

Early humans recipe for processing plants foods at Blombos Cave, South Africa (85-82 ka)

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Abstract

We present the results of archaeobotanical research conducted into the plant diet of early modern humans who intermittently occupied Blombos Cave on the southern Cape coast of South Africa during the Middle Stone Age (MSA). Botanical samples were taken from two combustion events in the MSA sequence dated to 85 and 82 kya (kya = thousands of years ago). Analysis of these samples shows charred starchy plants had undergone processing sequences prior to cooking. The plant cells show evidence of having been pounded whilst still fresh and some of these fragments indicate pounded starchy plant food was mixed with pounded seeds prior to cooking. We infer that these samples represent the earliest known example of food processing and mixing in a 'recipe' as part of early human foodways. We consider these findings and their role in human evolution in the context of human behavioural modernity.

Introduction

Here we present evidence of starchy plant remains recovered from combustion events dated to 85 kya and 82 kya in Blombos Cave, South Africa. We infer from indications of pre-processing, in this case pounding, then mixing of different plants followed by fire treatment, the earliest attested case of a 'recipe'.

Blombos Cave (BBC) is situated on the southern Cape coast of South Africa, within the Greater Cape Floristic Kingdom, around 300 km east of Cape Town (34°24' × 51''S, 21°13' × 19''E). The vegetation surrounding Blombos is a subtropical thicket–fynbos mosaic (strandveld) on calcareous coastal dunes¹. Fynbos is rich in underground storage organs making edible starchy plants then, as now, available year-round. Blombos Cave has a well-dated and stratified sequence that spans the Middle Stone Age² deposits (127.5 ± 16.9–67.8 ± 4.2 kya) (Fig. 1). The MSA layers are topped by a layer of sterile aeolian sand dune (~ 70 kya) and a Later Stone Age sequence dated to 2 kya^{3,4}.

The MSA at Blombos is identified in four phases (phases = layers identified with a human occupation characterised by particular lithic styles and hunting and foraging strategies). The upper two phases, BBC M1 and BBC M2 upper are associated with the Still Bay techno-complex dated to 77 – 73 kya^{5–7}. Other cultural markers from these phases include bone awls and points, engravings of parallel and joining lines on bone^{8,9}, beads made from *Nassarius kraussianus* shells^{10,11}, at least eight pieces of ochre engraved with geometric patterns^{12,13} and most recently an abstract drawing on a ground silcrete flake, dated to 73 kya³. The M2 lower phase dated to 85 – 82 kya, is represented by a low-intensity occupational horizon lacking Still Bay artefacts. The final M3 phase (127 – 94 kya) contains abundant evidence of ochre use, including engraved ochre and a liquid pigmented compound stored in abalone shells from a layer dated to 100 kya^{4,7}.

Context

This paper focusses on two of the ten botanical samples taken from across the Blombos Cave southern section (Fig. 1), that come from distinct anthropogenic combustion features, identified in section, from two layers of the M2 lower phase. Sample 1 from layer CGABh1, quadrant G7b, which is dated to 82 kya (total station ref: 2688) and Sample 2 from layer CGAC, quadrant G7b, which is dated to 85 kya (total station ref: 2728) (see Fig. 1). It is likely that these combustion events are remnant hearths that may have been either trampled and/or cleaned.

To establish that the route into the archaeological record was anthropogenic and that the manner of deposition was consistent with processing and cooking, we considered whether burrowing animals, other organic deposits (possibly aeolian) or other anthropogenic activity could have been responsible for these assemblages

The most likely taxa that would burrow in this cave would be *Procavia capensis* (Rock hyrax), which occur in the vicinity of Blombos today and *Bathyergus suillus* (Cape dune mole rat). Both species have a diet that is dominated by grasses and sedges, although *B. suillus* also eat bulbs and tubers. Neither species store food underground. Only *B. suillus* nests underground¹⁴⁻¹⁶. Both species defecate and urinate in outside latrines, which can sometimes be metres thick and which are visible to the naked eye in the archaeological record^{17,18}. Any assemblage attributable to either of these burrowing animals would contain a significant number of phytoliths and no phytoliths were present in this assemblage. We have, therefore, dismissed this possibility.

