THE RAW AND THE COOKED

A Study on the Effects of Cooking on Three Aboriginal Plant Foods from Southeast Queensland

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Replicative cooking and stone tool processing of three starchy plant foods from southeast Queensland – *Alocasia macrorrhiza* (native taro), *Blechnum indicum* (fern-root) and *Castanospermum australe* (Moreton Bay chestnut) – was undertaken (Fig 1). Residues were compared using microscopy and the biological stain Congo Red to investigate the effects of cooking on starch grains. Results revealed that the main morphological effects of cooking on starch are swelling, and disruption of the extinction-cross; and that Congo Red stains starch such that raw grains are distinguishable from cooked grains. Application of the Congo Red stain to the archaeological residues of three bevel-edged artefacts produced consistently reliable results, allowing identification of cooked, damaged and raw starch. Several grains observed on these artefacts were similar to those in cooked *B. indicum* samples. This study represents the first successful archaeological use of Congo Red, and the first detailed evidence of the effects of cooking on starchy plants known to have been cooked and processed by Aboriginal people.

Fig. 1. Southeast Queensland, showing general area of bevel-edged artefact distribution. Analysed artefacts derive from the archaeological sites marked by triangles.

Introduction

Plants formed a major part of the pre-European Aboriginal diet and many Australian plants, principally those with toxic properties, need to be cooked to make them digestible and palatable. Although ethnohistories record the cooking and processing of plants throughout Australia, very little direct archaeological evidence for these activities exists. While macro-botanical remains do not survive well in archaeological contexts, plant residues on stone artefacts demonstrate notable longevity. This study addresses this issue by developing a direct means for identifying past cooking from plant processing residues, in order to enhance archaeological knowledge of pre-European Aboriginal subsistence practices.

Starch

Starch is the only plant residue that can be unambiguously identified by microscopic analysis owing to its semi-crystalline structure. When starch grains are viewed in cross-polarised light a dark "Maltese cross" appears, and rotation of the polarising plate results in radial rotation of this extinction-cross around the centre of the starch grain. Cooking disrupts the starch grain's structure, resulting in partial or full loss of the extinction-cross (Banks and Greenwood 1975), a process termed gelatinisation (Fig. 2). Thus, starch grain analysis provides one direct method of identifying cooked starch in archaeological residues and, by inference, ancient plant food cooking.

Congo Red Dye

Congo Red is a disodium salt dye that stains swollen and damaged starch grains (Badenhuizen 1965; Cortella and Pochettino 1994). Since cooking starch grains causes swelling and damage to their semi-crystalline structure, Congo Red is an ideal stain to test for the presence of cooked starch in archaeological residues. This study is the first attempt to use Congo Red staining to identify cooked archaeological starch.

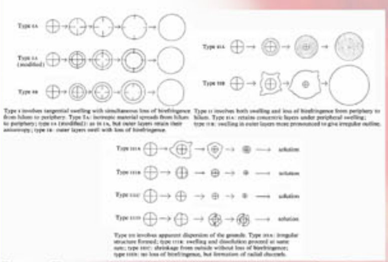

Fig. 2. Types of starch grain gelatinisation (Banks and Greenwood 1975).

Methods

Replicative Cooking Experiments

In order to investigate the effects of cooking on starch, three starchy plants (*A. macrorrhiza*, *B. indicum* and *C. australe*) from southeast Queensland were subjected to replicative cooking experiments. These plants need to be processed before they can be eaten (e.g. Johns and Kubo 1988; Sakai and Hanson 1974), and they are all reported in the ethnohistoric literature to have been pounded between stones after roasting. Replicative experiments involved each plant being pounded between two stones in both raw and cooked states. Microscopy was used to examine residues on the stones used in these experiments to determine the morphological effects of cooking on starch grains, then Congo Red was applied to ascertain whether staining could differentiate raw and cooked starch.

Archaeological Applications: Bevel-Edged Artefacts

Several investigators have identified "bevel-edged" artefacts as having been used specifically to process *B. indicum* in southeast Queensland (Fig. 1). These tools are characterised as having one or more edges truncated by a bevel and are usually made from river cobbles (Gillieson and Hall 1982; Kamminga 1981; McNiven 1992). Three archaeological bevel-edged artefacts were analysed using the methods developed from replicative experiments.

Fig. 3. Starch grain from cooked *A. macrorrhiza* sample (cross-polarised transmitted blue light, 500x).

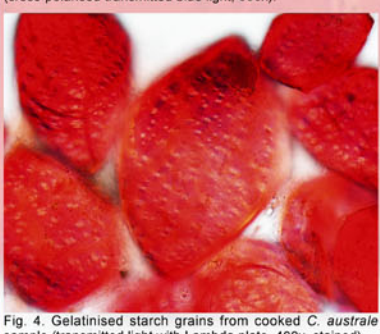

Fig. 4. Gelatinised starch grains from cooked *C. australe* sample (transmitted light with Lambda plate, 400x, stained).

