of alcohol for large-scale feasts (Joffe 1998:309; Spielmann 2002:197). The host of a feast, of course, was not necessarily the same individual who organized a drink's production. Yet, the ability to mass-consume these beers and wines was ultimately linked to a society's ability to mass-produce them. The organization of production could vary immensely and was shaped by the technological choices made by actors working within the biochemical constraints of saccharification, fermentation, and spoilage.

Operational Chains of Five Beverages Popular in Antiquity

MAIZE BEER

Although a wide variety of plants, among them manioc and peanuts, were used to brew beer in the prehistoric Andes, maize (*Zea mays*) was the most common (Gómez Huamán 1966:49–50; Nicholson 1960:290–91; Vázquez 1967:266–70). Maize beer, known as *chicha* in Spanish and *aqa* in Quechua, generally had a low alcoholic content (less than 5% by volume) but varied from 1% to 12% depending on the production method (Cavero Carrasco 1986:17; Moore 1989:685; Steinkraus 1979:42; Vásquez 1967:267). There is evidence that *chicha* was consumed in large quantities at feasts, and the Inca in particular were known for providing copious food and drink at feasts throughout the year in exchange for labor service (Cavero Carrasco 1986, Hastorf and Johannessen 1993, Morris 1979, Murra 1960, Saignes 1993).

Contemporary methods of preparing *chicha* are similar to methods described in the detailed accounts from the eighteenth to the early twentieth century (Información 1961 [1720]:13; Camino 1987:39–42; Hocquenghem and Monzon 1995:112; Ruiz 1998 [1788]:81; Tschiffely 1933:48–49; Wiener 1993 [1880]:731–32. Although we have no pre-Columbian recipes for *chicha*, similarities in the technologies of production strongly suggest that it has been made in much the same way since at least the Early Intermediate Period (200 BC–AD 750) (Gero 1990, 1992; Moore 1989).

There are many recipes for *chicha*, and the merits of different ingredients and cooking methods can be the subject of heated exchanges between indigenous brewers today (Moore 1989:686; Nicholson 1960; Perlov 1979). While these differences can significantly affect taste, they are minor variations on a common recipe (Moore 1989:686). To make *chicha* (fig. 1) one had to convert some of the starches in the maize to sugars. This conversion process could be initiated either by masticating maize flour or by allowing the maize to germinate and

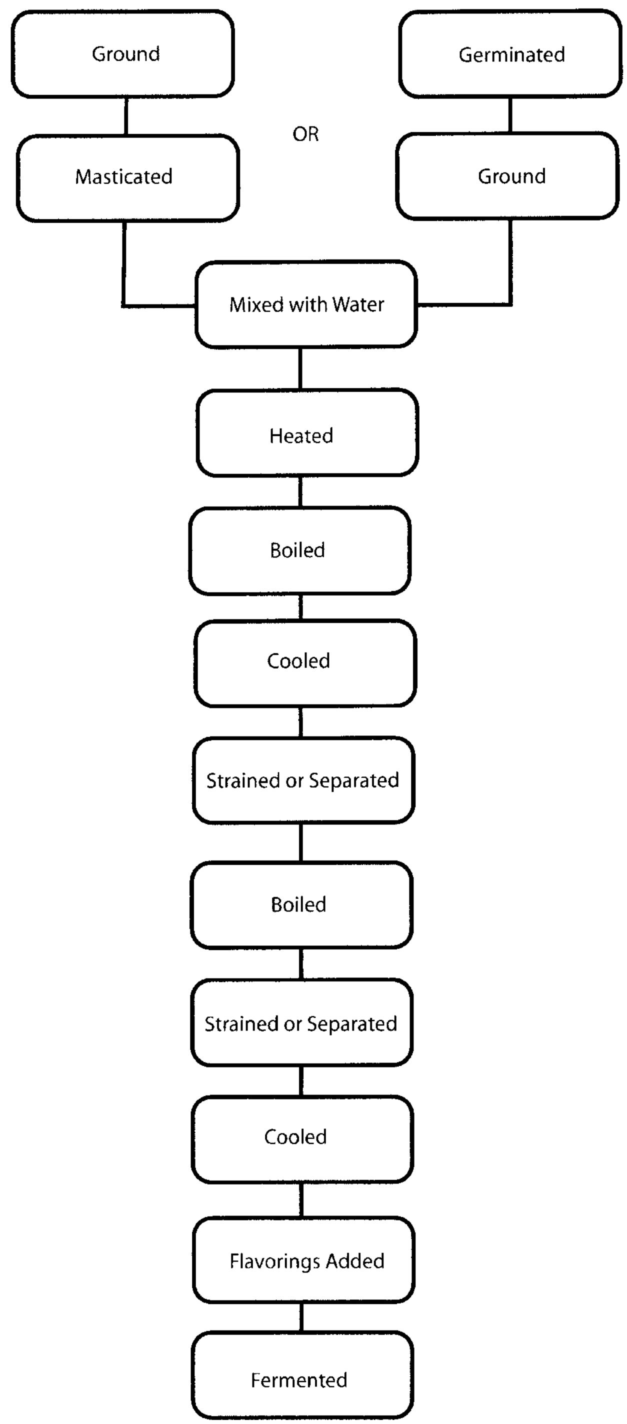

FIG. 1. *The operational chain for making maize beer.*

then grinding it into flour. Both methods appear to have been used in the prehistoric Andes (Cutler and Cardenas 1947:34; Moore 1989:686).

Hugh Cutler and Martin Cardenas (1947:41) vividly describe the mastication method (also see Soriano 1938: 236):

> The maize grains are usually ground by hand, often with a half-moon-shaped stone rocker (*maran uña*) on a flat stone (*maran*) as has been done for centuries. The flour is then mixed with saliva. On some of the larger haciendas it is still the custom to have women and children gather in groups to do this. The flour is moistened very slightly with water, rolled into a ball of convenient size and popped into the mouth. It is thoroughly worked with the tongue until well mixed with saliva, after which it is pressed against the roof of the mouth to form a single mass, then shoved forward with the tongue and removed with the fingers. The salivated morsels are dried in the sun and sacked for storage and shipment. They roughly resemble sets of false upper teeth.

The germination method, known to brewers as malting, was more complicated and time-consuming. The process began with soaking shelled maize in water for 12–18 hours. The maize was then removed from the water and spread out in a 5–7-cm-thick layer in a dark, dank place. After the maize had sprouted (in about three days), it was sometimes heaped into a pile, covered with a cloth, and allowed to sit for two days. The germinated maize was spread out under the sun in a thin layer to dry for two to five days, depending on weather conditions. The maize was then ground into flour to make malt (Nicholson 1960:295; Sillar 2000:109–10).

Next the flour was either placed in a pot with water and heated very slowly over the fire or added to a pot of boiling water that had been allowed to cool slightly. In both cases, the optimal range for saccharification by diastase (50°–60°) was likely maintained for at least 15–45 minutes. The mash was then allowed to boil. This mixture was alternately heated and cooled over the course of one to three days, and water was constantly added during the process as evaporation took place (Cutler and Cardenas 1947:45–47; Gillin 1947; Manrique Chávez 1997:308–9; Nicholson 1960:296; Soriano 1938:237). During this phase of the process, certain parts of the mixture were removed to make other products. In some cases, the mixture was allowed to cool completely so that it would separate into three layers. The uppermost liquid layer, *upi*, was transferred into another pot; the middle, jelly-like layer, the *misqui kketa*, was consumed or used to sweeten the *upi*; and the grainy third layer, *hanchi*, was usually fed to domesticated animals (Cutler and Cardenas 1947:45–46). In other cases, the mixture was not allowed to cool completely and instead was strained through a cloth or basketry sieve into another pot.

The liquid that had been transferred to the second pot was often boiled again and further refined by separation or sieving. Some of the *misqui kketa* was added at this time, as well as small amounts of flavoring ingredients. Sugar, cinnamon, orange leaves, peanuts, and sesame seeds are sometimes added today to the *chicha*, but it is unclear what was added to the mixture prehistorically (Cavero Carrasco 1986:116; Cutler and Cardenas 1947: 47; Perlov 1979:7). The liquid was finally transferred to a final pot to cool and ferment. Since the fermenting jars were not washed between batches, the vessels were already hosts to a variety of yeasts and bacteria from previous batches (Atacador-Ramos et al. 1996:404; Soriano 1938:310–12). After a few hours, the liquid began to ferment and bubble violently. The fermentation occurred in one to six days depending on elevation and environment, although three to four days was more typical (Cutler and Cardenas 1947:47; Soriano 1938:241). *Chicha* did not store well and tended to sour in less than seven days.

BARLEY AND EMMER WHEAT BEER

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 (Geller 1992*a*:127; Ghalioungui 1979:13). A major contributor to nutrition, beer was drunk daily with meals (Samuel 2000:537). It was also a popular item at civil and religious feasts and was taken as medicine, given as a wage or rations, owed as taxes, and offered to the gods (Crothers 1903:143; Finnestad 1997:226; Geller 1992*b*:24; Ghalioungui 1979:145; Joffe 1998:304; Kemp 1989:125; Shafer 1997:17, 23). Beer is attested to in the earliest written records from Mesopotamia and Egypt (Smith 1995:9; Samuel 2000:537–38) and likely predates the emergence of complex societies in the region (Braidwood et al. 1953, Geller 1993). The beer generally had an alcohol content of 3–6% (Kemp 1989:120; Samuel 2000:553).

Although there is no consensus on the details of the brewing process, the basic operational chain can be reconstructed from the artistic record, ancient documents, and the material residues of brewing (fig. 2) (Darby, Ghalioungui, and Grivetti 1977:502–12; Hartman and Oppenheim 1950:6–16; Hornsey 2003:48–72, 83–86; Katz and Maytag 1991; Lutz 1922:78–96; Samuel 1996, 2000). Delwen Samuel's reconstruction of the process in Old Kingdom Egypt is perhaps the most accurate (Samuel 1996, 2000; Samuel and Bolt 1995). According to Samuel, the brewer first 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 in order 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 in order to induce

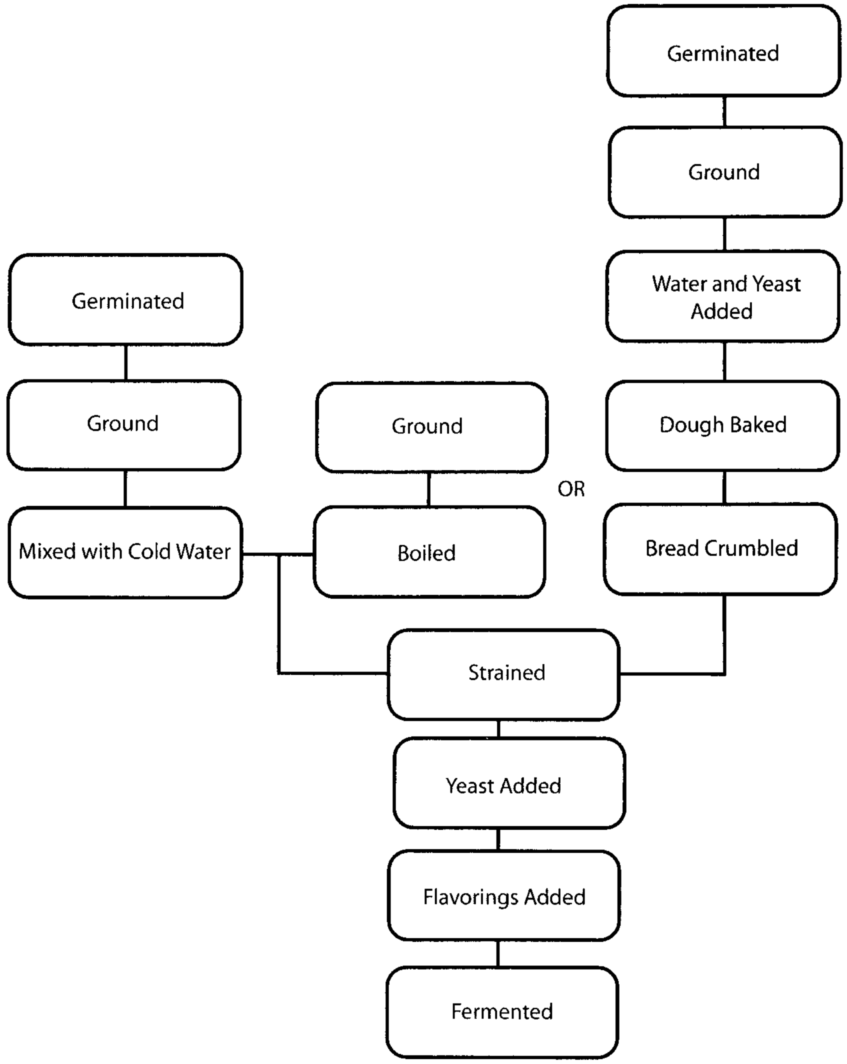

FIG. 2. *The operational chain for making barley and emmer wheat beer.*

saccharification in the warm water (Samuel 2000:551–53).

