

An Experiment in Maize Processing and Charring

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Introduction

Maize was and still is an important food stuff in much of the New World. Maize is genetically flexible; hundreds of maize races exist adapted for many cultural uses and to an extreme range of ecological niches. Maize has served not only as food but as a religious and social symbol. The prehistoric importance of maize is illustrated in its abundance in the archaeological record. Maize appears in garbage heaps, household structures, religious structures and is even depicted on prehispanic Peruvian pottery. Unfortunately, archaeologists working in open sites usually recover only kernel or cob fragments, rarely whole cobs. An unknown array of forces effects these isolated maize fragments before an archaeologist ever finds and analyses the remains; everything from disturbance by worms to differential deposition by humans for ceremonial purposes may occur. Therefore, reconstruction of prehistoric races of maize is very difficult. Knowing the appearance and distribution of these ancient races of maize could help us reconstruct the evolution of maize as it was mediated by humans.

Many paleoethnobotanical specialists have attempted replication of archaeological maize by charring modern varieties, in order to better reconstruct the pre-charred morphology of the ancient maize by assessing the effects of charring. These experiments have been largely unsuccessful in producing undistorted, charred maize which resembles the maize typically recovered archaeologically. Toward this goal, Goette (1989) developed a method of charring maize which caused little kernel and cupule distortion. She found the charred unprocessed maize bore little resemblance to Peruvian archaeological maize; since maize kernels found archaeologically in Peru often lack their embryos and much of their pericarps, while the charred experimental maize invariably retained both. Due to this discrepancy, we postulated that maize found in archaeological sites is probably the result of maize charred after having been processed. This hypothesis led to our experiment, reported here, wherein we tested the effects of three Peruvian processing methods on

traditional races of maize and reported the appearance of these processes after charring. For each of the maize races processed, we noted the appearance of the kernels before processing, after processing and after the processed kernels were charred. Measurements and photographs were taken after each stage.

Common Peruvian methods of processing maize were identified from modern and historic sources (Bird 1970, Gade 1975, Garcilaso de la Vega 1960[1571]). From the various methods, we chose boiling with wood ash to peel the maize (*mote*), parching over a high flame to toast the maize (*kancha*) and fermenting the sprouted maize as a beer (*chicha*) for our experiment. The appearance of their products should be very distinctive. These three general methods are wide spread in much the New World.

Gade (1975), Bird (1970) and Culter and Cardenas (1947) suggest various races of South American Andean maize ethnographically preferred for each of these processes. We selected three races of maize characteristic for the chosen processes: *chullpi* for *kancha*, *cuzco* for *mote* and *huilcaparu* for *chicha*. The *chullpi* and *huilcaparu* were purchased in 1989 in the shelled state at a Bolivian open market in Cochabamba. The *cuzco* was purchased the same year in La Paz. We chose shelled maize over unshelled because sources indicate maize was traditionally sorted and stored after shelling. By using shelled maize, we mitigated the influence of researchers' preference towards mid-cob or so-called "perfect" kernels.

Methods and Materials

The *chullpi* maize used for *kancha* is an Andean sweet corn with very long kernels (Figure 1a). The cob is short and wide with indistinct rows, averaging about 18 rows (Grobman et al. 1961). Although it is a sweet dent corn, *chullpi* is only used dried for *kancha*, never in the fresh state. The *kancha* process is very simple: dried *chullpi* is placed in a clay pot (we had a *kancha* pot from the Central Andes) over very high heat. A handful of kernels is toasted in less than three minutes when stirred constantly. The resulting maize is toasted yellow with slight browned areas speckled across the swollen surface of the pericarp. A distinctive crack in the pericarp occurs down the embryo due to puffing of the formerly shrunken "sugar" portion of the kernel. The radical of the embryo protrudes upward through the cracked pericarp in many specimens (Figure 1b).

Mote (which is similar to North American hominy) is prepared in the Vilcanota valley of Peru with the very large floury kernels of *cuzco* (Figure 2a) (Gade 1975). *Cuzco* has 8-10 rows of kernels on a mid-range ovoid cob (Grobman et al. 1961). We

used aprox. 1 cup of hardwood ash in 2 quarts of water to process 50-100 kernels of *cuzco*. The water and wood ash form a lye solution with a pH of about 10. Once the ash and water mixture is boiling the kernels are added. The pericarps begin to loosen after ten minutes of boiling over a medium-high flame. The kernels are then rinsed under running water while being rubbed together, removing any remaining pericarps and many of the points of attachment. *Mote* maize has a distinctive "hominy" smell and is light buttery yellow in color (Figure 2b). Traditionally the peeled maize is added to soups or dried and stored for later use (Gade 1975). A second boiling in soup causes an enormous expansion of the kernels as they absorb water; the characteristic puffy appearance of *mote* or hominy results.

We chose *huilcaparu* for *chicha* over other traditional varieties because *huilcaparu* germinated better in our lab and is the most commonly used *chicha* maize in the Cochabamba Valley. *Huilcaparu* a maize frequently grown in the Cochabamba Valley with 14-18 rows of slightly dented grey-blue kernels (Figure 3a) (Cutler and Cardenas 1947). The process of producing *chicha* is long and complex-well illustrated by Culter and Cardenas in their 1947 article. Freshly sprouted kernels are dried then milled. The resulting flour is boiled, allowed to settle and the supernatant is removed for fermentation. The fermenting process takes 3-5 days.

The *chicha* processing technique we used is as follows: The maize was soaked overnight in water and a vermiculite matrix, then sprouted for five days at 25°C in the moist vermiculite. When the majority of kernels (15-20% of the kernels did not germinate) had radicals as long as the body of the seed, they were removed from the vermiculite and dried over night. During germination the expanding radical and hypocotyl pushed away the pericarp covering the embryo. The moist sprouted kernels were swollen to the limits of their pericarps, causing a puckered appearance across the top of the kernels, which was retained after drying. As the kernels dried, the radical and hypocotyl became very delicate and broke off easily as did the pericarp covering the embryo (Figure 3b) [Ethnographic sources state the broken embryo parts were collected and saved for *chicha* production (Nicholson 1960)]. The sprouted kernels are usually ground after drying. However, our processing sequence was stopped at this point because milling destroys kernels. Also, Nicholson (1960) indicates that the maize is sold or stored in the sprouted and dried state until needed for *chicha* production.

These products of processing were charred in the burning apparatus illustrated in Figure 4. This procedure used a coffee can filled with sand that was placed on a cement block over a bunsen burner. Goette (1989) found that an alternation of low

temperature heating followed by cooling periods resulted in charred kernels with low distortion rates and maximum strength, as seen in the archaeological record. Our processed kernels were placed in a reducing environment of sand and burned for 2-3 hours then removed from the hot sand to cool. The temperature of the sand at the beginning of a burning session was 24°C but at the end of the session it was between 121-178°C. It took between 12 and 60 total burning hours to produce in kernels with a charred appearance. *Kancha* kernels took the longest time to char-up to 60 hours; *chicha* kernels took between 24 and 50 hours to char; *mote* kernels took only 12 hours to completely char. The rate of endosperm extrusion was 5-35%, which correlated with the processing method. *Mote* had the lowest endosperm extrusion rate of less than 5%. *Kancha* and wet-charred *chicha* kernels had similar extrusion rates of about 10-15%. Interestingly, dry-charred *chicha* kernels had a very high extrusion rate of 20-35%.

