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Reviewed Article:

Experimental Recreation of a Pumpkin (Cucurbita spp.) Leather Mat

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The ethnohistoric record from the American Great Plains indicates that dried pumpkin (*Cucurbita spp.*) strips were often woven into mats as a form of food storage. This form of food storage was likely employed over large geographical areas and deep in time, but archaeological methods for identifying their production and use have been wanting. This experiment used ethnohistoric records to re-create pumpkin mats using bone and stone tools, with special attention to the types of residue and by-products created. We found that

while formal bone tools could be used with pumpkin, simple flake stone tools were more efficient. Two pumpkin mats were produced, one in which the rind had been charred and removed prior to processing and one with a raw rind; the raw rind mat succumbed to mould while the charred pumpkin mat was temperature stable for more than two years. Residues were documented on the tools, but the gourd did not contain starch granules, and only the rind (which was removed in this experiment) contains the diagnostic phytoliths. The chaîne opératoire of pumpkin mat manufacture in this experiment explains why microfossil evidence (starch, phytoliths) of the practice has not been recovered in the Great Plains. Without a chemical biomarker, proteomic or ancient DNA approach, the recognition of pumpkin leather mats may remain elusive, which greatly limits archaeological understandings of this important foodway that is closely associated with women's work.

> The creation of pumpkin leather mats on the Plains was considered women's work and labour intensive (Weltfish, 1965; Wilson, 1917). The ethnohistoric record indicates this practice likely occurred in large geographical areas in the American Great Plains covering extended periods of time, yet identifying this practice has been difficult archaeologically.

Introduction

Experimental archaeology allows for investigation into past lifeways that are obfuscated due to preservation issues. In the history of food, this is particularly salient where the organic nature of these incredibly important aspects of individual's lives are less likely to be preserved in the archaeological record (Hastorf, 2021). Experimental archaeology into past foodways provides insight into manufacture techniques, nutritional elements, and taphonomic concerns for understanding past peoples' relationships with traditional foods. In this study, we explore a particularly difficult tradition within the American Great Plains to trace archaeologically: plaited pumpkin (*Cucurbita spp.*) mats. Ethnohistoric evidence for plaited (braided) pumpkin mats guided an experimental reconstruction of two mats. Traditional materials of stone and bone were utilised in the reconstruction of the pumpkin mats and tested for potential microfossil residues. In the discussion, we explore insights gleaned from the experiment as related to the ability to identify this foodstuff in the archaeological record.

Within the North American Great Plains, indigenous foodways revolved around a variety of wild and cultivated crops, which varied greatly over time and space. Within areas of the Plains, squash (*Cucurbita spp.*), was likely utilized in the Archaic[1] (Adair, 2003), with the other two of the "three sisters", maize (*Zea mays*) and beans (*Phaseolus vulgaris L.*) differentially established within the early Ceramic period (~1000 AD/CE) (Adair, 2007; Bozarth, 1998; Drass, 2008; VanDerwarker et al., 2016). Other flora also accompanied these domesticated species, which included domesticated and cultivated taxa like sunflower (*Helioanthus annuus* var *annua*.), Jerusalem artichoke / sunchoke (*Helianthus tuberosus*), amaranthus (*Amaranthus*

spp.), and other plants utilised as foodstuff and for medicinal purposes. American Bison (*Bison bison*), deer (*Odocoiulus spp.*), rabbit (*Lagomorpha spp.*), and various turtles dominate the faunal component of diets as reconstructed in the archaeological record of the region (Drass, 2008; Roper, 2006).

In this study, we explore the *chaine operatoire* for the production of pumpkin mats. As elaborated below, the ethnohistoric record indicates that pumpkin mats were an important part of Plains diets, especially because of their relatively long storage capabilities.

Ethnohistoric Records

There are limited ethnographic records for pumpkin mat production, but two well-known works do provide some understanding of the *chaîne opératoire* for the process. An overview of the process within Pawnee traditions is related in Gene Weltfish's book *The Lost Universe* (1965). The second record comes from Maxi'diwiac or Waheenee-wea, more often called Buffalo-Bird Woman[2], through Gilbert Wilson's work on Hidatsa agricultural practices (1917). Both of these narratives come from the twentieth century, after metal tools had been widely adopted among displaced tribal peoples. The major difference between the two accounts was if the pumpkins were roasted prior to weaving.

The Pawnee account describes the process with roasting the rind first (Weltfish, 1965, p. 246):

"The pumpkin rinds were removed by roasting them in the fire until they could scrape off the outer rind with a fresh-water clamshell. Each individual pumpkin was roasted and set to cool, then scraped. Some people peeled them with a knife, but this was time-consuming and was considered wasteful. Small pumpkins 4 inches or less in diameter were neither roasted, peeled, nor halved-they were simply cut into blocks, laid out on a tent skin and dried. They could be cooked any time now with the large roasted corn to add flavor. The standard-size pumpkins were cut in half, the pulp and seeds taken out, and the halves cut into a series of circular rings each about 11/2 inches wide. They were hung on a rack and when they had dried somewhat were pressed underfoot to express some of the water as was done with the sliced buffalo meat, then hung up again to dry further. At night the pumpkin rings were left on the rack covered with an old tent skin. By the time the mature dried corn crop was coming in, the pumpkin strips would be dry enough that they could be woven into checker-plaited mats. They would alternate the processing of this corn with the making of the pumpkin mats, ri-katsitu "braid-woven".