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. 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 (Samuel 2000:555; Geller 1992*b*:21). Although yeast cells have been identified in ancient residues, the specific varieties of yeast used remain unknown (Hornsey 2003:71). 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) (Hornsey 2003:71; Samuel 2000:547). Having fermented for a few days, the beer was decanted into jars and sealed for storage or transport (Samuel 2000:555–56). 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 (Hornsey 2003:90–91)

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 (Darby, Ghalioungui, and Grivetti 1977:538; Katz and Maytag 1991:27). 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 (Darby et al 1977: 541; Lutz 1922:79; Montet 1958:87; Samuel 1996:3).

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 (2000:555). The baking of beer loaves is, however, well-documented in Mesopotamian records—this step, for example, is included in another stanza of the hymn with which this article begins (Civil 1964; also see Hartman and Oppenheim 1950; Hornsey 2000:83–91).

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 (Darby, Ghalioungui, and Grivetti 1977:543; Hornsey 2003:62–63; Katz and Maytag 1991:32; Kemp 1989:123–24; Montet 1958:87). Other flavorings, such as lupines, skirrets, and radishes, are mentioned as having sometimes been added to the brew during fermentation (Darby et al. 1977:543; Katz and Maytag 1991:30, but see Hornsey 2003:62–63). No evidence for the use of dates or other additives has yet been found in beer residues, however, and it is possible that these items were used only rarely for special brews (Samuel 2000:556).

Beer was difficult to store, and a deep concern over the storage and spoilage of beer is found in Egyptian funerary texts (Darby, Ghalioungui, and Grivetti 1977:532). 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 (Darby et al. 1977:547; Lutz 1922:81; Montet 1958:88). 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 (Darby et al. 1977:547; Katz and Maytag 1991:33; Montet 1958:88). *Bouza*, a beer made in Egypt today using a similar process, tends to sour and spoil in a few days (Atacador-Ramos 1996:421–25; Geller 1992*a*:125–26). It is likely that ancient Near Eastern beer lasted no longer than a week.

RICE BEER

Of the myriad of alcoholic beverages produced in ancient South and East Asia, rice beers were among the most prominent (Chang 1977:68; Tannahill 1973:153). Known as *handi* in India, *chu* in Bangladesh, *sake* in Japan, and *suk* in Korea (Archer 1974:361; Durkan 1971:3; Xiao 1995:43), rice beer has been common in China since at least the Shang Dynasty (1700–1100 BC) (Chang 1977:30–31; Hao et al. 1999; Huang 2000:155). Since the provisioning of abundant amounts of alcohol was an important responsibility of hosts (e.g., Yamamuro 1979:274; Burkhardt 1958:102), rice beer was an essential ingredient of feasts held in East Asia (Xiao 1995; Kondō 1984:17). Rice beer is stronger than *chicha* and pulque, with an alcohol content that is generally 10–20% by volume (Huang 2000:179; Sargent 1979:278). Although different varieties of rice (*Oryza sativa*) can be used, *japonica* is the most commonly used today.

There were various ways to brew rice beer (Huang 2000, Xu and Bao 1999). The simplest recipes involved pouring boiling water over rice, adding human saliva to begin saccharification, and then allowing the mixture to ferment for about a week (Kondō 1984:13). The Santals of India create rice beer by allowing a mixture of boiled rice, water, roots, and bark to ferment for three to five days (Archer 1974:20, 361, 363). The recipes used in China since at least the Han Dynasty (221 BC–AD 207) are more complex (Huang 2000:154). These recipes, mirrored in the earliest known recipes from Japan, may better reflect how most rice beer was made in many of the more complex societies of the region. An understanding of the basic production process for this class of rice beer can be gleaned from data from early historic records, more detailed accounts of Chinese and Japanese recipes from the past three centuries, and traditional production techniques that are being used today (Atacador-Ramos et al. 1996:439–47; Huang 2000:178–203; Kodama and Yoshizawa 1977; Kondō 1984:16; Xu and Bao 1999). The first step in making rice beer (fig. 3) was to run the grains through a mill of rough-surfaced rollers that scraped clean the surface of the grain (Nunokawa 1972:455–56; Yoshizawa and Ishikawa 1989:139). This process, called polishing, removed from the surface of the grains undesirable minerals, lipids, and proteins that would destroy the clarity of the brew (Kondō 1984:40; Nunokawa 1972:455–56; Xu and Bao 1999). The rice was then washed several times in water before being steeped in large vats for up to 25 days. Most early rice recipes, however, suggest that rice was usually steeped for a week or less (Huang 2000:184, 195–97), and sake brewers in Japan today steep rice for only 1–20 hours (Nunokawa 1972:455–56; Atacador-Ramos et al. 1996:441). The steeping liquid sometimes included hops, cocklebur, or smartweed (Huang 2000:184–85). The grains were drained of excess water for a few hours after steeping was concluded.

After the rice was completely drained, the grains were steamed for 20–60 minutes to gelatinize the starches (Yoshizawa and Ishikawa 1989:139). Cold water was then poured over the rice, and the batch was spread out to cool on bamboo mats. After cooling, the steamed rice was added to a large, open vessel of water to make a dense, mushy mash called *moromi*. In contrast to the situation of the beers previously described, saccharification and fermentation occurred at the same time in the *moromi* through the addition of *koji* (*jiu ou* in Chinese), a concentrate of fungal amylases, proteases, and other enzymes (Atacador-Ramos et al. 1996:442; Huang 2000:260; Murakami 1972:640), and young mash, or *moto*, containing yeasts (Yoshizawa and Ishikawa 1989:149–50).

Koji could be made from rice that was first polished and then steamed. The grains were then spread over a series of wooden beds and covered with a cloth for two to three hours to achieve even temperature and moisture. After this period, seed mold of *Aspergillus oryzae* was sprinkled over the rice, incubated for up to seven weeks, and then sun-dried to stop the growth of the mold before

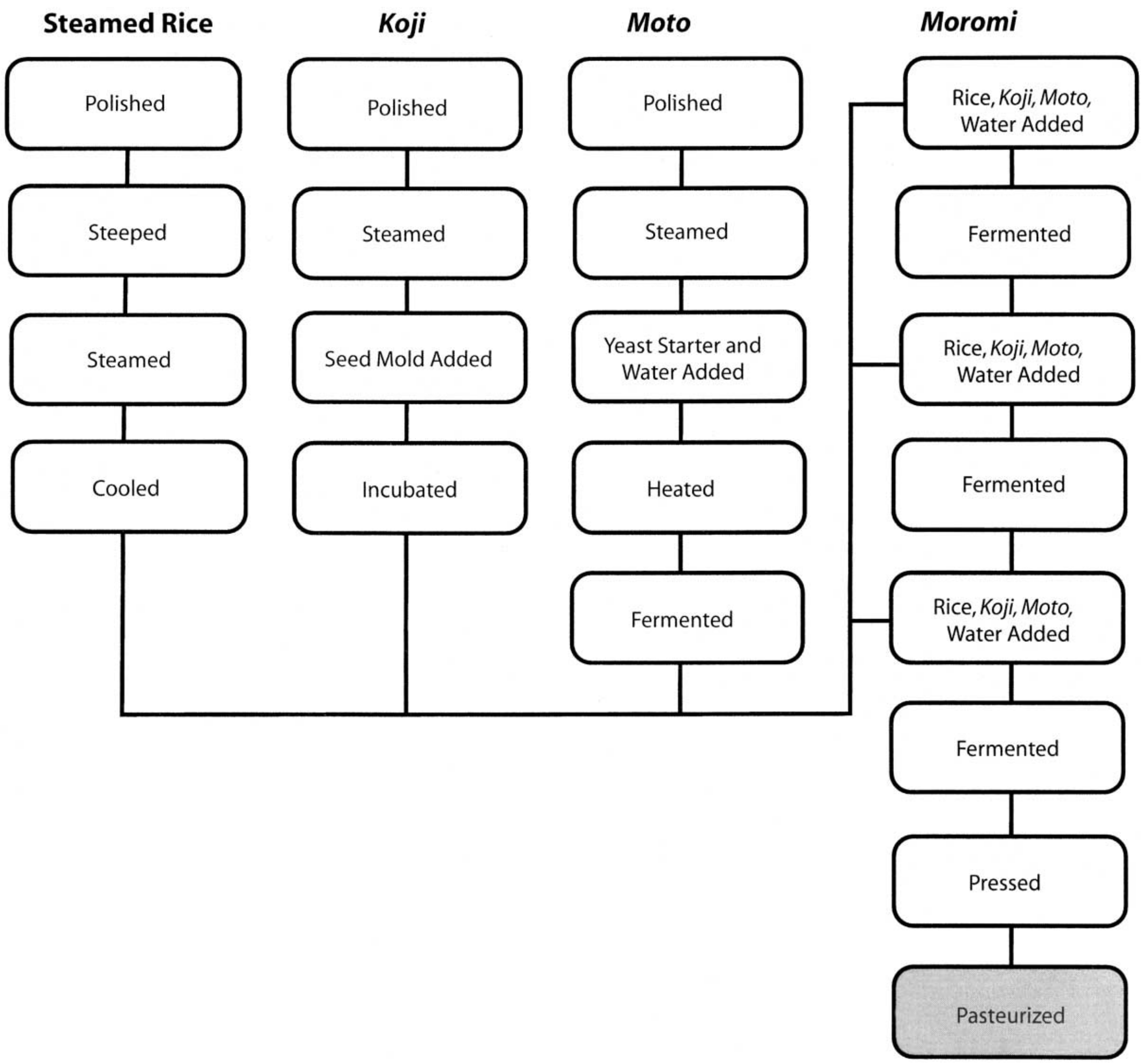

FIG. 3. *The operational chain for making rice beer. The final stage, pasteurization, was added during the Tang Dynasty.*

sporulation (Nunokawa 1972:461; Kondō 1984:43). During this time the mixture was stirred to lower the temperature, promote uniform growth, and release CO_2 (Atacador-Ramos et al. 1996; Lotong 1985:248–51; Yoshizawa and Ishikawa 1989:146).

Moto was made by mixing *koji* with steamed rice to form a starter for the yeast culture. Over the course of 13–19 days, the mixture was heated very slowly (0.5–1° per day). As the temperature rose and available nutrients were consumed, different groups of microorganisms were replaced by others. During this process, lactic acid bacteria increased the acidity of the mixture. By the end of the period, only the fermenting yeast *Saccharomyces sake* survived. After a resting period of 5 days that allowed the sake yeast to grow, the *moto* could be added to the *moromi* (Kodama and Yoshizawa 1977:446–54; Yoshizawa and Ishikawa 1989:149–50).

Moromi was fermented through a process called stepwise mashing that enabled the yeast population and hence alcohol content to build up substantially. On the first day, steamed rice, *koji*, and water were combined with *moto* in a vessel (approximately one part *moto* to three parts rice, water, and *koji*) and heated to about 10–12°C. The mixture decreased the overall yeast count, but the acidity and elevated temperature encouraged yeast growth and accelerated the saccharification of starches. Brewers added nearly twice the amount of steamed rice, *koji*, and water two days later. After waiting another day for further yeast growth and starch breakdown, the amount of material was doubled again in a third addition. After this initial fermentation, the mixture was often transferred to smaller, narrow-necked jars and covered for further fermentation (Atacador-Ramos et al. 1996:443; Yoshizawa and Ishikawa 1989:156–57).

