

CHAPTER 12

THEIR STAFF OF LIFE: INITIAL INVESTIGATIONS ON ANCIENT EGYPTIAN BREAD BAKING

by

Delwen Samuel

12.1 Introduction

During the 1987 season at Amarna, a project commenced on ancient Egyptian bread-making. It was prompted by the site's numerous well-preserved archaeological contexts connected with baking, and the abundance and excellent state of preservation of cereals and other plant remains. Bread was a staple in ancient Egyptian diet and its production a major focus of daily life. The overall goal of this study is to understand cereal processing and baking techniques used by the ancient Egyptians. The primary approach is through experiments replicating equipment, tools, and methods of the past. Thorough archaeobotanical analysis is a time-consuming process; much more work must be done before the Amarna material can be fully related to other forms of information. One context associated with cereal processing, a mortar emplacement, has been investigated in detail, and results are included here. Finally, questions raised during the course of the work, and investigations which should be pursued in future, are considered.

Despite extensive archaeological finds and many surviving representations of baking, the record is not all-encompassing, and aspects of bread-baking remain unclear. By approaching the subject from an entirely different angle, some ambiguities should be resolved. Experimentation is useful to test the feasibility of theories on bread-making based on tomb art. Quantitative and qualitative measures of resources and effort can be obtained by replicating ancient equipment and imitating its use. Synthesizing all sources of evidence will create a reasonably reliable picture of baking.

Fortunately, the Egyptians left many-different records. Perhaps best known are the numerous tomb reliefs, paintings, and models which illustrate bakery activity. Informative as they are, the meaning of actions can be obscure. The order in which pictures were meant to be read is sometimes uncertain. Often steps are missed out; what must have occurred between one scene and the next is not always obvious to present day observers. The archaeological record is frequently interpreted with reference to artistic material, but the latter does not explain everything which is found.

Excavations of fortresses, temples, tombs, and settlements have unearthed a myriad collection of structures and artefacts related to baking. Archaeological items include mortars, quern emplacements, and whole bakeries with ranges of ovens. Smaller objects associated with bread-making are rubbing stones used at querns, bread moulds, and, in tombs, funerary bread itself. Another source of evidence for ancient baking is archaeobotanical remains. Work at Amarna provides an excellent opportunity to study ancient plant material. Preservation, primarily by desiccation with a small charred component, is outstanding. Most botanical finds elsewhere in Egypt have been made from tombs. Amarna is one of the few settlement sites to include retrieval of plant remains; these can be directly correlated to a specific context in order to reconstruct treatment of plant resources which were transformed into food. They form an invaluable corpus of direct evidence for cereal processing. Results from archaeobotanical analysis will provide useful guidelines for experimental work. Finally, administrative records provide some information on broader aspects of bread-production such as supply of grain, and measures and proportions of ingredients.

This report describes the work which has been done to date on the Amarna bread-baking project. A summary of the artistic evidence is presented, showing the type of information it provides, and the questions it leaves unanswered. Preserved ancient bread is the finished product of baking; information is included on some loaves in the Manchester Museum collection. A full description of experiments carried out at Amarna during the 1987 season demonstrates how they

have been used to augment and clarify other types of evidence. Although the experimental programme has focused on bread-making, of the New Kingdom (c. 1600–1000 BC), this being the period represented at Amarna, the evidence from earlier periods is also discussed.

12.2 Artistic evidence

As with so many ancient Egyptian activities, the rich legacy of tomb paintings leaves us numerous lively accounts of bread-baking. Until now, these, along with tomb models, have provided most of our information about ancient Egyptian bakery. The subject has been studied in depth by numerous scholars (Klebs 1915; Montet 1925; Wreszinski 1926; Wild 1975; among others). Most syntheses have focused on Old Kingdom representations, but, as Wild (1975: 594) points out, procedures change over time and differ according to who received the bread. Tomb art does show some differences of technique and equipment throughout the various eras but on the whole remains stylized and uniform. There is little to indicate what distinguishes the numerous types of bread which were made; at least fourteen types are listed for the Old Kingdom, and forty breads and cakes for the New Kingdom (Wild 1975: 594).

12.2.1 Old Kingdom.

A. *Baking in the fire.* The simplest method of bread-making is described by Moussa and Altenmüller from the Old Kingdom tomb of Niankhkhnum and Khnumhotep at Saqqâra (Moussa and Altenmüller 1977: 153). A relief shows mixing dough in a bowl, kneading or shaping the loaves, and baking directly on hot ashes. Quick and straightforward, this was no doubt a common way of making fresh bread for peasants working in the fields throughout all eras.

B. *Baking in moulds.* Many tombs show the use of moulds. In a particularly clear and ordered sequence, reliefs from the Old Kingdom mastaba of Ti at Saqqâra show bread-making in flower-pot shaped moulds (see Epron *et al.* 1939: Pl. 66, for good line drawings of the scene). A very similar sequence also appears in the tomb of Niankhkhnum and Khnumhotep (Moussa and Altenmüller 1977: 69, Pl. 23).

The general consensus of interpretation is that empty moulds were stacked upside down over a fire to heat. Dough was then poured into hot moulds and a preheated lid of similar design placed on top. The bread cooked by heat from the moulds alone. Figures poke sticks into these moulds; according to the hieroglyphics in various tombs they are “testing”, “checking”, or “making firm”. Junker (1953: 162) states they must be checking the bread to see that it was firm or done; they could not be stirring as this would break up the bread. Other Old Kingdom tombs which show similar activity include those of Rahenem Asa at Deir el-Gabrâwi (Davies 1902: 19, Pl. 20) and Pepiankh of Meir (Blackman 1924: 35–36, Pl. 13).

C. *Baking in ovens.* Paintings in the tomb of Pepiankh also show another type of baking, with a style of oven also known from tomb models. (One example in the Cairo Museum is model 258 from the tomb of Niankhpepi at Meir, Sixth Dynasty. Darby *et al.* [1976: 510] illustrate another). Three round or square slabs are propped up against each other and covered with a fourth slab laid horizontally over the others, forming a small enclosed chamber. According to Wild (1975: 596), these simple ovens appeared towards the end of the Sixth Dynasty and perhaps were used for cooking bread directly on cinders. Another possibility is that griddle cakes or flat loaves were baked on top, as Blackman (1924: 35–36) suggests. This sort of oven is also described by Klebs (1915: 92).

12.2.2 Middle Kingdom. By the Middle Kingdom, some changes can be seen. Long conical moulds are shown, in keeping with the style of moulds found at Middle Kingdom sites (Jacquet-Gordon 1981: 16). Scenes from Beni Hasan (Newberry 1893: Pl. 12) show conical moulds being filled with dough, and these moulds stacked lengthwise in an oven. The bakery model found in the Middle Kingdom tomb of Meketre (Winlock 1955: Pl. 65) shows a basketful of conical objects in a room with square ovens. Winlock (1955: 29) interprets these as loaves, but, equally, they could be moulds waiting to be used. A painting in Antefoker's tomb depicts tall narrow conical moulds being filled with dough from pots (Davies and Gardiner 1920: Pl. 12A).

In contrast to scenes from the Old Kingdom which show dough being poured into moulds, the figure in Antefoker's tomb handles a piece dense enough to hold, and firm enough to be shaped. Wild (1975: 595) states that these loaves, too, were baked in moulds hot from the oven without further exposure to heat. Both at Beni Hasan (Newberry 1893: Pl. 12) and in Antefoker's tomb

(Davies and Gardiner 1920: Pl. 8) another type of baking is shown. A low hearth is covered with what appears to be a lid, and, in the Beni Hasan representation, a loaf seems to be placed on the lid. An "oven cover" was reconstructed from numerous fragments of earthenware found at the Middle Kingdom site of Abu Ghâlib (Larsen 1936: 55–57); these extremely coarse and roughly fired sherds are thought to be from oven lids such as those shown in Antefoker's tomb.

12.2.3 New Kingdom.

In the New Kingdom, styles have changed again. Both in the tomb of Kenamun (Davies 1930: 51, Pl. 58) and in a Ramesses III court bakery scene (Storck and Teague 1952: 69; Erman 1971: 191) a barrel-shaped oven is shown for baking flat round loaves. Although Storck and Teague (1952: 69) believe the loaves illustrated in the Ramesses scene are presented in plan, but probably were laid on a shelf inside, Erman (1971: 191) states they were placed against the outside oven wall. The Kenamun baker is reaching inside his oven, with a round loaf in his other hand. Wild (1975: 597) states that bread was baked by placing loaves directly on the internal oven wall; this is still a common practice in many Near Eastern countries. Figure 12.1 shows modern bread being baked in this way.

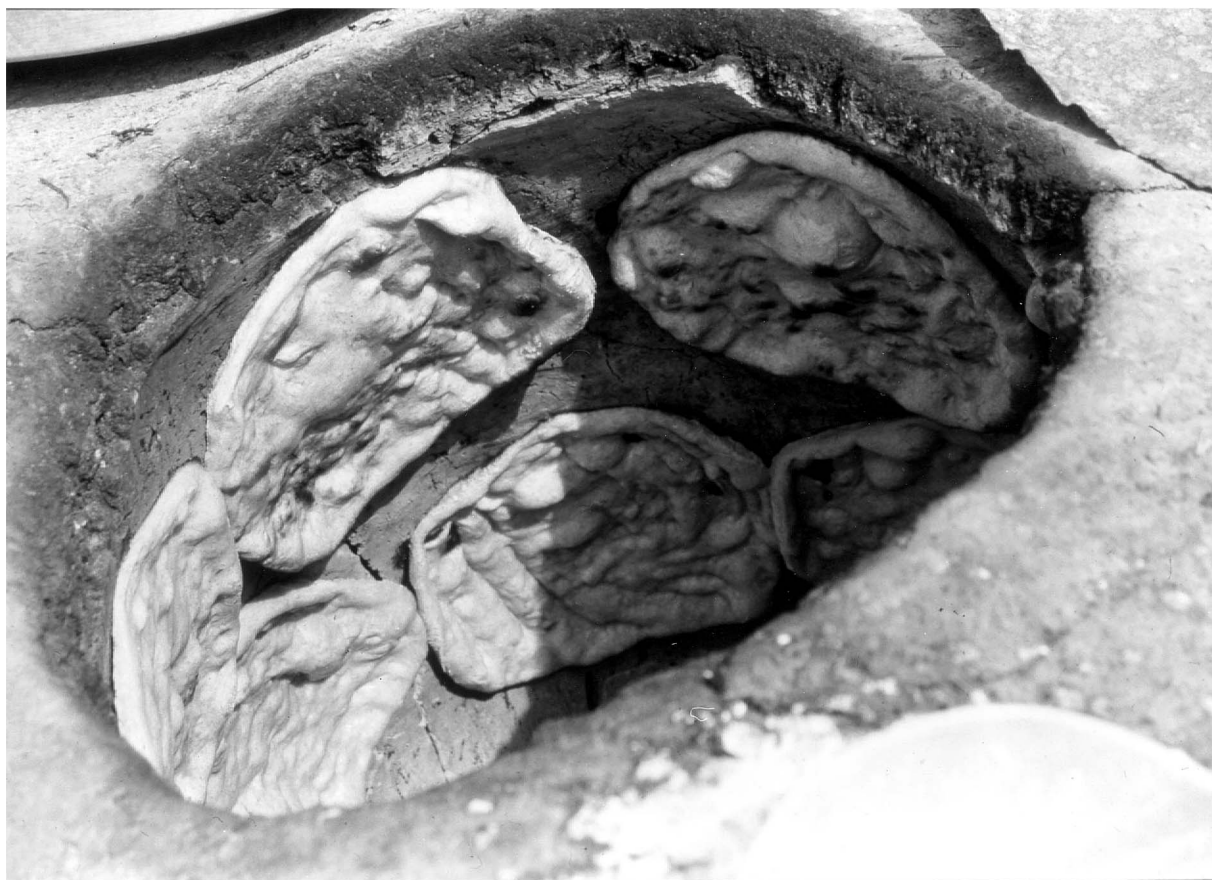


Figure 12.1. Bread being baked in a modern round oven at the village of Tell Zagan, near Hessake, Syria.

12.2.4 Questions left unanswered by the artistic record.

A. Use of moulds. Detailed though many of these scenes are, there are questions which cannot be answered by studying them alone. Baking bread by leaving dough to set in preheated moulds clearly seems to be an Old Kingdom method. However, although Wild (1975: 595) ascribes this technique to the Middle Kingdom as well, this was not necessarily so. Mould shape by this time has changed, and the walls in particular are much thinner; they would retain less heat than the massive pots of earlier dynasties. If Antefoker's bread scene is accurate, dough is no longer thin enough to pour: it is dense and stiff. Would heat from moulds be sufficient to bake loaves properly? The actions depicted do not preclude baking moulded bread in ovens; the Beni Hasan

Investigations into bread baking

oven scene (Newberry 1893: Pl. 12) could indicate either preheating moulds or baking bread in moulds.

No hint is given to suggest whether moulds were re-used. Jacquet-Gordon (1981: 22–23) notes that the older, heavier type of bread moulds are quite often intact, but later conical moulds are nearly always broken except from contexts where they seem to have been unused. The moulds at the Middle Kingdom Kuban fort (Emery and Kirwan 1935: 33–38) are one such example. Those found unbroken in Chapel 556 at the Workmen's Village (AR IV: 74) were similarly thought to have been unused. Jacquet-Gordon's explanation (1981: 22–23) is that loaves were more easily extracted from bowl-shaped moulds, and the massive ceramic construction made them more durable. Loaves must have been difficult to extract intact from long narrow moulds and may have been broken in order to free the bread.

The great heaps of broken bread moulds found at the New Kingdom Amarna bakeries (Rose 1987: 118, 119) can be seen in either of two ways. Such large sherd deposits may have accumulated from extracting baked loaves by shattering moulds. The coarse texture and rough construction of moulds (Jacquet-Gordon 1981: 11) suggest quickly made, disposable ceramic ware. On the other hand, moulds may have been re-used. Making ceramic moulds does require some time and material, which must have been considerable for bread baked on the large scale suggested by great temple bakeries. Even if coarse moulds were re-used, it is likely they would eventually have broken in the course of handling and repeated heating, enough to create the sherd dumps which we now observe beside bakeries.

Elizabeth David (1977: 309) and Hilary Wilson (pers. comm.) both describe tempering modern ceramic moulds by coating with fat and heating at high temperatures several times, so that the pottery becomes saturated and prevents dough sticking to the sides. David (1977: 309) recommends a liberal coating both inside and outside with oil, while Wilson states that only white animal fat will work successfully. No scenes which can be interpreted as tempering have yet been noted, but this may not have been part of bakery activity. The best evidence to support the hypothesis that ancient Egyptians tempered their moulds in this way would be analysis for lipid traces from bread-mould sherds. To my knowledge this has not yet been done but may be possible with present chemical techniques.