The plaited pumpkin mats were arm's length and 2 feet wide. The individual strips had shrunk in the drying to an inch in width. It took about two hours to weave a pumpkin mat. In the afternoon, each woman would make two mats before supper. The dried pumpkin was used by cutting off a number of the 2-foot strips in the width with small portions of the cross pieces adhering to them. The very smallest pumpkins about the size of tomatoes were boiled fresh

and eaten in the morning for a breakfast during this harvest period. They were very much relished".

Among the Hidatsa, Buffalo-Bird Woman relates that her practice did not include roasting the pumpkin and demonstrated that a bone knife made of a bison (*Bison bison*) or cattle (*Bos taurus*) scapula could be used to cut the pumpkin into strips (See Figures 1 and 2). Buffalo-Bird Woman described her understanding of squash knives, though she had limited experience at the turn of the 20th century (Wilson, 1917, p. 106):

"Squash knives of bone were still in use when I was young. I have often seen old women using them but, as I recollect, I never saw one being made. The knife was made from the shin part of a buffalo's shoulder bone; never, I think, from the shoulder bone of deer, elk, or bear. The bone of a buffalo cow was best, because it was thinner. If the squash knife was too thick, the slices of squash were apt to break as they were being severed from the fruit. Bone squash knives, as I remember, were used for slicing squashes and for nothing else. A squash knife should be cut from green bone; it would then keep an edge, for green bone is firm and hard. I do not think I ever saw anyone sharpening a bone knife so far as I can now recollect. There was no handle to a bone squash knife, beyond the natural bone. A bone squash knife lasted a long time. Old women in our village who used these bone knives, brought them out each summer in the squash harvest...My mothers used a white man's steel knife for slicing squashes; but as I have said, there were old women in the village who still used the old bone knifes".

Although these are the only two surviving ethnohistoric records for plaited pumpkin mat production, it has been assumed that this was a common practice among a variety of Great Plains peoples. For example, while a narrative on pumpkin processing was not recorded for the Wichita, Edwin Curtis photographed a Wichita woman with a beautiful, tightly woven pumpkin mat in 1927 (See Figure 3).

With these slightly different processes for pumpkin mat production, we chose to make two features of our experiment variable: the roasting of the pumpkin prior to weaving and the cutting of the pumpkin rings with stone or bone tools.

Other references to pumpkin use among indigenous peoples of North America

Gourds were important foods for a diversity of indigenous groups throughout North America beyond the Plains - so important that they are present in several creation myths, such as among Caddo peoples (Elkins Carter, 1995). Historic Jesuit sources from the 1630s to the 1720s referenced that a great asset that pumpkins possessed was the ability to be preserved during the winter months, and especially when other food sources were scarce. Iroquois peoples in the Lake Huron area stored pumpkin in bark-lined storage pits, where the fruit was

stored for consumption during the winter months (Ott, 2012, p. 18). The Iroquois would scrape out the pumpkin to remove the seeds and the unwanted portion of the pumpkin. Afterwards they would cut the fruit into rings, string them together, and hang them to dry. The dried pumpkin provided needed nourishment with a convenient way to pack the food while on trips (where it had the consistency of beef jerky) with little fear of spoilage (Ott, 2012, p. 18). The Illinois Indigenous Tribe scraped out the pumpkins, cut them into rings, and dried them in much the same way as the Iroquois. Pumpkins could be stored for several months, where pieces could be cut and used in boiling pots of meat and corn for flavour (Hurt, 1987, p. 35). In the American southwest, the Pima would place mature pumpkins in storage pits where they would remain stored until February, or even up to April, without the fear of spoilage. In contrast, the immature pumpkins were cut into narrow strips for drying and eaten immediately (Hurt, 1987, p. 46). In these examples among the Iroquois, Illinois and Pima, pumpkin was cut and dried for storage, but there was no reference to weaving the dried strips into a pumpkin mat. In the southeast, the Cherokee and the Creek also raised pumpkin, but there is no mention of storage after harvest within ethnohistoric records (Hurt, 1987, p. 33).

