Sweet Beginnings

Stalk Sugar and the Domestication of Maize

by John Smalley and Michael Blake

Elaborating on the recent suggestion by Hugh H. Iltis that the direct ancestor of maize was initially domesticated not for its grain but for its sugary pith or other edible parts, this article proposes that during the initial period of maize domestication the stalk provided a key source of sugar for many uses, including the making of alcoholic beverages, and that the social importance of alcohol production helped precipitate its early and rapid spread. Several lines of evidence are examined to evaluate the merit of this hypothesis, and topics for further archaeological research that might contribute to this effort are suggested.

John Smalley studies the role of alcohol use in early agricultural societies and sedentarization in hunter-gatherer societies, with a focus on the Tarahumara of northern Mexico. His interest in maize stalk sugar dates to a period 20 years ago in which he grew sweet corn commercially and became aware of the very sweet taste of the sap in the stalk. Born in 1945, he has a B.A. from Simon Fraser University [1992] and a diploma in education [guidance studies] from the University of British Columbia [1996].


The present paper was submitted 15 v 02 and accepted 8 v 03.

1. Many people have taken the time to discuss these ideas with us over the past few years, and we thank them for their insights and suggestions: Hazel Ackner, Bruce Benz, Bert Brink, Brian Chisholm, Christine Hastorf, Warren Hill, Hugh Iltis, David Kaplan, Bill Litzinger, Dana Lepofsky, R. G. Matson, Michael Oltean, Dolores Piperno, Mary Pohl, Christia Roberts, Alf Siemens, and John Staller. We are indebted to four anonymous reviewers for their helpful comments and suggestions.

Teosinte (Zea mays ssp. parviglumis) appears now to be the most widely agreed-upon candidate for the ancestor of domesticated maize (Z. mays ssp. mays), but there are, at best, only partial answers to questions of how, when, and where this process took place [Wilkes 1967; 1985; Beadle 1980; Iltis 1972, 2000; Matsuoka et al. 2002]. In a break with conventional wisdom, Hugh H. Iltis [2000:36 and quoted in Crosswhite 1982] has recently suggested that the direct ancestor of maize “was initially domesticated not for its grain but for its sugary pith or other edible parts.” We elaborate on his suggestion by proposing that during Zea’s initial period of domestication the stalk provided a key source of sugar for many uses, including the making of alcoholic beverages. Furthermore, we suggest that the social importance of alcohol production was a precipitating factor in Zea’s early and rapid spread. In this paper, we examine several different lines of historical and archaeological evidence to evaluate the merit of this hypothesis. We propose that a new research focus on the development of the sweet stalk may help to shed light on both the evolution and the dissemination of maize.

This idea is not as strange as it might initially seem. Sugar and other sweeteners have long been important components of the human diet. In the Old World, the sugarcane plant (Saccharum officinarum) came to dominate the commercial market for sugar—both as a general sweetener and for making alcohol—about 1,000 years ago [Mintz 1985]. It was initially domesticated in the humid tropics of Pacific Asia and spread throughout the world because of the demand for sugar. In the New World there were very few indigenous sources of sugar. Surprisingly, however, one of those sources was the genus Zea (including various species and subspecies of maize and teosinte), a close relative of sugarcane. In fact, maize and sugarcane are both members of the Andropogoneae tribe in the grass family [Graminiae or Poaceae] [Clayton and Renvoize 1986:28]. Some researchers have claimed that the genus Saccharum can cross with Zea, producing infertile hybrids [Janaki-Ammal 1938; Mangelsdorf 1974: 72–73], but others consider this claim unproven [Clayton and Renvoize 1986:331]. Whether or not they are able to hybridize, both sugarcane and maize stalks produce sweet juice which can be easily extracted and its sugar concentrated for use in making syrup and alcoholic beverages.