B. *Oven types*. Barry Kemp (AR IV: 76) has suggested that certain types of oven were used specifically for firing moulds, and others were for baking moulded bread. This theory derives from the association of complete moulds in the square oven of Chapel 556 found at the Workmen's Village at Amarna (see also Chapter 11 in this volume). Larsen (1937: 51–56) found fragments of bread moulds in square hearths, but these sherds were in a different type of oven. The square kiln at Mirgissa, a Middle Kingdom site, is more closely related to the example at Amarna and, like the latter, had many whole bread moulds associated with it (Holthoer 1977: 16, Pl. 72:2). The bakery model from Meketre's tomb (Middle Kingdom) (Winlock 1955: 29 Pl. 64) shows moulds or conical loaves in the same room as square ovens. The artistic record is not precise enough to test this apparent association.

12.3 Ancient bread: examination of loaves held at the Manchester Museum

A valuable source of information on ancient Egyptian baking is the offering-bread preserved in tombs, and some has been examined. For instance, Leek (1972: 1973) has analysed several samples of varying provenance for grit content, cereal type, weed contaminants, and presence of protein and starch. The Manchester Museum has some ancient uncharred Egyptian bread in its collections. I am grateful to Dr A.J.N.W. Prag and Dr A. Rosalie David of the Manchester Museum for their help, and permission to examine the loaves which are on display.

These three loaves are all funerary offerings from tombs and may not be representative of the bread eaten as daily fare, but it is probably safe to assume that their manufacture and production were similar in some respects to everyday bread. Each specimen is different from the other, covering a range of bread types. I measured loaf dimensions and examined the surfaces using a x10 hand lens. Observation under a microscope would be preferable, but enough detail has been noted to suggest what the bread was made from and how it had been formed.

The smallest loaf is a flat bun from Deir el-Bahari. Roughly circular in shape, the average diameter is 50–55 mm and it is approximately 20 mm thick. It is slightly bowed in cross-section,

so that one side is convex, and the other is concave with a small rim around the edge. This latter side has one large crack and several smaller ones but is smoother compared to the other surface. The fairly straight bevelled edge suggests it had been shaped in a mould. The loaf is a deep reddish brown, darker than the other two examined. It is possible that red dye was added to the dough. This practice is suggested in a scene from the Middle Kingdom tomb of Antefoker (Davies and Gardiner 1920: Pl. 11). Most noticeable is the extremely chaffy texture: indeed, the bun seems to be made of chaff held together by paste. On closer examination cracked grain particles can be distinguished. Fragments of both chaff and grain vary in size, but, in general, the grain has been crushed quite finely, and the chaff is large and coarse. Identification of the chaff using a hand lens was difficult since distinguishing features were not visible. The texture and venation appear to resemble that of barley. One grain is imbedded on the surface so that the cross-section is exposed. Its shape is not that of barley. It most closely resembles wheat but is only 1 mm from dorsal to ventral side, and 1 mm in breadth. If not from a weed grass, it must be a runt grain. The very coarse texture must have made such a loaf unpalatable and unnutritious for humans. The presence of a possible runt grain in an extremely chaffy loaf suggests the dough may have been prepared from wastes of grain cleaning. Since it was an offering to the dead and not meant to nourish the living, edibility may not have been of primary concern.

Very different in shape and texture is a flat biscuit-like loaf, No. 6604 from Sedment, resembling a small "oxhide ingot". It is rectangular with rounded projections at each corner. Its irregularity when viewed from any angle suggests it was formed by hand rather than in a mould. The maximum length from tip to tip is 110 mm, while the centre length is 105 mm. Breadth varies from 95 mm at the edge to 75 mm across the centre. One side is much thinner where the loaf appears to have been pinched or flattened so that it is 5 mm thick, while the opposite side is about 12 mm thick. In cross-section it is very bowed both longitudinally and transversally.

On one side the colour is pale brown, of a similar shade to modern wholemeal bread. The other side is much darker with cracks running across it and was obviously exposed to heat or a heated surface. The dark colour does not extend right to the edges, suggesting that the loaf was placed on a hot platter or rack to bake. The pale side is smooth and covered with traces of charred chaff. This may have been caused by baking on or in chaffy embers. One relief showing bread cooked directly on the fire is from the Old Kingdom tomb of Niankhkhnum and Khnumhotep (Moussa and Altenmüller 1977: 153, Pl. 76; see Section 12.2, Artistic Evidence), although the scene is not depicting funerary bread. I could not distinguish similar traces of burnt chaff on the dark side, but they may have blended into the slightly scorched surface. One length of small twig or straw measuring 13.5 mm is half imbedded on this rougher-looking side, as well as a scattering of fairly coarse grains of sand. These two types of inclusion, together with the darker colour, make it likely that this is the underside of the loaf.

When first made, it would probably have been much more palatable than the small bun. Although some chaff could be seen on the surface there is not much, and it is considerably finer. The texture, too, is finer and denser; the flour was ground until the few larger particles were the size of modern rough-ground oatcake meal. Two whole grains of wheat protrude slightly, one on each side of the loaf.

The other bread loaves I examined were fragments of larger loaves, all from Deir el-Bahari. One came from what must have originally been a round loaf about 120–130 mm in diameter, and 15–20 mm thick. One side is very smooth and slightly concave with a rounded rim, while the opposite side is coarser and more open-textured and concave. Its overall regular shape strongly suggests that it was baked in a mould. If so, the smooth side was probably pressed against the mould. Much the palest of the loaves, it is made of very coarsely ground emmer wheat. Entire and nearly whole grains can clearly be seen. The few bits of chaff are very small; there are also several other inclusions. Imbedded in the surface are two hulled weed grass grains, and at least five whole dark seeds which I could not identify. They may have been from weed plants or deliberately added as flavouring. This loaf had a few very coarse sand grains adhering to the surface and in the fractures. Bread of this type must have been very chewy. A smaller fragment came from a loaf which was originally round and has a dimple in the centre of the smoother side.

All these funerary loaves are coarse-textured to varying degrees. Except for the small bun, which is mostly chaff, the flour used seems to have been reasonably clean and roughly ground, and large grain particles were not sifted out. The presence of dark seeds in one loaf is worth

Investigations into bread baking

investigating further, as they are probably either flavourings or tolerated components of flour.

In attempting to replicate ancient preparation techniques, the composition of these loaves suggests that for some types of bread, grain can be ground coarsely, that the flour need not be bolted, and that loaves can be placed in moulds or shaped by hand and laid on racks or platters to bake. These loaves provide direct information on a few of the many types of ancient Egyptian breads.

12.4 Experimental archaeology

12.4.1 Introduction.

In examining the techniques used by ancient Egyptians to bake bread, the evidence left to us now is literary, artistic, and archaeological. This evidence, though copious, is inadequate, and there are gaps in our knowledge, both of processes and their effects. Two examples illustrate how the extant material fails to provide a complete picture. The first is the question of sieving. Tomb art clearly depicts sieving as a part of the milling process (see for example, Kenamun: Davies 1930: Pl. 58; Ti: Epron *et al.* 1939: Pl. 66), but it is not always clear at what stage sieving was carried out. The pictures in Antefoker's tomb (Davies and Gardiner 1920: Pl. 8) suggest flour was sieved after milling, perhaps showing the process of bolting (removing the bran to produce fine white flour). Other representations seem to illustrate sieving to remove chaff and impurities after grain has been dehusked or broken up in mortars (Storck and Teague 1952: 66, 68). The point at which sieving was used would alter flour volume and bread quality from a given measure of grain. The efficiency of milling action itself may be reduced if chaff is not completely removed from grain.

The second example concerns a process which, to my knowledge, is not represented in the artistic record. Emmer, like all glume wheats, requires vigorous processing to free grains from their tightly enclosing chaff (Renfrew 1985: 179). Ethnographic observations carried out by Gordon Hillman (1984b: 129) in Turkey and Glynis Jones (1984) in Greece, show that processing of glume cereals with traditional tools and by traditional techniques includes the parching of spikelets. Parching involves lightly roasting spikelets to render the chaff brittle, so that subsequent pounding easily frees the grain. I am unaware of any obvious illustration in the ancient Egyptian record of parching, whether in harvesting and threshing scenes, or in milling scenes. However, Peet and Loat (1913: 1–7) describe in detail structures from predynastic Abydos which they conclude are grain kilns for parching wheat.

It is possible that parching was not used by the ancient Egyptians. Hillman (1984b: 129) suggests that this may not be a crucial step. In arid places, drying and pounding may be sufficient to process particular strains of emmer effectively. Electron spin resonance spectroscopy can be applied to the question of parching. This chemical technique is capable of demonstrating the past heating history of material containing radical carbon (Hillman *et al.* 1983: 1235). The method has been used successfully on uncharred archaeological grain from several sites in Egypt (Hillman *et al.* 1983: 1236; Hillman *et al.* 1985: 55–57); (Hillman 1987: 104 describes ESR work done on gut contents of Lindow Man — a somewhat different application). Tests are planned on chaff from Amarna to determine past maximum heating.

To answer such questions, another approach to the exploration of ancient bread-baking is experimental work. It has several advantages. Theories which interpret baking scenes and models can be tested for feasibility. Through experimentation, an attempt can be made to reconcile archaeological evidence with other sources; results may indicate that interpretations should be re-evaluated. At Amarna, Frankfort and Pendlebury (*COA* II: 45) found long racks near bread ovens which they interpreted as drying racks where bread was laid out before being baked. There is not always an archaeological association between ovens and such racks; the pictorial record does not illustrate them. Cooney (1965: 73) reproduces a bread-baking scene which might well depict the big bakeries of Amarna, but not enough detail was originally included to give much information about their operation.

By imitating ancient techniques, we can examine the results of particular sequences of actions, determine constraints imposed by those methods, evaluate efficiency and wastage, and estimate household and institutional supply requirements. Some specific questions which will be investigated in future years with experimental techniques are listed in Section 12.6, Future Work.

In this way, new ideas are generated and areas which need further investigation are highlighted. Perhaps most exciting of all, aspects of ancient Egyptian lifestyle come alive by re-enacting tasks which were common, a basic routine of life.

12.4.2 Problems associated with the experimental approach.

Some difficulties are involved in the reconstruction of ancient bread-baking. Since no landrace of emmer is known under cultivation in present-day Egypt, there is no possibility of working with emmer directly descended from that used by the ancient inhabitants. Landraces from elsewhere have to be substituted; these may have many different characteristics. However, modern emmer is more likely than any other type of wheat to behave like ancient Egyptian emmer. The biggest barrier to accurate experimentation, however, may well be ignorance and lack of skill by the experimenter. Obviously it will be impossible to equal the competence of ancient millers and bakers who pursued a long-standing tradition all their lives. It is hoped that practice through trial and error will eventually produce reliable results, despite the lack of virtuoso ability. There is no way to prove that a given sequence is an accurate representation of what happened in the past. However, by cross-referencing plausible experimental work with all sources of evidence, valid new suggestions should be obtained.

During the 1987 season at Amarna, we began some experiments connected with bread-baking. Most of the work was preparatory, constructing the tools and installations required for practical trials. Towards the end of fieldwork, we carried out some brief experiments on grinding and baking.

12.4.3 Preparation of installations and equipment.

In the field, we first had to set up replicas of tools and equipment. We attempted to use original objects when these were available and sufficiently robust to resume their past function. Structures already excavated at Amarna were the primary models. Some of these, most recently excavated by the present team, are still visible at the Workmen's Village; otherwise photographs and plans of installations from the Workmen's Village were used, including a photograph of a beautifully preserved kitchen (Peet 1921: Pl. 27). The reconstructed "bakery" was established in an abandoned building which had been built by Peet and Woolley in the 1920s for their workmen, from ancient mud bricks salvaged from the city of Akhetaton. The three replicated structures were a mortar emplacement, a quern emplacement, and a round oven. The original for each structure is described here, and the method of building the replica set out.

A. *The mortar.* Two complete limestone mortars were excavated from the Workmen's Village in 1986. The house designated Gate Street 9 had a particularly well-preserved emplacement, apparently in a special little room, walled on four sides (see AR IV: 32). Since these ancient heavy stone mortars are strong enough to be re-used, the one from Gate Street 9 was incorporated into the emplacement replica. The inner diameter at its mouth measures 30 cm. Because it was not hollowed out evenly, the depth from the lip varies from 21 to 25 cm (Figure 12.2). The angle of curvature is quite steep, probably to ensure that the contents would not fly out during pounding.

The emplacement constructed for this mortar was not so elaborate as its original location. At the Workmen's Village it had been set into a pit in the centre of a small open space, whereas the replica was flush against a wall. The positioning of the new mortar pit was controlled by practical considerations: first, a convenient use of space in the small room where the "bakery" was built, and, second, the most easy spot to dig into the debris-covered floor. The pit was deep enough for the lip of the mortar to be just about even with ground level. Originally the mortar had fitted snugly into an alluvial mud plaster lining, but, since it had to be removable from our replica setting, the pit was made considerably wider and the mortar lodged with stones. To provide a flat platform for working, and to prevent sand or earth being kicked into the mortar, a small area beside the pit was paved with flat stones in rough imitation of neatly placed paving around the original emplacement.

Contemporary models and paintings show the ancient Egyptians standing over mortars wielding long-handled pestles. Models at the Cairo Museum show the use of such pestles, and paintings in many tombs depict similar scenes. As yet, I am unaware of the species of wood which the ancient Egyptians used to make pestles. The replica was made from a length of sawn 5 x 5 cm pine timber, which may be too soft. Its height was determined by what I found most convenient and efficient to use with the mortar. Its length in relation to my height is consistent



Figure 12.2. Mortar from Gate Street 9, used in the pounding experiment.

with proportions shown in ancient art. I used a hammer and chisel, and an electric sander to fashion the pestle; speed and convenience concerned me more than adherence to traditional wood-working techniques. The replica pestle has a sanded narrow section at the top where it is gripped, and the base has been smoothed and somewhat rounded, but the curvature is very slight.

B. *The quern*. Ancient Egyptians of Pharaonic times used solely variants of saddle querns; rotary querns were only introduced just before Hellenistic times (Darby *et al.* 1976: 506). At the time of the New Kingdom, querns were fairly elaborate structures. The long and narrow base-stone was set on to a platform which supported it and held it at the correct angle. Scattered across the site of Amarna today, one can occasionally see these distinctive quern stones, but they are usually shattered. To make a good quern stone no doubt required a considerable investment of time and skill; probably most were taken as part of the household goods when people moved away (Kemp *pers. comm.*).¹ A surface find of granite stone in good condition with no apparent chips or damage was retrieved from the Main City (from the surface of the eastern part of building Q48.4) and incorporated into the replica quern emplacement. It is approximately 40 cm long and 18 cm wide and its greatest depth is approximately 11 cm. The working surface is somewhat concave from end to end (longitudinally) but slightly convex from side to side (transversally) (Figure 12.4).