Pumpkins, Squashes, and Gourds

There are six species of pumpkins and squash (*Curcurbita L. spp.*) that are grown worldwide for consumption of their fruit and seeds, with a variety of subspecies and varieties. As fruit and varietal terms including "pumpkin," "summer squash," "winter squash," "gourd," and "cushaw" have been inconsistently applied to the diverse subspecies and varieties of domesticated *Cucurbita,* it is sometimes difficult to distinguish between accounts of different crop subspecies (Kates 2019). In general, *Curcurbita* crops are referred to as pumpkins and squashes, but individually, these crop subspecies are referred to by their botanical name or "pepo pumpkin and squash" for *C. pepo ssp. pepo, "*ovifera pumpkin and squash" for *C.* pepo ssp. o*vifera,* "cushaw" for *C. argyrosperma ssp. argyrospema,,* "giant pumpkin" for *C. maxima ssp. maxima,* "figleaf gourd" for *C. ficifolia,* and "butternut squash" for *C. moschata*, although many common and varietal names can be used to refer to these crop subspecies (Kates, 2019, See Table 1). As the exact botanical origination of *Cucurbita* varietals are unclear for what was used in the creation of what we are calling pumpkin mats, we made the decision to use a small organic orange "pumpkin" variety as it broadly matched the size and shape of the fruit photographed by Gilbert Wilson.

Subspecies	Cultivar groups	Origin	Current cultivation	Most common uses
C. pepo L. ssp. Pepo **(pepo pumpkin and squash)**	Pumpkin, vegetable marrow, cocozelle, zucchini, round ornamental gourds	Mexico -10,000 B.P.	Worldwide	Fruit (immature, mature)

C. pepo L. ssp. ovifera (L.) D. S. Decker var. ovifera (L.) Harz (ovifera pumpkin and squash)	Scallop, acorn, crookneck, straightneck, oviform ornamental gourds	Eastern North America -5000 years B.P.	Worldwide	Fruit (immature, mature)
C. argyrosperma C. Huber ssp. argyrosperma (cushaw)	Silver-seed gourd, green-stripe cushaw, calabaza pipiana	Southern Mexico -7000 years B.P.	Limited. Mexico, USA, Central America	Seeds (snack food, oil, meal); fruit (usually, mature)
C. maxima Duchesne ssp. maxima (giant pumpkin)	Banana squash, delicious squash, buttercup squash, hubbard squash, show pumpkins, turban squash, kabocha	South America -4000 years B.P.	Worldwide esp. Africa and Asia	Fruit (immature, mature, decorative)
C. moschata Duchesne (butternut squash)	Cheese, crookneck, bell	Unknown (Mexico, Central America, or South America) >5000 years B.P.	Worldwide esp. Africa and Asia	Fruit (immature, mature)
C. ficifolia Bouche' (figleaf gourd)	None commercially recognized. Other names include Malabar melon and shark fin gourd	Unknown (Mexico, Central America, or South America) >3000 years B.P.	Limited. Mexico, Central America, South America, China. High (>1000 m) altitudes	Fruit (immature, mature), as rootstock

TABLE 1. CULTIVATED NORTH AMERICAN PUMPKINS AND SQUASH. ADAPTED FROM KATES (2019), PARIS (2016; 2012), SMITH (2006), AND DECKER-WALTERS AND WALTERS (2000).

Materials and Methods

Materials

Eight medium pumpkins from Veg-Fresh Farms (organic QAT 93134), labelled as "Good Life Organic Pie Pumpkin," were utilised in this experiment. Four pumpkins would remain as raw pumpkins while four others were roasted for this experiment.

Raw pumpkins	Weight (kg)	Roasted pumpkins	Weight (kg)
RA1	1.793	RO5	1.591

RA2	1.639	RO6	1.878
RA3	2.090	RO7	1.305
RA4	1.376	RO8	1.811

TABLE 2. STARTING WEIGHT OF SAMPLE PUMPKINS.

Stone tools from the archaeological teaching collection at Wichita State University (See Figures 6-8) were used to shape one cow (See Figure 4) and two bison (See Figure 5) scapula into cutting implements.

Methods

Bison scapulae were used to create bone knives. Bison scapula (No. 1) had no flesh on the bone and was aged, which accepted good scoring from a stone tool. First, the spine from the dorsal side of the scapula was removed by scoring the bone using simple flake tools. After scoring, the spine was removed by striking the bone using a hammerstone. The bottom portion of the scapula was removed by scoring the bone with the same tools and striking the bone with a hammerstone against a grinding stone, which was used as a base. After removing the spine and the distal edge, the grinding stone was used to sharpen the scapula. The scapula was angled while sliding the scapula across the grinding stone with a back-and-forth motion to create a sharpened bevel edge.

The methodology for the second bison scapula (No. 2) was altered slightly. This scapula was scored from both sides of the scapula using a simple flake tool. The scoring procedure was used until a noticeable difference in colour from the cortical surface of bone. The plantar side of the process was scored deeper than the dorsal side. A hammerstone was used to strike the plantar side to break the process. This required several strikes and left 12 fragments, shown in Figure 9. Unlike bison scapula No. 1, the glenoid cavity of the scapula was left intact. The sharpening process was started by grinding the medial end on the grinding stone; most of the grinding occurred on the ventral side but the dorsal side was also sharpened in an effort to create a cutting edge more quickly.