The possible use of maize’s ancestor as a source of sweet juice has fascinating implications for some of the key questions about maize’s domestication and spread. For many decades, researchers have focused almost exclusively on the cereal crop significance of early Zea use and have seldom considered that, initially at least, the plant may have had other uses. While this has not limited the extremely productive debates about maize’s origins and spread, it has perhaps channeled discussions and research in such a way as to give preference to interpretations that rely on Zea’s evolved characteristics [i.e., large cobs, many large kernels, and storability] rather than its initial ones [i.e., small, hard kernels, small cobs, and sweet stalk]. We will examine ethnographic
been included. Fermentation of maize may increase the amount of protein because of the growth of microorganisms [Super and Vargas 2000]. Many of the amino acids in collagen are nonessential and can be manufactured in the body. This means that some of the carbon in collagen may come from sources other than protein.

As Smalley and Blake point out, stable carbon isotope ratios in bone carbonate may be a better indicator of small amounts of C₄ plants in the diet, since carbonate incorporates carbon from dietary carbohydrates, fats, and protein not used in protein synthesis. Increasingly, stable isotope studies now include stable carbon isotope ratios from both bone carbonate and bone collagen.

In our attempts to determine whether dietary protein and whole diet were isotopically similar among peoples of highland Ecuador [Ubelaker, Katzenberg, and Doyen 1995], we found that the carbon isotope ratios of collagen and carbonate were closely correlated. We included analyses of biological apatite in order to determine if some of the animal protein in the diet was from domesticated animals consuming C₄ plants. We interpreted the close correlation of stable isotope ratios in the two tissues to indicate that both protein and whole diet were similar in their stable carbon isotope ratios. We also concluded that the small difference observed between high- and low-status individuals was due to consumption of maize beer. This conclusion was based on evidence from ceramic vessels and from the stable isotope results. For beer to cause a difference in the δ¹³C of carbonate versus collagen it would have to contribute more carbon to the carbonate [most likely as carbohydrate] than to the collagen [most likely as protein], but this does not appear to be the case. There are small but significant differences between δ¹³C in high- and low-status individuals for both collagen and carbonate.

What these two studies suggest is that, through stable carbon isotope analysis, one would be more likely to pick up consumption of a maize or teosinte beer than to detect consumption of sugar from chewing on maize or teosinte stalks. It would be helpful to carry out nutritional analyses of traditional maize beer.

Augusto Oyuela-Caycedo
Department of Anthropology, University of Kentucky, Lexington, Ky. 40506, U.S.A. (aocayce2@uky.edu).

Explanations like the one proposed by Iltis [2000] and refined by Smalley and Blake help us to break away from the classical preconceptions of a conjectural archaeology (Stoczkowski 2002) toward more realistic views. The stalk-sugar hypothesis helps us to account for the inconsistencies in the evidence recovered from carbonized remains, pollen, starch, and phytoliths in the search for the magical yellow kernel or cob. Differences remain as to where maize was first domesticated. The early presence of maize in Peru, Ecuador, Panama, and Colombia [Piperno and Pearsall 1998] associated with a lithic technology of seed processing lends weight to the argument that the consumption of maize occurred earlier in these locations than in Mesoamerica. Differences also exist in terms of how much maize contributed to the diet and in what form it was used.

In the case of San Jacinto 1 and 2 in the savannah lowlands of northern Colombia [at 200–500 m.s.l.], some evidence clearly supports the arguments of Smalley and Blake. San Jacinto 1 is a special-purpose site, one of a variety of sites generated in the landscape by collectors. It has the earliest fiber-tempered pottery in the New World, dating between 6,000 and 5,300 B.P. [uncalibrated], and this pottery was used for serving and even fermentation rather than for cooking (Oyuela-Caycedo 1995, Pratt 1999, Raymond, Oyuela-Caycedo, and Carmichael 1998). Cooking vessels that use sand temper appear around 5,300 B.P. in San Jacinto 2, as well as in Monsu, Puerto Chacho, and Puerto Hormiga and in Ecuador and Panama (Oyuela-Caycedo 1996, Raymond 1998). The abundant ground-stone technology, especially manos and metates, at San Jacinto 1 indicates a processing of grains for flour, and the large number of earth ovens indicates a seasonally consistent use for steam cooking (Oyuela-Caycedo 1998). New evidence indicates that the Poaceae and starchy parenchyma that were used at the site were maize [Oyuela-Caycedo and Bonzani n.d.]. Judging from the case of San Jacinto, it can be indirectly argued that maize was used for the extraction of sugar and fermentation. Direct proof is lacking, but the context of the pottery seems to support its use for serving liquids on special social occasions (pottery was not abundant but was highly decorated). We have contextual evidence of the use of seeds for flour and the cooking of possible “tamales” in the earth ovens and their consumption at the site.

