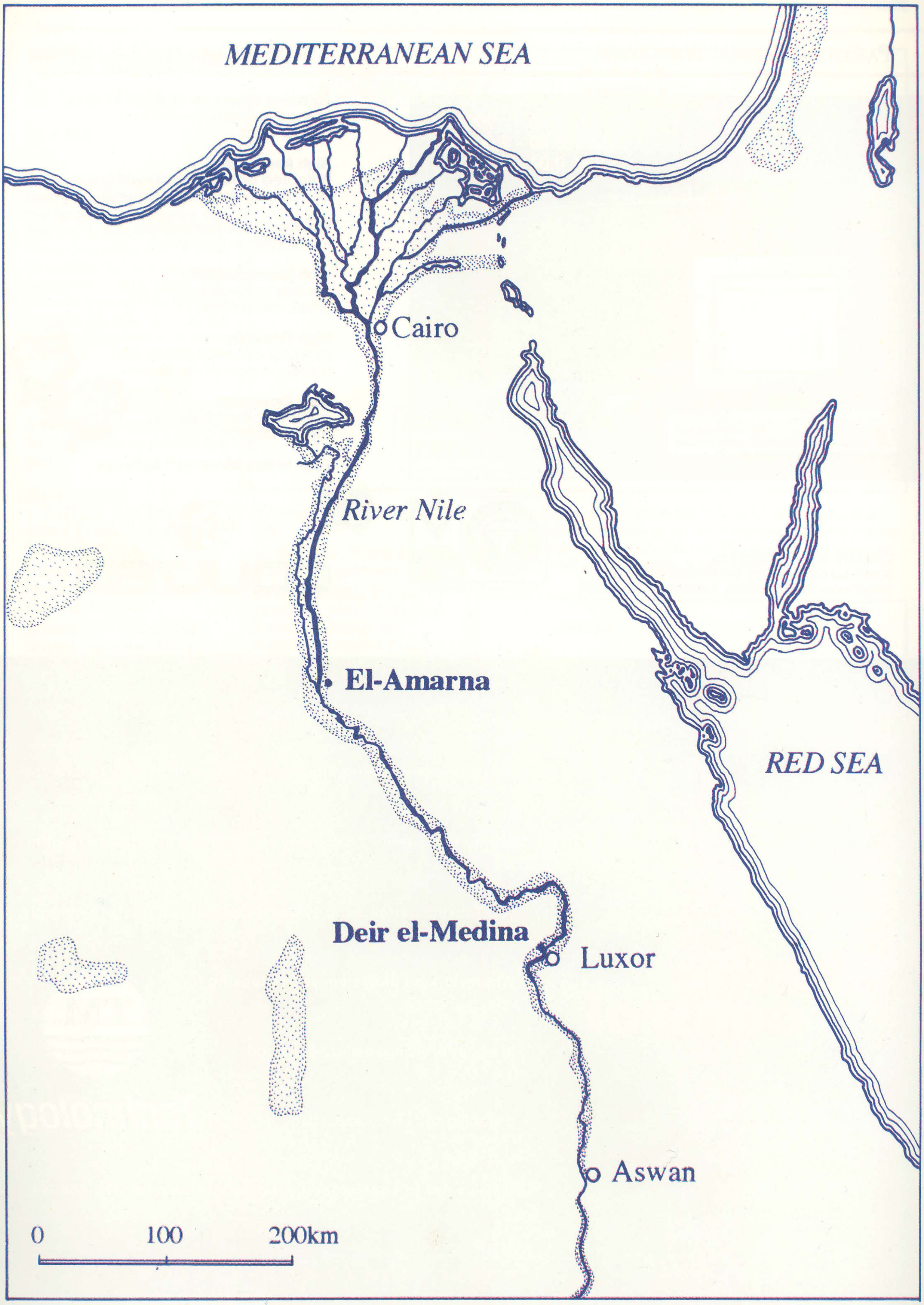
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Rediscovering ancient Egyptian beer

In 1990, the Egypt Exploration Society approached Scottish and Newcastle Breweries for help. The Society was looking for technical and financial support to launch an investigation into beer-making in ancient Egypt. This was the beginning of a partnership which, over the past five years, has considerably increased the understanding of the brewing process as it was at the time of Tutankhamun almost 3,500 years ago. In this exclusive article for Brewers' Guardian, Delwen Samuel and Peter Bolt of Scottish Courage Brewing Ltd describe the detection work involved in the project

ANCIENT Egyptian inscriptions and documents show that beer, together with bread, was a daily food. Beer gave nourishment to wealthy and poor alike, was an important offering to the gods, and was placed in tombs for the afterlife. It provided daily refreshment and special beers were made for state occasions and local festivals. It was probably the most reliable liquid to drink as well.