The cow scapula (No. 3) had meat residue and sinew on the bone which required de-fleshing. The stone tools used for scraping proved to be very difficult. After removing the flesh to expose the bone, the same stone tools were used to score the scapula on both sides of the scapular spine. The scapula was held on the grinding stone while being struck several times with a hammerstone. This proved unsuccessful, so the scapula was flipped to the opposite side and struck several times. This process was repeated; however, the bone did not break, and it was determined that the bone was too flexible and raw for tool manufacture.

Experiments

Raw Pumpkins (RA1, RA2, RA3 and RA4)

Cutting the raw pumpkins (RA1-RA4) required a sawing motion to score a ring, which required two people due to poor grip with the raw rind. One person cut using the bone squash knife from bison scapula No.2, while the other person rotated the pumpkin. This process continued until the pumpkin RA1 rind was cut through completely in half. The seeds and pulp were removed by hand before the bone squash knife was used to scrape the pumpkin clean. The 1 1/2in (~4 cm) width circular rings were accomplished by one person cutting the pumpkin using a sawing motion while rotating the pumpkin half. By using the middle part of the blade, the bone squash knife provided the best results. As the circular rings progressed toward the bottom of RA1, the remaining portion of the pumpkin was set on the ground and was cut from the inside using the corners of the bone squash knife. The bone squash knife was held from the end and side. The first pumpkin RA1 required one hour and two minutes to cut in half, extract the pulp and seeds, and cut into rings.

The participants used a slightly different technique on the second and third raw pumpkins, RA2 and RA3. A large, lithic flake was used to score the raw pumpkin initially. Then, after scoring the raw pumpkins of RA2 and RA3, a bone squash knife was used to make the final cuts in the scored areas. Unlike the previous three pumpkins, for RA4, a modified flake (not the bone squash knife) was used to score and cut RA4 in half. Using the stone tool to score the raw pumpkin RA2, RA3, and RA4 provided a significant time saving, as each required only 20 minutes each for preparation.

Pumpkin	Technique	Time (m)
RA1	Two people, bone knife	62
RA2	Multiple people, scored with flake, cut with bone knife and lithic	20
RA3	Multiple people, scored with flake, cut with bone knife and lithic	20
RA4	Multiple people, lithic flake tools	20

TABLE 3. RAW PUMPKIN RING MANUFACTURE TIME.

Roasted Pumpkins (RO5, RO6, RO7 and RO8)

The methodology of the roasted pumpkins included the preparation of the pumpkins, roasting, skin removal, cutting, pulp and seed removal, and ring production. Pumpkins RO5-RO8 were roasted by placing them on the edge of a fire pit and rotated periodically from 30 - 41 minutes. After roasting, the outer skin was removed from RO5 by using the bison bone tool (squash knife, No. 1). The burnt skin was easier to remove than the less burnt areas. After the outer skin was removed, the pumpkins were cut in half; however, with the skin removed, the pumpkins were slippery and difficult to hold. The participants used a sawing motion initially and then attempted chopping. This was attempted while one person held the pumpkin in place while a second person would chop. The bone squash knife was held in both hands while using the centre of the blade. Another method was attempted by sawing a line around the pumpkin using a back-and-forth motion and then chopping through the scored

line. While one person held pumpkin RO5, a second person held the bone squash knife in place on the scored line and chopped through the pumpkin by striking the bone squash knife with a hammerstone. After the RO5 pumpkin was cut in half, the participants removed the pulp by using their hands and bone squash knife to extract the pulp and seeds.

The first circular ring was produced by making a ring around pumpkin RO5 using a sawing motion. This was accomplished with one person holding, cutting, and rotating the pumpkin in one motion. The corners of the bone knives proved to have the best results, and the second ring was accomplished using the same technique. The first pumpkin RO5 required 59 minutes to remove the skin, cut in half to remove the pulp and seeds, and produce rind rings. We expect processing time to be reduced with experience.

The participants used a different technique on the second and third roasted pumpkins RO6 and RO7. The pumpkins were scored around the outside using a modified flake. The flake cut through the roasted pumpkins RO6 and RO7 with greater ease. The pulp and seeds were removed by hand, and then scraped using the modified flake. The bone squash knife was used to cut the first circular rings, and it was noted that the pumpkins that were roasted evenly made the cutting easier overall. The remaining rings were cut using the modified flake. RO8 proved to be more challenging because it was much softer and more difficult to handle. Since RO8 was a much softer pumpkin, the same technique was used as RO6 and RO7; however, the squash knife was not used because the cutting process of the rings required a gentle slicing motion to prevent smashing the pumpkin, so a modified flake was used for each slicing procedure. Preparation of RO6, RO7, and RO8 only required 18 minutes each following the roasting (See Figures 10 and 11).

Pumpkin	Technique	Time (m)
RO5	One person, bone knife	59
RO6	Multiple people, scored with flake, cut with bone knife and lithic	18
RO7	Multiple people, scored with flake, cut with bone knife and lithic	18
RO8	Multiple people, lithic flake tools	18

TABLE 4. ROASTED PUMPKIN RING MANUFACTURE TIME.