Maize researchers found that width, length, tip-to-shoulder, thickness and angle measurements give a good analytical description of individual kernels and were therefore the measurements we used (Goette 1989, King 1987, Pearsall 1980). The measurements we used are depicted in Figure 5. The width, length, and tip-to-shoulder measurements were made by placing the kernels on grid paper marked in 1 millimeter squares. Hand-held sliding calipers measured thickness. The compressed sides of the kernels were arranged on 360° circular graph paper to determine the angle measurements. A random sample of 150 kernels from a larger sample of 300 kernels were measured for *chullpi* and *huilcaparu* at each stage; unprocessed, processed and processed-charred. The *cuzco* sample was smaller with 150 kernels being the large sample and 75 kernels being the measuring sample. The measurements of kernels distorted during charring were included whenever possible.

Results

Results of the maize kernel measurements are illustrated in Figures 6-10. Figure 6-10 are comparisons of unprocessed, processed and processed charred maize for the three tested processes. Each figure illuminates one measurement data set; Thickness, Length, Width, Tip-to-Shoulder, and Angle respectively. The percentile box-plots allow an easy visual estimation of the full range of variation of the data. The five lines of the box-plots show the 10th, 25th, 50th (median), 75th and 90th percentiles, the small circles show the <10 and >90 percentiles. In each figure we see not only the median but also the range of measurements the encompass.

The greatest changes occurred in the increased thickness of processed and charred kernels (Figure 6). Through the processing and charring stages of the experiment, length generally decreased (Figure 7), while width showed little change (Figure 8). As a result of decreasing length, the tip-to-shoulder measurement showed a corresponding decrease (Figure 9). Angle measurement showed an increase after processing and charring, but the charred median measurements are still within the expected limits for each race (Figure 10).

Perhaps the most important result is the appearance of the charred and processed kernels. The *chullpi / kancha* kernels kept their characteristic cracked embryo after charring. Even the protruding radicals survived charring intact. The browned and puffed areas of the pericarp became fragile after charring but the pericarp retained its integrity. Charring increased the overall puffiness of the *kancha* kernels (Figure 1c). *Kancha* kernels have little resemblance to most archaeological maize because they retain both their embryo and pericarp.

Huilcaparu lost the delicate hypocotyls and radicals leaving holes where they had emerged from the embryo. The pericarp covering the embryo was also lost during charring. Processed and charred *huilcaparu* has a crack down the embryo similar but distinctive from the crack in processed and charred *chullpi* (Figure 3c). Although charred *chicha* maize doesn't bear much resemblance to Peruvian archaeological maize, it does provide us with some characteristics to look for in archaeological sprouted maize.

Those kernels which most resembled Peruvian archaeological maize were the carbonized mote kernels of *cuzco*. The endosperm of *moted cuzco*, having lost its restricting pericarp in processing, expanded greatly with charring. The expansion left the embryo with a sunken appearance. Although sunken, the embryo is still persistent even after the mote boiling and charring processes (Figure 2c).

The *mote* kernels of *cuzco* were the quickest to char and were the most durable after charring of the three processed maizes, thereby making them the strongest candidates for preservation. Historical sources also indicate maize was processed with ash in much of North and South America. Maize processed with wood ash could therefore make up a large portion of the archaeological maize, assuming some unidentified force causes *mote* kernels to lose their embryos.

Conclusion

I believe the products of *chicha*, *kancha* and *mote* production, as produced in our experiments, would be distinct in the archaeological record. The remains of

chicha production could be identified by the distinctive radical/hypocotyl holes and the missing embryo pericarp. These *chicha* characteristics might occur in any sprouted maize so archaeological context must to be considered. *Kancha* kernels might be less distinctive because unprocessed kernels also puff during charring. However, the protruding radical and the embryo crack would be good distinguishing characteristics for kernels which had been quickly parched over a hot fire. *Mote* kernels would be the most distinctive. *Mote* is the only processing method which results in kernels that lack the pericarp and have a greatly expanded endosperm.

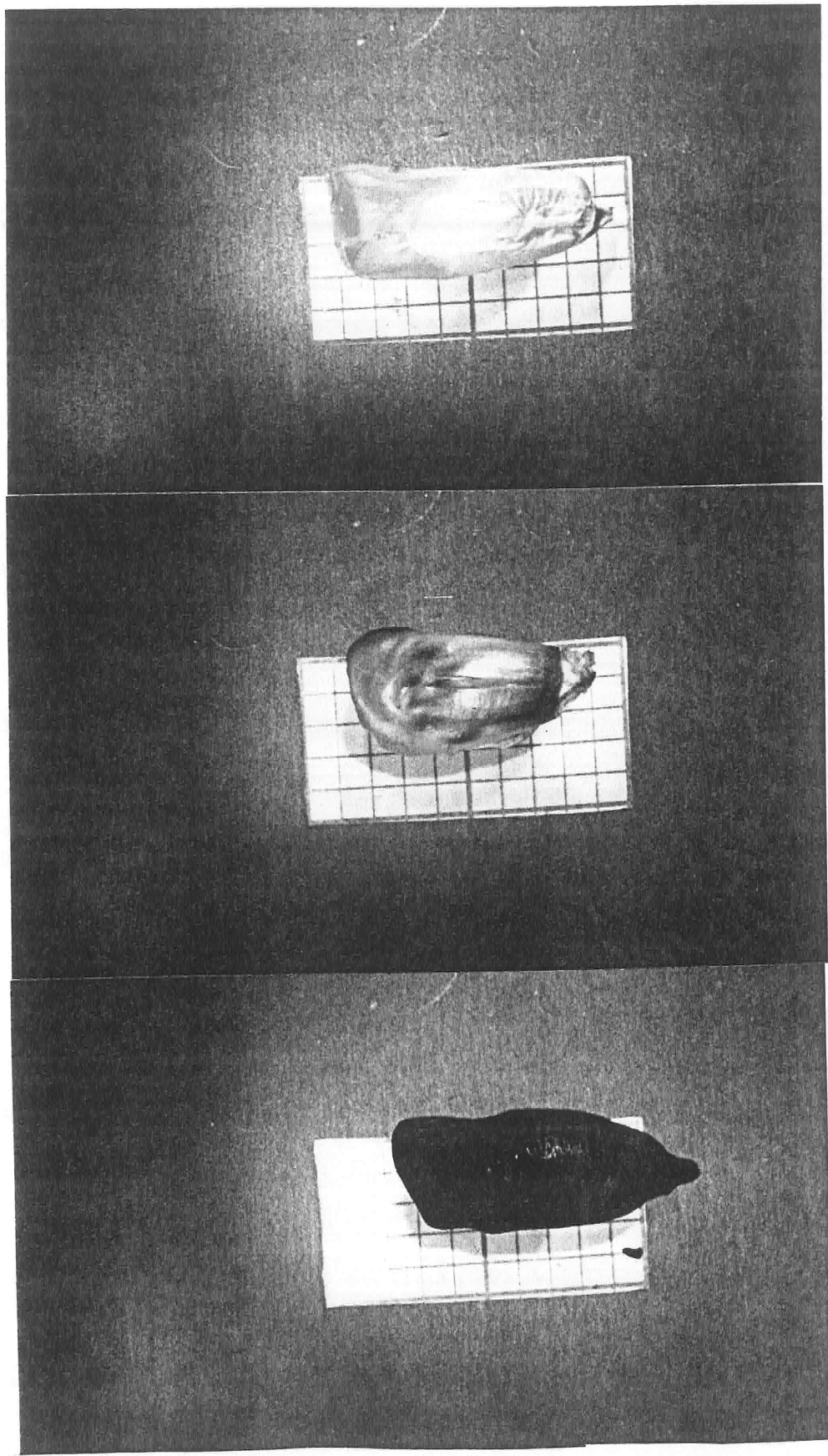
Unfortunately, ethnographic sources reveal an enormous variation in the maize varieties preferred for *mote*, *kancha* and *chicha*. It is probably safe to assume that the prehispanic populations of Peru had as widely varied taste as the modern residents of Peru. And Goette (1989) found that maize with different endosperm types char differentially. Therefore, we cannot make a direct correlation between the appearance of archaeological maize and our modern processed and charred maize. However, I believe the above outlined "distinguishing characteristics" are a result of the processing method and not just the maize variety. Thus, we could use the characteristics to distinguish processing method but not the maize variety which underwent processing.