There are organic deposits with humified remains and these have the appearance of combustion features in section but contain no/very few charred plant remains of any kind. It is possible that this vegetation may have blown into the cave, as has significant amounts of sand. These deposits may account for three unsuccessful samples out of the ten (see Table S.3, S.I.). Humified plant remains have little identifiable cell structure and provide a clear contrast with samples that contains a high density of charred plant remains with clear cell structures in a close spatial context, as with the samples discussed in this paper.

The other route into the archaeological record may be attributed to plants, such as sedge grasses, used by hunter-gatherers as bedding. Occasionally, the rhizomes and tubers remained attached to these grasses when gathered and used as bedding as at Sibudu Cave^{19,20}. The bedding was then burned as part of a periodic cleansing of the cave leaving charred rhizomes and tubers. This scenario leaves a distinctive archaeological signature of long burned layers in the stratigraphy, or if not burned, then long white layers created by phytoliths from decomposed sedge grass stems, both visible at Sibudu Cave²⁰. At Sibudu the parenchyma from these rhizomes and tubers has perfectly preserved cell structure, indicating they had dried before burning. This is not the case at Blombos and no phytoliths were found in the SEM process.

The density of charred starchy plant fragments recovered from these two contexts (see Results - Table S.3 in the S.I.) were significantly higher, forming around 40% of all charred plant fragments in the sample, compared to the zero presence and low density of parenchyma fragments in the control sample and non-

combustion event samples. This result attests to the likelihood of these samples coming from an anthropogenic combustion event and that their presence was not accidentally tracked or trodden into the cave, where the density is likely to have been more random and less spatially concentrated.

That these combustion events may have been used for cooking food is supported by the presence of other anthropogenic evidence, including vertebrate remains and three lithic fragments, the latter also coated in burned sediment and ash.

Finally, the evidence of the fragments themselves. The 'folded' appearance of the root and tuber cell structure is the unique result of the starchy tissue being pounded when fresh. This pounded tissue was then mixed with pounded seeds and cooked. Only humans are known to cook and use this multi-step processing prior to cooking ²¹.

Analysis Of Starchy Plant Tissue - Parenchyma

Starch is the means by which all green plants store energy. Plants store starch in the form of granules in tissue called parenchyma, which can be found in leaves, stems and seed endosperm. For many plants the energy reserve to feed new plant growth comes from starch stored in underground storage organs, such as underground stems (tubers), rhizomes and roots ^{22,23}. The parenchyma found in underground storage organs has a number of distinct morphological and identifying characteristics: the cells have a distinct organisation structure; the cells are different from the elongated fibres, tracheids and vessels in wood fragments; rhizomes and tubers can have secretory cavities (that can contain essential oils such as the flavour in ginger or secondary metabolites as a defence mechanism) and lateral or terminal buds and detachment scars on the endermis; and distinct organisation of the vascular structure ^{24,25}. These features allow the identification of cooked starchy plants ²⁶.

The moist conditions at Blombos Cave are not conducive to the preservation of plant remains by desiccation. The parenchyma tissue from these burned samples is preserved as carbon. Charred parenchyma has also recently been found at Klasies River dating to 120 kya ²⁶ and at Border Cave dating to 170 kya ²⁷ and form testament to a deep history of human cooking and eating starchy plant foods.

Results

The full archaeobotanical methods for analysis and modern reference collection creation can be found in the supplementary information.

The parenchyma fragments recovered from both samples as a percentage of all charred fragments is high, 41% and 43% respectively (see S.I.). The high density of parenchyma suggests that these fragments came from anthropogenic combustion event, albeit not intact. The evidence of processed and mixed starchy plant foods within these charred contexts is explained by human cooking of starchy plants.

The charred tuber parenchyma identified from sample 1 is rounded and indicates it has been subjected to mechanical friction, supporting the hypothesis that the context had been subject to either trampling or cleaning ²⁵ (Fig. 2A). Fragment 2B is an example of rhizome pith parenchyma that had been cooked from fresh where the cells have been deformed by escaping steam (Fig. 2B) ²⁵. Eleven fragments from both samples displayed this cell structure. The evidence that they were cooked while fresh and moist would indicate that these rhizomes and tubers were neither used for bedding or fuel but were plant foods brought into the cave by humans.