The traditional view of ancient beer

Until recently, most people have looked at ancient Egyptian beer using statuettes, models, reliefs and paintings, all from tombs. These were intended to recreate provisions for the afterlife and, as beer was so important, there are many brewing scenes. Although these representations seem very detailed, they are difficult to interpret. The actions are rarely explained and often appear to be out of sequence.

Broadly speaking, the established view of ancient Egyptian brewing, drawn from tomb scenes, is as follows. Beer loaves were made from a richly yeasted dough. Malt may or may not have been used. This dough was lightly baked and the resulting bread was crumbled and strained through a sieve with water. Ingredients like dates or extra yeast might have been added. The dissolved mixture was fermented in large vats and then the liquid was decanted into jars which were sealed for storage or transport.

This simple picture leaves many questions unanswered. Which of the two cereals of ancient Egypt, barley or emmer wheat, was used? Perhaps both were made into beer. Were dates a standard ingredient, as hops are today? Were other flavourings used, and if so, what were they? What distinguished the many types of beers named in the texts? How long did beer take to make, and how much labour was needed? Were there any by-products of brewing, and if so, what were they used for? The list could go on.

Looking for traces of ancient beer

For the joint Scottish and Newcastle Breweries/Egypt Exploration Society project, a new approach was needed. We turned to the archaeological record and we decided to focus on brewing practices during the time of Tutankhamun, a period called the New Kingdom (1550-1100 BC) *(figure 2)*.

The most important clues survive thanks to Egypt's extremely dry climate. Plant debris created from food preparation can be recovered right from the place

Continued overleaf

Figure 2. Uncovering archaeological evidence for brewing: three large clay cylindrical ovens in mud brick casings. Each division on the scale is 25 cm. These ovens line one wall of a chamber which is part of a temple kitchen complex at the site of Amarna. Burnt grain and chaff were recovered from the floors of similar chambers. This evidence, together with distinctive pottery vessels, suggests that beer and bread were made here

Figure 1 (left): Map of Egypt. Two sites which have provided important evidence for ancient Egyptian brewing practices are Amarna and Deir el-Medina. Both date to the period known as the New Kingdom which lasted from 1550 to 1070 BC. The stippling indicates the areas under cultivation at this period, along the Nile valley and in the western desert oases.

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where it fell, and separated from the surrounding dirt using a flotation machine. Plant remains and rare traces of prepared foods are well preserved in Egypt's arid deserts. The brewing project can therefore make a detailed study of actual ancient beer residues and of the by-products generated in beer production *(figure 3)*.

The flotation machine operates on the simple principle that light organic matter will float on the surface of water, while heavy silt, sand and gravel will sink. In this way, the plant remains scattered throughout the earth excavated from archaeological sites can be easily separated. A careful record of the location of each soil sample is made. This means that the ancient seeds, chaff and other pieces of plant can be related to the tools which had been used to process them. In addition, the rooms or work areas where food processing took place can be pinpointed *(figure 4)*.

Figure 4. Flotation retrieves ancient plant remains. A close-up view of the flotation machine, based on an oil drum. Soil from archaeological excavation is poured into the water. The heavy, inorganic portion sinks and the light plant material floats. It is guided over the weir, through the spout, and captured in the sieves. The sludge is drained away through a tap at the bottom of the machine. Desiccated olive leaves from Amarna's Christian Coptic levels (4th-6th century AD) are recovered in this sample