After 25–70 days of final fermentation, the mixture was pressed to separate out the liquid from the grains. While modern brewers further filter their rice beer (Yoshizawa and Ishikawa 1989:161), it is unlikely that this was done in the past. The resulting liquid could be drunk at this point or stored. If the beer was to be stored, it was heat-pasteurized— a process first used by brewers in the Tang Dynasty (907–618 BC). Although there were several techniques for pasteurizing beer, one of the most common techniques was as follows (Huang 2000:187):

> Two pieces of beeswax, five slices of bamboo leaves, and half a pill of serrated arum, are added to a jar of newly pressed wine, which is covered with mulberry leaves. It is placed on a steamer and heated until the wine inside begins to boil. The wax acts as a defoamer and prevents the wine from frothing over. When the fire dies down the jar is removed, placed in a heap of lime, and allowed to cool very slowly.

After pasteurization, the beer was put into narrow-necked jars, sealed tightly, and stored at mild temperatures (Xu and Bao 1999). Most rice beer was stored for less than a year before it was consumed (Chang 1977:120), but it could last ten years or longer (Anderson 1988:98). Rice beer's long shelf life was a result not only of its pasteurization but also of its high acidity and alcohol content.

AGAVE WINE

Ancient Mesoamericans produced alcoholic beverages from a wide range of plants, including saguaro, pitahaya, nopal, and mesquite (Bruman 2000). Pulque, fermented from the juices of the agave (largely *Agave atrovirens* and *A. americana*), was one of the most common (Anawalt 1993:18; Atacador-Ramos et al. 1996:389; Feinman, Nicholas, and Haines 2002:33). The archaeological record indicates that hunters and gatherers used magueys thousands of years ago (Parsons and Parsons 1990:1), and the consumption of pulque likely extends at least into the Early Classic period (AD 150–650). The Aztecs regularly consumed pulque (Aasved 1988:364; Pellicer 1988; Madsen and Madsen 1979:38; Slotkin 1954:1089), and males who participated in state ritual ceremonies could "drink into a stupor without consequence" (Taylor 1979:30). The drink typically has an alcohol content of 4–6% by volume (Atacador-Ramos et al. 1996:389).

The production of pulque appears to have changed little since the Spanish conquest (Guerrero Guerrero 1980:70), and several scholars have recorded the process as performed in the twentieth century by specialists called *tlachiqueros* (La Barre 1938, Bruman 2000, Guerrero Guerrero 1980, Parsons and Parsons 1990). To make agave wine (fig. 4), the inner sweet juice of the agave, called *aguamiel*, must be extracted and fermented. Pulque cannot be produced until the agave plant is 7–25 years old (Parsons and Parsons 1990:18); only then can its juice be extracted effectively (Guerrero Guerrero 1980:70; Taylor 1979:31). During the plant's pubescence, it is periodically pruned to accelerate its development (Parsons and Parsons 1990:26–27).

One of the most common techniques used to extract *aguamiel* involved the castration of the flower shoots, or *quiote*. When the *quiote* was about to form or when it was still short and tender, a pointed pole was used to remove the bud tip and the cluster of modified leaves that protected it. The *tlachiquero* then destroyed the embryonic floral peduncle of the *quiote* that surrounded the buds with a few careful blows of the same pole (Bruman 2000:68; Parsons and Parsons 1990:29–31). The agave was left alone for anywhere from several weeks to a year or more (Parsons and Parsons 1990:32) while the bud swelled as a result of the *quiote's* having been destroyed. At the appointed time, the *tlachiquero* used a sharp instrument to puncture the entire surface of the top of the bud to a depth of several inches. The mashed tissue was left in place for about a week to rot and then was easily removed. The rotting of the agave flesh created an irritation to the plant that stimulated the flow of sap to the area (Bruman 2000:69).

After a week, the rotted tissue was removed to form a cavity in which the sap was collected. In a larger plant, this cavity could be 20 inches deep and 12 inches in diameter (Bruman 2000:69). The walls of the hole were carefully scraped with a copper spoon to remove the scar tissue that had formed. Within a few days after the scraping, the plant produced a steady flow of sap that continued until the plant was exhausted and the leaves shrank and collapsed into fibrous straps (Bruman 2000:69). An agave would typically produce 3–7 liters of sap daily over the course of six to seven months (Bruman 2000:69; Guerrero Guerrero 1980:71), and a larger plant could sometimes produce more than 1,000 liters (Bruman 2000:69; Parsons and Parsons 1990:37). The constant flow necessitated the removal of the sap at least twice a day, and the *tlachiquero* scraped the walls of the hole daily to maintain the flow (Parsons and Parsons 1990:35–36). The sap was extracted from the cavity with a pipette made from the dried hull of a calabash, deposited in another container, and carried to another location for fermentation (Aasved 1988:364; Bruman 2000:70).

There are other ways in which the juice of the agave can be extracted. For example, an early-seventeenth-century account by Ruiz de Alarcón describes a simpler procedure in which the *quiote* was removed, the bud was dug out, and the hole was tapped right away (Bruman 2000:69). Another technique was to cut the leaves off of a mature plant to reach the center, or heart, of the plant. The *tlachiquero* then dug out a hole in the heart, scraped the walls of the hole, and allowed the sap to flow over the course of several months (Guerrero Guerrero 1980:70; Taylor 1979:31). These methods, while more expedient, yielded less total sap then the first method (Bruman 2000:69; Guerrero Guerrero 1980:70). Once the *aguamiel* was transported to the place of pulque production, the *tlachiquero* poured the sap into a large vessel made of clay, wood, hide, or, more recently, fiberglass (Aasved 1988:364; La Barre 1938:227). If the vessel had never been used to make pulque before, a starter of pul-

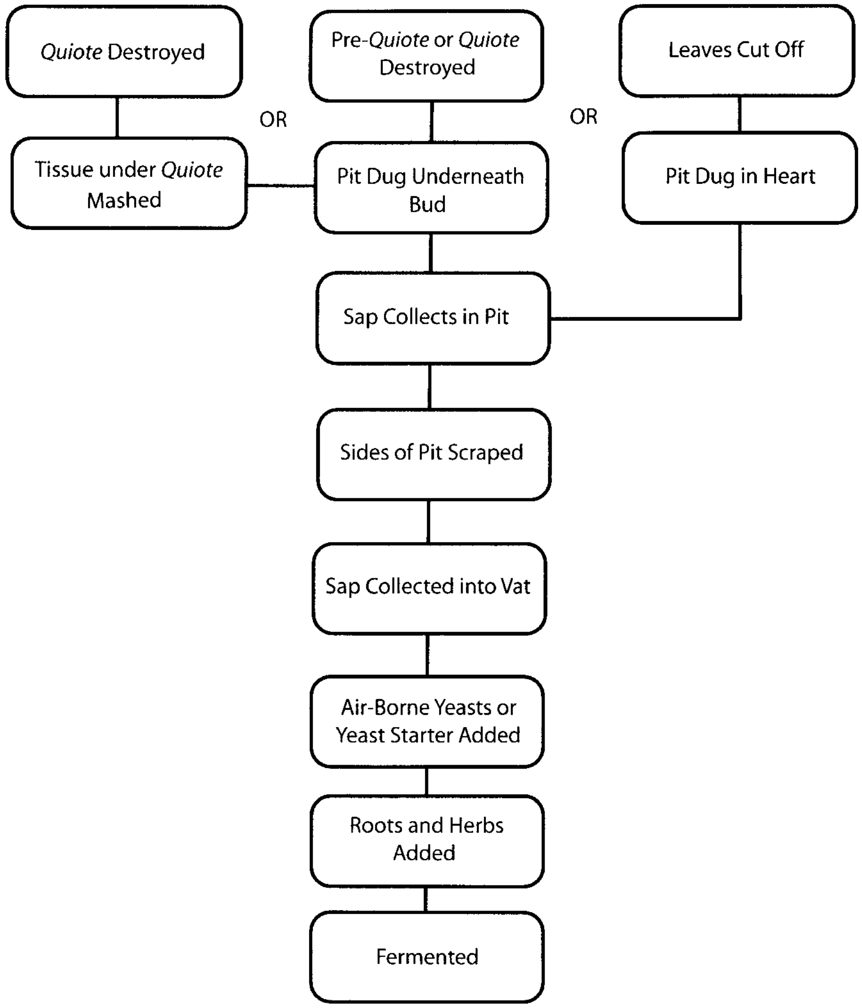

FIG. 4. *The operational chain for making agave wine.*

que with the necessary microorganisms, primarily the yeast *S. cerevisiae* (Atacador-Ramos et al. 1996:393), was placed in the vessel or the pulque was simply left open to airborne yeasts (Parsons and Parsons 1990 :46, 100). In most cases, the dregs of the previous batch of pulque were left in the barrel to stimulate fermentation (Bruman 2000:70; Madsen and Madsen 1979:42; Parsons and Parsons 1990:100).

Roots, herbs, and pieces of agave were sometimes added to the vats during the fermentation period to change the brew's taste (Taylor 1979:31). Fermentation typically took 3–12 days but could take considerably longer depending on additives and weather conditions (Anderson et al. 1946:887; Aasved 1988:365; Parsons and Parsons 1990:45; Steinkraus 1979:39). Pulque should be consumed within a few days after fermentation is complete because "it quickly undergoes a putrescent decomposition and acquires a most objectionable stench" (Bruman 2000:71; also see Parsons and Parsons 1990:99). However, Mesoamericans now and in the past had access to additives, typically strips of bark, that appear to impede the development of bacteria by lowering the pH of the pulque. Further, some modern groups extend the drink's shelf life by placing hermetically sealed jars in underground pits. In the best cases these measures allowed pulque to be stored for up to a month (Dahlin and Litzinger 1986:731).

GRAPE WINE

Grape wine, called *tin* or *geštin* in Mesopotamia and *ỉrp* in Egypt (Joffe 1998:304; Lesko 1978:3; McGovern 2003:151), has an alcohol content of 8–14% by volume. The wild grape subspecies *Vitis vinifera sylvestris* was the source of almost all ancient wine and was likely domesticated in Mesopotamia and the Levant by at least the fifth millennium BC (McGovern 2003; Renfrew 2003:57; Zohary 1995:28–30). *V. vinifera's* resistance to disease and cold, its high natural acidity, and its high sugar content made the species ideal for alcohol production (Kunkee and Goswell 1977:325). Wine was commonly served in large quantities in ancient Egypt and Mesopotamia (Fales 1994:370; Grivetti 1995:11; Lesko 1978:4). Wine was a symbol of power and status in these societies (Lesko 1978:3; Joffe 1998:302) and tended to be used in feasts that signaled social differences (see, e.g., Dietler 2001:85).

The techniques used to make wine in the ancient Near East were similar in broad outline to the ones used by vintners today (fig. 5) Grape vines required constant attention (Sasson 1994.401)—among other activities, trellises were built and maintained, grazing animals were kept at bay, dormant vines were pruned, and plants were watered (Jackisch 1986:39; Lesko 1977:15; Murray 2000*a*: 584; Olmo 1995:37; Powell 1995:104; Zohary 1995:23). All of this work had to be done throughout the life of a vine even though the plant did not produce grapes usable for wine production during its first three to five years of life (Sasson 1994:401; Joffe 1998:300). When grapes were harvestable, workers picked the fruits, often by hand or with a sharp blade or stone, and put them in baskets that were carried to a treading area (Lesko 1977:17; McGovern 2003:89; Montet 1958:106; Murray 2000*a*:585).