The surface texture varies across its length. At each end the stone has been worn very smooth, but the centre is slightly pitted and roughened. This rough surface would help to grip and pulverize the grain. Eventually constant friction would have worn the stone smooth, and it would

¹ Note the apparent quern stones, of a red colour (=granite), amongst commodities used to pay local taxes at Edfu in the Rekhmire taxation scene, Davies 1943: 35, Pl. XXXI, bottom.

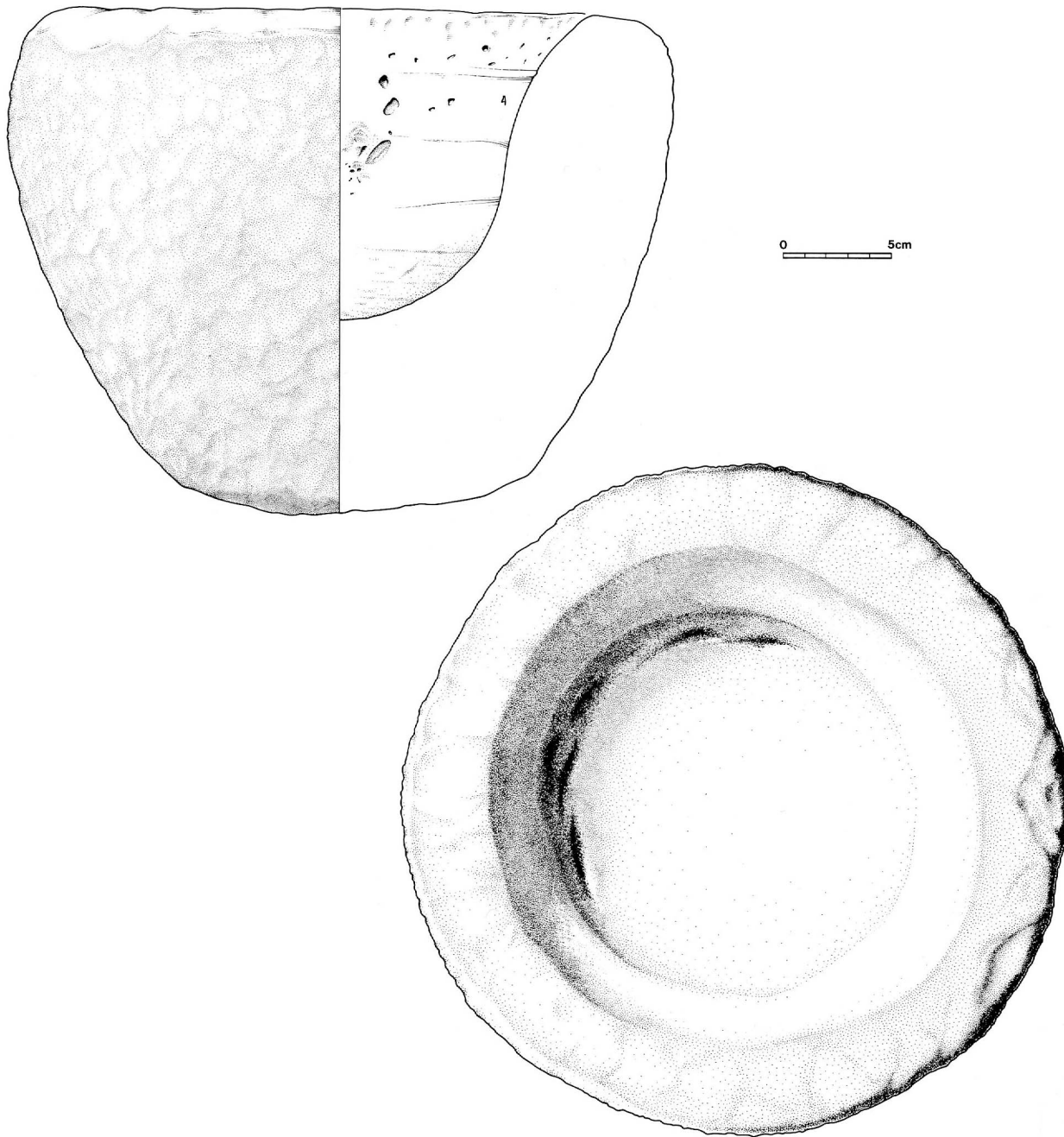


Figure 12.3. Drawings of the mortar from Gate Street 9, showing angling and shaping (originals by A. Boyce).

probably have been roughened again or “pecked” (thanks to Dr Robert Miller for pointing out this term). This may be the explanation for two textures across different parts of the stone. A very small patch of waxy material was adhering to the working surface. This was removed and saved and may eventually be submitted for analysis. Whether it was deposited in the course of grinding, or after the stone was abandoned, is impossible to say. I can think of no explanation for it within the context of grinding.

The rubbing stone which I used was also a surface find in the Main City. These black basaltic stones are often observed scattered across the site, and were particularly prolific at the Workmen’s Village, where they were occasionally used in the building of walls. Whether grain-milling was

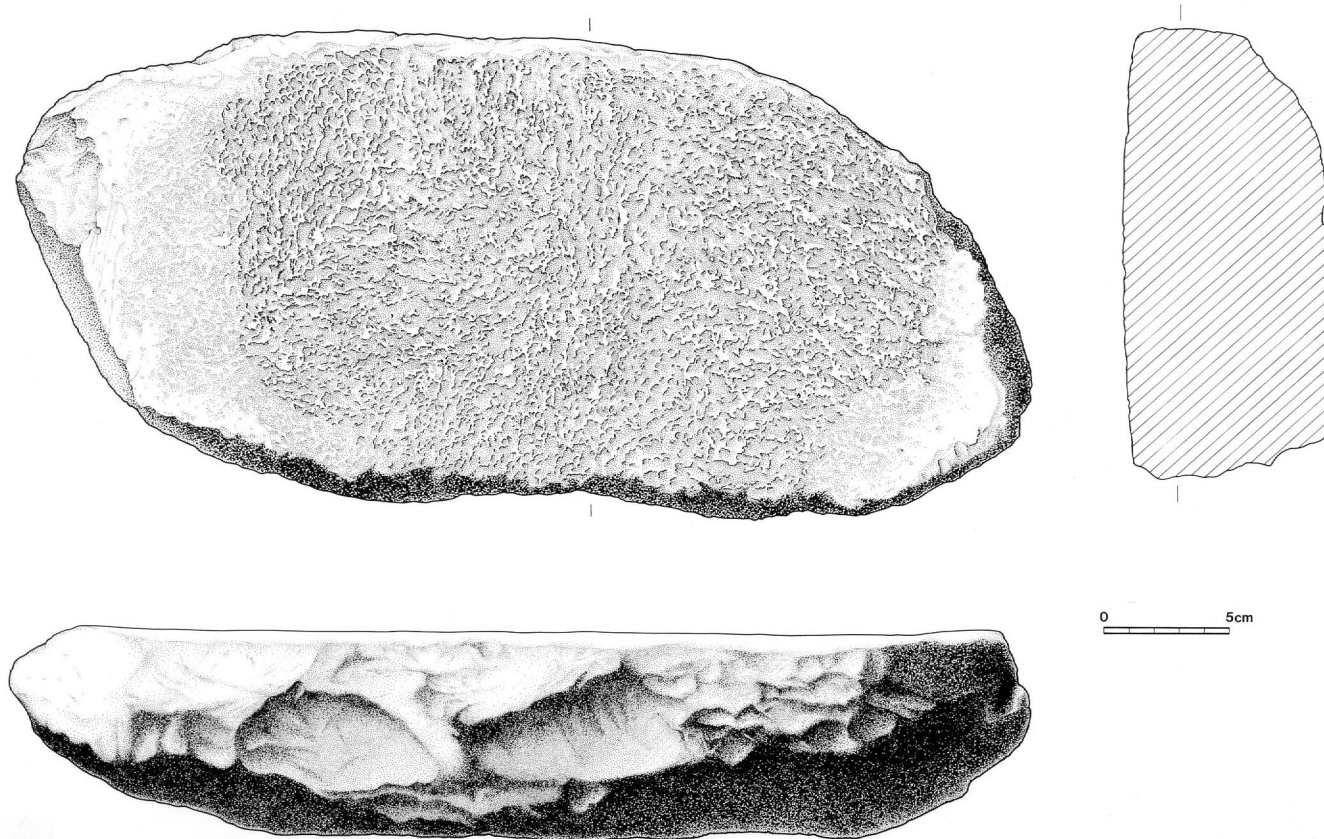


Figure 12.4. Quernstone used in the grinding experiment. Note the slightly bowed shape from end to end and the slight convexity from side to side. The stone is relatively rough in the centre and smooth at each end. Rendering of the rough texture has been emphasized for clarity (originals by A. Boyce).

their only function is conjectural, but it is likely that the majority of them were used for this purpose, since grinding was an ubiquitous activity to judge from the numerous quern emplacements. I collected many, and from these chose one which was well shaped and comfortable for me to use. Its working surface is slightly rounded and quite smooth. It is wide enough to be gripped in both hands but does not extend beyond the width of the base stone.

Quern emplacements or traces thereof have been excavated at Amarna, both at the Workmen's Village and in the Main City (for example, Peet 1921).² A similar design is recorded by Bruyère (1953: 97) from Deir el-Medineh. The model for the replica which I built is that found in Gate Street 8, Front Room South. Plans of this structure are found in Figures 1.1 and 1.2 of *AR III*: 2, 4 and it is described on p. 3 of the same publication.

The replica was built as closely as possible to the same measurements. It is set up in a south-west corner of the abandoned building, against the south wall. After clearing a strip of ground and levelling it, I traced out the dimensions of the emplacement base. Materials for construction were easily found. I recycled fallen bricks from the derelict house; they were very convenient to use, since they are original ancient mud bricks and therefore of the right dimensions. At the time Peet and Woolley's workers' house was built, mud-plaster bread ovens were also installed. By breaking the ovens into chunks and adding water to "reconstitute" the plaster, I made a thick mud paste to cement the bricks together. The emplacement was made by laying a box of mud bricks

² A good specimen was found in the house excavated in the Main City in 1987, and will be published in the next volume of *Amarna Reports*.



Figure 12.5. Quernstone on unfinished replica quern emplacement, side view.

against the south wall to form a small square enclosure. The side closest to the west wall was built up 25 cm higher than the other two. To support the quern stone, the interior was filled with stones and sand, as the original seemed to have been, until it formed a slope running from the highest wall down to the lower edges. The stone was set on to the sand bed, (Figure 12.5) which I then plastered over to form a smooth solid surface. The surface has an oval gap where the stone can be set and removed. To complete the structure according to the style of my model, I laid a smooth firm surface behind the highest side of the emplacement and on the far side opposite the quern stone. After pouring water over fine sand and trowelling it the areas dried to form a hard surface. These sections are surrounded by a low mud-plaster border. Figure 12.6 shows the completed replicas of mortar and quern emplacements.



Figure 12.6. Completed mortar (right) and quern (left) emplacement replicas.

C. *The oven.* In the Workmen's Village there are many round ovens which have been found in chapels as well as in houses. There are two types: one is a free-standing clay oven liner as described by Kemp (AR IV: 73), the other is a more substantial structure made of mud bricks surrounding a ceramic liner (see AR IV: 56, for example; a similar oven from the Main City is shown on Pl. 17:6 of COA II).

The replica oven was modelled on the well-preserved mud-brick round oven excavated in the Main Chapel. With Paul Nicholson, whose help I gratefully acknowledge, mud bricks mortared with plaster were laid to make a circular oven, slightly inward-curving toward the top. As with the Chapel oven, a small hole was left at the base. Having used up all the old oven plaster, I made more from dried dung, straw temper, and some sand mixed with water. This improvised plaster worked well as mortar for mud brick, but was less successful as oven lining, because it cracked after drying. The solution is to ask the local people how they make mud plaster, so that correct proportions and ingredients are used. My mud plaster recipe could certainly not be used to make a free-standing plaster oven. A second, minor problem is that the curvature of the oven is not as pronounced as the original. This may affect heat retention. Figure 12.7 shows the replica oven with thermocouple in position.

12.4.4 Experiments

A. *Aims.* Three aims of the first experiments using these three reconstructed installations were: 1) to see whether they worked successfully; 2) to observe their effect on whole grain used in experimentation; and 3) to gain experience using non-authentic ingredients as a starting point for more intensive and accurate trials in future.



Figure 12.7. Replica oven with thermocouple in position.

B. *Correlation with ethnographic studies.* When one is trying to replicate past techniques accurately, reference to ethnographic work is essential. To gain reliable and complete information, there is no substitute for proper observation of contemporary traditional methods. Recent ethnographic evidence, such as that so comprehensively gathered together by Gordon Hillman (1981, 1984a and b, 1985), is of some relevance to the interpretation of ancient Egyptian techniques. The sequence of post-harvest, pre-cooking crop processing (threshing, winnowing, etc.) in Egyptian tomb paintings is broadly similar to that still to be seen in the Middle East. However, for the milling and baking techniques which form the main focus of this preliminary report, much of this data is less relevant, as methods and equipment used in ancient Egypt are not used in Near Eastern communities. Ethnographic records from Africa may be more applicable, and remain to be explored. Wherever possible, ethnographic parallels are discussed, as in the consideration of parching. Future work on this project will include fuller references to relevant ethnographic and ethnohistoric evidence.

C. *Experimental procedure and results.* As a substitute for emmer, which is rare and was unavailable to us for the 1987 season, we used locally purchased bread wheat. It was bought fairly clean, although analysis of a fraction showed inclusions of dirt clumps and some weed seeds. Bread wheat is free-threshing, whereas emmer is a glume wheat. High levels of the protein gluten in bread wheat are responsible for expansion and elasticity of modern yeast-raised breads (David 1977: 10). Although emmer wheat has a high gluten content, it contains less than bread wheat and does not rise as much. Also, other protein types, texture, and starch content are different in these two wheat strains (LeClerc *et al.* 1918: 216–217).

i) *Grinding.* The following processing sequence was carried out to test the use of the mortar and quern emplacements.

1) Sieving with a 1.7 mm geological sieve removed fine dirt and chaff.

Investigations into bread baking

2) A small handful of grain was placed in the mortar. Some large impurities were noticed and picked out at this stage. No more than a handful at a time could be pounded, otherwise grain shot out of the mortar (Figure 12.8).