Drying

After the raw and roasted pumpkins were cut into 1 1/2in rings, they were hung from a rod and elevated off the ground with two lawn chairs outdoors in Wichita, Kansas, USA, for six days in October 2021 (See Figure 12). The raw and roasted pieces were then cut with a lithic flake and flattened by hammerstone to pressthe rings into strips. Once the rings were flattened, one mat was woven from the raw and roasted strips, respectively, in a simple basketweave pattern. The woven mats were returned outside to continue drying. The raw pumpkin mat developed mould due to the cloudy weather and high humidity in the first two

weeks, but the roasted mat was not affected.[3] After 25 days from the initial drying, the mat woven from the raw pumpkins was discarded due to mould; the roasted mat, however, was thoroughly dry and weighed 200g (See Figure 13). The roasted mat then hung in an interior window of the Archaeology of Food Laboratory at Wichita State University for one year, in which time it never developed mould or any signs of deterioration, though several small pieces were sampled for sensory evaluation over the year (See Figure 14). This storage period was chosen simply to observe the stability of the dried pumpkin in indoor conditions.

Sensory Evaluation

After the 25 days of curing, the dried, roasted pumpkin mat had the consistency of meat jerky and was of a muted umber colour. It took a few minutes of holding the pieces in a person's mouth to soften, which would allow the mat pieces to be chewed and swallowed. Two one-inch pieces were left in a small cup of water and after 5 minutes, the pumpkin was rehydrated; the original orange colour returned and became soft to the touch. After one year of curing, the dried, roasted pumpkin mat maintained the same sensory qualities.

Starch Testing

Pumpkins were also tested for storage starch presence in the flesh and seeds. A small raw pumpkin piece (~25 g) was inserted into a 50 mL beaker of water with two drops of iodine. After the piece of pumpkin was hydrated, a glass rod was used to break apart the pumpkin material to put a small section onto a microscope slide. Using a pipette, the mixture of water, iodine, and pumpkin, was removed and the sample was applied to two slides.

A raw pumpkin seed was cut in half and dropped into a small beaker of water with two drops of iodine. After the seed softened and hydrated, a glass rod was used to break apart the seed material into smaller pieces. Using a pipette, the mixture of water, iodine, and pumpkin seed was distributed on two slides. A fifth slide was prepared by breaking a raw pumpkin seed in half and tapping the exposed end on a slide with a water/iodine mixture.

Slides were sealed with a cover slip and clear nail varnish and observed completely under regular and polarized light microscopy, 20x - 400x magnification with a Leica DM750P Microscope. No starch granules were observed. Phytoliths were not tested.

Discussion

Chaîne Opératoire

Bone and Stone Tool Use

Two different forms of bone knives were produced in this experiment. One group discarded the spine of the scapula and the lateral portion of the scapula to produce a bone squash knife

that was smaller and easier to hold. The second group of participants decided not to remove the bottom portion of the scapula, which provided more bone to grasp. The bison scapulae were sharpened by angling the bone and using a back-and-forth motion against a grinding stone. It was determined while cutting the pumpkins that the cutting edge on each scapula could have been sharper. The fresh cow scapula required much more work to de-flesh the bone of residual tissue and sinew, did not accept a good score from the stone tools, and proved to be too raw and flexible. When being struck, the cow scapula would bend, not break; too fresh of bone, therefore, was implied to be not the ideal tool blank for bone knives.

Stone tools were much more efficient in cutting the pumpkins in all stages and did not have to be a prepared tool form to be effective. Novice flintknappers, such as in this experiment, could make simple flakes to be used as expedient tools for the processing of the pumpkin mats. The availability of good lithic raw materials certainly affects the choices of individuals for tool selection; the results of the present study implies that no specialised tools are required for pumpkin mat manufacture. The experience also calls into question the archaeological bone tool category of "squash knife", which has been employed sporadically on the Plains. While Buffalo-Bird Woman records observing others using a bone knife in pumpkin mat manufacture, it is clear that a greater variety of tool forms should be considered as possible evidence of producing pumpkin mats. Bone knives are relatively rare in archaeological assemblages of this region; however, expedient lithic tools and bevelled two or four-sided chipped stone knives are quite common (Blakeslee and Hawley, 2006; Grenawalt, 1995; Sollberger, 1971; Wedel, 1959).

Storage and nutrition considerations

Raw pumpkins can be stored whole up to three to five months effectively at 50o-55o F (10-13 o C)and 70-75% relative humidity (Barnes-Svarney and Svarney, 2015). By controlling the heat and sunlight, drying can be very effective in removing water from the mats, which makes it less prone to the growth of organisms, including moulds and bacteria. While drying vegetables can cause a loss of flavour and vitamin content, fruits, such as pumpkin, maintain much of their flavour and vitamin content when dried due to the acidity of the fruits, see Table 4 (US Department of Agriculture, 2019). Within Pawnee ethnographies, a half-mat was considered sufficient for an individual's single day of food (Wilson 1924, 239). Individual households would keep three to five mats in the house, with one or two in additional storage in pits (Weltfish 1964: 270).