A two-step process was used to extract the juice from the grapes. First, the grapes were thrown into vats and crushed by workers walking barefoot over them (Lesko 1977:17; Montet 1958:106; Murray 2000*a*:586; Wilson 1988:31). The juice flowed into pottery containers through holes near the bottom of the vats (Lesko 1977: 19; Lutz 1922:53; Murray 2000*a*:586; depictions from Old Kingdom Egypt do not show these containers [McGovern 2003:90]). The second stage in the pressing process was designed to capture the remaining juices from the treaded grapes. The treaded grapes, including stems, seeds, and skins, were placed in a sack. Workers twisted either the two ends of the sack, poles tied to the sides of the sack, or one side of the sack with the other side tied to a fixed pole to press the remaining juice out of the mixture (Lesko 1977:19; Lutz 1922:54–55; Murray 2000*a*:588–89; Montet 1958:106–7; Wilson 1988:31). The juice that was extracted at this second stage was either added to the juice from the treading or fermented separately (Murray 2000*a*:590).

The conversion of sugar to alcohol began quickly when the sugar-rich grape juice came into contact with the natural yeasts found on the grape skins, on the walls of the jars, or on other winery equipment (Jackson 2003: 230; Lesko 1977:20; Murray 2000*a*:590). In this process, now called maceration, there were a number of yeasts and molds that could initially prosper in the sugary, hypertonic juice (Kunkee and Goswell 1977:344–50). As alcohol content rose and tannins were released, almost all of these microorganisms died off and only varieties of *S. cerevisiae* could thrive (Jackson 1999:603–5; Joshi, Sandhu, and Thakur 1999:656). In modern winemaking, maceration occurs after crushing (by treading or mechanical means) but before the wine is pressed and allowed to complete its fermentation (Jackson 2003:229). In the case of the ancient Near East, it is unclear if maceration was a separate step in the operational chain or

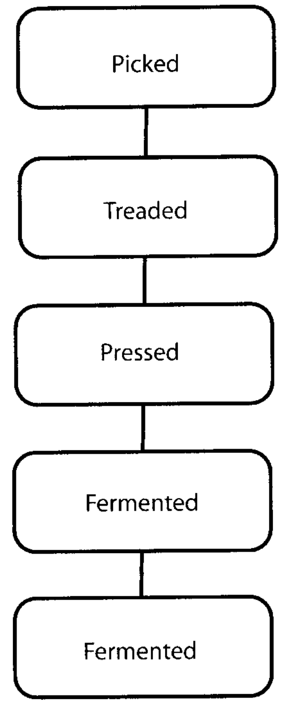

FIG. 5. *The operational chain for making grape wine.*

occurred in the fermenting jars when pressed juice was mixed with juice from treading that still contained stems and skins (Ghalioungui 1979:10; Lesko 1977:20). Since prolonged contact with grape skins adversely impacts a wine's taste, it is likely that the juice from treading was strained at some point in the process (Murray 2000*a*:591). White wine, if it was made, was likely strained after a brief maceration time (a few minutes to a few hours), since prolonged exposure to grape skins changes the color of the wine (Lesko 1977:18; McGovern 2003:152; Murray 2000*a*:591; Jackson 2003:229).

Primary fermentation in large-mouthed jars took from a few days to a few weeks depending on weather conditions and the type of wine desired (Murray 2000*a*:590), with a three-to-four-day fermentation period being perhaps most likely (Jackisch 1986:19). Wine jars may have been left outside to speed fermentation, although there is some evidence for cooler and slower fermentation (Murray 2000*a*; Wilson 1988:31). After fermentation slowed, the wine was either transferred into smaller-mouthed jars or allowed to remain in the fermenting jars. In both types of vessels, the jars' mouths were likely sealed with semipermeable stoppers of reeds or papyrus and then with a layer of mud and straw. A small hole was sometimes left in the plaster to allow carbon dioxide to escape (Lesko 1977:20; McGovern 2003:88; Murray 2000*a*:591; Wilson 1988:31). In these cases, the holes would be sealed a week or so later to prevent exposure to oxygen after final fermentation was complete (Jackisch 1986:19; McGovern 2003:55).

Wine was not racked and allowed to mature as it is today (Jackisch 1986:20). Instead, it was shipped soon after fermentation was completed and drunk young (Ghalioungui 1979:10; Lesko 1978:3; Powell 1995:110). This was done for two reasons. First, the jars were porous, and thus wine could be stored for only about five years before it completely evaporated (Lesko 1977:23; Wilson 1988:31). Second, *Acetobacter* and other microorganisms often caused increasing spoilage over time, although wine's low pH, high viscosity, tannins, and high alcohol content worked to preserve it (Jackson 2003:251–54; McGovern 2003:55). It is therefore unlikely that most wines were stored for more than a year before they were consumed (Murray 2000*a*:593).

Operational Chains and Elite Aspirations

Maize beer, barley and emmer wheat beer, rice beer, agave wine, and grape wine were important alcoholic beverages that were all successfully mass-produced for political feasts in the ancient world. While we discuss a few specific links between the operational chains used to make these beverages and ancient political economies, we concentrate on the general implications of their manufacturing methods. The operational chains involved were quite distinct, reflecting in part the biochemical constraints of creating ethanol from maize, barley, emmer wheat, rice, agave, and grapes and in part the particular technological choices made by actors working within these constraints. By engendering a drink's operational chain we can begin to understand the challenges and opportunities it presented for leaders and elites who sought massive amounts of alcohol for feasts. In this section we consider some of the more salient differences between these chains (table 1) and their implications for political economy.

SHELF LIFE

One of the most important reasons for the fermentation of foods and drinks is to delay spoilage (Steinkraus 1996: 3). It is therefore perhaps surprising that many indigenous alcoholic beverages had a shelf life of less than a week (Haggblade and Holzapfel 1989:247). Maize, barley, and emmer wheat beer typically spoiled in a week, and agave wine lasted less than a month under the best of conditions. Rice beer and grape wine, in contrast, could last for well over a year. The differences in shelf life of these beverages had important implications for the timing of feasts and the organization of labor. The short shelf life of maize beer, barley and emmer wheat beer, and agave wine necessitated that all of the alcohol for a feast be produced in a few frenetic days preceding the event. In the case of maize beer, brewing took a minimum of 6–9 days using the mastication method and 10–16 days using the germination method. Barley and emmer wheat beer took 8–14 days to make. In both cases, it would not have been possible to produce two successive batches of beer for an event because the first batch would have spoiled before the second batch had finished fermenting. Agave wine took 13–22 days to produce from the time a *quiote* was destroyed. Since pulque could be stored for only a month, it would also have been difficult to brew two successive batches from scratch. For these three beverages, therefore, both the number of laborers available at a particular time and the quantity and capacity of brewing equipment available acted to limit the size of a feast. Beer production for feasts in ancient Egypt, for example, was constrained in part by the size of the breweries (Geller 1992*a*; Winlock 1955:26). Brewery Hk24A at Hierakonpolis could brew up to 390 liters of beer for a feast if sufficient labor was organized to brew at optimal levels (Geller 1992*b*:21). The maximum that the brewery could produce was the total volume of all of its vats. In a second example, the maximum production of an Andean *chicha* brewer was about 100 liters if sufficient wood, water, and pottery vessels were available (Jennings n.d.). The mass production of *chicha*, pulque, or beer required that everyone and everything necessary for brewing be available in a short period before an event occurred.

In contrast, production of rice beer and grape wine could occur over a much longer time because the beverages could last for at least five years. Since the products of multiple batches could be used at a feast, a leader or elite could stockpile these beverages, while hosts who relied on *chicha*, beer, or pulque could not. The ability to stockpile the finished product meant that one could in essence stockpile the ingredients, labor, and equipment that were involved in making it. A vineyard in ancient Egypt, for example, employed "7 men, 4 lads, 4 old men, and 6 children" to produce 1,550 jars of wine (Lesko 1977:38). After five years, the owner of the vineyard could stockpile as much as 7,750 jars of wine for a feast. If grape wine spoiled as fast as pulque, however, perhaps as many as 35 men, 20 lads, 20 old men, and 30 children would be needed to make 7,750 jars of wine, as

TABLE 1
Differences in Features of the Operational Chains for Five Beverages

Raw Material	Preparation Time	Shelf Life	Plant Maturation	Stockpiling
Corn	6–16 days	7 days	Less than 1 year	Grains or flour
Barley/wheat	8–14 days	7 days	Less than 1 year	Grains or flour
Rice	31–85 days	10 years	Less than 1 year	Grains or polished
Agave	13–22 days	30 days	7–25 years	Sap (in situ)
Grape	12–36 days	5 years	3–5 years	None

well as more treading vats, presses, and other winemaking equipment.

Another advantage of longer shelf life was that alcohol production could be uncoupled from the event at which the alcohol was consumed. Alcohol production and feasts could therefore be scheduled at more convenient points during the year. For example, several batches of sake were traditionally made during the coldest winter months for events that transpired throughout the year (Kodama and Yoshizawa 1977:433). Brewing therefore occurred not only during a natural break in the agricultural cycle when labor was more readily available but also during a time of cold temperatures that was most conducive to stepwise mashing.

The beverages served at feasts, of course, did not need to be produced in the community where the event was held. Yet one's ability to import alcohol for a feast was also significantly influenced by a beverage's shelf life. In Mesoamerica and the Andes, the slow speed of human and animal transport and their low weight capacities virtually guaranteed that pulque and *chicha* were produced and consumed locally (Aasved 1988:365; Moore 1989: 688). Even in the Mediterranean, where more efficient transport was available, beer was rarely exported. Exchange networks for grape wine, however, stretched across the Mediterranean (Joffe 1998:302; Lesko 1977:13; Montet 1958:87–88; Powell 1995:107–11). Since rice beer and grape wine could travel greater distances, they could more easily be used as vehicles for prestige (e.g., Helms 1988). A good wine cellar in the ancient Near East was a mark of sophistication, and elites competed to collect both domestic and imported wines (Joffe 1998:302; Lesko 1977; McGovern 2003:193–94). The same was true of rice beer in China and Japan (Huang 2000).

PLANT MATURATION AND THE STOCKPILING OF INGREDIENTS

Rice, barley, emmer wheat, and maize are cereals that germinate, flower, and die within a year. Grains used for brewing are available for harvest for only a few weeks each year, and annual yields can vary considerably. Alcohol production rates, in the absence of grain storage, would therefore also fluctuate substantially from one year to the next. Grapevines and agave plants, in contrast, are not annuals. Grapevines take 3–5 years to mature and agaves 7–25. Although returns on investments in these plants were less immediate, the plants were quite hardy and generally a more reliable source of alcohol once they matured. If fields contained plants of diverse ages, then an annual harvest could be maintained. The Aztecs, for example, likely tended agaves at different stages of maturity to ensure continuous pulque production (Parsons and Parsons 1990 :18). However, grapevines and agaves were not immune to insects, blights, and other kinds of predation (e.g., Gale 2003). Elites and leaders who relied on feasting with cereals would have been more vulnerable to annual fluctuations in yields, while feast sponsors who depended on grapes and agaves would have faced greater risks of catastrophic failure if crop losses forced a minimum 3–7-year hiatus in alcohol production as new plants matured.

While a plant's life cycle influenced the timing of alcohol production, a more important scheduling factor was probably the ability, or inability, to stockpile ingredients at different stages in the operational chain. The ability to stockpile ingredients allowed a feast sponsor more time to gather raw materials from multiple sources and, perhaps, over multiple harvests. The most storable ingredient of the five beverages discussed was *aguamiel*, because the agave plant can yield its juices for beer at any point after it reaches maturity. While the amount or flavor of the sap may change during a plant's lifetime, the plant can store its sap until the need arises. Even when the *tlachiquero* chooses to castrate an agave plant in order to extract the highest quality and quantity of *aguamiel*, he or she still has the luxury of waiting for up to a year to begin collecting the sap.

Barley, emmer wheat, rice, and maize can be stored in different forms during different stages of alcohol production. Depending on conditions, all of these cereals could be stored in antiquity for well over a year in granaries or pits (Bray 1984:383–401; LeVine 1992*a*; Murray 2000*b*:527–28). Malted and unmalted maize, emmer wheat and barley flour, and polished rice could be stored for a few months, and the Egyptians may have stored mash in jars for adding to subsequent brews (Cutler and Cardenas 1947:41; Samuel 2000:555). As the grains became more processed, however, they generally became more vulnerable to spoilage. The higher sugar content of malted grains, for example, leads to higher predation from insects, and flour generally becomes rancid quickly if temperature and humidity are not carefully controlled.