The cycle of mobility, territoriality [Oyuela-Caycedo 1998; Binford 2001:375], and social aggregation [see Dilley et al. 2003] must be important in understanding the stalk-sugar hypothesis, but, surprisingly, these aspects are not considered by Iltis [2000] or by Smalley and Blake. Maize was a secondary source of food because of its limited availability in time [dry season] as well as in space (floodplain and the banks of rivers and creeks). It was probably cultivated at the end of the rains on the fertile, cleared areas of creek and river banks and collected in the dry season three to five months later. Environments with a strong dry season, such as at San Jacinto and Loma Alta or Real Alto in Ecuador, favored the occasional seasonal processing of maize as a beverage, for sugar extraction, or for consumption as a meal. Understanding of the timing or seasonal constraints of maize production is a key aspect [see Bonzani 1997, 1998] that may reinforce the stalk-sugar hypothesis of the evolution of teosinte to maize.

The process of the domestication of maize must have begun a long time before San Jacinto 1 was occupied by territorial forager populations. Much of the archaeological research on maize is concentrated on highly visible sites when the early stages of domestication of maize or wild maize or teosinte probably took place on the banks of creeks, rivers, and lakes after the water had receded.
(see Denevan 2002:95). The planting or natural occurrence of this resource was most likely concentrated, making it easy to harvest during the dry season in the Tropics.

The complexity of the subsistence strategies of foragers and collectors needs to be reexamined. The importance of other plants that were exploited and managed, such as gourds, roots, and palm fruits, is only starting to emerge (Dillehay and Rossen 2002). We are still far from understanding the complex technological and cognitive capacity of “hunter-gatherers” and their patterns of food consumption in conjunction with environmental constraints (Bonzani 1998) and social storage (Binford 2001:171). With explanations like the one presented by Smalley and Blake, we can start to move along the right track of studying an unknown past without biased preconceptions. With more intensive research in the tropical lowlands we should be able to resolve the issue of the origins of maize from a biological, archaeological, and social perspective in a few years.

DEBORAH PEARSALL
Department of Anthropology, University of Missouri–Columbia, 107 Swallow Hall, Columbia, Mo. 65211-1440, U.S.A. (pearsalld@missouri.edu).

Smalley and Blake are to be commended for a thorough job of reviewing the ever-growing literature on maize domestication and for providing a succinct summary for this paper. The historical and ethnographic reviews of maize-stalk sugar use are also helpful and informative.

I also consider it likely that teosinte was initially harvested for its green fruits or sweet stems and that successive harvesting and planting of seeds to increase supplies of the plants led to the emergence of the nonshattering maize cob with its naked seeds and a shift in focus to use of those seeds [kernels] (Piperno and Pearsall 1998:161). I am uncertain, however, whether the hypothesis that the initial use of teosinte/early maize was as a sugar source is testable, at least through phytolith analysis. At present only maize leaves and leaf-derived tissues [such as husks] and maize cob residues [soft and hard glumes, cupules] can be identified archaeologically by phytoliths; identifying silica deposited in stalks has not been a focus of research (see Pearsall 2000 and Chandler-Ezell, and Chandler-Ezell 2003 for details on the existing identification methods). Much of the silica in maize stalks is amorphous, although some fibers, vascular elements, and epidermal cells are recognizable. The established maize diagnostics do not occur in stalks. Perhaps it might be possible to establish criteria for identifying stem-derived silica [rather than leaf- or inflorescence-derived silica] on tools or human dentitions; only future research will tell.