Poorly preserved and mechanically stressed or broken fragments are common throughout the Blombos samples. The poor preservation is often a result of phosphatisation (Fig. 2C) and mechanical breakage caused by movement with the sediment and trampling (Fig. 2D).

The broken parenchyma cells (Fig. 2D) have straight, pointed edges, with fractures showing no particular pattern across the cells. These broken fragments may have been trampled or mechanically fractured after burning. The process of phosphatisation gives the cells an indistinct appearance, as it breaks down the cell structure.

Evidence For Processing

However, throughout these two samples, there was a different deformation of parenchyma cell walls, where the cell walls appeared to have 'folded' inwards. These examples have been identified as evidence of starchy plants having been processed by pounding. The identifications were made by comparison with micrographs of experimental work conducted by Wollstonecroft *et al.* (2008) (28) using modern tubers of *Bolboschoenus maritimus* (L.) Palla (sea club rush) (Fig. 3).

Figure 3: Pounded sea club rush tuber parenchyma tissue, shown in scanning electron micrograph (inset left): cell rupture is evident cell separation and fissures along the middle lamellae. csg = Compound native starch granule, cw = cell wall, ml = middle lamella, s = single native starch granule, (adapted from the original in Wollstonecroft *et al.*, S24, Fig. 4, Vegetation History and Archaeobotany, 2008, DOI: 10.1007/s00334-008-0162-x and reproduced with the kind permission of Springer publications). Compared similar archaeological processed parenchyma exhibiting 'folded' tissue outlined by white box (right) from fragment 101, sample 1 (82 kya). (Micrograph: C. Larbey)

Comparative cell wall structures were found in the samples from Blombos Cave. Parenchymatous tissue from the tubers in the experiment in Fig. 3 were first pounded when the tuber was raw and moist and then cooked ²⁸. The result indicates that when fresh roots and tubers are pounded, the cell walls of the parenchyma do not break but fold inwards. This process could only occur whilst fresh. Once cooked, the cell walls become brittle and when broken, such as by trampling, the parenchyma breaks, exhibiting straight edges across cells at random.

In the experiment it was noted that heating alone did not soften sea club rush tubers, although heating caused the starch granules to swell and gelatinise, a process that makes starch more susceptible to

alpha-amylase breakdown during digestion. In fact, boiling for any length of time did not appear to soften the tissue, until pounded.

The micrographs in Figs. 4A and 4B exhibit evidence of the parenchyma having been processed by pounding. The cell walls appear 'folded' rather than sharp-edged and broken or decomposed by phosphatisation. Sample 1 has 27 fragments and Sample 2 has 32 fragments that exhibit signs of pounding processing prior to cooking.

Figures 4C and 4D provide evidence of ruptured seeds combined with the pounded parenchyma. Six burned fragments in total exhibit pounded parenchyma with seed inclusions. The seed testa morphology appears similar in each case with testa cells measuring 10–18 µm. Seeds rarely rupture unless they are ground or pounded²⁹ and are often found whole and capable of identification to species from archaeological latrines and sewers, *e.g.* the Carco V sewer at a Roman site in the Bay of Naples³⁰. The evidence from Blombos cave suggests mixing and cooking of plant foods that include pounded tubers and pounded seeds for food and flavour.

Discussion

Although only a few thousand years apart, these hearths were formed during different climate cycles, 85 kya corresponding with a cold stadial and 82 kya with a warmer inter-stadial but each representing a persistence in behaviour (Fig. 5). When combined with the findings of cooked roots and tubers from intact hearths from Klasies River, South,²⁶ the cooking and consumption of starchy plants appears to have persisted during significant oscillations in climate (Fig. 5). These variations in climate would have meant cold, wet, arid and/or extreme heat.

So whilst lithic technologies such as Howiesons Poort and Still Bay may be climate-mediated responses to ecological changes^{32–34}, the foraging for, cooking and processing of starchy plants appears to have persisted.