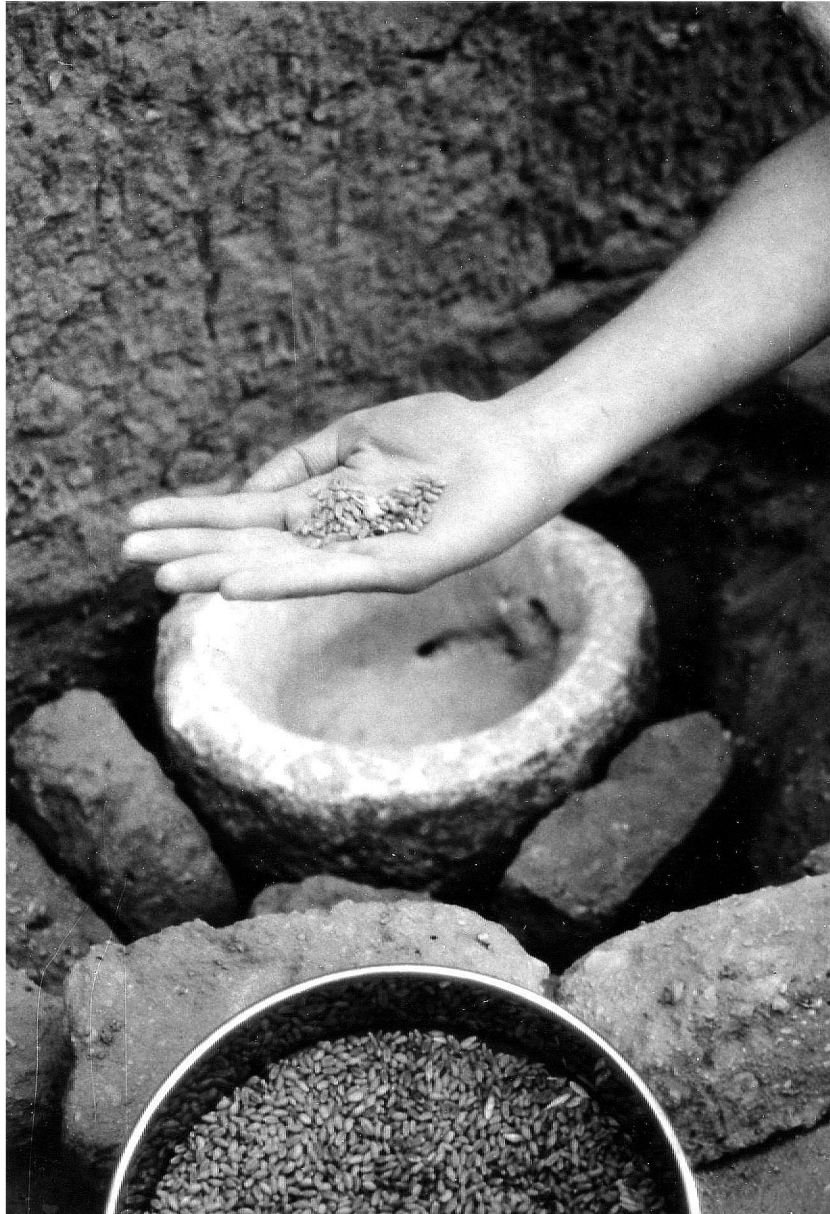


Figure 12.8. Amount of grain pounded at one time in the mortar.

3) Grains were rapidly broken up with a few strokes of the pestle. The pestle was easy to use and did not require much force to fracture grains (Figure 12.9). Because of the mortar's steep sides and narrow base, it was somewhat awkward to scoop out the meal. After pounding, most grain had fragmented into a wide range of sizes. A few kernels remained entire (Figure 12.10).

4) Fifteen to twenty ml of fragmented grain was placed on the quern stone. No more than this could be ground at a time, because flour fell off the sides instead of sliding over the edge into the catch basin (Figure 12.11).

5) Because the quern emplacement is only about 40 cm from the wall, the miller is lodged firmly between the two. The base of the body is well supported by thighs, knees and feet, leaving the upper body completely free to apply great force on the upper stone against the base stone (Figure

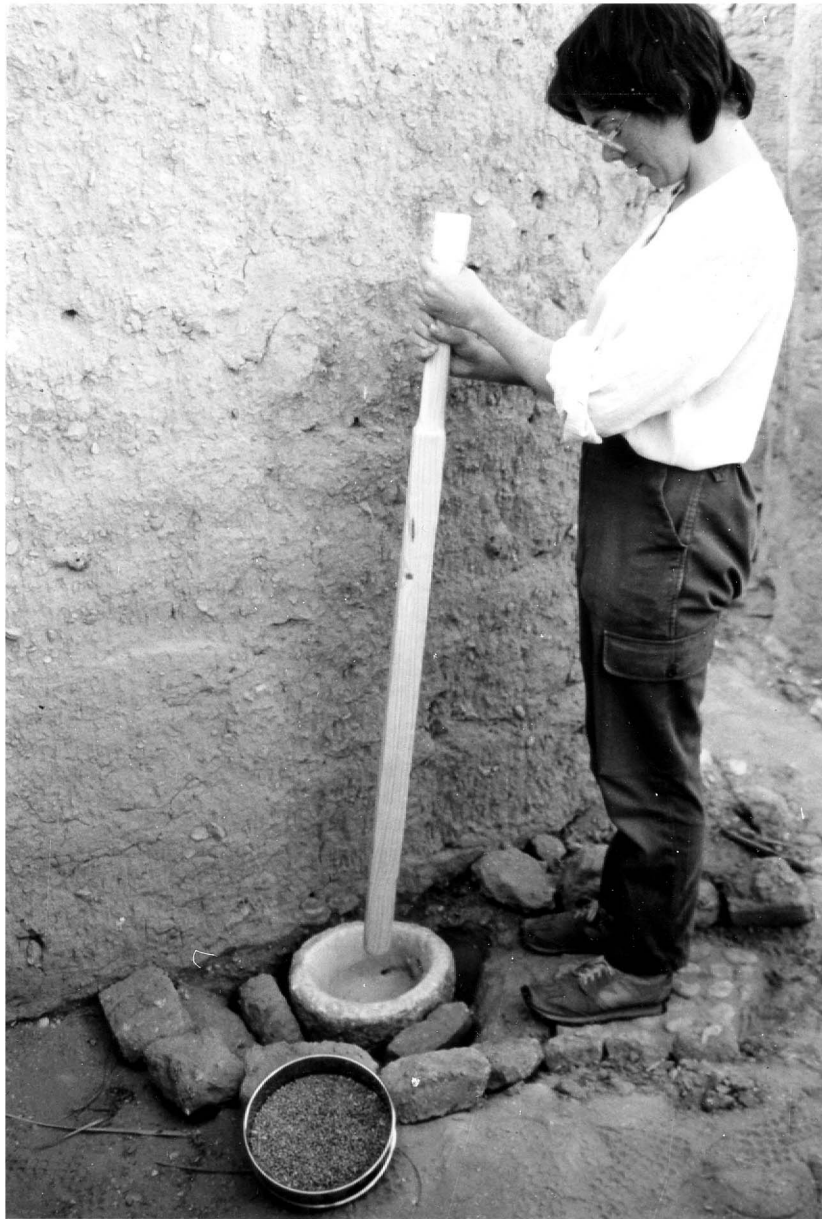


Figure 12.9. Pounding with replica mortar and pestle.

12.12).

6) In this position it took me about two minutes to grind meal into fine textured flour, but doubtless this time will be reduced with practice. The longer the grinding, the finer the flour.

7) Flour was not sieved afterwards. Depending on the fineness of the sieve, most flakes of bran could have been removed. Any large fragments of grain could have been retrieved and returned to the quern for more grinding.

8) After approximately two minutes grinding for every 15–20 ml of fragmented grain, I obtained fine flour mixed with bran fragments which measured approximately 1 mm².

9) Flour was not easily collected. A basin was placed beneath the stone's lip and flour fell or was brushed off the quern and into the basin. A cloth running from top to base of the quern would make it easier to catch most flour.

ii) *Discussion of the grinding experiment.* This trial showed that both mortar and quern can be used successfully to make quite fine flour. I was intrigued to discover how the body position

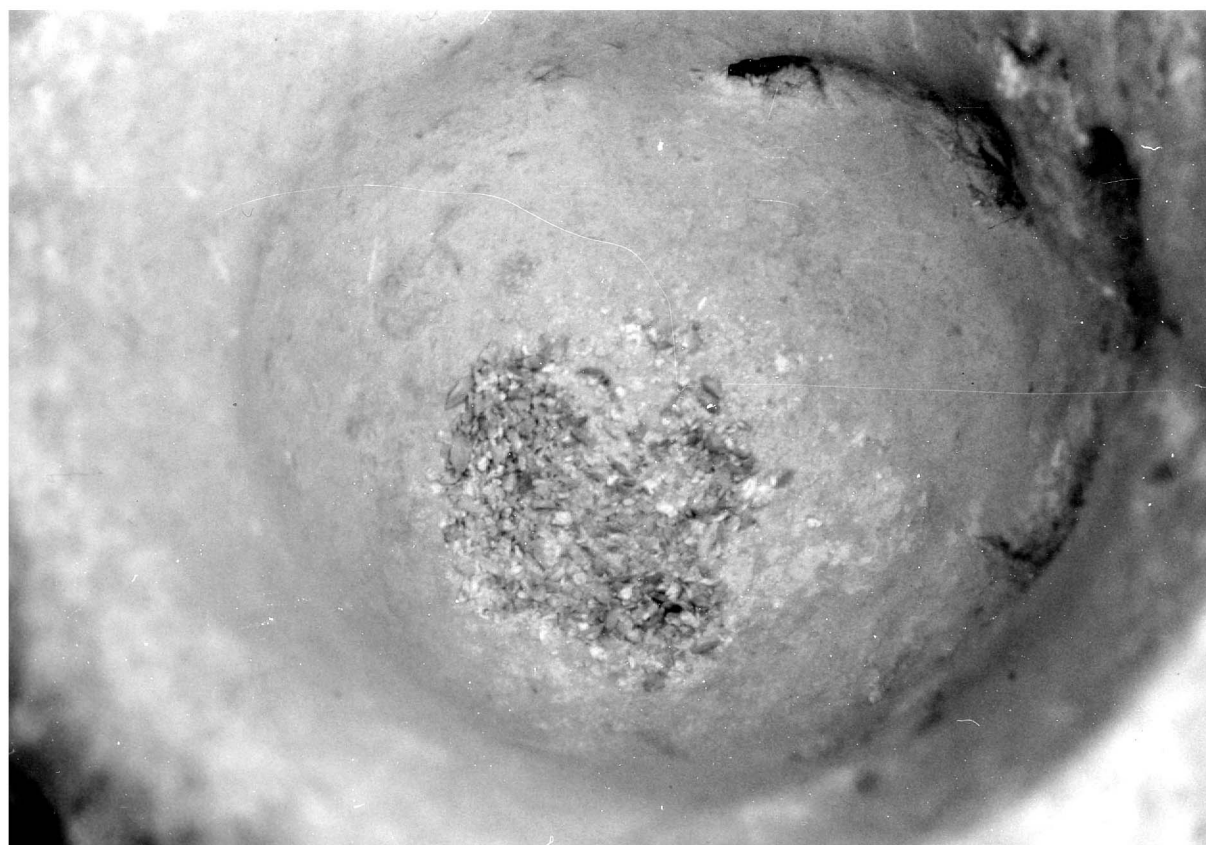


Figure 12.10. Grain in the mortar after pounding.

allows such powerful grinding. It is clear why emplacements are often so close to a structural wall, leaving a space which at first sight appears too narrow for a person to fit. This concertina body position is depicted in some tomb models. Rather than being poorly crafted, models such as that in the British Museum (No. 40915, from Sedment, Sixth Dynasty, 2050 B.C.) and Cairo Museum (presently in Upper Room 27, from Saqqâra, no display number) are accurate, if impressionistic, depictions of millers working hard at quern emplacements.

In 1970, Dr A.J.N.W. Prag of the Manchester Museum, together with Mr J.W. Johnson, then at the National Trust's watermill in Nether Alderley, Cheshire, and the late F.F. Leek, carried out some grinding experiments. (I am most grateful to Dr Prag for allowing me to examine flour samples from these experiments, and for discussing this work with me.) They found that grinding whole grains of bread wheat on an ancient Egyptian saddle quern only crushed them, and very little flour was produced. Prompted by Leek's (1972) discovery of sand particles throughout samples of ancient Egyptian tomb bread, they tested the effects of grinding grains with the addition of small amounts of sand. This abrasive caused rapid production of flour. They concluded that ancient Egyptians deliberately added sand to cereal during the grinding process, as Pliny claims the Carthaginians did (quoted in Leek 1972: 131). When the experimenters cracked grain in a mortar prior to grinding, even without the addition of sand, a small amount of flour, about 25% by volume, could be produced. Owen (1970) writes that by addition of 1% sand to cracked fragments, 55% extraction was achieved in half the time. This suggests that fragmentation by pounding in a mortar is a useful prelude to grinding flour. To judge from the results I achieved, adding sand is not necessary for efficient grinding. It is possible that emmer behaves differently from bread wheat, but both the Amarna and the Manchester experiments used bread wheat. The quern type and its use probably are important in milling efficiency. To be certain that sand is unnecessary, further experimentation using various styles of ancient Egyptian saddle querns and emmer wheat is desirable.



Figure 12.11. Flour being ground on the quern emplacement.