One aspect of the paper that particularly intrigues me is the difference in the archaeological evidence for maize-stalk chewing between Mexico and Peru. While the evidence is not abundant for either region, being limited to dry caves in Mexico and dry caves and the desert coast in Peru, the apparent lack of evidence for the chewing of maize stalks in Peru suggests to me that human interest in maize had shifted to grain production by the time the crop was introduced into South America. (A quick review of Towle 1961 yielded no references to maize quids from coastal sites.) Once maize spread outside the range of teosinte, kernel and cob size were no longer constrained by crossing with ancestral or weedy Zea relatives. The subsequent increase in maize productivity—larger kernels and larger cobs—that emerged through the process of harvesting and planting eventually produced a plant that could compete in yields with native South American root and tuber crops such as manioc [Manihot esculenta]. I believe that we need to consider the apparent delay in the emergence of maize as a dietary staple in South America in the context of the productivity of a diverse array of native root crops and to consider that evidence for forest clearance may also be indirect evidence of these crops. Why grow some relatively unproductive maize along with root crops? Like other annual seed crops, maize is easy to store, high in protein, and quick-growing and can either be eaten green or grown for harvest of mature seeds. The dominance of maize late in prehistory in western South America may also relate to its greater ease of storage and transport in comparison with other crops.

Smalley and Blake suggest that increasing evidence of cob and kernel accumulation in and around archaeological sites could be used to argue for a shift from stalk processing to grain production. While it is true that any use of maize that requires heat [parching, toasting, roasting, stewing] would increase the likelihood that kernels and cob fragments would enter the archaeological record as charred remains, the absence or rarity of charred maize is more difficult to interpret. Was maize rarely charred earlier in prehistory because stalks, not kernels, were the focus of production, because garbage disposal practices did not include burning of food residues, or because fragile charred remains were destroyed over time in deposits?

Finally, Smalley and Blake ask what proportion of the maize phytoliths from house deposits at Real Alto reported in Pearsall (2002) came specifically from stalks and leaves and what proportion from maize cobs. The evidence for maize at Real Alto reported in Pearsall (2002) is based on the presence of cross-shaped phytoliths, which are produced in maize leaves and husks. Maize stalks do not produce these bodies. Research in progress on the analysis of food residues on stone tools and human dentitions from Real Alto should shed new light on the issue of domestic versus ceremonial use of maize and on its importance relative to other crops.

DOLORES R. PIPERNO
Smithsonian Tropical Research Institute, Balboa, Republic of Panama (pipernod@tivoli.si.edu).

This fine article presents an intriguing and plausible hypothesis for why maize was disseminated out of its Mex-
ican cradle south into the tropical forest of Central and South America during the Archaic period and, indeed, why teosinte was originally brought under cultivation and domesticated. We still do not have archaeological sequences from Mexico pertaining to the earliest history of maize, so we cannot yet specify whether the fruitcases of teosinte were initial targets of selection pressure by nascent *Zea* cultivators. I have a feeling that at the outset most important domesticated plants, including maize, were used as food. Nevertheless, it is clear that *chicha* production and feasting were important aspects of social relations in many regions of the Americas. Smalley and Blake’s paper lucidly and appealingly discusses these issues and will cause scholars to think about maize domestication in new and important ways.

The discussion of possible skews in bone collagen isotope ratios resulting from maize consumption primarily as calorie-rich stalk sugar or grain *chicha* is very interesting, and it highlights the growing importance to debates about maize of having good data on the bone apatite fraction. I have questioned (Piperno 1998:427–28) the appropriateness of using bone isotopes, especially collagen, from the standpoint of detecting maize consumption in the kinds of mixed tropical horticultural economies now well-evidenced from several sites in southern Central America and northern South America dating to between ca. 7,000 and 5,000 B.P. (Piperno and Pearsall 1998, Piperno et al. 2000). In these situations, many calories came from C₃ plants such as manioc, other roots and tubers, and tree crops. I was especially worried about what *chicha* drinking practiced as part of periodic ceremonial activities would do to those ratios. Smalley and Blake’s consideration of how drinks made from maize stalk sugar and the grain might directly suppress a collagen bone isotope signal for maize relative to that expected for nonbeverage grain consumption adds an important new dimension to this problem.

I think that before we head straight to the ramifications of maize as an alcoholic beverage, we ought to consider more the role of *chichas* as important sources of dietary calories and fats. While it is true that one could ferment just about anything quickly in the tropical heat, nonalcoholic kinds of *chichas* made from any number of fruits and grains, including maize, are routinely consumed in the Neotropics today. These drinks, whether fermented or not, are typically high in calories and fats and may well have formed important dietary inputs and supplements in the pre-Columbian era, even if maize *chichas* were made from relatively small-grained maize cobs. One can imagine that expert horticulturists in the tropical forest south of Mexico would have welcomed the odd maize plant and, forever seeking new ones to make drinks with, quickly experimented with its beverage-making capacities.