Plant processing methods, whether grinding, pounding, grating, soaking/leaching, fermenting or boiling/roasting transforms the bioavailability for humans of the carbohydrates found in starchy plants^{35–40}. These processes essentially start the digestion process externally. They can also, in some species, neutralise some of the irritants and secondary compounds in plants, rendering them safer and more digestible. Different processes are required for different plants, as the physical and chemical composition of plants mean they respond in different ways to processing³⁶. Humans have a wide range of processing methods that they can apply either individually or in combination. The evidence presented here represents a complex multi-step processing sequence not previously observed in the archaeological record.

The discovery of mixed plant foods, with pulverised seeds forming an occasional ingredient in a pounded tuber-like matrix suggests that there may be taste/flavour preferences being expressed, beyond just the

meeting of subsistence needs. The seeds look to be similar, although their ruptured form inhibits identification to species, but their regular appearance throughout the assemblage, incorporated in parenchymous matrices, suggests a taste preference.

Before the use of fire, exploitation of starchy plant foods would have been limited^{21,36}. Hardy *et al.* (2015) argue that humans are biologically adapted to a starch diet, with the brain, red blood cells and reproductive organs dependent upon glucose. A carbohydrate diet would have been essential to provide the energy needed for the morphological changes that evolve in the genus *Homo*, such as larger brains, longer limbs and larger babies³⁷. This argument is consistent with evidence for the duplication in our salivary amylase genes in *Homo sapiens*⁴¹. It also indicates an early adaptation to a diet that included a larger proportion of starch⁴². The ability of humans to adapt their generalist diet to ecological niches has allowed them to colonise most biomes across the planet⁴³, and yet the ecological intelligence required to accomplish this may have been underestimated⁴⁴. The botanical and ecological knowledge to identify safe plant species, in a seasonal botanical landscape, not only as a food itself but in its ability to attract animals⁴⁵, the technical knowledge to know which and how many processing steps will make them edible and the culinary skill to mix plant foods for flavour is possibly another measure of what it is to be human.

Conclusion

We offer evidence of the changed morphology of charred plant remains as the earliest multi-step plant processing and cooking, along with the mixing of plants from levels dated to 85kya and 81kya. This evidence comes from two combustion events from the M2 lower phase of the MSA levels in Blombos Cave, South Africa; each level representing very different climatic contexts. Whilst hunting technologies and strategies have changed in response to varying ecologies, these results would suggest that the hunter-gatherers at Blombos Cave retained the ability to find starchy plants that they were able to make digestible by processing. This persistent behaviour of processing, combining and cooking foraged starchy plants in the form of a 'recipe', we suggest, is a significant addition to the suite of modern human behavioural attributes.