Mortar pounding makes cereal easier to grind and also reduces the size of bran fragments. A much coarser flour, due to large pieces of bran, would be produced if grain were milled whole on the quernstone. Given that sand does not seem essential to produce flour for the quern type found at Amarna, at least, and on the assumption that it was not in common usage for milling, grit inclusions in bread analysed by Leek (1972) are more likely to have come from another form of contamination. Dust and sand are ubiquitous in Egypt, even when efforts are made to eliminate or reduce them. Modern Egyptian bread made of flour from a mechanized mill and baked in a village bakery can be extremely gritty, as members of the team at Amarna have often experienced. Also, it is possible that millers took less care to clean cereal of earth clumps for funerary bread. They may have skipped the time-consuming and meticulous task of picking over grain as it was added to mortars and querns for grinding. Much preserved tomb bread seems extremely husky (see Section 12.3, Ancient Bread), more so than can be imagined palatable or digestible, even if we allow for a greater tolerance or taste for fibre and unprocessed foods. The

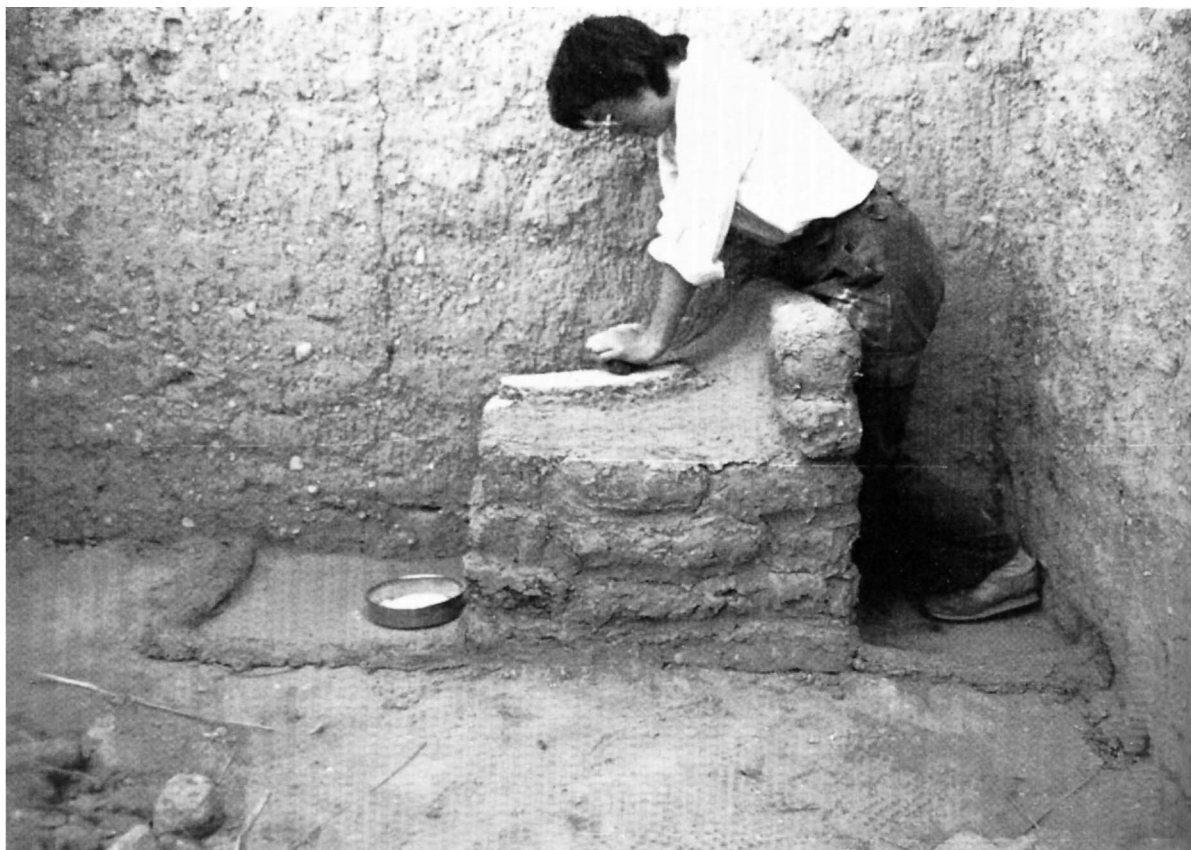


Figure 12.12. Milling grain at the replica quern emplacement. Note concertina body position.

small bun from Deir el Bahari in the Manchester Museum is one example (see Section 12.3, Ancient Bread), and there are others. This reinforces the idea that funerary bread may not necessarily be similar to that which was eaten daily.

iii) *Bread baking.* We tested the performance of the replica oven and New Kingdom style bread moulds made by Paul Nicholson and Pamela Rose (see Chapter 11, this volume) in one bread-baking trial. Organic wholewheat flour from Neal's Yard Bakery Cooperative in London, and organic six-row barley (bere) meal from Boardhouse Mill in Birsay, Orkney, were used to make bread dough. Two batches were produced: one of 100% wheat flour, and one of 50% wheat/50% barley flour. The following is the sequence of bread-baking from making the dough to the final product. The names of tombs appearing in brackets after certain steps contain scenes suggesting those actions. Each is discussed in Section 12.2, Artistic Evidence.

1) Recipes used.

i) Whole-wheat dough
500 g whole-wheat flour
1 tsp. salt
approx. 260 ml water

ii) 50% wheat–50% barley dough:
250 g whole-wheat flour
250 g bere meal
approx. 350 ml water

Flour and salt were stirred together in a bowl, and just enough water added to allow the flour to cohere. The barley/wheat combination absorbed much more water than pure whole-wheat flour. The dough was mixed, and kneaded for about 5 or 10 minutes.

2) Both batches of dough were left for an hour. On the day this experiment was carried out, the ambient temperature was about 18°C. The dough was placed under lamps for added warmth. Neither rose appreciably, since yeast was not added.

3) After an hour each batch was kneaded briefly. Although less water had been added, the whole wheat dough was much more sticky. Loaves were pre-shaped into long narrow forms (Antefoker).

4) Palm-frond and dung-cake fuel was laid to make a fire for preheating ceramic bread moulds.

These moulds were stacked around the edge of the fuel (Ti, Niankhkhnum and Khnumhotep, although in the experiments moulds were not stacked upside down) (Figure 12.13).



Figure 12.13. Replica moulds stacked around a palm frond and dung cake fire for preheating.

5) When the moulds had been heated in this fire for a few minutes, they became too hot to touch and were removed with a stick (Ti, Niankhkhnum and Khnumhotep) (Figure 12.14). Since bases were too narrow to support the moulds upright, they were propped in the sand by digging a small depression and heaping loose earth around the bases.

6) Half the moulds were dusted with flour to see if this would have any effect later when extracting baked loaves (Figure 12.15). The pre-shaped loaves were fitted into moulds (Figures 12.16 and 12.17).

7) A pottery sherd was placed over each filled mould, on the advice of Paul Nicholson (Figure 12.18). Moulds were placed around the round oven's inner circumference and surrounded by dried dung and palm-frond fuel (Figure 12.19). The oven was fitted with a thermocouple to record baking temperatures (Figure 12.20).

8) The fire burned without additional fuel for an hour, reaching a maximum of 640°C in 12 minutes. Table 12.1 shows the pattern of oven temperature.

9) The first loaf of bread was removed after 46 minutes, and the rest shortly thereafter. Each loaf had shrunk slightly from the side of its mould at the top but could not be removed without breaking the mould. Dusting with flour before inserting dough made no difference. Lightly tapping with a hammer shattered the pottery, leaving an intact and edible conical loaf of bread.

iv) *Discussion of the bread-baking experiment.* There must be many inaccuracies associated with our method. Some of these can be rectified by referring to other sources of evidence; others can only be worked out by further experimentation. Without any idea of whether there was a standard recipe for moulded breads, nor what this recipe might be, the simplest mixture possible was used. The close association of baking and brewing in tomb scenes and models suggests that yeast was used to make bread. However, it was not used in this experiment.



Figure 12.14. Removing heated replica moulds from fire with a stick.



Figure 12.15. Dusting replica mould with flour before inserting dough.



Figure 12.16. Fitting dough into moulds.



Figure 12.17. Fitting dough into moulds.



Figure 12.18. Covering filled mould with a pot sherd.



Figure 12.19. Moulds placed in the replica oven.

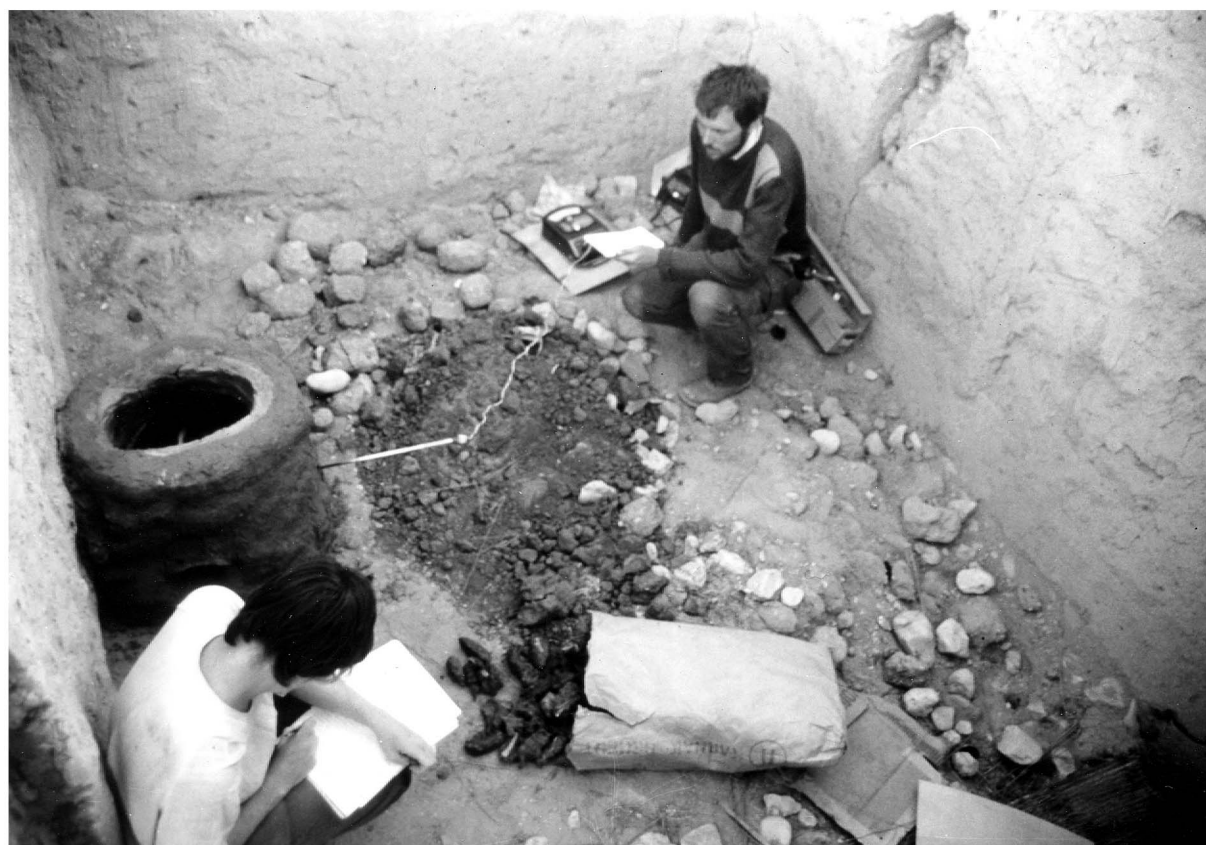


Figure 12.20. Monitoring the bread-baking experiment. Note the bag of dried dung cakes, lower centre.

Ancient Egyptians used both emmer and barley for bread; presumably proportions varied for different types of bread. The samples of ancient bread that Leek (1973: 201) had analysed were either made from emmer, or a mixture of emmer and barley. Temple payments seem to have shifted from barley to wheat between the Middle and New Kingdoms (Gardiner 1941: 27, 28). If we extrapolate from this, composition of daily bread may have changed over time also.

The next point to consider is the preheating of the moulds. Many authors consider that various bread-baking scenes include this step (see Section 12.2, Artistic Evidence). The method we used is certainly not this particular technique of the ancient Egyptians. Three reasons rule out preheating in an open fire:

- 1) Fire leaves scorch marks on the ceramic, but none is seen on moulds recovered archaeologically (Larsen 1936: 57; AR IV: 76).
- 2) It is difficult to extract hot moulds from the fire pit, and they are awkward to handle once removed, especially since they do not stand unsupported. In our experiments a small depression was scratched in the sand for each mould, but preparation ahead of time could make better provision for holding moulds upright while they were being filled with dough.
- 3) By the time each mould is picked out from the fire, filled with dough, and placed in the oven ready for baking, most moulds have cooled off. Tomb paintings and models portray a group involved in bread production. A more streamlined approach, with several people doing specific tasks, would make the whole process quicker. Still, the greatest loss of time is extracting hot moulds from the preheating fire. Reducing the handling of preheated moulds could be achieved by keeping moulds in the same place for all operations, but such a procedure is even more awkward if tall narrow round ovens are used for baking. Klebs' (1915: 95; among others) interpretation that dough was placed in hot moulds and left to bake without further heating may apply to the thick bowl shapes of Old Kingdom moulds, but judging from current results seems unlikely for

Investigations into bread baking

Time (Mins)	Degrees Celcius	Time (Mins)	Degrees Celcius
0	20	29	180
2	20	30	175
4	200	32	160
5	360	34	145
7	520	35	145
10	570	37	140
12	640	39	125
14	620	40	120
15	520	42	120
17	450	44	110
19	440	45	105
20	420	(1) 46	100
22	400	47	100
24	320	49	90
25	240	50	80
27	220	55	75
		60	60

(1) First bread loaf removed.

Table 12.1. Change of temperature in the oven used for the baking experiment, using an unrefuelled dung cake and palm frond fire.

the more thinly constructed New Kingdom styles, since moulds cool off so quickly. It is obvious that such hot moulds were difficult to handle.

Elizabeth David (1977: 310) recommends prewarming when baking in terracotta flowerpots. She is describing a method of baking yeast bread; certainly when we are dealing with living yeast, dough should be kept warm in order for the organisms to thrive. David's (1977: 239) table of dough temperatures shows that a wide range is suitable for yeast survival; temperatures between 24°C and 32°C are ideal for dough fermentation. Such heating could easily be attained by warming moulds in embers, or even by laying them out in the sun during hot weather.

The method of baking flat bread shown in the tombs of Ramesses III and Kenamun (see Section 12.2, Artistic evidence) may also have been used at Amarna, as suggested by the thick-walled construction of some ovens found there (*AR IV*: 56, for example). Present-day traditional ovens, found in North Africa and the Middle East (illustration in Darby *et al.* 1980: 513, Fig. 12.8b), retain and re-radiate enough heat after firing to bake flat bread placed directly on the interior lining.

The same point about scorching bread moulds applies to the experimental method of baking bread. Thermocouple readings taken during our experiments (see Table 12.1) show that a straw and dung fire can reach temperatures over 600°C without extra fuel being added; if such a fire was encouraged and refuelled before adding uncooked loaves, it might be that enough heat is retained to bake bread in preheated ceramic moulds, in glowing embers in an oven. Again, more experimentation is required to see whether this is feasible.

Baking using moulds may well have involved placing the moulds upside down. Models show moulds stacked upside down, presumably over a fire, as the attendants shield their faces. These have been interpreted as preheating, but could just as well be actual baking. Elizabeth David's (1977: 310) recipe for flowerpot baking gives specific instructions: "The trick about making good flowerpot bread is to bake the loaves upside down." Modern ovens come equipped with convenient sliding racks. In baking replica ancient Egyptian moulded bread upside down, some way of supporting moulds inside the oven will have to be devised, since artistic depictions are not helpful on this point. Whatever method was employed to bake moulded bread, lack of scorching indicates that moulds were not exposed to open flame, and our future experiments must take



Figure 12.21. The finished product: a baked loaf still in its mould.

account of this.