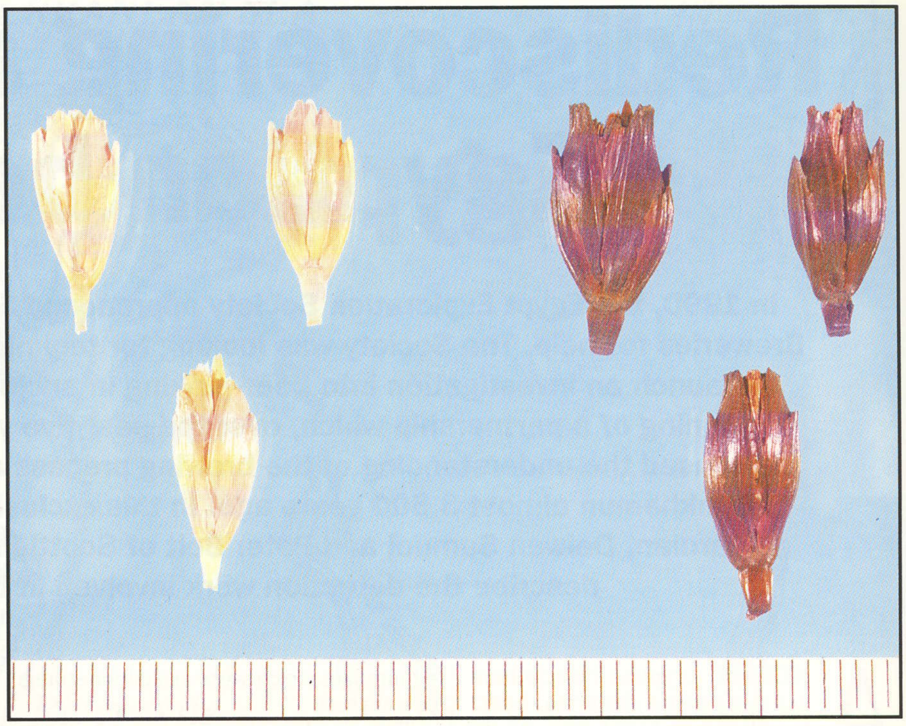

Figure 3. Emmer wheat, ancient and modern. On the left are modern emmer spikelets and on the right, desiccated ancient Egytptian emmer spikelets. Apart from the darkened colour of the ancient spikelets, the resemblance is striking, highlighting the excellent preservation of organic remains in Egypt's arid climate. Emmer is a type of archaic cereal known as hulled wheat, because when threshed, the ear breaks up into these spikelets. Further vigorous processing is needed to break open the tough chaff and release the grain inside. Although ancient Egyptian cereals look so similar to their modern counterparts, they are incapable of germination now. The aging process has damaged the proteins and destroyed enzyme activity.

There are two sources of food remains. One has already been mentioned: the offerings placed in tombs to provide the dead with food for the afterlife. Large quantities of foodstuffs have been recovered from a variety of such tombs. The second place to find food is in the debris of ancient settlements, produced and disposed of by the people who lived and ate there.

Residues from settlements are usually retrieved in very small amounts, often as thin crusts on broken pot sherds. Vast quantities of broken pots are excavated from archaeological sites. On a tiny proportion, the contents of their last use have happened to adhere and survive to the present day *(figure 5)*.

Not all residues are derived from brewing, so how is it possible to tell which came from ancient beer? There are two possible indications. Firstly, brewing would have involved the production of liquids and wet masses. A dark line on the interior wall of a vessel, for example, above a solid mass which has shrunk away into the base, shows that the original contents have reduced substantially due to evaporation.

More conclusively, shreds of bran or chaff are clues that cereal is an ingredient of the residues. It is reasonable to assume that most cereal-based residues which originally had a high water content were derived from brewing – beer was the prime cereal food along with bread.

What was used to brew?

Whole grain, chaff and bran shreds have answered the question of which cereals were used for brewing. Both barley and emmer wheat have been identified in the ancient beer remains. Usually, just one or the other cereal was used by itself, but sometimes both were mixed together. We can't say yet whether the Egyptians had a preference for emmer or barley. The choice of cereal might have depended on the type of beer they wanted to make.

Fermentation is obviously a key part of brewing. Fermentation micro-organisms are far too small to be detected with the naked eye or low power magnification. To find evidence for this crucial ingredient, the scanning electron microscope (SEM) has been used. This tool allows the study of greatly magnified views of surfaces. Large yeast colonies have been found in some residues. Clumps of bacteria have also been detected in some ancient dregs. These might well be lactic acid bacteria, but cannot be identified by morphology alone. Micro-organisms of any type have very rarely been detected in the archaeological record before.