The labor demands of brewing could also be spread out over a couple of months because of the storability of processed grains. Some of the most labor-intensive aspects of brewing, such as harvesting, malting, grinding, and milling, can be done long before the remainder of the brewing process. For example, masticated maize flour was stored in sacks in early-twentieth-century Peru, and malted maize flour was stored by brewers in the 1970s in Bolivia (Cutler and Cardenas 1947:41; Perlov 1979:7). Activities with significant labor and time requirements could therefore be scheduled at convenient times. This was especially important for hosts who served short-lived maize, barley, and emmer wheat beer because the drinks had to be brewed and fermented immediately preceding a feast. Sufficient barley for beer, for example, could be gradually milled (as well as winnowed, sorted, and sieved) during the course of daily activities by many families (Samuel 2000:559–63).

None of this flexibility was possible with grapes. Grapes cannot be stored for more than a few days before they begin to rot. In Santa Barbara today, vintners are adamant about picking grapes at a certain time, handling them with exceptional care, and finishing the initial pressing, treading, and fermentation in a few days. Ancient growers had similar concerns, and harvest time was a period of nonstop activity in vineyards (Murray 2000*a*: 85–90). In contrast to the other beverages, wine requires that all the work, from harvesting the grapes to transferring wine into jars for secondary fermentation, be completed in a single burst of activity. A vineyard owner therefore could not wait for the best time of year but had to work in September or October when the fruit ripened. While the grape harvest did not conflict with the earlier harvests of other grains, vintners still competed for labor with the growers of other autumn fruits. Moreover, the short processing window precluded the sharing of equipment because production could not be easily staggered. The labor and equipment crunch was a significant hurdle for leaders and elites who strove to organize the mass production of wine.

LABOR COSTS AND TRANSPORTATION HURDLES

Assembling enough people during the most labor-intensive moments, including some individuals with specialized knowledge of the brewing process, represented one of the greatest challenges for the mass production of these beverages. Rice beer, for example, could take up to 85 days to make, but for much of this time either the rice was being steeped or the beer was undergoing final fermentation. During steeping and fermentation, little to no work needed to be done. The four days of stepwise mashing in the middle of production, however, were a period of constant, intense work in which steamed rice, *koji*, water, and *moto* were combined several times and the mixture was constantly stirred to maintain proper temperatures. The two major labor crunches in pulque production occurred when the *quiote* was destroyed and in the days (or weeks) in which the agave's sap was collected. After sap collection, the brewer's work for the remaining 3–12 days of production was minimal. The most labor-intensive activity in *chicha* production was the hand milling of maize into flour. Mastication was also a particularly labor-intensive step, and there were busy moments in the 1–3 days of saccharification. Labor demands were therefore highest in pulque and *chicha* in discrete episodes near the beginning of production. The making of barley and emmer wheat beer required the largest inputs during milling, when the mash was made, and when the wort was decanted into jars for fermentation. Smaller labor crunches occurred at moments during malting.

The labor requirements of brewing also depended significantly on the transportability of the ingredients used to make the beverages. Maize, rice, barley, and emmer wheat could be more easily transported over longer distances than most other plant products because the grains were lightweight, durable, and resistant to spoilage (e.g., Berdan 1996:127–32; Hunt 1987:164–67; 1995:289; LeVine 1992*b*:24). A feast's sponsor could therefore deliver grains to brewers in cities or any other place where skilled labor was readily available. The transportability of these grains, combined with their storability, allowed for a greater scale and centralization of production because beer could be made from multiple harvests from a wide area (e.g., Sigaut 1997). The beverage's short shelf life (except for rice beer) ensured that the place of production was often close to the place of consumption.

The main ingredients used to make pulque and wine were not as transportable. Grapes spoil quickly and could have been transported only over short distances. Most, if not all, wine making therefore occurred near the vineyards. As a result, wine production in the ancient Near East was more diffuse than beer production, and the workers who made the wine also tended to pick the grapes (Lesko 1977:29; McGovern 2003:143–44, 163; Murray 2000*a*:78). In a similar manner, the *tlachiquero* who brewed pulque harvested the sap of the agave. Alcohol production occurred on site because the sap was heavy and spoiled quickly (Aasved 1988:364; Bruman 2000:70; Parsons and Parsons 1990 :35–36). Since only human transport was available and pulque spoiled in a few weeks, it is likely that agave fields were located close to where the beverage would be ultimately consumed.

Other ingredients that could impact the organization of production were water and fuel (dung, wood, or other fuel sources needed to saccharify starches). No water or fuel was required to make pulque or wine. Substantial outlays of labor were therefore not required to transport fuel and water to the brewing site, nor did the availability of these items affect the location of production. In contrast, water and fuel were significant in the organization of the making of beverages from maize, barley, emmer wheat, and rice. Since firewood was sparse in the high Andes by at least the Middle Horizon (AD 600–1000) (Williams 2002), the collection of wood was a significant bottleneck in the production of *chicha* (Mayer 2002: 85–69; Sillar 2000:55–81). Much more water was needed to make sake than to make any of the other beverages described here. In China the large amount of water needed for steeping, steaming, washing, and stepwise mashing necessitated that breweries be located near mountain streams (Huang 2000:197).

Brewing, Feasting, and Politics

Feasting was and remains an important means by which power was gained and maintained (Hayden 1995, 1996, 2001). Offering guests enormous quantities of food and drink was a way of signaling solidarity, indicating status, paying debts, and rendering tribute. The detritus of feasting is sometimes identifiable archaeologically (Hayden 2001:46–58; Lau 2002; van der Veen 2003:416), and archaeologists have made important strides in reconstructing the "commensal politics" of these events (Dietler 2001:66). A feast, however, begins long before the meal is served and is usually the culmination of many weeks of labor by scores of people. The story of how the food and drink arrived at the table is just as critical as the social behaviors at the table to our understanding of the past.

We have here offered a methodology for exploring the links between feasting and political economy. Using alcohol as an example, we have argued that an analysis of the operational chains for the production of maize beer, barley and emmer wheat beer, rice beer, agave wine, and grape wine reveals considerable differences in the ways these beverages were made in antiquity. The recipes for making them are the results of biochemical constraints and the technological choices made by actors working within those constraints. By engendering these operational chains, we have identified some of the challenges and opportunities for leaders and elites who strove to produce sufficient amounts of alcohol for their political aims using these recipes. While some of our points have been touched on by other scholars (see, e.g., Dietler 1990), we feel that our approach provides new information on the ways in which political strategies could be constrained by the items chosen for mass production.

We have generalized the operational chains for these beverages for the sake of making broad comparisons. An important next step will be to track how these chains changed across time and space in particular cultural settings. This more nuanced understanding could be developed by combining ethnographic and archaeological evidence with residue analysis of the variety of vessels used in a beverage's production and consumption (e.g., Boulton and Heron 2000, McGovern 1997, Samuel 2000). Shifts in how these drinks were made resulted from new technological choices, and these choices would have changed, if only slightly, the hurdles faced by those who wanted to use alcohol to sustain their ambitions. By engendering these chains, scholars can more easily see the dialectics between new choices, technologies, environments, labor organizations, and other factors that helped to shaped political economies. An archaeology of feasting must not lose sight of the investments of time, labor, and material that underwrote the "commensal politics" of events.

Comments

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Justin Jennings and his coauthors have made a useful contribution to the growing literature on the archaeology of drinking and feasting by comparing the production processes of several different alcoholic beverages and discussing the implications of this analysis for an understanding of the labor requirements that underlie ritual events. I am in general sympathy with the goals and conclusions of their discussion, and my comments focus primarily upon two aspects.

The article describes its approach as "engendering" the *chaîne opératoire* of production, but it is not clear in what sense the descriptions of technical sequences offered here are "engendered." This claim seems to mischaracterize the gist of the analysis, which focuses primarily upon the physical processes and constraints in the various composite *chaînes opératoires* presented and their implications for labor demand and temporality. But there is actually little analysis of alcohol production as a social activity—that is, of the way in which techniques and technical choices are embedded in and constrained by social relations and cultural conceptions—and virtually no analysis of gender. This is perhaps understandable, given that the social and cultural aspects of *chaînes opératoires* are more complex and variable than the physical aspects and less susceptible to the kind of compressed transcultural comparison the article attempts. However, the *chaînes opératoires* concept (which was already inherently "engendered" in its original formulation [see Lemonnier 1976]) was designed as an analytical tool precisely to illuminate the complex interplay between physical and sociocultural constraints on technical choices in sequences of action, to make techniques and technical systems understandable as social facts (see Dietler and Herbich 1998, Lemonnier 1986). The gendered relations of production in the fermentation of alcohol are quite important: for example, they have implications for the strong relationship between polygyny and political power in many African societies (see Dietler and Herbich 2001). It would therefore have been quite useful to have considered this dimension, although this certainly would have complicated the discussion.

The paper offers some insightful observations about the implications of the shelf lives of different forms of drink for storage and transport possibilities and their ramifications in the use of alcohol in feasting and politics. I would simply add that certain forms of drink (such as wine), because of their superior preservation qualities, have a stronger potential to become circulating commodities—goods produced for exchange rather than immediate consumption at a social event. For example, as the authors note, most traditional beers last only a few days after fermentation and are difficult to transport any distance. They are also usually made from products that are a common part of the household agrarian base, and production is a household activity. Large-scale breweries are quite rare in the archaeological record, and those that have been found (e.g., in Egypt and Peru) were facilities of the state, designed to produce large quantities of drink for immediate consumption at adjacent sites rather than for trade. Wineries, in contrast, are far more common finds (e.g., see Brun 1993). This is because these were frequently specialized, capital-intensive facilities designed to produce commodities for trade. Therefore there is often a much greater spatial separation between the contexts of production and consumption with wine than with traditional beer. This means also that there was often much less direct control over production by individuals and groups using wine in the commensal politics of feasting: it was generally acquired by trade from independent producers, perhaps several times removed. In the ancient Greek and Roman systems, for example, vintners did not usually even market their own wine. It was purchased by merchants who transported it to ports in hide bags and then poured it into ceramic amphorae for subsequent shipping and trade (Brun 2003).

One might also add a few alternative details to the description of wine production. Nearly all the renowned wines of ancient Greece were made from grapes dried in the sun rather than pressed directly. This augmented the sugar content and made a more stable wine: the resulting higher alcohol level inhibited acetic bacteria. These wines are sometimes called passum (an uncooked sweet wine). Romans, in contrast, used to reduce wine by evaporation, making a defrutum (a cooked wine) that was added to wine in the process of fermentation as a kind of chaptalization (Brun 2003, Tchernia 1986).

I conclude by agreeing that the relationship between production and consumption of alcohol is a crucial target of analysis and that the *chaîne opératoire*, when fully deployed, is a useful tool for discerning the complex interplay between physical and sociocultural constraints on technical processes. This article is a welcome addition to the burgeoning archaeological literature on drinking and feasting and a further sign that the subject is finally being treated seriously as as significant domain of ancient social life.