Labour considerations

The ethnohistoric evidence suggests that during harvest, intensive labour required the help of many individuals, particularly women, to bring pumpkins out of the field for preparation. Harvest included corn, beans, and pumpkins, with pumpkins the last harvest. Our novice crew of ten took four hours to recreate the tools and prepare eight pumpkins for plaiting.

Ethnographic records reveal that Pawnee women would bring in the largest pumpkins first, then the next largest, and bringing the smallest back for preparation last. One parfleche (personalised rawhide carrying pouch) equalled five large pumpkins, or seven to eight medium size, or 12 to 15 small ones (Weltfish 1965, 246). A horse could carry only two parfleches per trip, and by using two horses it required five trips, or 20 parfleches in total (Weltfish 1965, 246). Depending on the size of pumpkins, the final number of pumpkins could number a few hundred. The typical size of one mat was two feet wide by two and half feet in length, and it was recorded that the Pawnee women could weave two mats in an afternoon (Weltfish 1965, 246). The mats that were recreated here were much smaller, measuring approximately five and a half by twelve inches (~12 x 31 cm).

After the production of the mats, they had to be stored. Digging and storing in a cache (storage) pit were considered women's work. It took two Hidatsa women two days and part of a third day just to dig such a pit. Then grass had to be cut, bundled, and placed in such a way as to line the pit. The corn, beans, and pumpkin mats had to be placed carefully to avoid mould and spoilage (Wilson 1917, 88).

The ethnohistoric record does not reflect the total amount of work invested by Indigenous women in the making of these mats. One must also realise that the pumpkin mats were produced after many days of harvest and food preparation of corn and beans. Indigenous women on the Great Plains invested many hours during harvest; in pale comparison, it would have taken our novice crew approximately twelve and a half, eight hour days to prepare 100 pumpkin mats representative of a single field harvest, without even harvesting or storing them.

Recommendations for Archaeologists

The archaeological evidence of pumpkin mat production is limited due to its organic nature. It has long been assumed that cache pits, particularly on the American Great Plains, would be a likely source of botanical information due to the storage capacities of the entity. Among the Pawnee, cache pits were shaped like a bell with a narrow neck at the top. The width of the mouth, or entrance, was commonly about two feet, and deep enough that a ladder was required to enter the bottom of the pit (Wilson 1917, 87). The pit was lined with grass bundles and filled with corn, and it appears that the pumpkin mats were stored in the centre of the shelled corn to protect the pumpkin mats from dampness (Wilson 1917, 92). The shelled ripe corn did not spoil easily; however, dried pumpkin was easily spoiled, as we learned in our recreation. Wilson indicates that much attention was paid by the Pawnee to store the pumpkin in the very centre of the cache pit and surround them on every side with loose corn which protected the pumpkin mats and kept them dry (Wilson 1917, 92).

Actual recovery of Cucurbit remains within cache pits has been limited. For example, the Kansas Historical Society's extensive testing regime near Arkansas City, Kansas, tested 82

features with 1,868 flotation samples-16 rinds compared favourably with *Cucurbita spp*. and a single seed was recovered (Adair, 2012, p. Table 15.1). Phytolith samples from the same project recovered a single Cucurbit phytolith sample from a pit (Bozarth, 2012, p. Table 16.1).

The *chaîne opératoire* of processed pumpkin mats reveal why recovery may be so low: there is little chance for charred seeds or rinds to be recovered in context of storage pits. The roasting of pumpkin rind also complicates the ability to identify this practice in the archaeological record; the diagnostic phytoliths associated with Cucurbits are within the rind (Bozarth, 1987, 1985; Piperno et al., 2002). The *chaîne opératoire* implied within this experiment is that it is best to discard the charred rind prior to manufacture and storage of pumpkin mats; this process would imply that diagnostic phytolith remains of pumpkin would be very limited, even in areas where the ethnographic literature indicates that they were most commonly kept, such as storage pits.

Other parts of the *chaîne opératoire* earlier in the production sequence, such as the ring manufacture stage, may be worth sampling for phytolith data, such as groundstone, expedient tool residues and generalised refuse areas. Since pumpkin mats were used to flavour a variety of stews, such as Pawnee blood broth (Wilson 1924, 237-238), ceramic vessels should also be considered as a potential source of microfossil recovery. To our knowledge, there is not an associated chemical biomarker for Cucurbits (Evershed, 2008).

Conclusions

The creation of pumpkin leather mats on the Plains was considered women's work and labour intensive (Weltfish, 1965; Wilson, 1917). The ethnohistoric record indicates this practice likely occurred in large geographical areas in the American Great Plains covering extended periods of time, yet identifying this practice has been difficult archaeologically.