We cannot predict how hundreds of years of deposition effects charred maize. The grinding force of freezing and thawing soil could wear away at the persistent but fragile pericarps of *kancha* and *chicha* kernels leaving them naked like *mote* kernels. The embryos of the kernels could be preferred by animals or soil microbes, removing before complete charring occurred; knowing that charring could take a fairly long time. We can only imagine the many forces which could occur before, during and after deposition.

Thus, we cannot prove that most archaeological maize has undergone any form of processing. But we do know that charred processed maize is quite distinct from unprocessed maize. And each of our three processing methods was generally distinct from the other processes. Finally, we recognize *mote* as the process which results in maize most resembling Peruvian archaeological maize.

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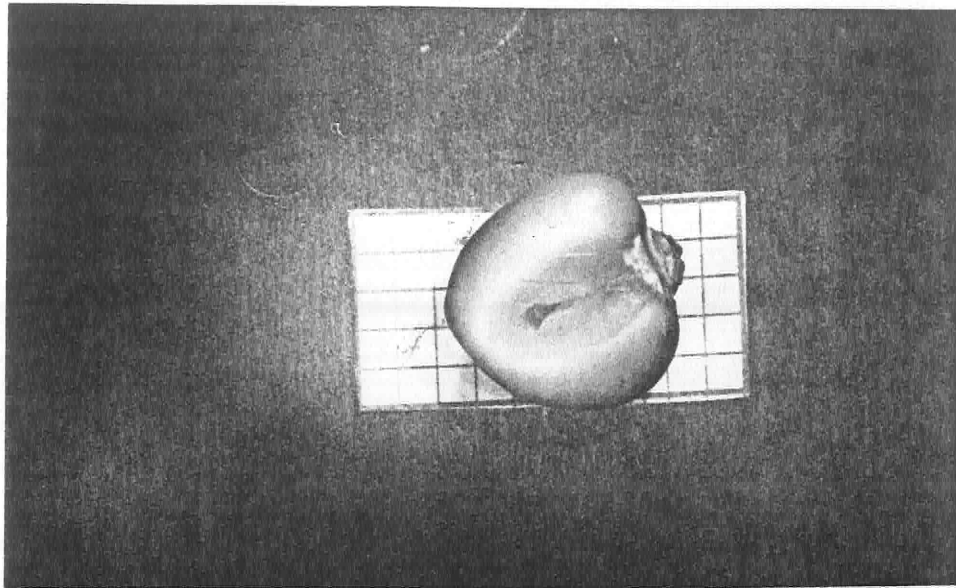
a.

b.

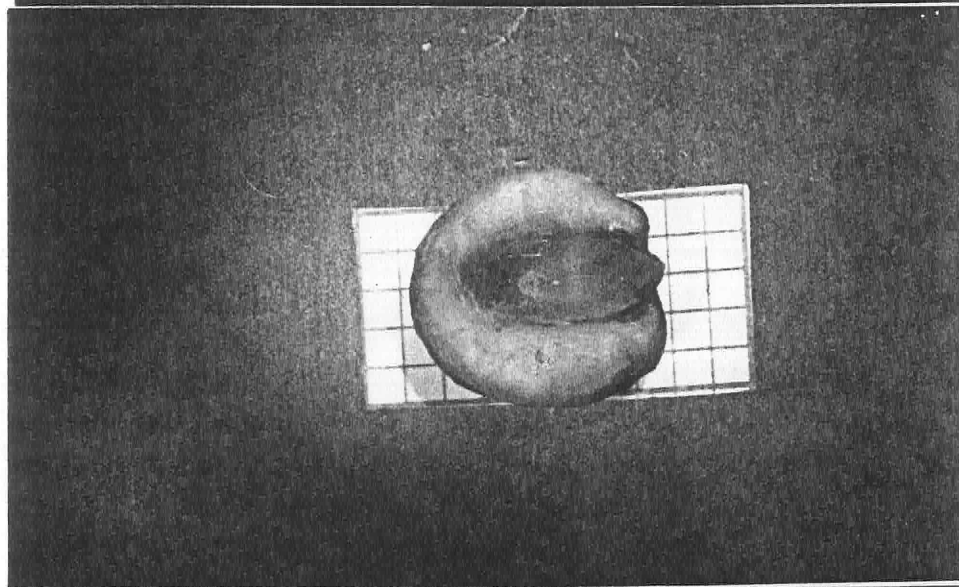
c.

Figure 1: Chullpi Kernels in Three Processing Stages a. Unprocessed

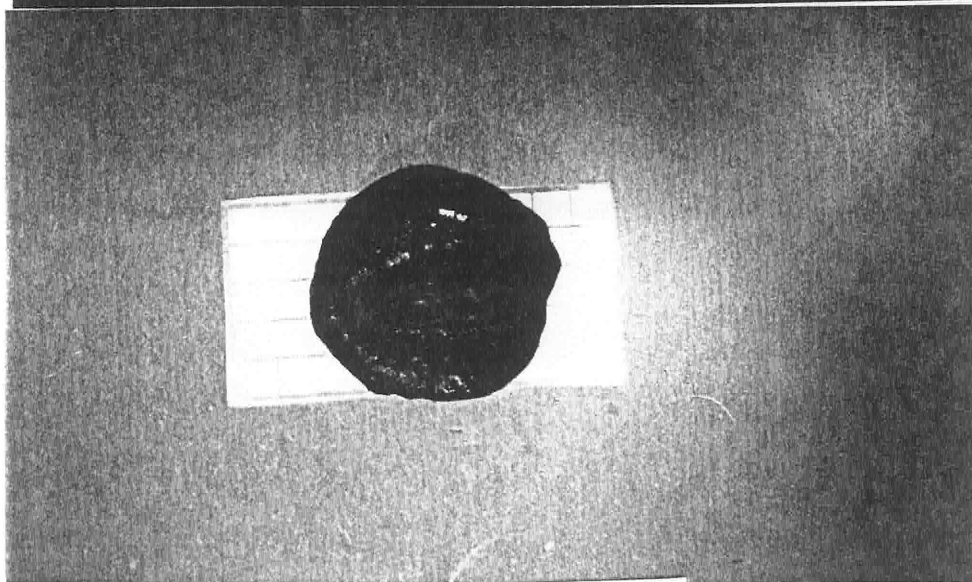
b. Processed for Kancha c. Processed and Charred



a.



b.



c.