Declarations

Competing Interests

None of the authors has any competing interests

Author Contributions

CL: Conception; design; data acquisition; analysis; interpretation of data

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Figures

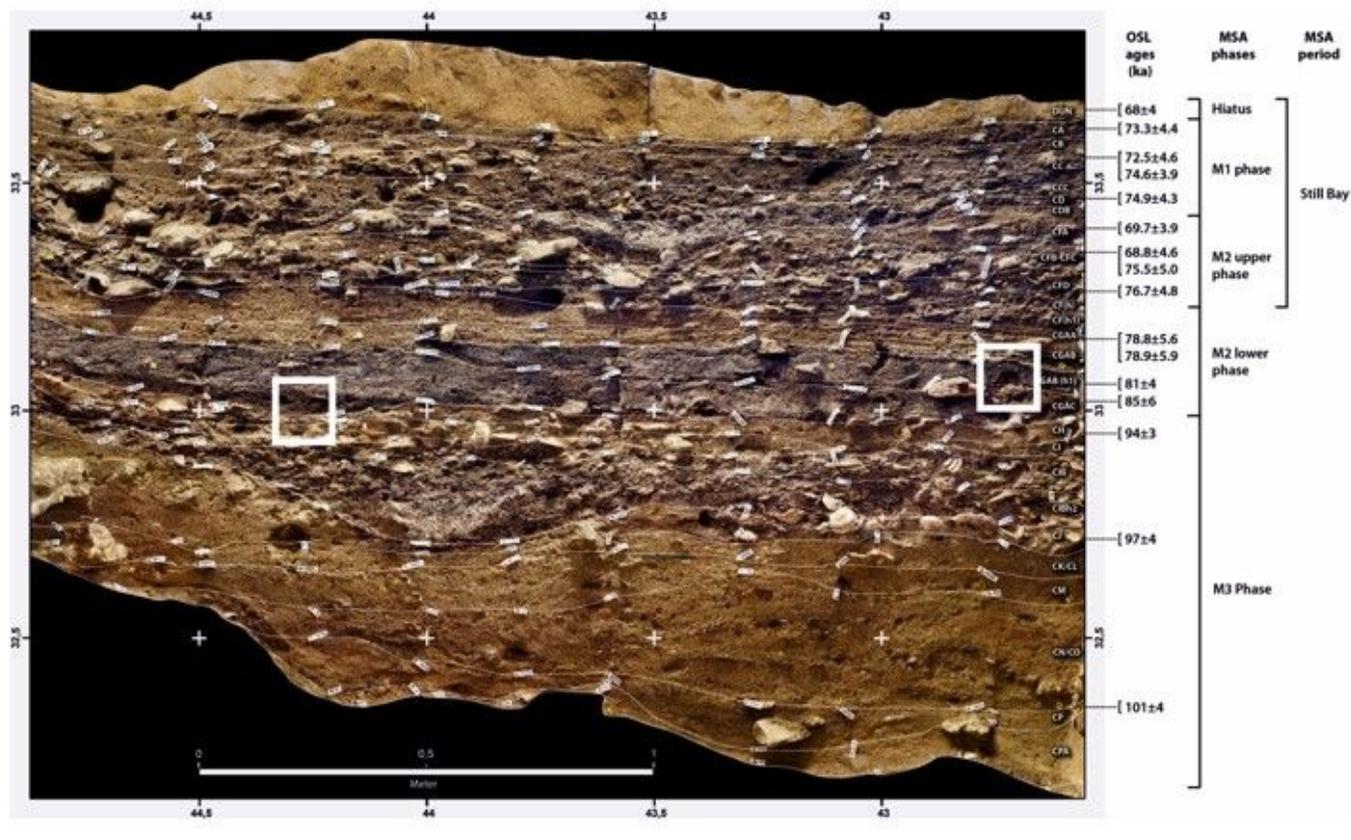


Figure 1

Stratigraphic sequence, dates and phases from Blombos Cave, South Africa. Left box indicates location of Sample 2 (85 kya) and the right box indicate location of Sample 1 (82 kya) (Adapted from an image by M Haaland)