The first conclusion of this experiment implies that no speciality tools are necessary for the production of pumpkin leather mats. While prepared bone knives can work for the process, our results indicated that, for novices, expedient stone tools were more effective overall. We also discovered that dried scapula were much easier to manipulate into bone tools than fresh scapula; it is possible that our novice status did not allow for the most efficient use of these tools. The experiment also tested the considerations for plaiting raw pumpkins versus those who had their rinds scorched first. While few differences were noted between plaiting the roasted versus raw pumpkins in this experiment, the raw pumpkin mat developed mould while the roasted pumpkin mat did not, despite being held in the same conditions. Presumably, this technological development provides some advantages, whether that be through the sanitising of the exterior rind of pumpkin, providing initial drying of the parts, or some other mechanism.

Due to the absence of starch and pollen, we recommend that archaeologists looking to identify pumpkin mat production test for phytolith residues, with residues contained on expedient tools, groundstone, ceramics, and within generalised refuse or midden sediments. Until a chemical approach can be developed for the identification of Cucurbits, phytoliths remain the best option for identification of pumpkin utilization (Bozarth, 1987).

During the recreation of pumpkin mats in this experiment, it was determined that it took 10 novices most of a day to recreate the mats that took one or two Pawnee women an afternoon to produce in the historic period. Our investigations, however, indicate that even novices could produce a nutritious, temperature-stable foodstuff capable of being preserved at least one year. This experiment stands as a testament to the specialized knowledge and skill of Indigenous lifeways.

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This experiment came from the communal work of a Wichita State University class, ANTH397AB/597AR Anthropology of Food and Nutrition in the Fall of 2021. We especially want to recognize the work of our colleagues: Ben Amezcua, Jennifer Banks, KM Carter, Darbee Chard, Adrien Emanuel, Savannah Gann, Brogan Gillmore, Angie Guevara, Cameron Hill, Misato Kawamoto, Megan Keahey, Laura Kennard, Robbyn McKellop, Ria Morgan, Savannah Shelite, and Morgan Yeager. Laura Kennard deserves special recognition for her notetaking, which was crucial to the writing of this manuscript. We also want to recognize two women for documenting the ethnohistoric practices of pumpkin mat manufacture for prosperity: Gene Weltfish and Maxi'diwiac, Buffalo-Bird Woman.

1 Archaic in this context refers to a specific time period in the Plains-approximately 10,000 years ago to 1,000 BP-in which Holocene environments were exploited primarily through mobile, foraging subsistence practices.

2 There are several different typographic spellings offered of Buffalo-Bird Woman's name; we chose this capitalisation, following Wilson's (1921) spelling in the telling of her life stories.

3 Neither of our ethnographic sources mentioned processing after the mat had been woven. It is possible that mats were additionally dried near fires after weaving to prevent the humidity and mold action that we observed in the mat woven from raw pumpkin strips.

Keywords experimental archaeology
methods & techniques
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FIG 1. OWL WOMAN CUTS A SMALL GOURD WITH A BONE KNIFE, CIRCA 1916. GILBERT WILSON, PHOTOGRAPHER, IN WILSON (1917). PUBLIC DOMAIN.

FIG 2. OWL WOMAN WITH A STRING OF GOURD RINGS, CIRCA 1916. GILBERT WILSON, PHOTOGRAPHER, IN WILSON (1917). PUBLIC DOMAIN.

FIG 3. UNNAMED WICHITA WOMAN WITH A PLAITED PUMPKIN MAT, CIRCA 1927. E.L. CURTIS, PHOTOGRAPHER. GETTY MUSEUM: 84.XO.755.4.11. PUBLIC DOMAIN.

FIG 4. RAW COW SCAPULA (BOS TAURUS), BEGINNING WEIGHT 0.803 KG. THE GREEN BONE WAS TOO FLEXIBLE FOR TOOL MANUFACTURE, SO THE BONE KNIFE MANUFACTURE WAS ABANDONED. PHOTO BY CRYSTAL A. DOZIER.

FIG 5. EXPERIMENTAL BONE SCAPULA TOOLS. BISON SCAPULA (BISON BISON) NO. 1 (RIGHT), BEGINNING WEIGHT 0.814 KG. BISON SCAPULA (BISON BISON) NO. 2 (LEFT), BEGINNING WEIGHT 0.856 KG. PHOTO BY CRYSTAL A. DOZIER.

FIG 6. STONE TOOLS USED ON BISON SCAPULA NO. 1 FROM THE STAUFFER CALKINS COLLECTION CATALOG NUMBERS 2003.10-00533 AND 2003.10-00535. HAMMERSTONE 95-14890. PHOTO BY CRYSTAL A. DOZIER.

FIG 7. STONE TOOLS USED ON BISON SCAPULA NO. 2 FROM THE STAUFFER CALKINS COLLECTION CATALOG NUMBER 2003.10-00509. HAMMERSTONE 73-22. PHOTO BY CRYSTAL A. DOZIER.

FIG 8.. GRINDING STONE (WICHITA STATE ANTHROPOLOGY TEACHING COLLECTION).