Figure 2: Cuzco Kernels in Three Processing Stages

a. Unprocessed

b. Processed for Mote

c. Processed and Charred

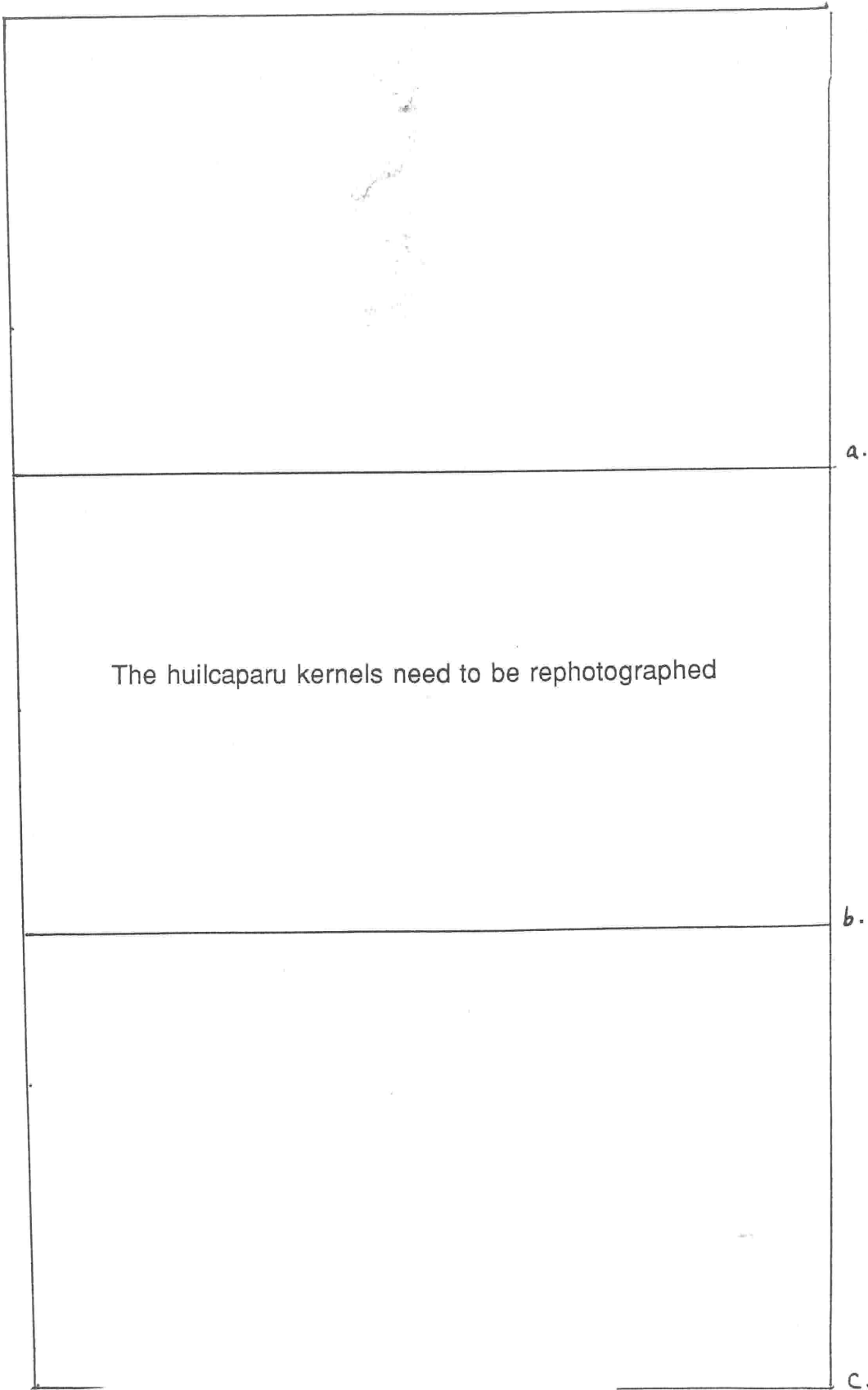
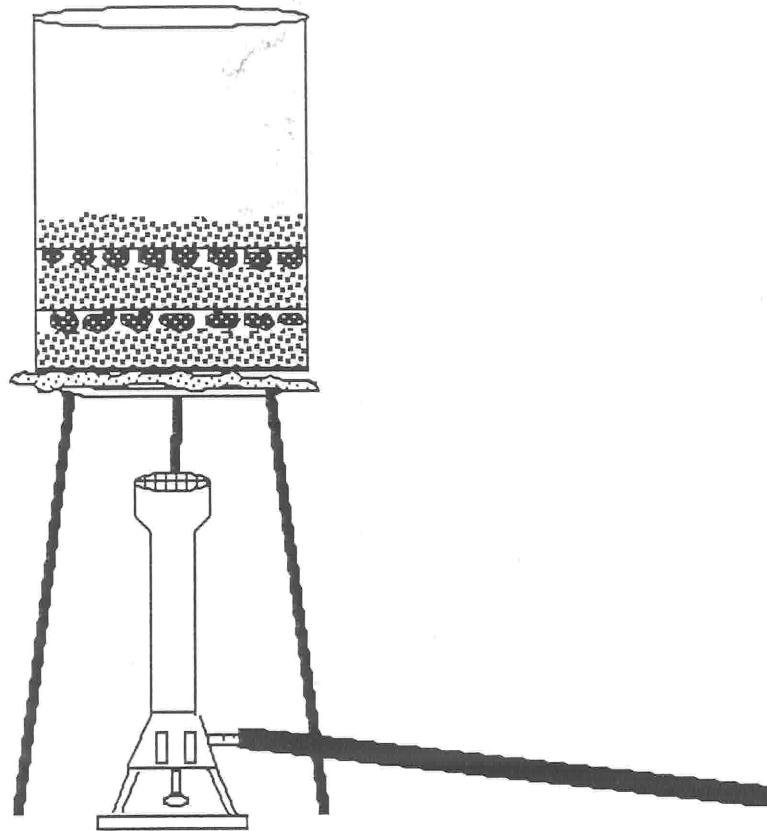