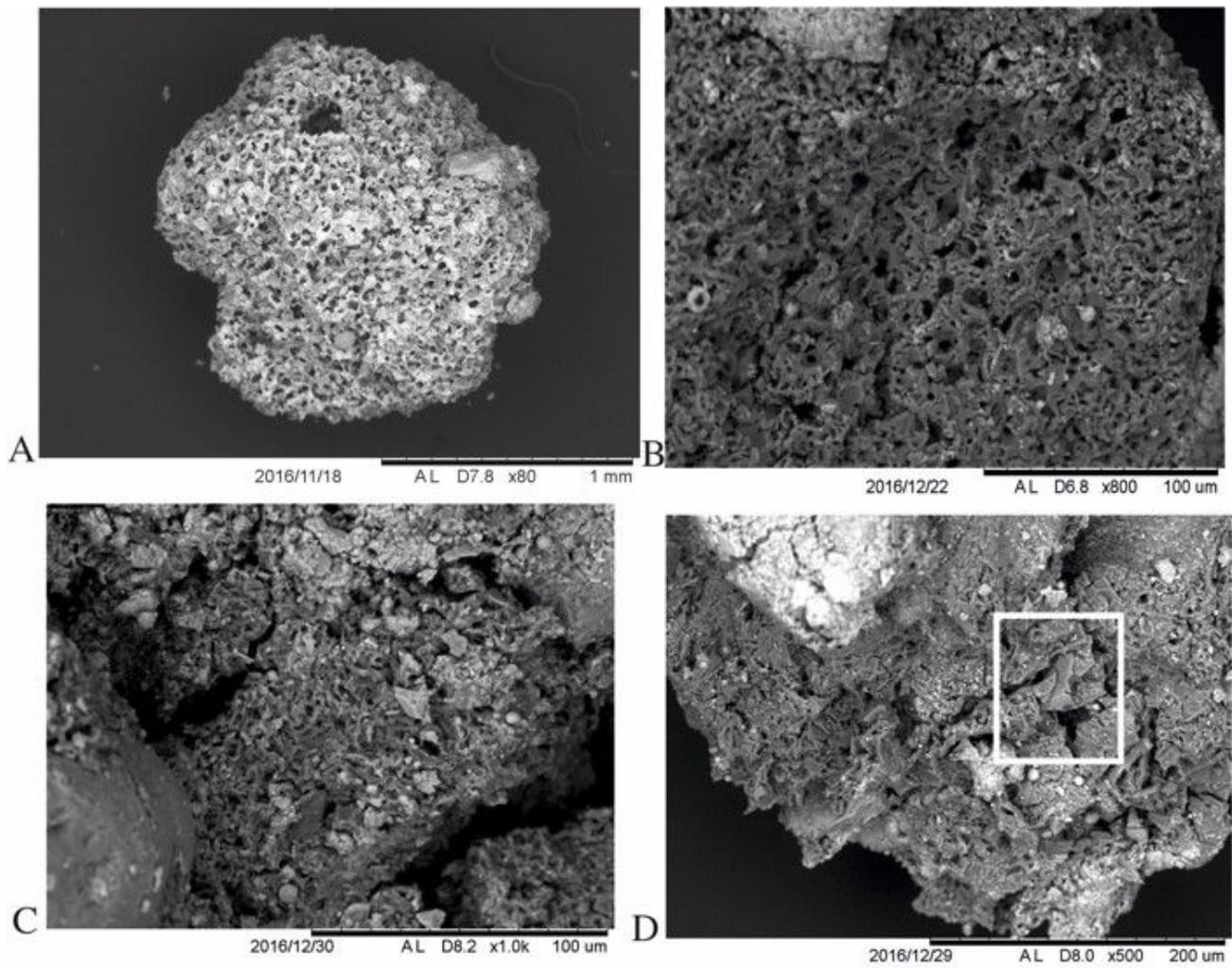


Figure 2

Blombos Cave Archaeological parenchyma from Sample 1: A: Charred archaeological tuber parenchyma. B: Charred rhizome pith parenchyma, with deformed cell structure indicating cooked from fresh. C: An example of poorly preserved parenchyma, with indistinct cell features. D: An example of broken parenchyma showing mechanical fracture where the fragments have straight, sharp broken edges that cut across cells (in box) (Micrographs: C. Larbey)