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The title of this paper puts me in the mood for relaxing and being meditatively calm. I see myself sitting in a teahouse or pub with the authors, quietly sharing a pint over warm conversation about the place of beer in the past. The paper is the opposite, it turns out. The authors describe the production techniques for five types of fermented beverages often traditionally produced for feasting in political encounters. The focus is on the production sequence, decisions that must be made, the labor, and the organization of a feast. This is the anxiety-provoking part of any gathering, the part with lists, timing, and quantities to worry about. They do not really even give us this, however. For years archaeologists have worked hard to uncover the food-producing end of the subsistence business; all of this has taken much hard field and laboratory work, but we are now beginning to have data and therefore bases for discussion about food production in many places around the world. With the increased interest in peopling the archaeological past, a focus on activities and performance has turned to the political and social impact of feasts in small-scale societies (Dietler 1996). Recent feasting literature has focused on the gastropolitics of the event, with good reason. In this approach, the evidence for such events has provided many examples of political action through the ubiquity of feasts archaeologically in the form of remains such as halls and presentation equipment. A merging of the production of the feast and its placement politically within societies is crucial at this juncture in the archaeological discussion. An operational-chain approach allows for the meaningful embedding of artifacts in social relations and is an excellent way to begin to situate feasts within cultural and political settings, but this is not the purpose of this paper. Instead, the authors focus on the steps and costs of beer and wine production techniques, including the costs of each phase of processing and the technological choices that are required. It is almost like a recipe book for five archaic beverages, disarticulated from any actual political situation, much less any archaeological political research question. What is there to debate in recipes? There are always more variations that can be found in the literature or ethnographically. The chain of events and investment varies between these beverages. We do learn about the key issues for serving fermented beverages, such as shelf life, stockpiling of harvested plant ingredients, and transportation, but to what end?

Overall, the presentation does not really engage with the anthropological issue of what operational chains are supposed to do. Rather, it provides the background for other work in those domains, with a focus on the making of surplus drink disarticulated from actual political situations and not a single archaeological example of such a study. They give us a sense of the labor crunches in these processes and the amount of labor required to have the drinks part of a feast, but I am left thirsty to know just how such a cycle might have participated in a political situation and how that would have been linked to the food part of a feast, let alone to the cultural costs. The second irony is the "engendering" part of their argument. Where are the people, not to mention the women? We need to try to get back to the people and their plans and aspirations when we talk about feasts. These authors seem to be concerned with the emphasis on peopling the past, but I see no evidence for this in this paper. While they provide a nice encyclopedic summary of the five main brewing processes, I miss the Marxist engendered and contextualized discussions that would allow for a study of past beer brewing and move us closer to the past lives that we want to study.

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22 IX 04

This is exactly the kind of analysis that we desperately need in ethnological work in general and in trying to understand the dynamics of feasting in particular. I absolutely agree that "an archaeology of feasting must not lose sight of the investments of time, labor, and material that underwrote the 'commensal politics' of events." Jennings and company are to be congratulated on their perceptive assessment of the state of our knowledge and on having employed appropriate techniques for identifying critical constraints in large-scale alcohol production. They help fill this lacuna in our research. The adaptation of the *chaîne opératoire* to an economic type of analysis is especially appropriate, even though I would prefer an English translation such as "manufacturing sequence" or "production sequence" rather than "operational chain." The approach is very similar to the design-theory framework that I have found so productive in dealing with stone tools, which focuses on various types of constraints (Hayden 1998). The substantive results concerning the effects of varying shelf lives, staple storability, and transportation constraints on labor requirements and production facilities are fascinating.

From my field knowledge, the assessments of the production of wine, pulque, and *chicha* are close to the mark. I would caution, however, that a more extensive treatment of rice beer is warranted, since, as Jennings et al. note, there are many variations in its production. They have chosen probably the most labor-intensive and time-consuming production technique (the production of sake, usually considered a wine) to compare with the other techniques. While I am not questioning their description of the production sequence of sake, we need to know more about the contexts of use for this specialized type of alcohol as well as the other alcohols discussed. I strongly suspect that it was traditionally used only by the wealthiest, who could support its very specialized production and could benefit most from such a storable brew. I would venture to guess that sake production really only emerged in the context of state-level elites during the early Chinese dynasties. Certainly the rice beer that I am most familiar with, brewed in large quantities for feasts among Southeast Asian hill tribes, involves much simpler and shorter production processes (more comparable to the brewing of barley and wheat beer), although I do not have specifics comparable to the information Jennings et al. have collected.

Another area which would benefit from greater attention and analysis is the estimation of the amounts of staples that are required to produce given volumes (and alcohol levels) of beers and wines. This is perhaps the major cost involved in alcohol production for feasts, yet Jennings et al. do not discuss it at all. From the limited information that I gathered among the Hmong in Baan Chan Kham, on Doi Suthep, one *tang* (10 kg) of hulled rice produces 13–15 bottles (750 ml) of rice beer. One *tang* of maize produces about 10 bottles of maize beer. Since guests at the more significant feasts typically consumed 2,000–3,000 liters of this alcohol, the very substantial magnitude of the surpluses required can be readily appreciated (ca. 1–1.5 metric tons of surplus rice just for rice beer). That alcohol production (like all feast food production) fundamentally requires surplus production also needs to be emphasized. Given that many families farm only a few *rai* of hill rice or maize and that hill rice production is typically around 25–35 *tang* per *rai*, the stresses that alcohol consumption can create if a family wishes to hold a major feast can be easily appreciated. Most of the time, large quantities of rice need to be borrowed or obtained through loans, resulting in a complex debt network in these communities. I would urge Jennings et al. to extend their analyses in this direction and to include brewing requirements in transegalitarian communities as well as in stratified societies.

It would be fascinating to see how other beer brews such as millet, manioc, and rye might compare with those discussed in this article, especially since rye appears to be the earliest domesticate in the Near East.

Finally, to extend the analysis even further, it would be useful if Jennings et al. could provide some information on the dietary importance of these alcohols in traditional communities. Such estimates are not easy to obtain, but some do exist indicating that alcohol consumed at feasts provided 20–30% of the total yearly calories for most individuals (Dietler 2001:81–82).

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Discussion of feasting and the socioeconomic role of food in different cultures, both ancient and modern, abounds in both the anthropological and the archaeological literature. This article is interesting in that its emphasis is on the production rather than the consumption of foodstuffs, in particular alcoholic beverages. This highlights a more recent trend in archaeology toward examination of the methods and the practicalities of production processes rather than the consumption or distribution of the finished product. In this article the focus is on the physical limitations and challenges inherent in the materials being used and their influence on the finished product. The technological knowledge and skills needed by those involved in production should also be considered.

The study of various types of beer (maize, barley, emmer) and wine (agave and grape) in different cultures is illuminating with regard to the authors' goals. Although they provide a detailed explanation of how each beverage might have been produced, a discussion of the roles of these different beverages in the different contexts of feasting (political marriages, religious events, victory celebrations, etc.) in each of the regions discussed (prehistoric Andean, Chinese, Egyptian, Mesopotamian, Mesoamerican) would have been of benefit. It is not just the practicalities of production that dictated what and how much was produced but the symbolic and social values of the beverages.

It would be interesting to consider what the goal of the drinking was and what role, if any, was played by the quality of the beverage. In antiquity, as today, certain drinks were probably associated with specific events. What was the ancient Egyptian or Mesopotamian equivalent of the champagne that is now associated with weddings? It is possible that in some Egyptian festivals wine was provided in preference to beer while in others, perhaps certain Hathoric rituals associated with specific mythic events (e.g., "The Destruction of Mankind" [Lichtheim 1976:197–99]), beer was preferred. At an event at which either or both beverages were served, it may have been the social breakdown of the consumers that dictated how much of each beverage was produced rather than the material constraints or the areas of production. Wine was possibly more often served to the elite, while beer would have been served to both the elite and others.

The quality of beverage may also have been significant in terms of the production process. Certainly the wines produced in Egypt were graded and the jars labeled: "sweet wine," "good quality wine," "very good wine," and wine "for merry-making," frequently with the estates of origin (Lesko 1977:22, 27). For a festival, would the cheaper "merry-making" wine have been produced, or would the finer vintages have been on offer? Again, the rank of the people imbibing might have influenced this decision.

Jennings et al. raise several interesting and valid points about shelf life and brewing equipment. However, the question of laborers and space depended to some extent on the host, at least in Mesopotamia and Egypt. If the "state" in the form of the king or a temple were hosting a feast, then the number of breweries available for the production of beer would have been much greater than if the hosts were others, for breweries at some distance from the feast site might have been used and other local breweries could have been pressed into service. In the former scenario, the effects of transportation on beverages and the logistics involved with these would have played a part in the production process. The question of the plant's life cycle's influencing the timing of alcohol production and the storability of these plants is a good point, but the authors might also have explored the idea that the scheduling of (many of) the feasts was related to the agricultural cycle and thus the plants may have influenced the *feasts* rather than the timing of the production of the beverages. Obviously this varies with the plant and the culture under discussion.

Perhaps the authors could further explore their ideas, especially with regard to questions concerning physical containers and storage, as well as the production process of the different beverages, by experimental archaeology. This might help to elucidate the difficulties involved in the different stages of the production process and storage and also contribute to a greater understanding of the economics involved in the production of feast foods. It is to be hoped that they will continue their research and, as they say, "track how these chains changed across time and space in particular cultural settings."

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This article is a very systematic study of ancient beer and wine production, and I applaud the authors for making me think about the wider implications of alcohol manufacture and the ability of leaders to muster sufficient drink for feasts. The quality of the investigations and the clarity of the writing in this manuscript show that undergraduates can conduct substantive research, especially when the topic is near and dear to their hearts. More professors should encourage students to do original research and publish their findings.

As Jennings et al. effectively demonstrate, the production of beers and wines varies substantially in the amount of time, energy, labor, and task organization required. Although most beers and wines took about two weeks to prepare, the organization of the production varied more widely, as did shelf life. I was especially struck by how labor-intensive and technically specialized rice beer production had become by the Han Dynasty. More than maize, barley, or wheat beers, it appears, some rice beers may have risen to the level of haute cuisine, marking the status of the customer. This level of prestige was also true for wine in ancient circum-Mediterranean societies, not necessarily because of the amount of time or specialized labor required to produce it but because individuals could curate these beverages. Like rice beer, wines had longer shelf lives and thus could be made well in advance of the feast. Since wines and rice beers could be transported over greater distances, they became exotic additions to local fare served at a feast, thus elevating the host's prestige. In addition, the potential for control over the production and distribution of rice beer and wines allowed hosts some degree of flexibility with regard to the organization of labor. At the same time, hosts who served *chicha*, wheat and barley beer, or pulque had to rely on the effective mobilization of community labor for the timely production of drink for feasts. Depending on the relationship between host and supporters, production demands may or may not have been met, potentially jeopardizing the "blissful mood" for revelers and ultimately the host's prestige.

One interesting avenue of research that this study opens up is the coupling of operational chains with modes of production for an understanding of the degree of elite competition and control over drink production. Jennings et al. imply that most festival drink was produced by corvée labor cajoled or pressed into service. Because the mode of production is not thoroughly addressed, we are left wondering how laborers were organized and where production was situated. Goods, including festive food and drink, can be made in the home (cottage industry), in villages that specialize in the production of a certain product (village specialization), in urban workshops, or in specialized locations near elite or royal compounds (attached specialization). Elites maintain control most effectively over goods produced where production locales are nucleated, the scale of production is large, and the laborers work full-time and/or operate under close supervision (see Clark and Parry 1990, Costin 1991, Inomata 2001). Attached specialists, in this case expert brewers, vintners, or kitchen help, afforded the most control, but people working in urban or rural workshops could have been asked to contribute drink as part of their tribute obligations. Although home brew may have been the least regulated and most unpredictable source of drink, elite demands may have been felt via less direct methods of regulation.

While working on the north coast of Peru, I drank my fair share of *chicha* made in homes, *chicharías*, and pottery workshops where the primary task was the production of large ollas, some of which were used for making beer for local use. Some Peruvian villages' claim to fame was their *clarita* (a particularly light and effervescent variety of *chicha*). From Craig Morris's (1979) work at Huanco Pampa we know that Inka administrators also used corvée labor to produce *chicha* while tribute-paying citizens resided at the provincial capital. Here, maize grain, masticated quids, or germinated flour could be stored in state storehouses until needed. Requisitioning *chicha* for Andean feasts could therefore be achieved in at least two ways: pooling the production of beer made by supporters in dispersed locations such as homes or workshops or staging the mass production of beer by laborers concentrated in administrative quarters. The most fail-safe methods involved oversight into the storage, production, and/or distribution of drink by people attached in some way to the individual(s) sponsoring the event. Wines and rice beers afforded this level of control and therefore elevated the status of individuals who could serve them in substantial quantities at feasts.