A question which is still being explored is whether flavourings were added to beers. Many Egyptologists believe that dates were a basic ingredient. The main evidence for this is the translation of a particular word, pronounced 'benner'. It is frequently associated with beer in documentary and artistic sources. It has usually been interpreted as 'dates', but another valid possibility is 'sweet thing'. This could include various commodities – including malt.

So far, no evidence of dates in ancient residues has been recovered, either from tissue shreds or from microscopic inclusions. Date fruits may have been an ingredient in some types of beer, but there is no good evidence to show that they were a standard ingredient. Other fruits and spices may well have been added at least sometimes. Further work is needed before the true extent of 'flavoured' beers can be properly assessed.

Searching for the brewing process

From the identification of plant fragments in ancient dregs, we are well on the way to knowing much more about ingredients. But we also want to know how those ingredients were used. To answer that more difficult question, the microscopic structure of the beer remains had to be studied. Here again, the scanning electron microscope has played an important role. It is possible to see that the sub-cellular structure is as well preserved by desiccation as the larger fragments of cereal. The processing information which we sought is preserved in the microstructure of starch granules.

The modern food industry has established that the structure of starch granules changes according to processing methods. For example, enzymes become active inside the grain when it germinates. These create pits and channels on large granules. Eventually, only hollow shells are left. When starch is heated in water, the granules swell, deform and – if enough water is present – eventually merge completely into one another. Changes such as these are easily spotted with the SEM. Analytical work on modern foods is directly relevant to the study of ancient beer, because such changes have been observed in the residues. The ancient starch preserves an invaluable record of past processing treatments *(see figure 6)*.

There are a number of problems though. Since the ancient residues are more than 3,000 years old, it is not surprising that they are often in less than perfect condition. Sometimes moulds have invaded, but only to a limited extent. It is not possible to know whether differences in residues are due to different stages in the brewing sequence or because they come from different types of beer. This makes individual residues difficult to compare. Finally, it can be a challenge to detect the several different stages of pro-

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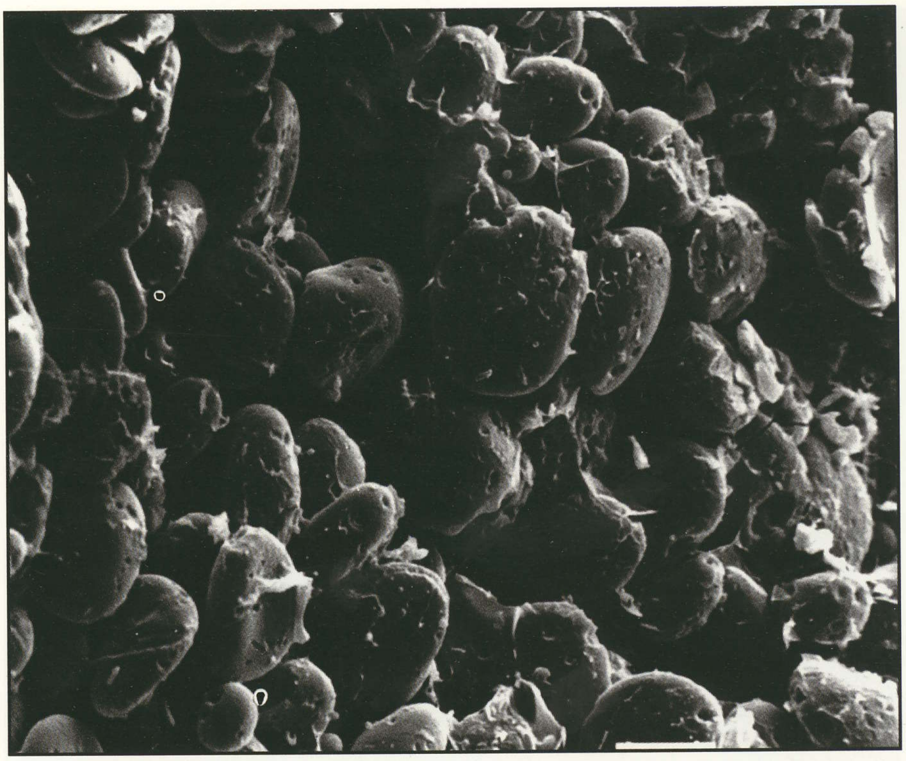