Our bread, made from modern mechanically ground flour, had a fine and uniform texture. To judge from the texture of the square loaf from Sedment (No. 6604) now in the Manchester Museum, ancient Egyptians were capable of producing quite a finely ground flour; other fragments from Deir el-Bahari also in the Manchester Museum are coarsely ground and crunchy looking. Texture may affect the necessary baking regimen. For example, coarsely ground grain may make a bread which needs roasting rather than baking temperatures and times. Baking may be achieved by long exposure to relatively low heat, but roasting is more likely to require more intense temperatures. This theory, again, awaits further trials.

v) *Conclusions.* Nearly every aspect of ancient Egyptian bread-baking is open to various interpretations and possibilities. The experiments we have undertaken so far at Amarna seem to have generated more questions than answers. We have discovered various areas which need more investigation, and have come up with several ways in which to approach artistic depictions of bread-baking. Since the ancient Egyptians had so many types of breads and cakes, they must have had correspondingly complex techniques to produce them. Thus far we have concentrated on bread in moulds. In the New Kingdom, this may not have been the most common daily bread. At Amarna, bread-mould sherds seem to be associated with temple bakeries and the “military and police post” in the Main City (Rose 1987: 119), and chapel ovens (AR I: 32–33), suggesting that they were used for special breads. In using any of the evidence to apply to experiments, this complexity must be borne in mind. Ultimately we hope to reproduce methods of baking which can be considered as plausible ancient Egyptian techniques. In doing so, we should learn a great deal about a central aspect of past Egyptian life.

12.5 Archaeobotanical work

12.5.1 Introduction.

As with other organic material at Amarna, the plant remains are beautifully preserved by desiccation. Indeed, they survive in such abundance that their presence is almost overwhelming. The tiniest items, rarely or never seen at other sites where preservation by charring eliminates light and papery material, are often found intact. The task of analysis is further complicated by the difficulty of separating fragile dried remains from large volumes of sand. Charred plants can be isolated and cleaned using flotation, but this is inappropriate at Amarna, since contact with water will destroy or distort desiccated plant material. A large number of soil samples have accumulated over the years of excavation; at present I have concentrated on plant remains from contexts presumed to be associated with the preparation of grain or baking of bread. These include, so far, mortar emplacements, quern emplacements, and round ovens. There are many other contexts and many other questions; given sufficient time, they will eventually be considered.

12.5.2 Goals.

Archaeobotanical goals range from those general ones which can be applied to any site, to questions framed to gain direct botanical evidence of grain processing and baking.

1) All archaeobotanical analysis begins with a survey of species represented in the assemblage. By determining which plants were being used in particular areas of the settlement, their associations and proportions, we should gain an idea of species which were important, what processes they may have undergone prior to transportation to that spot, and how they appear to have been manipulated before deposition (for example, Hillman 1981). Until now, most analysed plant remains from ancient Egypt have been from tombs. There are two reasons for this: firstly, most excavation has been on tombs; and, secondly, only recently have dwelling-sites been systematically sampled for plant remains. Amarna is one of the few Egyptian sites so far which provides botanical material from a former settlement, where daily activities of the inhabitants resulted in deposition of plant remains. Such a site is far more likely to preserve an assemblage which reflects actual use and manipulation of a diverse range of plants, than the carefully selected ritual offerings remaining in tombs. Therefore, it is reasonable to expect that some plants may be identified which have not previously been recorded for ancient Egypt.

Among the possibilities are *Triticum monococcum* (einkorn) and free-threshing wheats. Present evidence indicates agriculture first appeared about 10,000 years ago, in the Middle East (Reed 1977: 3). Throughout the Bronze Age in this area, emmer (*T. dicoccum*) seems to have been the dominant wheat (Hubbard 1980: 61) with einkorn appearing as a less abundant crop. According to Hubbard's (1980: 56) diagrams however, where einkorn appears, it is often associated with emmer. Since agriculture and crops almost certainly diffused into Egypt from this region, Helbaek (1953: 4) considers the possibility that the two glume wheats came into Egypt together, but he finds no evidence of einkorn. In the past, einkorn had been identified from a prehistoric grave at El-Omari (Debono 1948: 568), and Djoser's Third Dynasty tomb (Lauer *et al.* 1949–1950: 127–128, 156–157), but subsequent reinvestigation by Helbaek conclusively shows that these spikes actually derived from immature emmer (Helbaek 1953, 1955). Hopf (1981: 314) has recently stated that no einkorn has been satisfactorily identified from ancient Egypt.

Similarly, according to present archaeobotanical evidence, free-threshing wheat, although not a major crop, was present in the Bronze Age in Palestine, Syria, and Mesopotamia (Hubbard 1980: 58; Helbaek 1955: 94). Since trade between these regions and ancient Egypt flourished, it might be expected that crops would be exchanged and established. However, Helbaek (1955: 94) states that free-threshing wheat has not been reliably demonstrated in Egypt before Graeco-Roman times other than one sample of club wheat found in an assemblage dating from the earliest agriculture in Egypt (Late Neolithic). Clearly, any further investigations of crop remains from ancient Egypt, especially from settlement sites as opposed to tombs, will be of value in establishing whether einkorn and free-threshing wheats were indeed never cultivated or imported, or whether this apparent absence is due to an inadequate data base.

2) Condition of plant remains can suggest their past treatment. At Amarna, for example, Jane Renfrew (1985: 179) concludes that the very frayed and chewed appearance of some emmer spikelets indicates their use as a poor quality fodder for penned animals at the Workmen's Village. Noting and comparing the appearance and fragmentation of plant remains from grain preparation contexts should provide direct evidence for the effects of each processing stage.

General results may be obvious from the context, but precise effects may not. For example, mortars were obviously used for pounding. But were they used solely to dehusk tough glume wheats, or to break up grain prior to grinding? Perhaps both functions were carried out separately or at once. Hillman (1984: 129, 130) discusses the care taken by people using traditional methods to ensure grain is not broken, but his comments do not deal with cereal processing to make flour. An analysis of the condition of plant material deposited around mortar emplacements should help to answer this question.

3) The two points discussed above are more applicable to grain-processing contexts. Unless remains of accidental burning of bread were deposited nearby, analysis of oven contents is unlikely to elucidate preparation of bread itself. Such unintentional charring must have been quite rare in any case. However, samples from ovens will show what was used for fuel, and the results can be used in experimental work. Also, it is likely that chaff and straw from cereal cleaning were burnt, and this charred material will then add to the evidence for crop husbandry and processing (Hillman 1984a).

4) Reliable, complete sets of measurements can be obtained from the Amarna material. These will define the characteristics of the assemblage quantitatively, allowing comparison between contexts, and among other Egyptian sites, as well as Palestinian, Syrian, and Mesopotamian material. When we compare material from sites outside Egypt, proportions rather than absolute measurements will be important, since the charring process undergone by most preserved plant remains will have affected size. These comparisons will be of practical interest to Egyptologists, since trade commonly flourished between ancient Egypt and Middle Eastern areas. Comparative morphology may indicate that certain strains seem to be related, or perhaps are quite distinct.

5) Such excellent preservation of plant remains as that found at Amarna is rare and provides an opportunity to compare different classes of material preserved by both desiccation and charring; the effect of charring on preservation can be determined. These results may be very helpful for archaeobotanical analysis at sites where only charred plants survive.

6) Thorough archaeobotanical analysis of contexts at Amarna should produce evidence of cereal manipulation which can then be applied to experimental work. The assemblage and its condition in various contexts will indicate what processes were likely to have been applied; these can then be compared to other sources and incorporated into the modern replication of ancient bread-baking techniques.

12.5.3 Analysis.

A. Sampling. Soil samples from several seasons have been stored at Amarna since they were excavated. Samples relating to grain preparation contexts were picked out. Almost all of them are far too large to be completely sorted and analysed, and have been reduced to manageable volumes with a sample divider (riffle box) so as to produce a set of even and unbiased fractions. Scoresheets of samples split in this manner will contain quantities of material which must then be multiplied up according to the size of the fraction. For example, all quantities from a quartered sample must be multiplied by four to get an estimate of the numbers contained in the original bag of soil. Although the original sample may not reflect the actual size of its deposit, volumes of each sample are recorded so that some sort of comparison may later be made. If sampling is standardized, comparison will be more reliable. After the samples had been split down to manageable size (typically 250–500 ml), only the materials contained in that fraction were examined. However, in future, samples will be screened in their entirety for the largest items (those caught in a 1.7 mm sieve), while the smaller fractions will be divided as before. This will result in better statistical analysis of the relatively less frequent large fruits and seeds.

Flotation damages desiccated plant material, making it inappropriate for the separation of dried plant remains from the sand matrix. Dry sieving must be used. Even with this, however, there is still a great deal of inorganic material obscuring the plant remains. Separation requires painstaking and time-consuming hand sorting, removing objects of interest with forceps under a low-power dissecting microscope. An air blower similar to the system suggested by Ramenofsky *et al.* (1986) may be helpful, although this technique is potentially damaging. A good method which reduces the considerable time required to separate the plant material would be very useful. Once botanical remains have been isolated, they are sorted into broad categories. This permits each item to be compared to others of similar appearance and simplifies assigning specific names.

B. Identification and discussion. Presented here are the results of a preliminary analysis of one sample, a deposit around the mortar emplacement in West Street 2/3, Unit [2707] (AR IV: 8). From this deposit, the total volume of soil retrieved for analysis was 300 ml. Of this, 50 ml was organic; the remainder was sand. All the plant remains, unless otherwise stated, are uncharred. Obviously conclusions, particularly those relating to grain-processing procedure, will be limited until more comparative contexts can be examined in depth.

The most common species found in the mortar emplacement deposit is emmer wheat, *Triticum dicoccum*. It is represented by whole spikelets still containing wheat kernels, empty but whole spikelets, rachis segments, spikelet forks both with and without rachis segments attached, glumes, awn fragments, and light chaff (see Charles 1984: 18 for illustrated explanations of wheat morphology terms). Much less abundant is barley (*Hordeum*); some is six-row, but four-row is present as well. Most barley remains occur as rachis segments, but some light chaff and awn fragments have been noted, as well as a single whole grain. Culm nodes, straw, and reed stems are present. Various parts of other plants have also survived; their identification is as yet uncertain. These include fragments of twigs, wood, bark, and leaf-like material. Seeds of various taxa have been separated out, although many are not yet properly determined. A few charred remains were mixed in the deposit. They are all encrusted in soil, a fact which suggests that they came from mud-brick temper or by some other means unconnected with the cereal which was being processed in the mortar. Table 12.2 lists all the desiccated finds from this sample.

a) Wheat. Since most of the whole, filled spikelets of emmer are well preserved and easily measured, two tables of measurements are set out which characterize this group. Table 12.3 lists distinguishing criteria described by Hillman (in press). Table 12.4 presents the measurements of length, breadth, and glume length for whole emmer spikelets found in this sample. These can be compared to the figures which Helbaek (1953, 1955) obtained on Queen Icetis' wheat, and also they give an indication of the size and variation in this assemblage of emmer. Average measurements for empty but complete spikelets are similarly laid out (Table 12.5).

The most distinctive emmer trait is the shape of glume tips (Hillman, in press; Helbaek 1953: 6-7; Schieman 1954: 142, 145), but even in such well preserved material they unfortunately rarely survive. Other classes of wheat chaff have not yet been measured, with the exception of one peculiar spikelet fork. Measurements for this curiously einkorn-like item appear in the final row of Table 12.5. According to Hillman (in press), in a given assemblage of glume wheat, the ratio of attachment scar to total rachis width across the scar is a dependable trait separating einkorn and emmer. The attachment scar in einkorn is broad in relation to total width, whereas in emmer it is narrow. The ratio of scar width to total width is 70% on this particular spikelet fork. Of all measured rachises, the next largest ratios are 64% and 62%. The ratio average for whole and filled spikelets is 43% +/- 12, with a maximum of 64%. For whole empty spikelets, this ratio average is 41% +/- 14; the maximum is 62%.

Relying on one characteristic alone for identification, especially for a single, unusual item, is dangerous. The other obvious trait which seems to separate this spikelet fork from other measured spikelets is the very small angle formed by the insertion of glume bases. According to Hillman (in press), the angle of glume-base insertion is narrow in einkorn and broad in emmer. As Table 12.5 shows, angle insertion for this einkorn-like spikelet fork is 32°, whereas all other measured angles are greater than 52°; the average is 74° with a standard deviation of 14.

Of other characteristics which Hillman (in press) enumerates for einkorn, many appear on this anomalous spikelet:

1) The angle between the outer glume faces viewed from above. In emmer the angle is somewhat obtuse; in einkorn, nearly parallel. This spikelet has more or less parallel outer glume faces. (Glumes enclose light chaff and the grain within. They are more or less angular structures when seen in cross section. Each of the three sides which make up a glume is called a glume face.)

2) Prominence of the primary keel. This feature is difficult to ascertain, since most of it no longer survives. However, the angle formed by glume faces on either side of both primary keels is 90°, which is typical of einkorn. Hillman states that the angle around this keel in emmer is normally less than 90°. Measured Amarna spikelets are highly variable and by no means always less than 90°. Thus, this criterion is less useful for this particular assemblage (see Table 12.5).

3) Tertiary veins on the outer glume faces. These veins, between the primary and secondary keels, are clearly visible in emmer, but completely invisible in most einkorns. Since one glume

Item	Number	Volume (ml)
Soil sample		300
Botanical material		50
<hr/>		
<i>Triticum dicoccum</i> (emmer)		
Whole emmer spikelets, still containing grain		
From centre of ear	10	
Basal spikelet	1	
Terminal spikelet	1	
Whole, empty emmer spikelets		
From centre of ear	26	
Terminal	1	
Emmer rachis internodes		
Central	160	
Terminal	6	
Basal	2	
Basal emmer rachis with attached culm	2	
Emmer spikelet forks	66	
Emmer glume bases	151	
"Einkorn-like" (<i>Triticum monococcum</i>)		
spikelet fork	1	
<hr/>		
<i>Hordeum vulgare</i> (barley)		
Barley rachis internodes	14	
Barley rhachillae	6	
Whole barley grain	1	
<hr/>		
Other cereal fragments		
Culm nodes	10	
Unsorted chaff		23
Cereal beards	(equivalent of) 8-12	
<hr/>		
Miscellaneous items: all volumes negligible, unquantified		
Leaf fragments		
Bark fragments		
Twig fragments		
<i>Tamarix</i> twigs		
<hr/>		
Wild/weed seeds (1)		
<i>Lolium</i> cf. <i>temulentum</i>	14	
<i>Phalaris minor</i> (minimum number of seeds)	12	
<i>Rumex</i>	4 + fragments	
<i>Polygonum</i>	1	
<i>Carthamus tinctorius</i>	1 + several fragments	
Boraginaceae	5	

(1) There are several other seed types in the sample which have not yet been determined.

Table 12.2. All archaeobotanical finds from mortar emplacement deposit at West Street 2/3, Unit 2707. All the finds are desiccated.

For explanation of criteria abbreviations, see Notes below.