Figure 3: Huilcaparu Kernels in Three Processing Stages a. Unprocessed
b. Sprouted and Dried for Chicha c. Processed and Charred







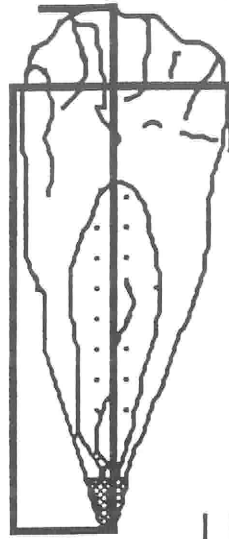
KEY	
Cement heat diff user	
Sand	
Maize kernels	
SCALE	
 = 1 inch	

Figure 4: Burning Apparatus

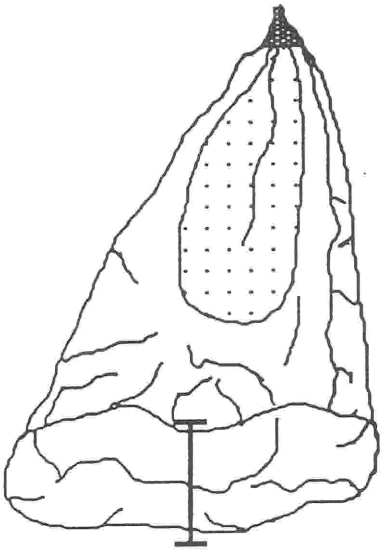
TIP TO SHOULDER

WIDTH



LENGTH

THICKNESS



ANGLE

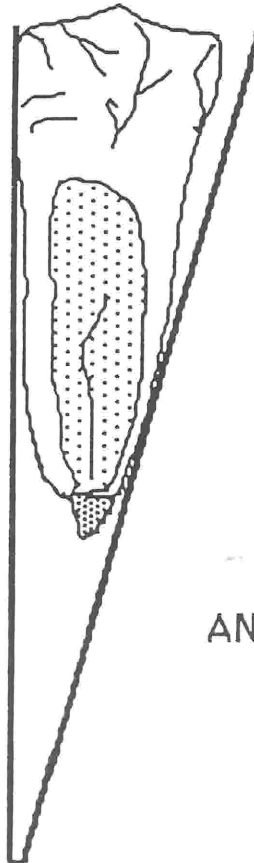
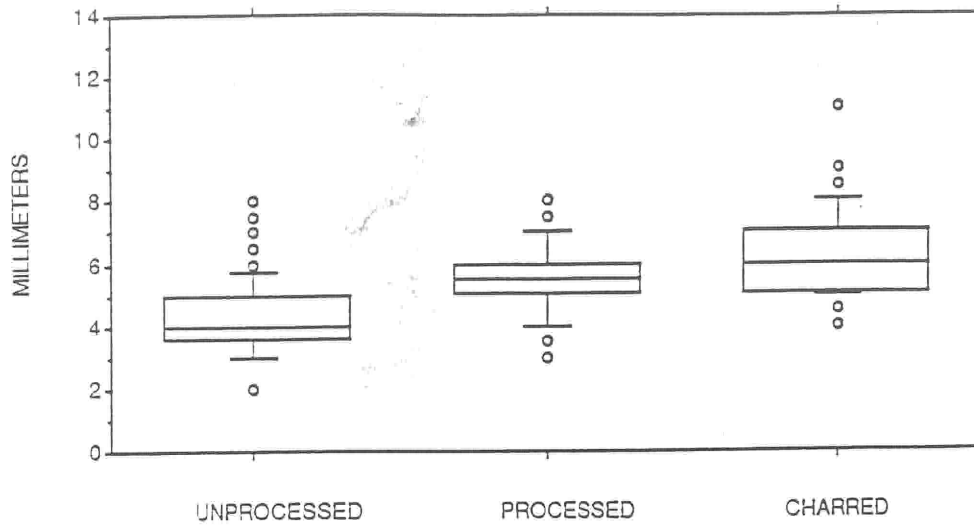