Results

Replicative Cooking Experiments

Examination of the experimental tools revealed that, morphologically, the most reliable indicators of cooked starch are swelling, and disruption of the extinction-cross (Fig. 3). However, swelling was not apparent in many samples, possibly because large starch grains gelatinise before smaller grains, which leaves visible, identifiable grains that are smaller than their raw counterparts. Examination of experimental tools suggested that gelatinisation of starch disrupts the structure enough to make gelatinised grains microscopically invisible without biological staining. Significantly, Congo Red dye stained gelatinised and otherwise damaged starch grains in such a way that raw grains were distinguishable from cooked grains. The stain revealed that cooked starch grains swell dramatically (often to over four times their original size), but usually retain their primarily round or oval shape (Fig. 4). Also, they generally retain enough of their structure for a modified "cross" to appear on their edges (as four dark points in their outline) in cross-polarised light (Fig. 5). Raw, damaged (as from processing) starch grains also exhibited modified extinction-crosses, with partially cooked grains perhaps taking on this appearance as well, but such stained grains were much smaller than the gelatinised grains. In contrast, undamaged raw grains retained the usual dark extinction-cross when viewed in cross-polarised light, and did not stain (Fig. 6).

Archaeological Applications: Bevel-Edged Artefacts

Application of the Congo Red stain to archaeological stone tool residues produced consistently reliable results, allowing differentiation of cooked (Fig. 7), damaged and raw starch grains. Additionally, several starch grains observed in the archaeological samples (Fig. 8) are similar in size and appearance to those observed in experimental, cooked *B. indicum* samples (Fig. 9).

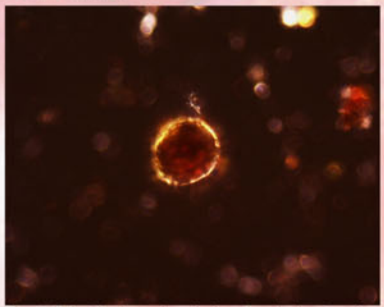

Fig. 5. Gelatinised starch grain from bevel-edged artefact (cross-polarised transmitted light, 400x, stained).

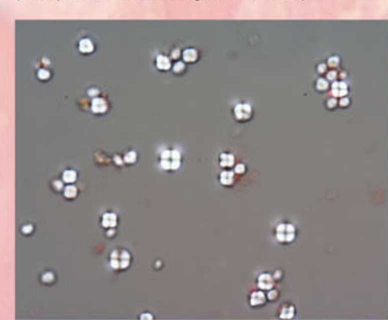

Fig. 6. Starch grains from raw *C. australe* sample (cross-polarised transmitted light, 400x, stained).

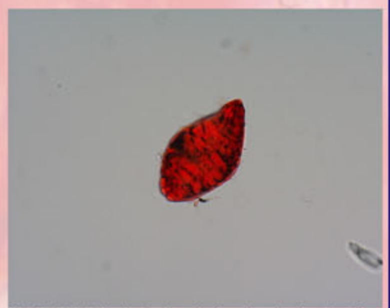

Fig. 7. Gelatinised starch grain from bevel-edged artefact (transmitted light with Lambda plate, 400x, stained).

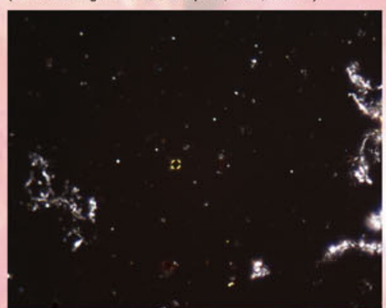

Fig. 8. Starch grain from bevel-edged artefact (cross-polarised transmitted light, 400x, stained).

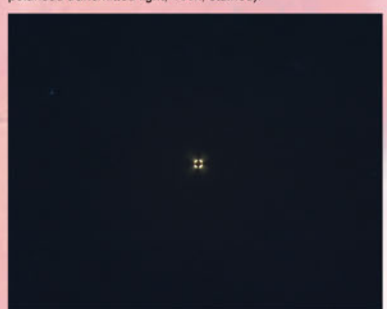

Fig. 9. Starch grain from cooked *B. indicum* sample (cross-polarised transmitted light, 400x, stained).

Discussion & Conclusions

Congo Red staining is a reliable method for identifying cooked starch and thus facilitates the detection of past cooking of starchy food in stone tool processing residues. The bevel-edged artefacts analysed all exhibited plant material similar in type and appearance to the material observed on the experimental processing tools, and stained starch grains were found in far greater numbers on the bevelled faces and edges of the artefacts than on other areas, enhancing the interpretation of these residues as deriving from plant processing. The presence of raw, unstained starch grains, small, stained starch grains and large, stained, gelatinised starch grains also indicates processing of both cooked and raw starchy plants. A number of starch grains that are similar in size and appearance to *B. indicum* starch were identified on the artefacts. These results strengthen the argument that bevel-edged artefacts were used to meet the needs of processing *B. indicum*. While this functional association has mainly been documented for southeast Queensland up to Cooloola and Fraser Island, the artefacts examined here originated from the northern extremity of southeast Queensland (Fig. 1). These results therefore support an expansion of the area where this association occurs to include the coast near Miriam Vale where *B. indicum* was also available. This work enhances our understanding of pre-European Aboriginal plant subsistence practices and provides a set of methods that may be used by archaeologists to investigate archaeological residues deriving from cooked starchy foods.

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