	Angle btwn glume bases (A)	Angle 1° keels (B)	Angle 2° keels (C)	Scar/ glume dist. (D)	Scar width (E)	Spkt width (F)	Index (%) (G)	Rachis length (H)
1	98	95	128	0.78	1.11	2.67	42	3.0
		92	115	0.89				
2	85	90	109	0.67	1.22	2.78	44	3.22
		81	100	0.78				
3	122	102	130	0.56	0.56	2.11	26	2.78
		103	133	0.56				
4	102	90	147	0.56	1.0	2.22	45	2.44
		105	132	0.56				
5	75	100	130	0.67	0.67	2.0	33	2.56
		90	115	0.78				
6	79	100	122	0.56	1.56	2.44	64	2.56
		116	131	0.56				
7	85	90	135	0.56	1.0	2.0	50	2.44
		90	110	0.78				
8	83	119	136	0.45	0.78	2.0	39	2.22
		110	135	0.56				
9	88	102	139	0.56	0.67	2.22	30	2.22
		120	155	0.67				
10	58	90	130	0.67	1.11	2.0	56	2.22
		98	90	0.78				
11	88	161	124	-	-	-	-	2.89
		145	152					
12	55	103	106	0.56	1.33	1.89	71	2.56
		110	135	0.56				
Average:	88	99	126	0.65	0.97	2.2	43	2.60
Standard deviation:	17	11	16	0.13	0.30	0.29	12	0.34

Notes: Spikelet 11 is terminal, and therefore certain criteria are not present. Spikelet 12 is basal. (A) Angle between glume bases: angle glume bases make viewed broad side on. (B) Angle 1° keels: angle of glume faces on either side of primary keel. (C) Angle 2° keels: as (B) for secondary keel. (D) Scar/glume distance: distance between base of glume insertion and top of upper disarticulation scar. Often slightly different for each glume of spikelet. (E) Scar width: width of upper disarticulation scar. (F) Spikelet width: measured across upper disarticulation scar. (G) Index: Width of upper scar as a percentage of total spikelet width at the same level. (H) Rachis length: measured from top of upper disarticulation scar to base of lower disarticulation point.

Table 12.3. Measurements of whole emmer spikelets, still containing grain, according to criteria set out by Hillman (in press).

	Length	Breadth	Glume Lengths (1)		
1.	12.88	5.62	8.34	8.64	
2.	11.74	5.70	7.36	8.10	
3.	13.00	5.70	8.34	8.82	
4.	12.36	5.84	9.06	9.08	
5.	11.64	3.46	-	-	(2)
6.	15.08	6.30	9.44	9.44	
7.	11.00	5.26	7.98	7.60	
8.	14.24	5.04	8.74	-	(2)
9.	12.92	4.48	7.88	8.14	
10.	14.96	4.76	9.12	10.06	
Average:	12.98	5.18	8.58		
Standard deviation:	1.40	0.80	0.74		

(1) All measurements in mm.

(2) Glume tips broken off.

Table 12.4. Length, breadth, and glume length measurements for whole emmer spikelets containing grain, using Helback's (1953) criteria. The basal and terminal spikelets are not included in this table.

	Angle btwn glume bases (A)	Angle 1° keels (B)	Angle 2° keels (C)	Scar/ glume dist. (D)	Scar width (E)	Spkt width (F)	Index (%) (G)	Rachis length (H)
Averages:	74	93	124	0.66	1.06	2.33	41	.71
Standard deviations:	14	9	12	0.13	0.27	0.24	14	0.50
Maximum:	108	120	155	0.89	1.44	2.89	62	4.33
Minimum:	53	80	102	0.34	0.67	1.89	32	2.11
Number of individuals:	26	49	40	42	27	26	26	27
Anomalous "einkorn-like" spikelet fork:	32	90	120	0.33	1.14	1.48	71	-

Table 12.5. Averages of Hillman wheat identification criteria for empty emmer spikelets, and measurements of an anomalous spikelet fork. (See Table 12.3 notes for explanation of criteria abbreviations).

extends 2.67 mm, and the other extends only 1.67 mm from glume insertion point, the pattern of venation is difficult to distinguish. That portion which does survive is fluted rather than veined. On all other emmer spikelets which have been examined, distinct venation can be differentiated below 2.5 mm from the glume insertion point.

4) The vertical distance between the upper edge of the disarticulation scar and lower edge of glume insertion is large for emmer but small for most einkorn spikelets. The average for this distance in measured empty emmer spikelets from this assemblage is 2.71 mm \pm 0.50; on the anomalous spikelet this distance is about 0.3 mm.

The only surviving feature which does not correspond to Hillman's criteria for einkorn is the angle around the secondary keel. In einkorn examined by Hillman, this angle is about 90–95°, whereas the spikelet under discussion has angles of approximately 120°. Although Helbaek (1953: 10) stresses size can be very misleading, taken together with other measurements, it is a characteristic worth considering. This einkorn-like spikelet fork is smaller than average; its width across the disarticulation scar is 1.48 mm, whereas the assemblage average is 2.33 mm \pm 0.24. The small size could be indicative of a terminal emmer spikelet, but this specimen clearly lacks the characteristic glume position of terminal emmer spikelets. In comparison to the traits set out by Hillman, this spikelet has several characteristics indicative of einkorn. I hesitate to state that it is unquestionably *T. monococcum*. This form of wheat has never been satisfactorily demonstrated in Egypt (Schiemann 1954: 149; Hopf 1981: 314), and claiming its presence on the basis of one attenuated spikelet fork is insufficient evidence. Nonetheless, if similar spikelets are found after more detailed examination of material from Amarna, the possibility of einkorn in ancient Egypt, at least as a contaminant in emmer fields, should be reconsidered. The identification of this item as einkorn would be lent support if future definite finds of einkorn from other sites in Egypt are made. Otherwise, any claim for identification of einkorn must remain very uncertain.

As Helbaek (1955: 95) notes for his samples of Queen Icetis' wheat, the morphology of emmer from this mortar emplacement is highly variable. Often, one glume is placed at a wide angle relative to the rachis axis, whereas the other glume is set fairly straight. The overall result is thus a medium insertion angle between the two. A similar situation is to be observed for the outer glume faces. One glume face is more or less perpendicular relative to the rachis segment, while the other is distinctly obtusely angled.

The action of the mortar broke up the spikelets in various ways, as indicated by the diverse types of chaff in the sample. Those spikelets which retain most of their chaff but which have lost their grain, are generally breached in the same way. The abaxial glume and light chaff have been torn away, leaving a space for the grains to fall out. Because rodents had obviously chewed much of the cereal chaff remains, it cannot be assumed that such breakage was solely the result of pounding. It may be an artefact of rodent predation. Experimental work in conjunction with ethnographic comparison should allow us to determine the characteristic forms of breakage. Hillman's (1984b: 130) comments on ethnographic records may be of relevance. Pounding might have been intended to dehusk only and separate out whole grains. If rodent damage can be distinguished from processing fragmentation, an index of processing efficiency may be estimated.

Grain or fragments of grain must have been scattered at the time but have been consumed by rodent or insect action. Cereal brush fragments are evidence for the former presence of grain. These hairs crown the distal end of the wheat caryopsis (see Charles 1984: 20, Fig. 2C) and are presumably unpalatable to the type of insects or rodents active here. If amounts of wheat brush can be taken as a guide, there seems to have been the equivalent of roughly 8–12 exposed cereal grains in the sample. This compares to 12 retrieved whole, filled spikelets.

b) *Barley*. Six-row and four-row barley have been found from various tombs in ancient Egypt (Täckholm *et al.* 1941: 286). Finds of two-row barley are uncertain. All three forms are known, at least until recently, in Egypt today (Täckholm *et al.* 1941: 279). Of three spikelets on each rachis of two-row barley (*Hordeum distichum*), only the median one is fertile. All three spikelets are fertile in six-row barley (*H. vulgare*). Four-row barley (*H. vulgare* var. *tetrastichum*) is essentially the same as six-row; each rachis bears three fertile spikelets, but the lateral ones are slightly raised out of line with the median spikelet. Each variety can be distinguished on the basis of glume placement and pedicel formation. Four- and six-row barley have six well-developed glumes attached to the rachis internode; lateral glumes of two-row barley are attenuated. Only the median pedicel of two-row barley is well developed; lateral ones are much smaller. All three

pedicels are more or less equal in size for six-row barley and four-row barley, although lateral pedicels may be slightly smaller in the latter and are slightly above the median.

In this mortar assemblage, 14 rachises of barley are present, forming only 6% of all rachis or spikelet remains in the sample. Average length from disarticulation at the base to the top of the upper disarticulation scar is 2.73 mm \pm 0.46. Of these rachises, only one is definitely six-row as shown by the clear pattern of surviving intact glume bases, and the three equally large pedicles which once supported three grains. Three other rachis fragments probably derive from six-row barley to judge from pedicles of equal size, but glume stubs are poorly preserved, making the designation somewhat uncertain. Raised lateral pedicels on six other rachises indicate the presence of four-row barley. Because distinguishing features are absent or poorly preserved on the remaining four rachises, it is difficult to assign them to either six- or four-row barley. None of these rachises could be from two-row barley.

One whole hulled-barley grain survives intact. Its hull has a distinctive wrinkled pattern, which also appears on loose barley chaff in the sample. The barley found by Lauer *et al.* (1949–1950: Pl. III) also has this wrinkling. A few of these fragments are unusual in that the lemma and palea survive intact but the grain has gone. Pounding will not strip the tightly enclosing hull unbroken from barley. Rodents would probably have chewed through hulls. Insect consumption is the most probable agent for the appearance of these remains. One empty hull has a round hole halfway down the palea, again suggestive of insect activity.

c) *Relative abundance of wheat and barley.* These cereal remains appear to be from primary deposition during the use of the mortar, and this seems to be reflected in the type of chaff present. No stratigraphic evidence for secondary deposition has been observed. When remains from other mortar emplacements have been analysed, it will be possible to characterize assemblages from this context category and to identify secondary deposition. At first glance, it appears that emmer was used much more than barley. However, these two cereals have different characteristics which make it unlikely that mortar deposits, in particular, will reflect their relative amounts. Barley rachises are tough, so that threshing in the field will tend to strip spikelets off, leaving whole rachises, or large sections, intact. In contrast, emmer rachises are brittle; when threshed, the spike shatters into individual spikelets still adhering to single rachis segments. Thus, wheat and barley taken to the mortar have already been differentiated with regard to the presence of rachis internodes. Threshing should affect the survival of awns for both cereals equally. Although awn fragments from the sample are presently unquantified, a casual survey shows that emmer awn fragments are far more frequent than those of barley.

There remains the possibility that barley was not always processed like emmer so that less barley was taken to the mortar. A conclusion about relative abundance at the site as a whole cannot be made from one sample alone; plant remains from different contexts all over the site should be examined. The question is worth pursuing in the light of Gardiner's (1941: 27) observation, based on different ink colours for amounts of wheat and barley in ancient documents, that grain payments in the New Kingdom were mainly made with emmer rather than barley. His discussion focuses on tax assessments, but payments to workers might have followed the same pattern (as at Deir el-Medina, where, in the late New Kingdom, emmer payments were roughly twice the quantity of barley payments, Janssen 1975: 460).³ People living in the Workmen's Village may have been dependent for cereal supply on grain payments. If this was the case, and emmer is the most common cereal at the site, Gardiner's proposal would be shown to cover such situations as well.

d) *Other items.*

i) *Lolium cf. temulentum.* Fourteen hulled caryopses of *Lolium* are found in the sample, the chaff still tightly enveloping the grain. Many lemmas still retained their awns. According to Täckholm (1974: 707–708) and Bor (1968: 92–99), the only two awned species of *Lolium* which occur in Egypt are *L. multiflorum* and *L. temulentum* var. *macrochaeton*. When we refer to modern material, *L. multiflorum* is much narrower in relation to breadth and also much smaller overall. The largest *L. multiflorum* spikelet observed is about half the width and slightly shorter

³ Janssen 1975: 129–130 notes that: "when the difference in price is small ... it is always emmer which is the cheaper. Again one may cite in particular Pap. Turin 1907/8, where barley is in most cases double the value of emmer, and once three times as expensive, while in one entry the price is more or less equal".

than the archaeobotanical specimens. Compared to *L. temulentum* reference specimens held at the Department of Archaeology and Anthropology, Cambridge University, ancient caryopses are much less turgid, but absolute length and breadth measurements are similar. The ancient spikelets compare very favourably with the smallest reference spikelets in length, breadth, and thickness, as well as rachilla size. Bor (1968: 93, 99) gives modern lemma length measurements for Iraqi specimens of *Lolium multiflorum*. They range between 6 and 8 mm. Length measurements in Table 12.6 refer to grain, not lemma length; lemmas are about 1 mm longer than caryopses. Reference specimens of *L. multiflora* are distinctly ciliate on the palea keels, whereas those of *L. temulentum* are smooth; the keels of ancient specimens are almost smooth.

Measurement	Average	Standard Deviation	Minimum	Maximum
Length	4.6	0.56	3.9	5.6
Breadth	1.8	0.17	1.6	2.1
Thickness	1.1	0.15	0.7	1.3

Ratios: Length to Thickness: 4.2
 Length to Breadth: 2.6
 Thickness to Breadth: 0.6

Table 12.6. Measurements of fourteen *Lolium* specimens, taken across widest part of grain, with chaff still surrounding caryopses. All values in mm.

Täckholm (1974: 707) states that *L. temulentum* var. *macrochaeton* is common where it occurs, but this species is not found around Amarna now. *L. multiflorum*, however, is a very common weed of fields, gardens, canal banks, and similar habitats, and its modern range includes the Amarna region.

These ancient hulled-grass caryopses may be from a small seeded form of *L. temulentum*, or may be immature forms and harvested before grains filled out completely. The "cf." designation here will be retained until more reference material can be compared, since small size, lack of turgidity, and non-occurrence in modern times makes identification somewhat insecure. Should they prove to be *L. temulentum*, and present range resembles past distribution, the interesting possibility arises that grain supply to the Workmen's Village was imported from elsewhere. *L. temulentum* has already been identified amongst ancient animal droppings from Site X1 at the Workmen's Village, AR I: 58–59. Table 12.6 lists measurements which were taken across the widest part of the grain, with chaff still surrounding the caryopses.

ii) *Phalaris minor*. Two entire seeds and fragments of a minimum of 10 seeds of this species are positively identified. The excellent state of preservation allows certain identification on the basis of its single sterile lemma scale; all other Egyptian species of *Phalaris* have two scales (Täckholm 1974: 741). The only missing features are the hairs which typically cover the seed, but their bases are clearly visible. Fertile lemmas of the two complete seeds measure 3.2 mm and 3.3 mm, slightly longer than measurements of 3 mm which Bor (1968: 364) gives for modern Iraqi populations. Täckholm (1974: 741) records *P. minor* as a common plant along the length of the Egyptian Nile. Bor (1968: 364) states that this species grows in desert depressions, as a weed in alluvial fields, and along irrigation channels, so it is not surprising to find it among crop remains.

iii) "Leaves". Four tiny leaf-like fragments are recorded. They are prominently veined on one side. Examination under a scanning electron microscope may show cell and stomatal arrangement, which may aid identification. These fragments may be remains of *Rumex* perianths. Laterally compressed, short oblong "seeds" in this assemblage may actually be *Rumex* tubercles formerly attached to the perianths. If so, they will be very useful for identification, as forms of perianth and their tubercles are distinctive in this genus, whereas the seed enclosed by pericarp alone is not. This merits further investigation.