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This paper presents some important cross-cultural concepts of how the industrial steps (*chaîne opératoire*) in making an alcoholic beverage are constrained by the starting materials themselves—whether a grain, root, fruit, or plant exudation—and the specific means used to saccharify and ferment their carbohydrates. Jennings et al. then apply this understanding of alcoholic beverage production, with implications for agriculture, land and capital formation, labor, storage and transportation, etc., to what is arguably a key motive force in human culture and technology—elite display and emulation in the form of banquets and grand celebrations. A similar approach of "deconstructing" other ancient technologies (e.g., pottery-making [McGovern 1986]) has proven useful in shedding light on their social, economic, and political underpinnings.

As admirable as the goal is of reconstructing ancient fermented-beverage production, this paper too often falls into the trap of projecting modern or near-modern templates back into the past. Because the available archaeological evidence—contextual, botanical, chemical, documentary, and artistic—is generally very limited, the authors have often relied on ethnographic and/or ethnohistorical accounts. But technologies, like cultures, have undergone significant changes over time. Despite qualifications and the goal of drawing broad lines of distinction among the five alcoholic beverages described, one can easily come away with the idea that specific methods requiring so many days, so many workers, so much land, certain temperatures, etc., were being employed thousands of years ago.

The discussion of rice beer, for example, relies too much on recent Japanese sake production. Ancient Chinese rice "wine" and "beer" production—involving a variety of beverage types with differing amounts and degrees of alcohol and aromatic properties, as described in the earliest Shang Dynasty texts—precedes the transfer of these beverages to Japan by at least a thousand years and probably many more. Before the Japanese developed specific mold and yeast colonies for amylolysis and fermentation, the ancient Chinese were much more eclectic, as they continue to be today. Besides *Aspergillus oryzae*, *Rhizopus*, *Monascus*, and other fungus species, depending on environmental availability, where used to break down the carbohydrates of rice and other grains into simple, fermentable sugars. It should also be noted that the amylolysis/fermentation agent is usually referred to as *qu*, not *jiu ou*, and that the wine yeast (*Saccharomyces cerevisiae*) is not airborne.

A more exacting and nuanced approach is needed to reconstruct ancient rice "wine" or "beer" production before the emergence of the complicated mold amylolysis system. For example, in Neolithic China, grain was probably masticated and/or malted. Given different tools and containers as well, beverage production in this period would have been quite different from more recent Japanese sake production and have had differing impacts on ancient feasting and sociopolitical structures.

Similar questions can be raised about the scenarios for ancient beer and grape wine production. For example, it is debatable that Samuel's reconstruction of Old Kingdom beer-making in Old Kingdom Egypt can be applied to Mesopotamian technology, with its own traditions. Emmer (and einkorn and bread wheats) were used sparingly throughout the ancient Near East because they are more difficult to ferment than barley.

Given the title of the paper and since, by the authors' own definition, "wine" and "beer" are mutually exclusive, the inclusion of grape wine is surprising. Yet, this addition is useful in showing that beverages made from high-sugar fruits differ in significant ways from beer. What goes unnoticed, however, is the relative ease of making wine as compared with beer. Grapes have their own yeast (unlike cereals), so that once the juice with its concentrated simple sugars has been extracted (no need to break down starches), fermentation is initiated. Grapes and other fruits also produce a beverage with a higher alcohol content than beer (with notable exceptions, such as Chinese rice "wine"). Such beverages keep better, have the potential of improving with aging, and can be transported. It is no wonder that they were preferred by the elite for their celebrations, funerary ceremonies, and daily sustenance (McGovern 2003).

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This paper offers an intriguing perspective on ancient feasting which gives rise to a variety of possible agendas for research. As the authors point out, much research on ancient feasting has concentrated on consumption, but widening the enquiry to examine the preceding stages of provision offers great potential for furthering our understanding of ancient political economies and social interactions.

The paper suffers, however, from a failure to grapple with the complexities of the topic and includes numerous inaccuracies. To take one example, the description of beer biochemistry includes errors relating to the definition of hydrolysis, the interaction of starch and water at low temperatures, and the definition of malt. Not only do these shortcomings obscure the accurate interpretation of ancient food practices, but they hinder broader analysis of the problems faced by those who aimed to produce surplus food and alcohol for feasting.

Jennings et al. imply that the operational chain involved in producing Near Eastern beer, the area with which I am most familiar, was essentially the same in ancient Mesopotamia and ancient Egypt, remaining broadly unchanged for millennia. There is clear archaeological evidence, however, that pre-Dynastic brewing was different to that of the New Kingdom. Neither is likely to have involved beer loaves (Samuel 2000). I have not studied the archaeological evidence for Mesopotamian brewing, but the documentary and artistic data support the traditional view that loaves were precursors to beer in the Mesopotamian process, at least in some periods. Therefore the operational chains were quite different for these widely differing times and areas.

This conflation is unfortunate, for it obscures accurate comparative analysis of ancient surplus beer production. For example, there may have been changes in the flexibility of elite production over time in Egypt. In pre-Dynastic Egypt brewing vats were large, fixed structures, at least in the centralized contexts that we know of at Hierakonpolis and Abydos (Peet and Loat 1913), and thus elite beer production may have been limited. By New Kingdom times and probably earlier, brewing took place in smaller moveable pottery vessels. Beer was made from staple cereal crops in both ancient Mesopotamia and ancient Egypt, two highly organized and hierarchical states; the reasons for very different production methods and their specific organizational implications and time constraints may be a useful area to explore.

It is very important to emphasize that food provision is a highly complicated undertaking, that evidence for ancient food preparation is difficult to obtain and interpret, and that without a sound grasp of the technology and activities involved, any wider interpretation will be inaccurate. The operational chain of food production is made up of details, and in the differences may be local preferences or critical variations in production.

In order for engendered operational chains to be taken forward as a fruitful concept, it is essential that we have a detailed understanding of specific ancient food technologies. The archaeological evidence must be underpinned by appropriate ethnographic parallels and carefully designed experiments to understand actions, labour investments, and time requirements (see, for example, Samuel 2000 and, in another context, Bayliss-Smith 1999). This multistranded approach is a fundamental necessity and not, as Jennings et al. suggest, a method of providing a "more nuanced understanding" of food operational chains. The archaeological evidence itself needs to be carefully assessed to detect homogeneity or variation in production within a culture for any given period before change over time can be inferred. Otherwise, regional or social differences—of interest in their own right—may be erroneously interpreted as temporal developments.

One area not touched on by Jennings et al. is how feasting operational chains were embedded in wider social, economic, and political economies: how 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. This appears to have been the case for New Kingdom Egypt. In some cultures, elites may have had access to different technologies and materials compared with domestic households. Relevant archaeological indicators may include centralized large-scale brewing facilities, scattered small-scale or domestic facilities, differences in production installations and tools, associated archaeobotanical remains, and visible or chemical residues.

The study of ancient food provision is not easy, nor is it an undertaking which provides rapid results. The archaeology of food is a highly complex and challenging field, requiring many strands of evidence. This paper contributes by opening up a profitable area of enquiry. However, it is essential that primary studies and syntheses of food in the past be based upon detailed analysis and a firm understanding of food processes.

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Agricultural and food-producing technologies constitute a field so immense that the more research is done on it, the more research seems necessary. The paper by Jennings et al. is very welcome in this respect. It makes so many points that a full comment would take nearly as many pages as the article itself, so I shall limit myself to a few questions centered on storage, which has been of special interest to me for a long time (Gast and Sigaut 1979–85).

From the point of view of storage, beers and wine are two opposite cases. 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, and therefore they must be made on demand. And they can be made on demand because the grain or flour (and I would add, malt) of which they are made can be stored for months. Conversely, grapes do not keep at all (unless dried, which is another story), and therefore wine has to be made immediately following the grape harvest and stored as such. Now, storing wine is a difficult business. It was pointless to grow and harvest grapes in any "large" quantity (I leave out the question of what "large" means here) as long as people lacked the means and the know-how to store the wine for at least a few months. This may help to explain why the making of wine is more recent and much more geographically restricted than the making of beer. Wines made of the sap of plants such as agave or palm are not subject to the same constraints as grape wine proper, since the harvest of the sap may take place over a much greater part of the year.

A second difference is a consequence of the first. Since it always had to be done on a rather large scale, wine making 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. The observation was made long ago by Adam Maurizio (1970 [1933]:112–13) for the so-called primitive societies. In continental Europe, beer making became a craft in the early Middle Ages, if not earlier, but in Britain housewives went on brewing their own beer at home well into the eighteenth century (using malt bought at the maltster's). In his *Cottage Economy* (1979 [1822]), William Cobbett vehemently opposed the discontinuance of this age-old custom, which he said would destroy the fabric of the English family; drinking homemade beer (moderately) at home was being replaced by drinking industrial beer (immoderately) in pubs, where, outside the control of their wives, men were free to spend too much of their earnings to intoxicate themselves.

We may smile today at Cobbett's one-sidedness, but he had a sense of the socialness of technology which can still be a model for us now. Going back to ancient history, we may hypothetize that a chief or a king who wanted to treat his guests properly had to have many wives (or women slaves) for food and drink preparation. This technoeconomic basis for large-scale polygamy has sometimes been alluded to but, as far as I know, has never been seriously studied, nor have been the consequences of wine making's being a men's task in European societies.

As I have said, the very immensity of the field is the main difficulty in commenting on the paper of Jennings et al. My hope is that it will be instrumental in persuading archaeologists, historians, and anthropologists from all over the world that beer and wine technology is a matter of first-rate importance for understanding human societies and that they should organize to study it.

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Jennings et al. propose that because alcohol production and feasting were inextricably interwined in ancient societies it might be more productive to study the methods involved in the production of the beer and wine used at feasts rather than focusing on the effects of feasting (as has been traditional among anthropologists). They have produced an extensive survey of the steps involved in the production of a variety of alcoholic beverages from around the world. They suggest that by re-creating production sequences we can elucidate and comprehend the problems that faced large-scale feast organizers. The aim of their paper is to reveal the substantial variation in the manufacturing processes of alcoholic beverages from around the world, and this knowledge, they claim, should provide important insights into a society's political economy.

It is more than likely that the first successful creation of an alcoholic drink took place unintentionally when someone searching for sweet juice crushed grapes or other fruit, cut the bud from an agave plant, or squeezed or chewed the stalks of corn's ancestor and then collected this juice in a container and left it in the summer sun for a full day. The natural yeasts present in the air and on the skin of some fruits would have mixed with the juice, fermented, and produced an alcoholic drink. Because of the lack of storage and the difficulty of transport, this early small-scale use would likely have persisted for many centuries and taken place only after people had settled down. Many juice sources are wild or slow-growing; fruit trees and grapes take five years, agave a minimum of seven; therefore increasing the supply is difficult. There are two notable exceptions, both of which are annuals—maize and barley. They allow a huge increase in supply in less than a year and, interestingly, are directly connected with successful large-scale societies in Egypt, Mesoamerica, and South America.

This paper focuses on the production and consumption of alcohol specifically for feasts rather than for daily use. It would seem likely that production methods became entrenched while comparatively small quantities were being produced on a regular basis. As the techniques improved and equipment was manufactured, quantities could be increased. For example, the Tarahumara of northern Mexico spend a quarter of their labour producing *tesquino*, their cornstalk beer, and have a *tesquinada* (drinking party) every ten days or so. It would seem, then, that a priority for a feast organizer would be getting these small-scale producers organized.

Jennings et al. focus on production struggles and assume that alcohol supply is the limiting factor in feasting. While most archaeologists agree with Brian Hayden's hypothesis regarding the importance of feasting, it is not clear which was more important, food or alcohol. Perhaps it was alcohol because when under its the influence people believed that they were transported to the world of the gods.

Jennings et al. suggest that differences in production sequences and costs help to shape feasting strategies. A problem with preservation, for example, would necessitate immediate consumption whereas the ability to stockpile, as in the case of wine, would allow a much larger supply and the possibility of spontaneity. There is, however, a small problem in "engendering operational chains" when there is no evidence of the particular method used to produce the beverage (for example, there are various ways of producing beer). Also, assuming that alcohol produced in large quantities for a feast was made by many small-scale producers, we have no evidence, nor are we likely to find any, of the way in which this production was organized. It will be interesting to learn from future work what the authors make of the variation they have reported.