Figure 6. Microscopy evidence for ancient malting. These 3,000-year-old starch granules from residue similar to that shown in Figure 5 are heavily pitted. Precisely the same pattern of starch granule pitting is seen on modern starch granules which come from malted grain. Enzymes break down the starch in this characteristic way. The scale at lower right is 10 micron

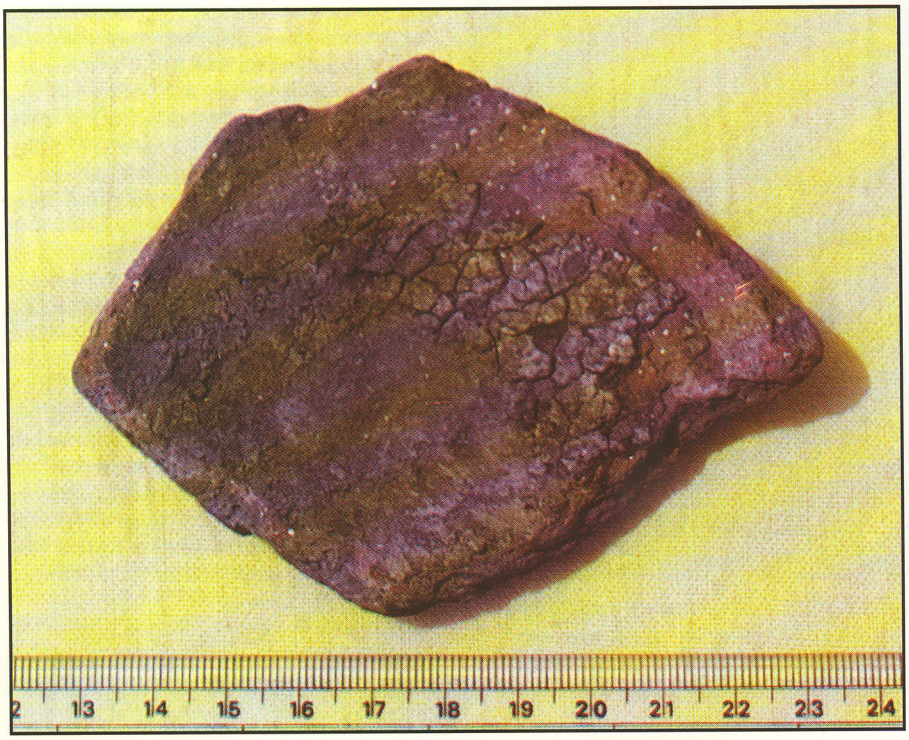

Figure 5. Ancient beer residue from Amarna. This pot sherd was discarded in an ancient Egyptian rubbish dump, probably because the vessel broke and was no longer usable. It has a thick crust of dried residue adhering from its last use. On close examination, tiny shreds of chaff and bran were visible, indicating the original contents had been made of cereals. Very small samples of this kind of food residue can give detailed information when analysed with the microscope.

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cessing which each residue passed through. If grain was treated differently, and then mixed together, the evidence becomes highly complicated.

To overcome these difficulties in interpretation, each individual residue is examined as thoroughly as possible. All available information is compared, such as amounts of chaff or vessel type. Major advances have been made in the understanding of ancient Egyptian brewing by careful study of starch microstructure, comparison to SEM studies from the modern food industries, and analysis of all the relevant archaeological data.

Ancient Egyptian malting

Some Egyptologists have proposed that a particular word in the ancient Egyptian lexicon, pronounced 'beshaw', means malt. The evidence of pits and channels on starch granules in the ancient residues, together with rare finds of sprouted grain, shows that malting was indeed a basic part of the ancient Egyptian brewing procedure. It is possible to draw conclusions well beyond this simple statement, however.

Figure 7 - Process conditions used in a micro malting trial of emmer wheat.