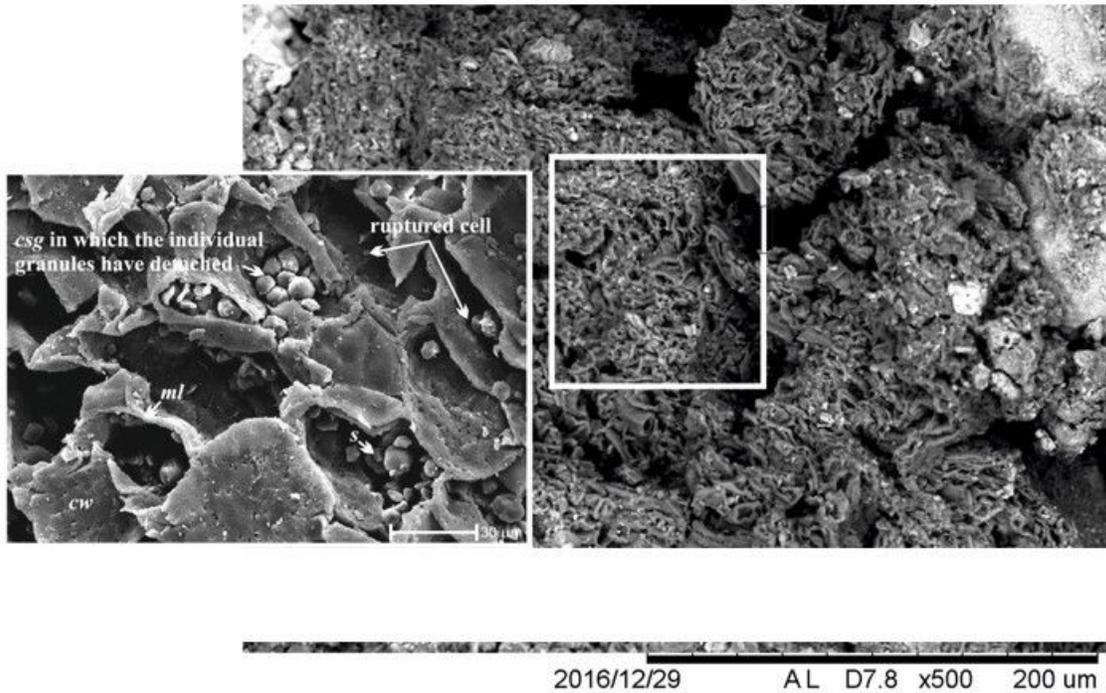


Figure 3

Pounded sea club rush tuber parenchyma tissue, shown in scanning electron micrograph (inset left): cell rupture is evident cell separation and fissures along the middle lamellae. csg = Compound native starch granule, cw = cell wall, ml = middle lamella, s = single native starch granule, (adapted from the original in Wollstoncroft et al., S24, Figure 4, *Vegetation History and Archaeobotany*, 2008, DOI: 10.1007/s00334-008-0162-x and reproduced with the kind permission of Springer publications). Compared similar archaeological processed parenchyma exhibiting 'folded' tissue outlined by white box (right) from fragment 101, sample 1 (82 kya). (Micrograph: C. Larbey)