Bone isotope ratios on collagen from the preceramic site Cerro Mangote in Panama indicate moderate maize consumption between 7,000 and 5,000 B.P., when starch grain and phytolith evidence from nearby contemporaneous sites also clearly evidences routine processing of kernels (Norr 1995; Piperno et al. 2000, 2001). It seems that in Panama an early and appreciable focus was put on the maize grain, but, as Smalley and Blake indicate, separating beverage from kernel consumption will be difficult even when maize kernel remains are retrieved because the processing techniques for the two were probably the same or very similar and regional variability in maize use and production was probably considerable.

In the Americas more than in southwestern Asia and Europe, the roles of specific crop plants and their dietary contributions varied across regional boundaries and changed through time in ways that we are starting to detect in archaeobotanical records (e.g., Piperno and Pearsall 1998, Perry 2002). In light of the considerable empirical evidence for maize consumption dating to the Archaic period in southern Central America and northern South America (ca. 7,000 to 5,000 B.P., depending on the region), moving from a debate about whether maize spread out of its Mexican hearth before it became a staple crop to discussions of alternative uses of early maize represents a timely shift in research direction. Smalley and Blake have made a very significant contribution.

ROBERT H. TYKOT
Department of Anthropology, University of South Florida, 4202 E. Fowler Ave., SOC 107, Tampa, Fla. 33620, U.S.A. (rtykot@cas.usf.edu). 22 VII 03

Smalley and Blake offer a very reasonable hypothesis for explaining the widespread diffusion of maize after its initial domestication from teosinte in west Mexico. Many agree that the small cobs of early maize plants would not have been very attractive substitutes for the wild and/or cultivated foods already being consumed in different regions, but few alternative explanations cohere with archaeological and other data have been proposed. While some have similarly hypothesized an early social rather than economic role for maize, particularly in the form of *chicha* beer fermented from maize kernels (e.g., Staller and Thompson 2002, Tykot and Staller 2002), their hypothesis is provocative in suggesting that it was the sugary stalk which was initially important. But is their hypothesis supported more than others by the available archaeological and other data?

The impressive assemblage of ethnohistorical examples of maize stalk sugar use presented serves as a very plausible explanation for the chewed stalks recovered at the Tehuacán Valley cave sites, but, unfortunately, quids have not been identified at early archaeological sites elsewhere, even in the dry caves of Tamaulipas, Guatarrero, and Ayacucho where maize remains have been found. Is this simply because maize was not chewed and discarded in these caves on a regular basis? [There is, of course, no question that these cave sites cannot be considered representative of habitation sites and the activities which would have occurred at them and therefore this is absence of evidence rather than evidence of absence.]

While it is also unlikely that maize macro-remains could be recovered from an open-air site, it is very possible that an area of modestly intensive maize activity
could be identified through systematic analysis of soil samples for maize phytoliths, starch grains, and carbon isotope ratios. Systematic analysis of anthrosols is becoming more common in archaeology and has potential for contributing to our understanding of early maize use, especially if stalk and cob remains can be differentiated (see Thompson and Staller 2000, Piperno et al. 2001, Pearsall, Chandler-Ezell, and Chandler-Ezell 2003).

At present, though, it is stable isotope analysis of human remains which has shed the most light on the quantitative importance of maize at different times and in different places. While significantly more published (e.g., Tykot 2002) and unpublished data are available than are presented by Smalley and Blake, their table 2 does give a fair overview of the contribution of maize to carbon isotope ratios in bone collagen. But it is not surprising that there is a major gap between the first documentation of maize by paleoethnobotanical evidence and its becoming noticeable in collagen carbon isotope ratios. The difference in ratios between C₃ plants and maize (about 14‰), the precision of a single isotopic measurement (usually no more than ± 0.2 for reference materials on most mass spectrometers but at least double that for skeletal samples), and the isotopic variation that is likely to exist within a population eating the same range of foods combine to require a positive shift of at least 1‰ to indicate the consumption of any non-C₃ foods. More important, maize would have to constitute at least 10% of the protein portion of the diet to produce noticeably different carbon isotope ratios in collagen. If maize stalks were initially important as a sugar source (fermented or not), they would contribute hardly at all to collagen, but the contribution of maize cobs to collagen would also be very minor if terrestrial and/or aquatic fauna were consumed in any quantity.