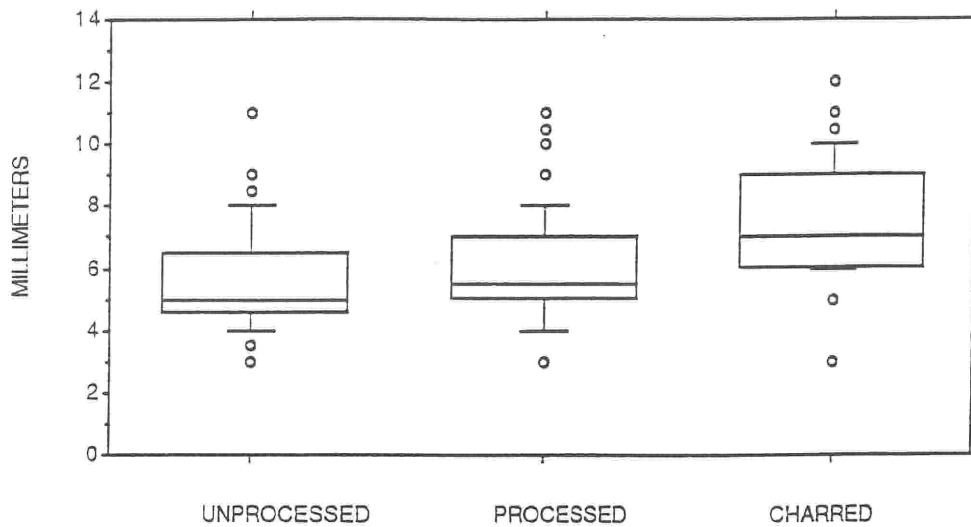
Figure 5: Measurements

THICKNESS

CHULLPI



CUZCO RACE



HUILCAPARU

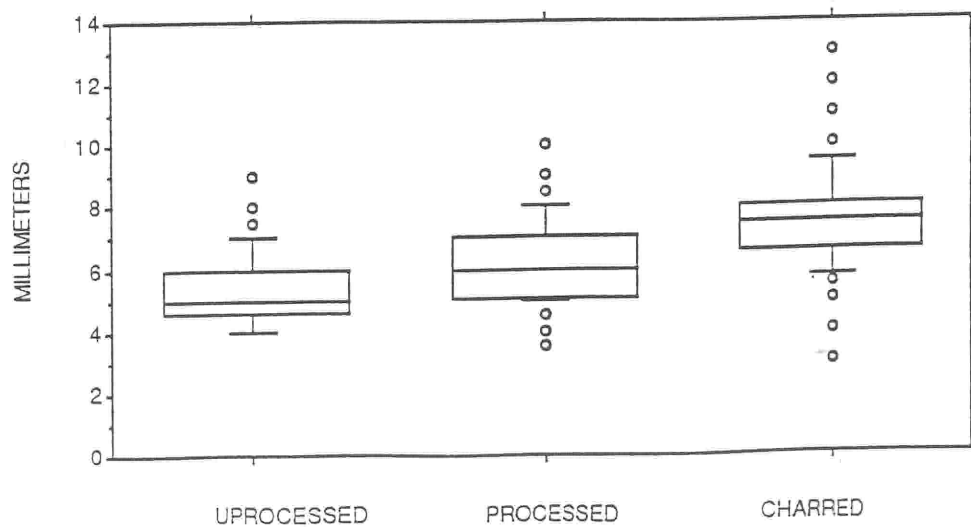
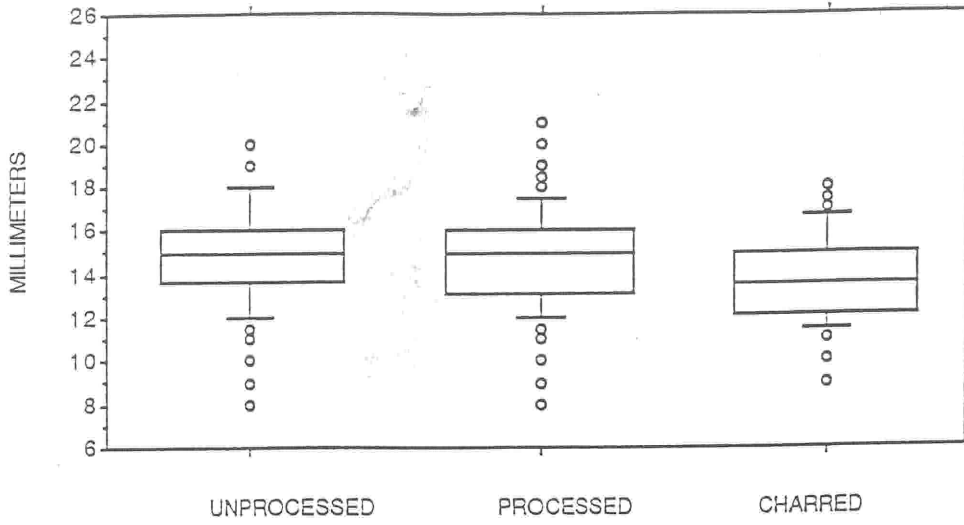


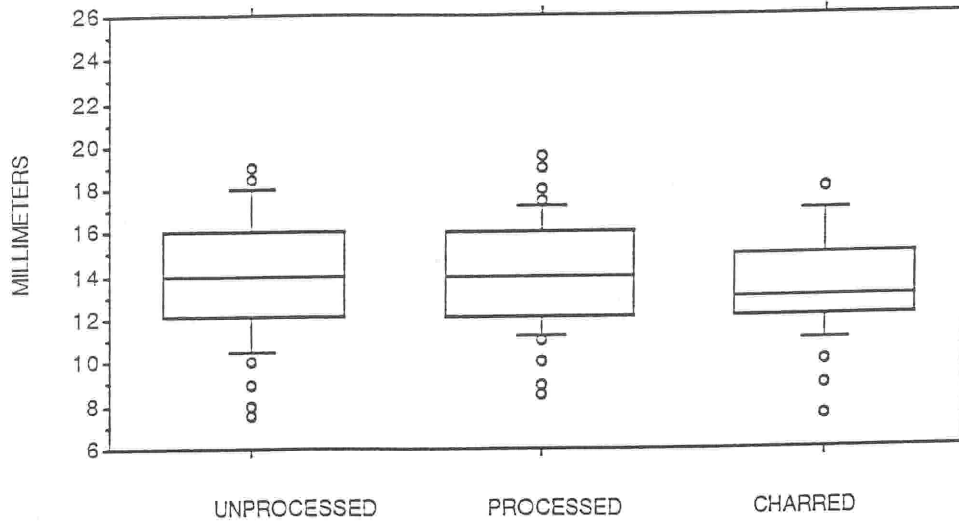
Figure 6: Change in Thickness with Processing and Charring

LENGTH

CHULLPI



CUZCO RACE



HUILCAPARU

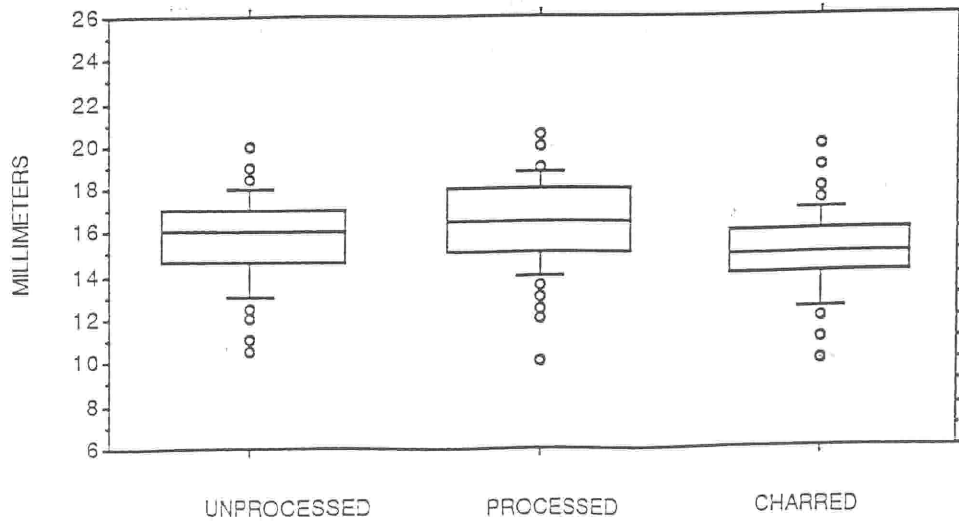
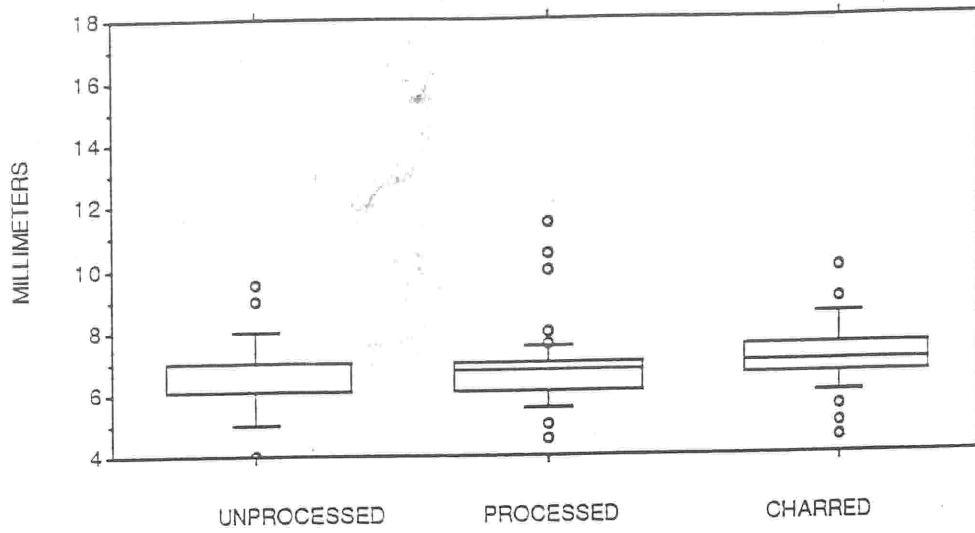