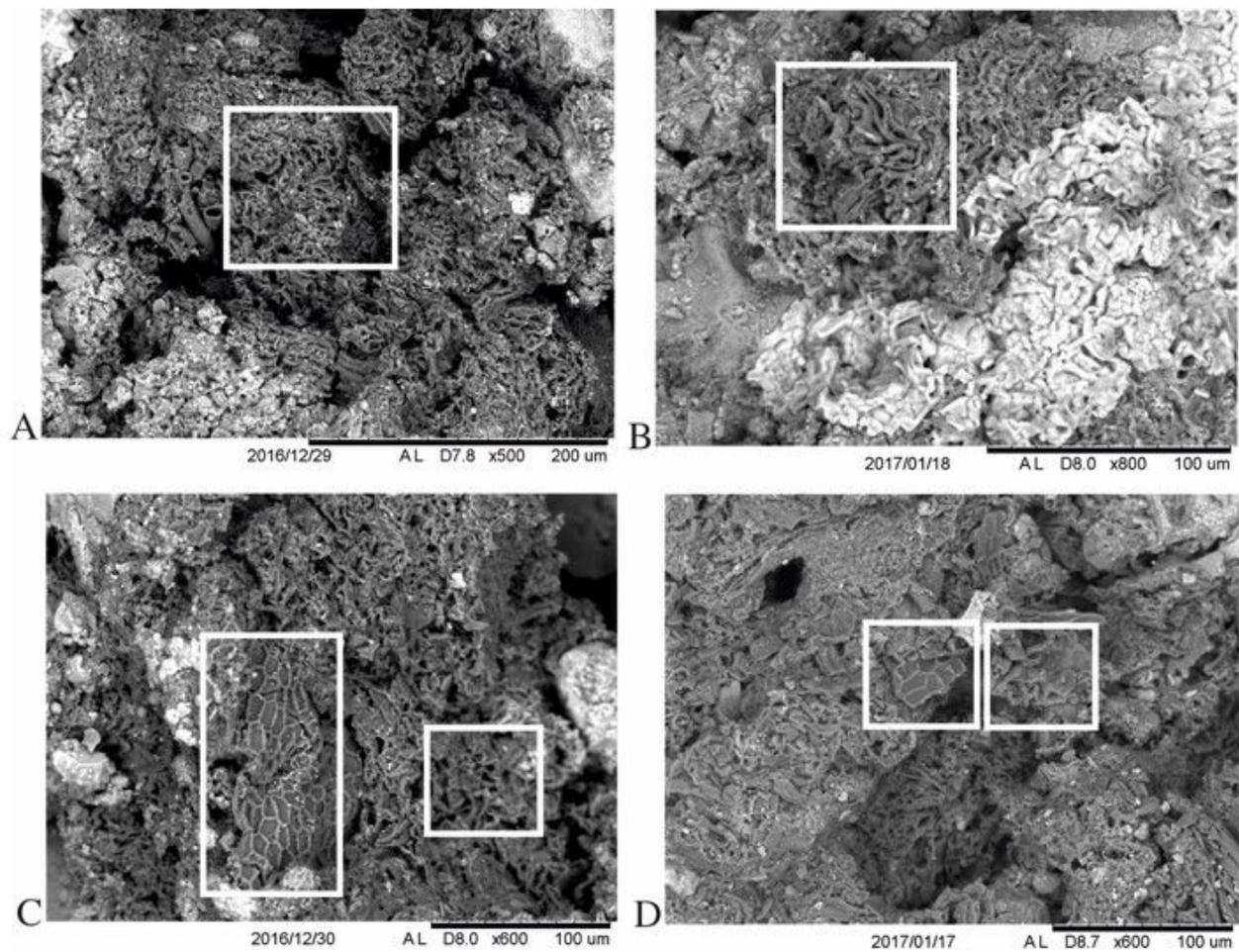


Figure 4

Blombos Cave archaeological pounded and cooked seed and tuber mixed plant foods from both samples. A and B: Exhibit cooked and pounded parenchyma from starchy rhizomes or tubers A = fragment 101, sample 1 (82 kya) and B = fragment 74, sample 2 (85 kya). C: Ruptured seed testa (left arrow) in pounded parenchyma matrix (right arrow) fragment 130, sample 1 (82 kya); D: Ruptured seed testa (left arrow) in pounded parenchyma matrix (right arrow) from fragment 61, sample 2 (85 kya). (Micrographs: C. Larbey)

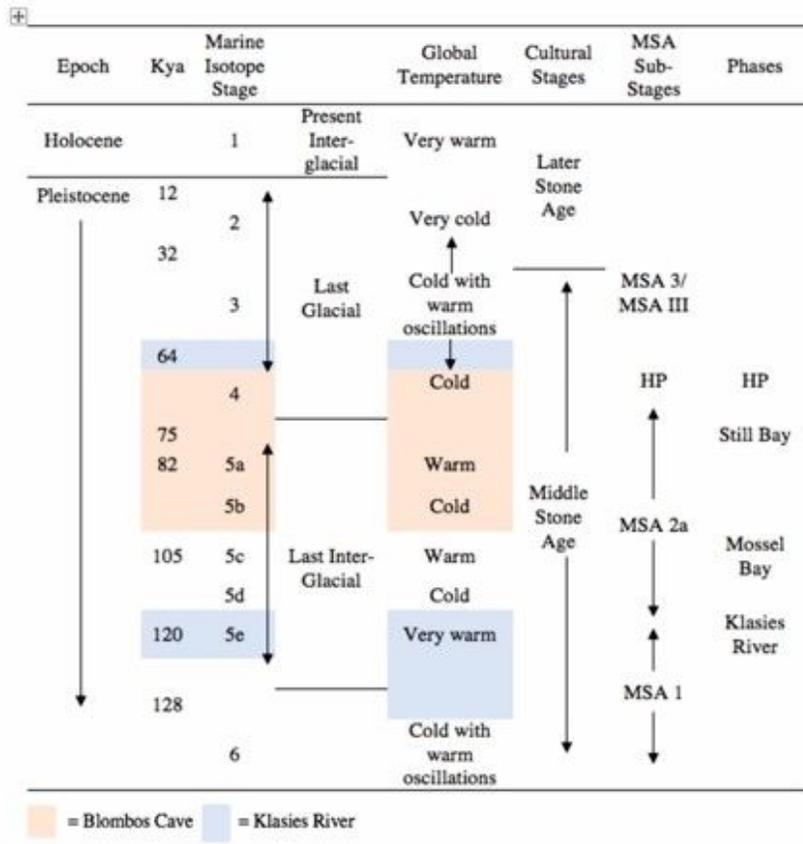


Figure 5

The periods and phases during which evidence now exists for persistence in cooking, processing and consumption of starchy plants during the MSA on the Cape coast of South Africa 26. (Image adapted from 31: 246)

Supplementary Files

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