Carbon isotope ratios in bone apatite and tooth enamel would, however, reveal when maize constituted 10% of the total diet, whether in the form of protein, carbohydrates, or alcohol. Unfortunately, far fewer isotopic analyses have been done on apatite and enamel, especially for earlier time periods. Both bone collagen and apatite reflect average diets over at least several years prior to death, and therefore maize’s isotopic contributions will be reduced if it is not consumed consistently from year to year. Further, it is likely that, prior to the establishment of storage facilities, maize was consumed mostly on a seasonal basis. The best way, then, to demonstrate the initial consumption of maize would be by analysis of hair or tooth enamel. Analysis of 1-cm lengths of hair would reveal dietary variation from month to month, while careful microsampling along a vertical transect of a tooth could also reveal seasonal variation. One study done of individuals from highland Ecuador shows a difference of at least 30% in maize consumption from season to season (Tykot, Ubelaker, and Wilson 2000). Since the available evidence strongly indicates that maize did not become a staple in many areas despite being present early on at great distances from highland Mexico, I agree wholeheartedly with Smalley and Blake that we must look for explanations other than its later importance as a cereal crop to account for its precocious spread throughout Mesoamerica and in much of South America. Their hypothesis is very sound, but more research is necessary to test whether it explains well the motivation and circumstances behind the initial domestication and spread of maize.

Reply

JOHN SMALLEY AND MICHAEL BLAKE
Vancouver, B.C., Canada. 7 viii 03

In his 1940 doctoral dissertation, written under the direction of Carl O. Sauer and published 60 years later, Henry Bruman (2000:57) observed:

Sugarcane, entirely unknown in aboriginal America, was one of the first economic plants to be introduced by the Spaniards. However, a sweet cane in the broader sense was not only known but widely utilized prior to the Conquest. The Indians had learned that green cornstalks contained considerable sugar; and in many and widely separated areas, it was common practice to crush the stalks, collect the juice, and boil it down to a syrup.

Hugh Iltis, in his address as Distinguished Economic Botanist to the Society for Economic Botany in 1998, after decades of research on teosinte, asked why ancient Native Americans would have been interested in it and suggested that “teosinte was not grown for its grain, but for other culinary virtues,” the primary one being its “sugar-containing pith” (Iltis 2000:30). We are pleased that most of the commentators assess our paper in the spirit in which it was offered—as an exploration of the archaeological intersections of these two pioneering contributions. Most of the respondents recognize that we were suggesting an initial hypothesis about why and how teosinte was domesticated and its descendant, maize, came to be one of the dominant food plants of the ancient New World. We are indebted to them for insightful suggestions and new ideas that will, we think, help guide future research on the topic.

Chavez’s report of the lack of ethnohistoric and ethnographic evidence for the chewing or processing of maize stalks for sugar in Peru and Bolivia raises some important questions. It may be that in the Andean region there was a long-standing use of maize stalks as fodder for domesticated animals and that present-day herders and farmers rely on the maize plant for its fodder potential. This suggests the possibility that prior to the widespread introduction of sugarcane pre-Columbian Andean peoples extracted sugary juice from the stalks and then fed the debris to their camelids and other domesticated animals. Although Chavez says that no early South American chroniclers mention the chewing or processing of maize stalks, Garcilaso de la Vega [1966 [1609]: 499] reports that “an excellent honey is made from the...
unripe cane, which is very sweet. The dried canes and their leaves are of great value, and cattle are very fond of them.”

Chavez observes that, in contrast to parts of Mesoamerica, the Andean region already had two sources of easily cultivable plants that could have produced fermentable sugars, potato and quinoa. Their presence may have lessened the need or desire to use maize stalks for their sugar content, and they may have retained greater value as animal fodder as he states. This point also supports Pearsall’s comment that “human interest in maize had shifted to grain production by the time the crop was introduced into South America.”