12.5.4 Concluding comments.

Archaeobotanical work is still at a very preliminary stage; the results so far have raised intriguing questions and pinpointed directions for further work, but no conclusions may yet be drawn. A good start has been made on characterizing one assemblage although many seeds await identification. The condition of plant remains from the analysed deposit is in keeping with its context; whole spikelets of emmer and various other seeds were pounded by mortar and pestle, producing a range of whole and fragmented pieces. Because of predation it is uncertain whether cereal grains were cracked at the same time they were hulled, although comparing chaff fragmentation patterns to ethnographic observations suggests they may not have been. The experimental and archaeobotanical record seem to be at variance on this point. Since analysis has not yet covered a range of contexts, it is too early to apply results to experimental work. A set of measurements and characteristics has allowed initial comparisons to other assemblages; ongoing investigations will allow comparison amongst different contexts within the site itself.

12.6 Future work

In the first year, the Amarna baking project has covered a number of aspects relating to ancient Egyptian bread. By looking at artistic evidence, samples of ancient bread, archaeological and archaeobotanical remains, and through experimentation, numerous questions have been raised which deserve further study. Old Kingdom tomb art shows baking with hot moulds, but evidence for similar practices in later eras is not conclusive. Since styles of bread mould change, it is probable that baking methods also evolved. Ancient documents record myriad types of loaf, but bread-baking scenes are not specific enough to judge what might differentiate them. Bread making and beer brewing are very often linked in models, reliefs, and paintings of daily life. Bread is thought to have been used for brewing, and it is very likely that yeast from the brewery was an ingredient of bread dough. The effect of baking with brewery yeast, and the type of bread which results, needs to be investigated. Another aspect of baking which is not clear from existing records is temperature regimens. Some bread may have been baked by placing semi-liquid dough in hot moulds, but greater temperatures for longer times might have been used for denser bread.

Possible re-use of bread moulds would have a considerable effect on supply of labour and resources, particularly for large temple or palace bakeries. All ancient sources of evidence are silent on this point; the only way to determine whether moulds are actually re-useable is to carry out experiments. Another question dealing with supply and wastage concerns the efficiency of the milling process. Numerous written records (Breasted 1906; Peet 1923; Nims 1958; Spalinger 1986; for example) deal with cereal stores given in tax and supplied to temples, or work out the amount of grain needed for specific types of bread and beer. Some grain is inevitably lost in the milling process. By replicating ancient techniques using ancient equipment an idea of efficiency should be established, and ancient documents re-evaluated with this information.

Cereal finds so far examined from the Workmen's Village are predominantly wheat, and wheat was used in the experiments as well. Barley does occur on the site, and it is worthwhile experimentally comparing wheat and barley processing. Gardiner's (1941: 26–27) work implies change in cereal use or popularity; experimental results in conjunction with ethnographic parallels may suggest why.

An important category of evidence is the plant remains associated with cereal processing on site. A beginning has been made on sorting and analysing this material. Additional samples will provide much more information to apply to interpretation of other records. In addition to this on-site work, further investigations into the extensive ancient literary and pictorial sources, which has been only briefly summarized in this paper, will continue. Ancient sources, such as Pliny and Herodotus, have recorded useful and relevant observations, which will be incorporated as well.

The following list summarizes topics which will be examined in the coming seasons at Amarna, and during follow-up work:

- 1) Baking with bread moulds: do New Kingdom style bread moulds retain enough heat to cook dough? Can bread moulds be re-used?
- 2) What is the link between baking and brewing? What type of bread does brewery yeast make, and what type of beer is made from loaves of bread?
- 3) How efficient is the ancient Egyptian milling process?

Investigations into bread baking

4) How do wheat and barley compare as ingredients in bread, both in taste and texture, and in processing to produce flour?

5) What does analysis of plant material retrieved from contexts associated with bread-making suggest about the process of cereal preparation?

Future seasons' work will expand on the material discussed in this report. This will lead to a clearer and more extensive knowledge of ancient Egyptian bread-baking.

Acknowledgements

My thanks to Willeke Wendrich for taking most of the experimental sequence photographs. Barry Kemp's guidance to the Egyptological literature was invaluable. I am most grateful to Gordon Hillman for access to his as yet unpublished data on einkorn and emmer identification, and also his help with the identification of some of the seeds. I am indebted to Joe Saxton for the loan of his word processor. Mark Nesbitt's advice and encouragement is especially appreciated. This project was funded by a grant from the British Academy.

References

- Blackman, Aylward M. (1924). *The rock tombs of Meir*. Part IV. The tomb chapel of Pepi'onkh the middle son of Sebkhotpe and Pekhernefert. Archaeological Survey of Egypt, 25th Memoir. London: Egypt Exploration Society.
- Bor, N.L. (1968). *Graminae*. Vol. 9, Flora of Iraq. Townsend, C. C., Evan Guest and Ali Al-Rawi, eds. Baghdad: Ministry of Agriculture, Republic of Iraq.
- Breasted, James H. (1906). *Ancient records of Egypt*. Volumes 1–5. Chicago: Chicago University Press.
- Bruyère, Bernard (1953). *Rapport sur les fouilles de Deir el-Médineh*. Cairo: L'Institut Français d'Archéologie Orientale.
- Charles, Michael P. (1984). "Introductory remarks on the cereals." *Bulletin on Sumerian Agriculture* 1: 17–31.
- Cooney, John D. (1965). *Amarna reliefs from Hermopolis in American collections*. Mainz am Rhein: Verlag Philipp von Zabern.
- Darby, William J., Paul Ghalioungui, and Louis Grivetti (1976). *Food: The gift of Osiris*. Vol. 2. London: Academic Press.
- David, Elizabeth (1977). *English bread and yeast cookery*. London: Allen Lane.
- Davies, N. de G. (1902). *The rock tombs of Deir el Gebrâwi*. Part II. Tomb of Zau and tombs of the northern group. Archaeological Survey of Egypt, 12th Memoir. London: Egypt Exploration Fund.
- Davies, N. de G. (1930). *The tomb of Ken-Amûn at Thebes*. New York: Metropolitan Museum of Art.
- Davies, N. de G. and Alan Gardiner (1920). *The tomb of Antefoker and his wife, Senet*. Theban Tombs Series 2nd Memoir. London: George Allen and Unwin Ltd.
- Davies, Norman de G. (1943). *The tomb of Rekh-mi-rê' at Thebes*. New York: Metropolitan Museum of Art.
- Debono, Fernand (1948). "El-Omari (près d'Hélouan). Exposé sommaire sur les campagnes des fouilles 1943–1944 et 1948." *ASAE* 48: 561–583.
- Emery, Walter B. and L.P. Kirwan (1935). *The excavations and survey between Wadi es-Sebua and Adindan, (1929–1931)*. Vols. 1 & 2. Cairo: Government Press.
- Epron, Lucienne, François Daumas and Georges Goyon (1939). *Le tombeau de Ti*. Fasc. 1. Cairo: Institut Français d'Archéologie Orientale.
- Erman, Adolf (1971). *Life in ancient Egypt*. tr. H.M. Tirard. Reprinted from the 1894 original by Dover Publications, New York.
- Gardiner, Alan H. (1941). "Ramesside texts relating to the taxation and transport of corn." *JEA* 27: 19–73.
- Helback, Hans (1953). "Queen Ictis' wheat: a contribution to the study of early dynastic emmer in Egypt." *Kgl. Danske Videnskab. Selsk. Biol. Meddelelser* 21: 3–17.

- Helbaek, Hans (1955). "Ancient Egyptian wheats." *Proceedings of the Prehistoric Society* 21: 93-95.
- Hillman, Gordon C. (1981). "Reconstructing crop husbandry practices from charred plant remains." In Mercer, Roger, ed., *Farming practice in British prehistory*. Edinburgh: Edinburgh University Press. Pp. 123-162.
- Hillman, Gordon C. (1984a). "Interpretation of archaeological plant remains: the application of ethnographic models from Turkey." In van Zeist, W. and W.A. Casparie, eds., *Plants and ancient man*. Rotterdam, A.A. Balkema. Pp. 1-47.
- Hillman, Gordon C. (1984b). "Traditional husbandry and processing of archaic cereals in modern times: part I, the glume wheats." *Bulletin on Sumerian Agriculture* 1: 114-152.
- Hillman, Gordon C. (1985). "Traditional husbandry and processing of archaic cereals in recent times: part II, the free-threshing cereals." *Bulletin on Sumerian Agriculture* 2: 1-31.
- Hillman, Gordon C. (1987). "Plant foods in ancient diet: the archaeological role of palaeofaeces in general and Lindow Man's gut contents in particular." In Stead, I.M., J.B. Bourke and D. Brothwell, eds., *The body in the bog*. London: British Museum Publications. Pp. 99-115.
- Hillman, Gordon, C. (In press). "Emmer cultivation at Breidden Hillfort during the late Iron Age." In Musson, C. and W. Britnell, eds., *Excavations at Breidden Hillfort, Powys*. Cardiff: Cambrian Archaeological Association Monographs and Collections.
- Hillman, Gordon C., G.V. Robins, D. Oduwole, K.D. Sales, and D.A.C. McNeil (1983). "Determination of thermal histories of archaeological cereal grains with electron spin resonance spectroscopy." *Science* 222: 1235-1236.
- Hillman, Gordon C., G.V. Robins, D. Oduwole, K.D. Sales, and D.A.C. McNeil (1985). "The use of electron spin resonance spectroscopy to determine the thermal histories of cereal grains." *Journal of Archaeological Science* 12: 49-58.
- Holthoer, Rostislav (1977). *New Kingdom Pharaonic sites: the pottery*. The Scandanavian Joint Expedition to Sudanese Nubia, Volume 5:1. Stockholm: Scandanavian Univ. Bosk.
- Hopf, Maria (1981). "Einkorn (*Triticum monococcum* L.) in Egypt?" *Journal of Archaeological Science* 8: 313-314.
- Hubbard, Richard N.L.B. (1980). "Development of agriculture in Europe and the Near East: evidence from quantitative studies." *Economic Botany* 34(1): 51-67.
- Jacquet-Gordon, Helen (1981). "A tentative typology of Egyptian bread moulds." In Arnold, Dorothea, ed., *Studien zur altaegyptischen Keramik*. Mainz am Rhein: Philipp von Zabern.
- Janssen, Jac. J. (1975). *Commodity prices from the Ramessid Period: an economic study of the village of necropolis workmen at Thebes*. Leiden: E.J. Brill.
- Jones, Glynis E.M. (1984). "Interpretation of archaeological plant remains: ethnographic models from Greece." In van Zeist W. and W.A. Casparie, eds., *Plants and ancient man*. Rotterdam: A.A. Balkema. Pp. 43-61.
- Junker, Hermann (1953). *Giza XI. Grabungen auf dem Friedhof des Alten Reiches*. Wien: Rudolf M. Rohrer.
- Klebs, Luise (1915). *Die Reliefs des Alten Reiches*. Heidelberg: Carl Winters.
- Larsen, Hjalmar (1936). "On baking in Egypt during the Middle Kingdom." *Acta Archaeologica* (Copenhagen) 7: 51-57.
- Lauer, J.-P., V.L. Täckholm, and E. Åberg (1949-1950). "Les plantes découvertes dans les souterrains de l'enceinte du roi Zoser à Saqqarah (IIIe dynastie)." *Bulletin de l'Institut d'Egypte* 32: 121-157.
- LeClerc, J.A., L.H. Bailey, and H. L. Wessling (1918). "Milling and baking test of einkorn, emmer, spelt, and Polish wheat." *Journal of the American Society of Agronomy* 10 (1): 215-217.
- Leek, F. Filce (1972). "Teeth and bread in ancient Egypt." *JEA* 58: 126-132.
- Leek, F. Filce (1973). "Further studies concerning ancient Egyptian bread." *JEA* 59: 199-204.
- Montet, Pierre (1925). *Scènes de la vie privée dans les tombeaux égyptiens de l'ancien empire*. Strasbourg: Publications de la Faculté des lettres de l'Université de Strasbourg. Fascicule 24.
- Moussa, Ahmed M. and Hartwig Altenmüller (1977). *Das Grab des Niankhkhnum und Khnumhotep*. Mainz am Rhein: Philipp von Zabern.

Investigations into bread baking

- Newberry, Percy E. (1893). *Beni Hasan* Part I. Archaeological Survey of Egypt. London: Egypt Exploration Society.
- Nims, Charles F. (1958). "The bread and beer problems of the Moscow Mathematical Papyrus." *JEA* 44: 56–65.
- Owen, David E. (1970). *Special exhibition: Bread and teeth in ancient Egypt*. Unpublished guide to the special exhibition at Manchester Museum.
- Peet, T. Eric (1921). "Excavations at Tell el-Amarna: A preliminary report." *JEA* 7: 169–185.
- Peet, T. Eric (1923). *The Rhind Mathematical Papyrus*. London.
- Peet, T. Eric and W.L.S. Loat (1913). *The cemeteries of Abydos* Part III. London: The Egypt Exploration Fund, 35th Memoir.
- Ramenofsky, Ann F., Leon C. Standifer, Ann M. Whitmer, and Marie S. Standifer (1986). "A new technique for separating flotation samples." *American Antiquity* 51(1): 66–72.
- Reed, Charles, ed. (1977). *Origins of agriculture*. The Hague: Mouton Publishers.
- Renfrew, Jane (1985). "Preliminary report on the botanical remains." In *AR* II: 175–190.
- Rose, Pamela J. (1987). "Report on the 1986 Amarna pottery survey." In *AR* IV: 115–129.
- Schiemann, Elisabeth, (1954). "Einkorn im alten Aegypten?" *Der Züchter* 24(4/5): 139–149.
- Spalinger, A. (1986). "Baking during the reign of Seti I." *BIFAO* 86: 307–352.
- Storck, John, and Walter Dorwin Teague (1952). *Flour for man's bread: A history of milling*. Minneapolis: University of Minnesota Press.
- Täckholm, Vivi (1974). *Students' Flora of Egypt* 2nd ed. Cairo: Cairo University.
- Täckholm, Vivi, Gunnar Täckholm, and Mohammed Drar (1941). *Flora of Egypt*. Vol. 1. Cairo: Fouad I University, Bulletin of the Faculty of Science, 17.
- Wild, Henri (1975). "Backen." *Lexikon* I: 594–598.
- Winlock, Herbert E. (1955). *Models of daily life in ancient Egypt from the tomb of Meket-rê at Thebes*. Cambridge (Mass.): Harvard University Press.
- Wreszinski, W. (1926). "Bäckerei." *ZÄS* 61: 1–15.