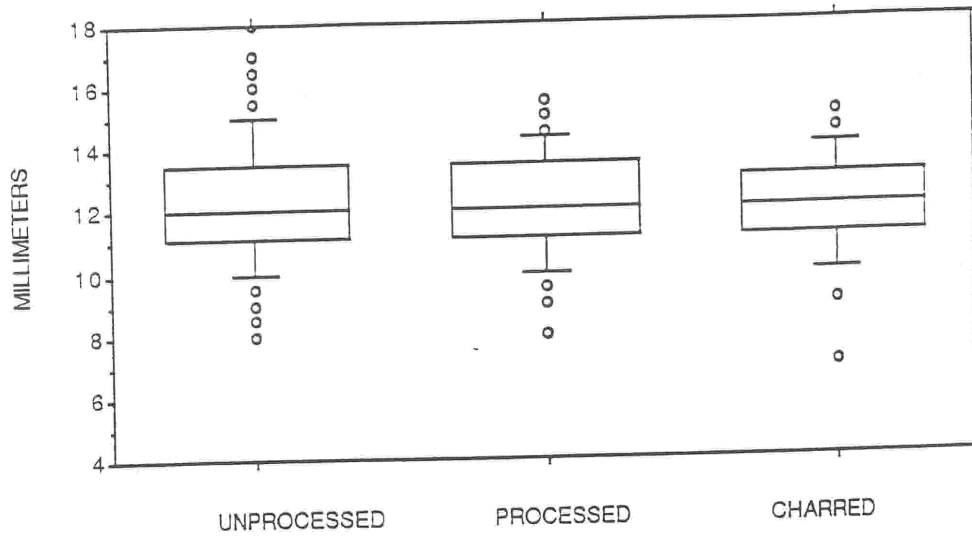
Figure 7: Change in Length with Processing and Charring

WIDTH

CHULLPI



CUZCO RACE



HUILCAPARU

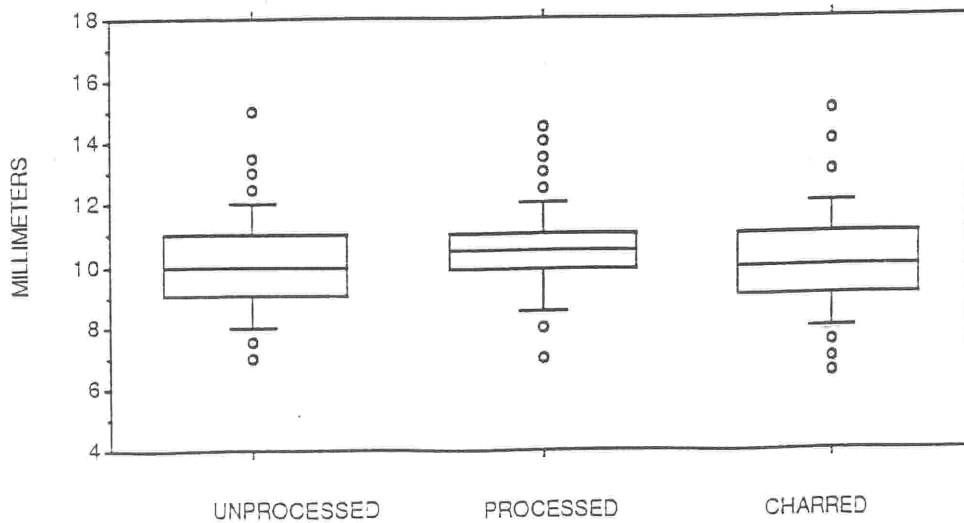
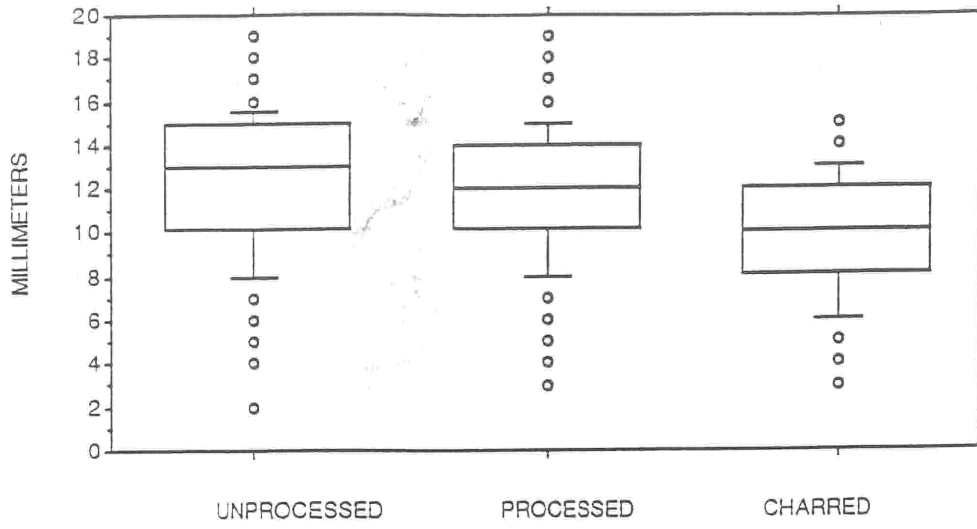


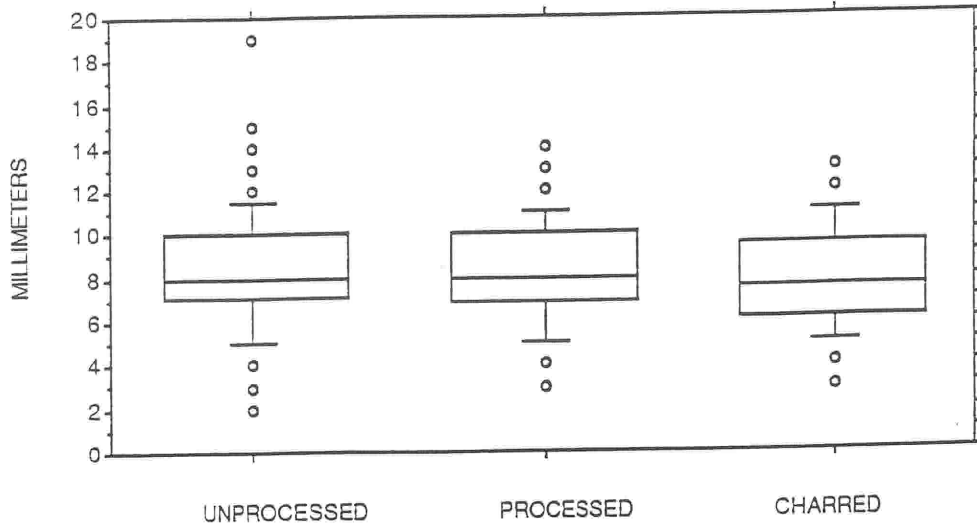
Figure 8: Change in Width with Processing and Charring