DeBoer, Pearsall, and Tykot also note that maize stalk quids have not been recovered in South American archaeological sites. Is this simply a matter of preservation, or could it be that the casual chewing of stalks for the sugary pith was simply not practiced south of Mesoamerica? The South American cave sites where maize remains have been recovered also contain the remains of camels, among many other species. The increasing dominance of camels in the faunal assemblages has led many to suggest that they were being domesticated—and certainly domesticated camels were common by the time domesticated maize was present (e.g., at Guatarrero Cave [Wing 1980:136]). We suggest that these domesticated animals may have consumed the quids and other stalk remains as Garcilaso de la Vega reported for cattle.

DeBoer’s observations about Amazonian forager-farmers’ using manioc, maize, and other plants to make beer for celebrations and drinking parties rather than for sheer survival are particularly relevant to our model. This directly relates to the important social lubrication that beer may have provided and its role in facilitating seasonal aggregations of widely dispersed communities. The ethnographic literature documents this throughout Latin America where alcoholic beverages were produced. How far back this pattern extends is the subject of current research, but we should consider the possibility that maize stalk beer was but one example of this larger social process. Archaic peoples may have been eager to find ways of creating novel foods and drinks for social gatherings and feasts, and maize stalk beer may initially have been one such source of novelty (Hayden 2003).

DeBoer questions whether large numbers of ceramic drinking vessels at a site would necessarily indicate frequent or large-scale beer drinking. We agree that the presence of serving vessels in an assemblage is not sufficient for the interpretation of a beer bash, but some sort of serving mechanism is a necessity. In order to make more reliable interpretations of vessel functions, it will be necessary to study many attributes besides shape to determine which pots were devoted to serving food and drink and which were used for cooking and storage. For example, we would expect serving vessels to show much more elaborate decoration. Cooking vessels should have temper characteristics that help them resist thermal shock. Oyuela-Caycedo presents an intriguing example of this pattern. He and his colleagues have found very early fiber-tempered pottery used for serving and fermentation. His study and others (e.g., Chavez, Arthur 2002, Staller and Thompson 2002) have identified chemical and microbotanical residues in ceramic vessels and should allow us to catalogue the range of uses of individual vessels and ultimately help distinguish vessels used for manufacturing and consuming beverages.

With regard to identifying vessels used to produce stalk beer versus maize kernel beer, Chavez reminds us of the need to develop methods of distinguishing between stalk and cob phytoliths. At present, as Pearsall points out, “only maize leaves and leaf-derived tissues (such as husks) and maize cob residues (soft and hard glumes, cupules) can be identified by phytoliths.” Ongoing research by maize phytolith experts such as Pearsall, Chandler-Ezell, and Chandler-Ezell (2003) may provide new means of differentiating between stalks and the other parts of the maize plant (and also between different species and subspecies of Zea).

Chavez’s evidence from excavations at sites on the Copacabana Peninsula in Bolivia supports our observation that the consumption of maize as a primary food staple did not become widespread until after about 3,000 B.P. Could the maize phytoliths he reports in dental plaque and in residues on cooking vessels and the low frequency of maize macrofossils in flotation samples be a result, as suggested earlier, of the use of agricultural plant debris as fodder for domesticated animals living in and around settlements? This argument is not wholly satisfying, because maize remains do become more common in later sites, when presumably there were even more animals around.

Eubanks provides an elegant hypothesis for the hybridization of Tripsacum and Zea, both of which have sugary stalks. The first implication of her suggestion is that early farmers may have used and even encouraged hybrid crosses to take advantage of the resulting increased sugar yields. The second is that this hybridization process could have accounted for the development of primitive cobs in early Zea. This scenario, which will undoubtedly be tested with new genetic data, fits well with Ilitis’s (2000:27) observations concerning Beadle’s “great teosinte mutation hunt” in 1971. The absence of observable mutations in about 70,000 teosinte plants and over a million fruitcases suggests that teosinte may never have spontaneously mutated on its own to become maize. Instead, the hybridization of teosinte and Tripsacum, outside of teosinte’s natural habitat, could have produced the early cobs that later became the object of so much human interest. The stalk-sugar hypothesis provides the mechanism for the initial planting of teosinte outside its natural habitat, leading to the opportunity for hybridization, perhaps first for sugary juice (which Eubanks points out is dramatically increased in Tripsacum-Zea hybrids) and only later for seed-bearing cobs.