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5 XII 04

This article presents a detailed and well-founded investigation of the biological process of fermentation and the operational chains involved in the production of five alcoholic beverages that were very popular in antiquity. Mass production of alcoholic beverages is considered to play an important role in feasting as a means for establishing and maintaining social, economic, and political structures. The technical details of production influence the organization of the feasting and the efforts of leaders and elites. Where we have written and iconographic sources we can learn much about the importance of feasting and the social, political, economic, and religious interactions involved. However, the production process is often less clear. As the case of beer production in Old Kingdom Egypt has shown, archaeological excavations of breweries are necessary to understand and reconstruct the process fully (Samuel 1996, 2000).

This article inspires to think about feasting with socioeconomic, political, and religious implications in regions far from Egypt and Mesopotamia. The evidence from an early Iron Age site in south-western Germany sheds light on early Celtic drinking behaviour. In the Late Hallstatt princely burial mound of Eberdingen-Hochdorf, near Stuttgart, a bronze cauldron was excavated with a total volume of 500 litres.The ancient contents (ca. 350 litres) are reconstructed to have been a mead preparation (Körber-Grohne 1985). The cauldron was part of a drinking and dinner service for nine persons. The central burial chamber contained the remains of a nobleman who is interpreted to have been a theocratic "princely priest" or "priest chieftain," the service for nine referring to an inner circle of nobles in an attendance system (Krausse 1996). The Late Hallstatt/Early La Tène site of Hochdorf is directly related to this grave mound and interpreted as a rural settlement. During excavations of the settlement, ditches were unearthed containing charred barley malt. A reconstruction suggests that the structures were part of an early Celtic brewery (Stika 1996); the malt kilns are too large for small-scale beer production. As further excavations directly around the burial mound have shown (Schmitt and Seidel 1998), there were five pits filled with charcoal, fire-cracked stones, and bones at its base. The loess of the walls and bottoms of the pits was burnt red by intense fires. The pits are interpreted as cooking pits in which whole animals were prepared as a part of ceremonial feasts at the burial mound. The beer produced in the settlement was probably consumed there. Statistical analyses have shown that the Hochdorf beer may have been spiced with mugwort and carrot seeds (Stika 1999:101), which would have preserved the brew for a long time.

Reply

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On behalf of my former students, I thank these ten scholars for taking the time to comment on our work. The goal of our paper was to stress the importance of feasting preparation and to show the potential of linking feasting preparation to political power through an operational-chains approach. While the commentators offer helpful criticisms of our reconstructions of the chains, they are broadly sympathetic to our approach.

Dietler, Hastorf, Ikram, LeCount, McGovern, Samuel, and Smalley suggest that alcohol production was often quite complicated, variable across time and space, and articulated in nuanced ways to gender roles, consumption patterns, class, and other aspects of culture. McGovern, for example, brings up interesting differences between Chinese and Japanese traditions of rice beer production. He suggests that Chinese brewing methods were much more variable than we indicated and rightly suggests that the different recipes for these beverages would have had quite different impacts on feasting strategies. In a similar vein, Samuel puts forward important differences between Mesoptamian and Egyptian beer and between beer brewed in Old and in New Kingdom Egypt. I agree completely that alcohol production was often complicated and varied substantially across space and time. In our article, however, we generalized the operational chains for these beverages for the sake of making broad comparisons that would help highlight the influence of differences on feasting strategies and hence political economy.

McGovern, Samuel, and Hastorf argue that a more narrowly focused use of this methodology to explore specific archaeological examples would have better met our goals. Samuel's (1999) work on bread making at the Armana workmen's village in Egypt and Hastorf's (1991) work on gender relations and food production in a Wanka village in the Andes are two exceptional examples of the power of this kind of research. Nonetheless, this work neither highlights the broad diversity of ways in which people have made food and drinks around the world nor shows how this diversity could have had varying impacts on political and economic decisions. Wide-ranging studies like ours throw specific case studies into relief and make them more meaningful. As Hastorf suggests, we need to get back to people and their plans when we talk about feasts. Broad comparisons like those done by Karl Marx and his students provide us with a necessary framework to study particular cultures and events and are not antithetical to this goal.

Hayden, Smalley, Sigaut, and LeCount touch on interesting issues regarding the ways in which operational chains may have changed over time. While there are biochemical and other constraints on methods of beer and wine production, we were careful to state that our operational chains could not be projected deep into the past. The recipes that we discussed were all used within stratified societies. How these beverages were first made and mass-produced remains unknown. As Hayden and Smalley suggest, there are many ways to make alcohol, and a number of these methods have far simpler recipes and shorter production times than the ones we described. These simpler beverages are important in less stratified societies today (Atacador-Ramos et al. 1996) and were likely important among transegalitarian communities in the past. To reconstruct the dynamics of the earliest feasting, more work will need to be done in at least two areas. First, we will need more ethnoarchaeological studies of feasting in transegalitarian societies that provide detailed, quantified data on feasting preparation. Brian Hayden's (2003) work and that of his students Michael Clarke (2001) and Ron Adams (2004) is beginning to fill this serious gap in our knowledge. Secondly, we will need to find better ways to reconstruct operational chains without the benefit of written records. As Samuel says, this can be accomplished only through carefully designed experimental work and residue analyses. While scholars in the Near East have made significant progress in tracing the origins of barley and emmer wheat beer and grape wine production using these methods, there has been virtually no work in this area on other alcoholic beverages. With my colleagues Hyukbum Kim, Ben Mabley, and James Tate, I am conducting preliminary experiments to identify the residues from stages of corn beer production. Much more work will need to be done in these two areas before we can hope to track changes in operational chains prehistorically.

I think that it is likely that there was more rapid innovation in alcohol production with the emergence of competitive and state feasting. In less stratified societies, alcohol would have more likely been produced at home and then pooled for feasting events. The drive for innovation in this brewing environment would have been weak. In more stratified societies where feasting occurred, there would have been a greater demand for mass production. As Smalley, Sigaut, and LeCount suggest, changes in the operational chains of beverages in stratified societies were often the result of changes in the mode of production as alcohol manufacture moved in some cases out of the home and into state- or elite-controlled breweries or wineries (also see Joffe 1998). Production was increasingly enlarged, centralized, and specialized. These conditions of necessity, proximity, and familiarity tend to increase the frequency of innovation (Fitzhugh 2001), and it would be interesting to trace the dialectic between operational chains and changing production environments.

We used the term "engender" in its traditional meaning—"to produce, to generate, to bring forth." By engendering operational chains we hoped to combine the *chaîne opératoire* concern of the interplay between humans and objects with a Marxist concern for how this interplay could be embedded within a production regime. As Dietler and others note, our broad treatment of beverages is not well suited to talking about specific examples, and we were unable to go into gender roles in the space of this article. Dietler, Hastorf, and Sigaut raise important issues regarding the role of women in alcohol production that should be discussed. Women often produce alcohol, and this control over the drink can be a source of conflict today (Holtzman 2001) just as it was in eighteenth-century Britain. In other cases, men make alcoholic beverages, especially when production occurs outside of the home (see Everett, Waddell, and Heath 1976 and Heath 1995 for discussions of cross-cultural gender roles). Gender roles governing food preparation are often deeply rooted (Weismantel 1988), and four of the five beverages we discussed were mass-produced predominantly by men during the broad periods upon which we focused (corn beer is the exception). We need much more research on how gender roles affected feasting strategies.

As Dietler points out, one area of our discussion that fits well with an expanded discussion of gender is the demand for labor. Control over sufficient labor at critical periods in a beverage's operational chain was an important hurdle in the pursuit of political power. Polygyny and other kinship strategies could be used to increase labor supplies, but the scale of the feast would be limited by the size of the kin pool. How leaders overcame these limits is an important area of archaeological inquiry, and perhaps changes in gender roles are part of the answer. Engineering shifts in gender roles might have made it easier in some societies for brewing to be done at a larger scale in a centralized location away from the control of women and families. If so, we will need to examine how elites were able to manipulate these deeply rooted roles.

As Dietler, Hayden, Ikram, LeCount, and Smalley note, we focused on the activities that occurred when the beer was brewed and the wine was made. They astutely point out that an examination of the operational chain before and after manufacture can also be used to consider aspects of political economy. As Hayden describes for the Hmong, significant outlays of land, labor, and resources are needed to produce the surplus rice used to make beer for local feasts. I have looked at the maize and land requirements needed to make corn beer for feasts in the Andes (Jennings n.d.). According to my calculations, it took as much as 870 kg of maize to make sufficient alcohol for 100 guests. Although this amount of corn may seem impressive, it could be produced from 0.6 hectare of land. An important next step in developing the approach that we have outlined is to compare the costs of surplus production for the ingredients used to make these alcoholic beverages.

We also did not have the space to explore at length the implications of the differences in the shelf lives of the beverages. I agree with Dietler, Ikram, LeCount, and Smalley that the long shelf life of wine and pasteurized rice beer had important implications for the ways in which it could be used at feasts. Longer shelf life allows these beverages to be curated and exchanged over greater distances and, as we stressed, facilitated staggered production and centralization. The commentators further point out that this also helped to sever the link between producers and consumers and allowed these drinks to rise to the level of haute cuisine. These additional points reinforce how changes in production chains, coupled with technological and cultural innovations, can lead to substantial changes in political economy. If rice beer had remained unpasteurized, what would have been the implications for the Shang Dynasty? What if the Incas and the earlier civilizations of Peru had found a way to keep corn beer fresh for years?

McGovern and Samuel note possible errors in the article that should be addressed. McGovern argues that wine yeast (*S. cerevisiae*) is not airborne. It is true that S. *cerevisiae* spores do not generally become airborne, being contained in an asci that does not rupture at maturity. We never said otherwise. What we said was that pulque was either fermented using a starter containing wine yeast or left open to airborne yeasts. During this open fermentation process, there are many different varieties of airborne bacteria, yeasts, and other microorganisms that can contribute to fermentation (Sanchez-Marroquin and Hope 1953). McGovern also suggests that the term *qu* is more widely used than *jiu ou* to refer to the fermentation agent used to make rice beer in China. A great many fermentation agents were used, and these terms changed over time. *Jiu ou* was one of these terms (Xu and Bao 1999), but I agree with McGovern that the more common term *chhü* (or *qu*) is the one that we should have used (Huang 2000:117).

Samuel mentions possible errors in our definition of hydrolysis, our description of the interaction of starches and water at low temperatures, and our definition of malt. I fail to see any error in the first two, and the third claim is based on what I feel is an overly narrow definition of malt. Hydrolysis is the breakdown of organic materials through the use of water. Starch is a homopolysaccharide of D-glucose units joined together by an α1,4-glycosidic bond. Hydrolysis breaks the bonds in the long glucose chains that form starches. For hydrolysis to occur, starch grains must come into contact with water and the enzymes that can break down the bonds. Starch grains are often resistant to penetration by water at room temperatures because the attraction of hydrogen bonds makes them wind tightly together. Heat weakens these bonds (Goyal 1996). We chose not to go into detail, but our general account of the biochemistry of alcohol production was accurate and well referenced.

Samuel is correct in faulting our implied definition of malt within the traditional schema of the brewing of beer made from wheat, oats, and barley, in which malt is created through the germination of seed grains. We used the term "malt" to designate any starchy substance that has been introduced to enzymes capable of breaking down starches into more simple sugars. This definition of malt is more inclusive of cross-cultural brewing practices, and I feel that we made clear how we were using the term. I would welcome a discussion with Samuel on these issues and possible others.

The commentators agree on the importance of linking food production to feasting in the archaeological record and have offered a number of fruitful avenues for further inquiry. Gastropolitics is immensely important, and we must remember that it began long before the first toasts were made. By tracing the operational chains that produced the food and drinks consumed at events, we may be better able to understand the pressures that hosts faced and the means by which they overcame them.

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