FIG 9. BONE DEBITAGE PRODUCED IN MANUFACTURE OF BISON SCAPULA NO. 1. PHOTO BY CRYSTAL A. DOZIER.

FIG 10. SIMPLE FLAKE STONE TOOL AFTER CUTTING PUMPKIN RINGS. PHOTO BY CRYSTAL A. DOZIER.

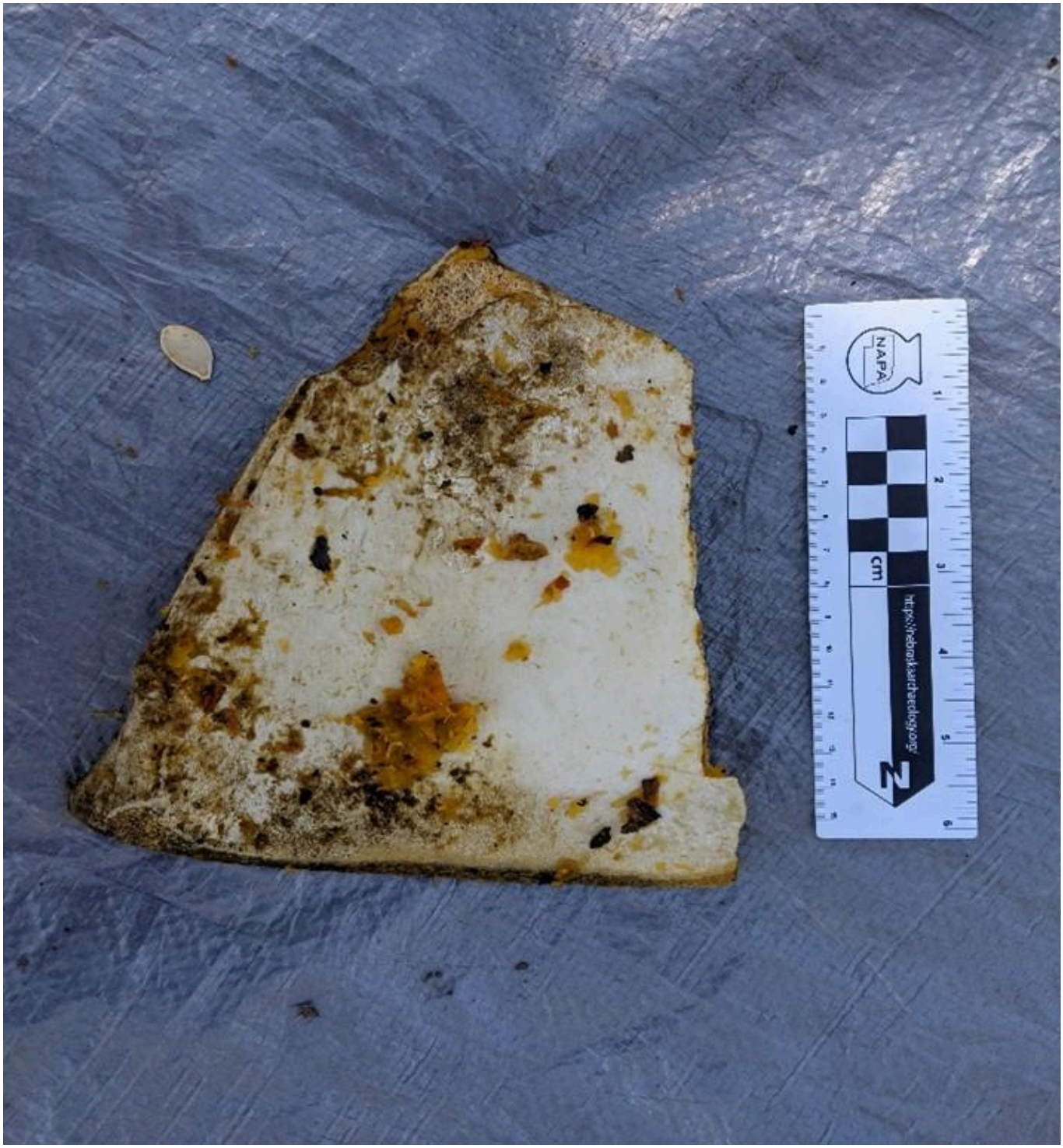

FIG 11. BISON SCAPULA NO. 1 AFTER CUTTING PUMPKIN RINGS. PHOTO BY CRYSTAL A. DOZIER.

FIG 12. RAW AND ROASTED PUMPKIN RINGS ON DRYING RACK OUTSIDE, OCTOBER 2021. PHOTO BY CRYSTAL A. DOZIER.

FIG 13. ROASTED CHECKER PLAITED PUMPKIN MAT, OCTOBER 2021. PHOTO BY CRYSTAL A. DOZIER.

FIG 14. ROASTED CHECKER PLAITED PUMPKIN MAT, SEPTEMBER 2022. PHOTO BY CRYSTAL A. DOZIER.