Piperno observes that experimentation with the beverage-making capacity of maize could have accounted for the early grinding implements and starch residues in Panama. She notes that horticulturalists could have been primed to experiment with any new plant that became
available. We should not forget that people may have begun to grow maize, as a supplement to a wide range of existing cultivars, simply for its taste and its novelty—possibly at a time of the year when such foods were most appreciated [see also Oyuela-Caycedo].

Gremillion’s argument that the absence of evidence for teosinte seeds in the archaeological record should not be taken as the basis for rejecting the food uses of teosinte is somewhat hard to follow. Teosinte seeds are extremely durable. If charred, they would be likely to last for millennia in the archaeological record [as are charred maize kernels]. Their near absence from archaeological sites in Mesoamerica would be surprising if indeed they were an important food source. Other small seed plants that were consumed regularly leave behind macroremains—either charred in open-air sites or desiccated in dry cave sites. Where small seeds were being harvested for food, then the potential for large numbers’ eventually making their way into the archaeological record by several pathways is high [Pearsall 2000:242]. Even in the humid Neotropics, charred seeds 1 mm or less in diameter are regularly recovered by modern flotation techniques. Iltis joked in his 2000 article [p. 27] that “[George] Beadle delighted in bringing with him a bag of Chicago-baked ‘teosintillas’ into the field and ‘experimentally’ feeding them to his captive associates, with an encouraging ‘not bad-tasting, eh!’ [Oh yeah! Made up of ground up grains but also woody fruitcases (cupules and glumes), they tasted nothing so much as salted, dry, brittle brown cardboard, an unacceptable candidate for human food, even if fed to us by a kindly Nobel Laureate].”

Katzenberg points to the significance of variation in δ13C values of bone carbonate versus collagen in individuals and the implications for the consumption of protein and carbohydrates. We agree that the best way to see the impact of maize beer consumption on δ13C values is to undertake nutritional analyses of maize beer and, as Piperno suggests, its nonalcoholic cousins) under controlled circumstances. Another useful future study would be the analysis of feeding experiments using traditional maize beer, maize, and C₄ plant alcohol. Such experiments are currently being planned by Brian Chisholm in the Archaeochemistry Laboratory at the University of British Columbia.

Tykot’s point about the large proportion of maize in the diet (> 10%) that is necessary for it to be isotopically visible is an excellent one. This is especially useful in rethinking the long-term trajectory of maize consumption in various parts of the New World. The timing of maize use as a staple may be revealed by comparing collagen withapatite δ13C values. As he suggests, it will be helpful to examine much larger samples of isotope data, particularly forapatite, in order to interpret the role of maize in the whole diet and not just the protein contribution.

Oyuela-Caycedo brings up the important point of modeling the early use of maize in relation to the broader issues of hunter-gatherer mobility and subsistence strategies. His work at San Jacinto indicates that maize was used seasonally in several forms: as a beverage, for sugar extraction, and for direct consumption. We agree that the key to its early adoption may have been its ability to bridge the wet-season–dry-season food gap. The various species of Zea were, however, grown in an exceedingly diverse range of habitats: from the arid north of Mexico and the Southwestern United States to the Northeast of North America and the tropical lowlands of Central and South America. The initial roles and uses of maize in these different geographic and social contexts must have been quite varied, and it is not possible to create one model for its earliest adoption. In the tropical lowlands it may have been planted on the banks of rivers and creeks after the waters had receded. In highland areas it may have been planted on seasonally watered hillsides or in forest clearings. There are many other possibilities besides. Maize’s ability to adapt to a wide range of environmental conditions [Muenchrah and Salvador 1995] makes it uniquely well suited to transportation and spread far beyond its homeland for many uses ranging from food to drink.

References Cited


MAC NEISH, R. S. AND M. W. EUBANKS. 2000. Compar-


Smalley and Blake  
Stalk Sugar and the Domestication of Maize | 703