TIP TO SHOULDER

CHULLPI



CUZCO RACE



HUILCAPARU

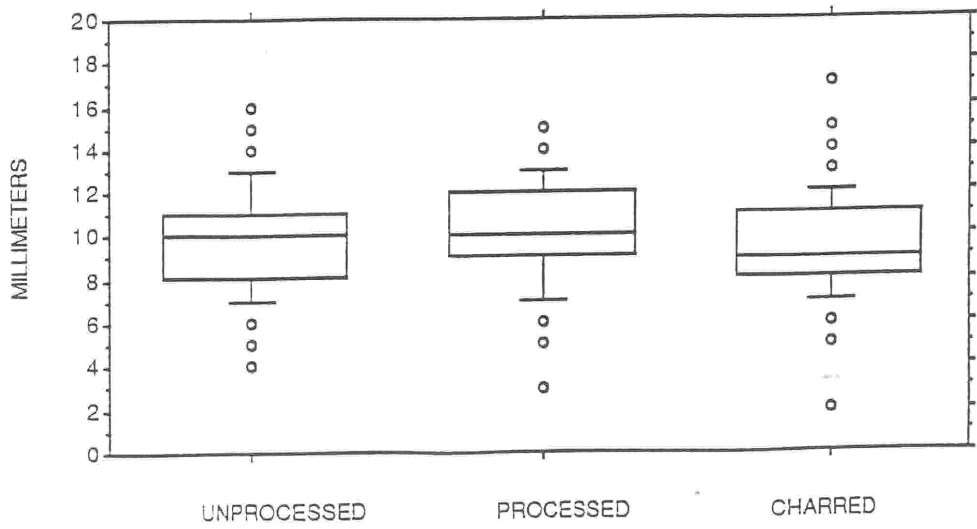
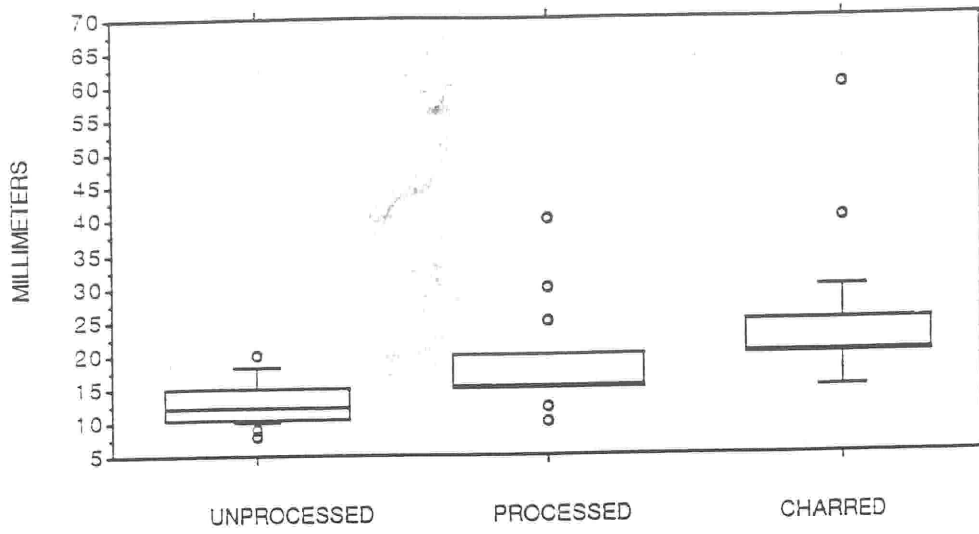


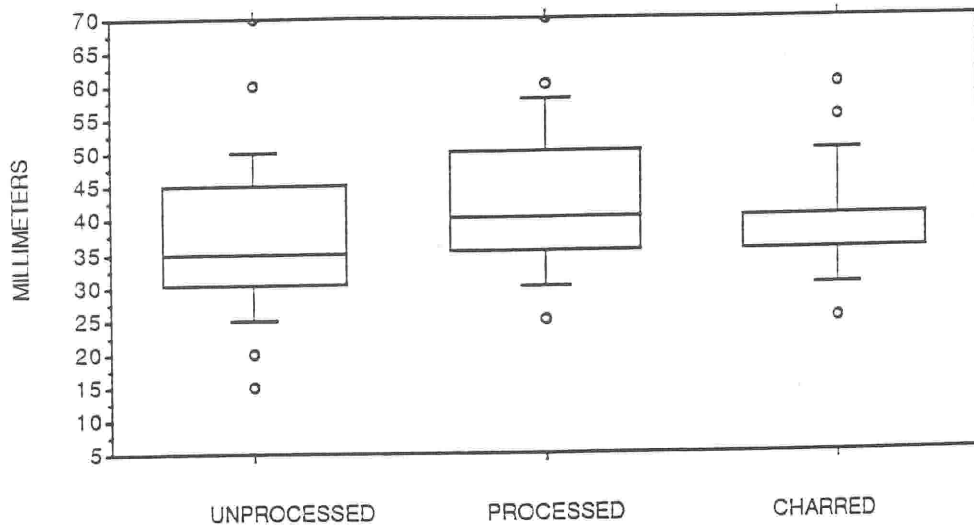
Figure 9: Change in Tip to Shoulder with Processing and Charring

ANGLE

CHULLPI



CUZCO RACE



HUILCAPARU

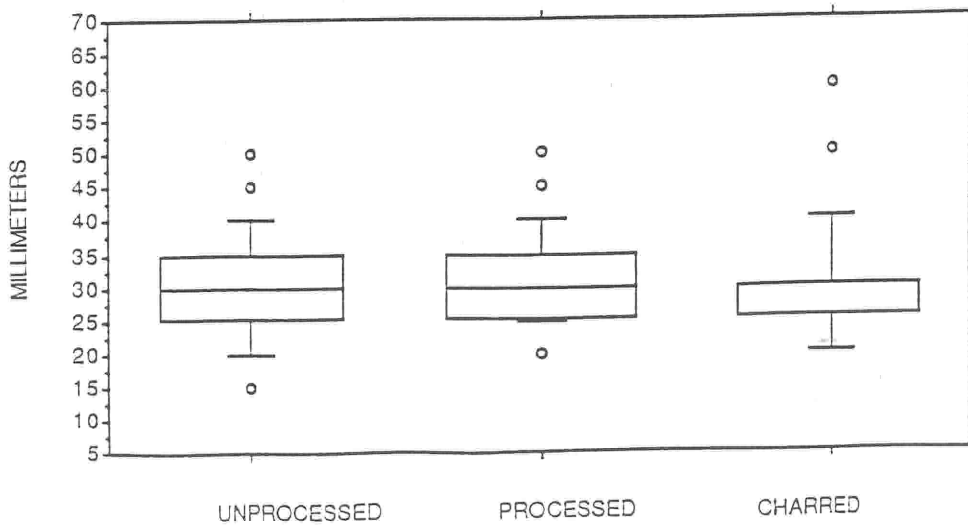


Figure 10: Change in Angle with Processing and Charring