Steep cycle
16 hours wet at 18° C
25 hours dry at 16°C
3 hours wet at 14°C

Germination temperature
12-13°C

Total wet process time
140 hours

Kiln
Isothermal at 70°C for 16 hours

Figure 8: Analytical results of the micro malted emmer wheat, compared to the modern industry standard white barley malt

Parameter	Emmer wheat	White Malt
Moisture	4.4	4.0
IOB Fine Extract (l/kg, dry base)	285	311
IOB Fine Extract (l/kg as is)	272	298
Wort pH	5.9	5.80
Soluble nitrogen (% IOB fine extract)	0.50	0.65
Malt total nitrogen (% dry base)	2.45	1.65
Free amino nitrogen (mg/l fine extract)	91	130
IOB wort viscosity (fine extract, cP)	1.54	1.50
Diastatic power (IOB)	9.3	80
Alpha amylase DU	10	50

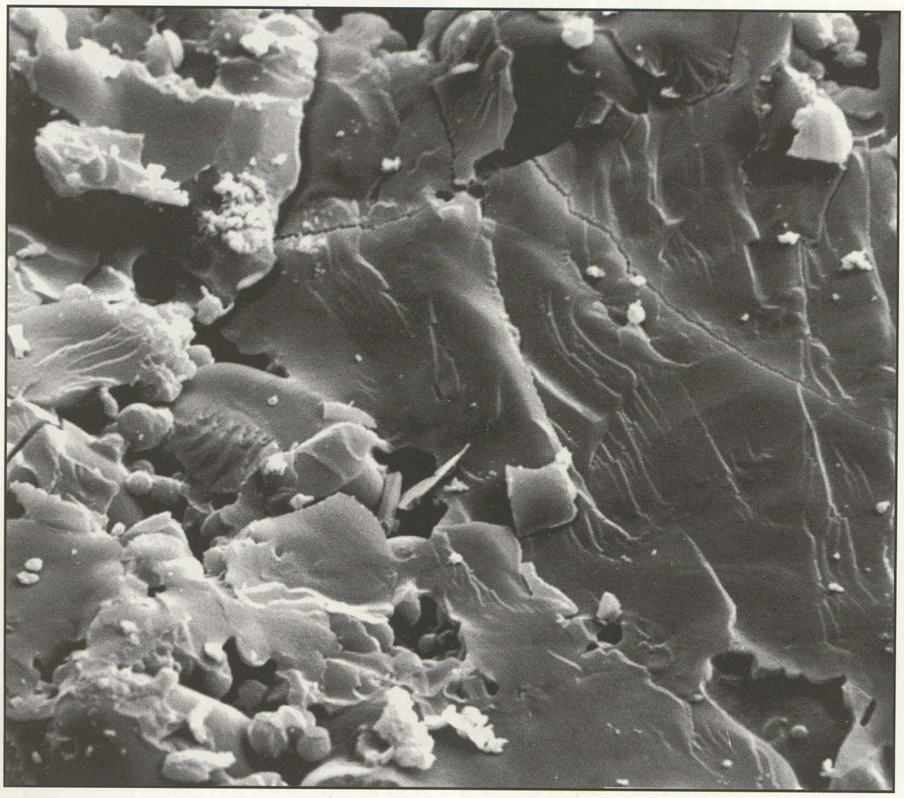

Figure 9. Microscopy evidence for ancient cereal cooking. This ancient starch comes from residue on another ancient Egyptian pottery vessel. A few individual starch granules are visible in the lower left corner, but most granules have fused together into a solid glassy-looking block. This appearance is typical of starch which has been heated in water. The scale at lower right is 10 microns.

Only viable, uncooked grain will sprout, so malting must have been an early step. Since there is a high risk of damaging barley in the course of removing or shredding the tightly fused chaff, it must have been germinated in the husk.

Emmer wheat, too, must have been sprouted in the husk. Unlike free-threshing wheats used virtually exclusively in modern times, the chaff of emmer wheat is very difficult to break up, and needs vigorous processing, an activity likely to damage the embryo.

Would emmer wheat have made good malt by today's standard? To determine this, Phillip Morrall at Moray Firth Maltings carried out a micro malting trial of some modern emmer wheat, kindly grown and made available by the National Institute of Agricultural Botany in Cambridge. *Figure 7* shows the process conditions used which are a typical modern malting cycle. His test showed that the average moisture content of the grain during germination was 48%, a level surprisingly similar to modern barley malting. Even the grains encased in their thick husks germinated well. After 24 hours germination, the malt had a slight lactic taste, which is a characteristic often associated with wheat malts.

Figure 8 compares the analytical results of the emmer wheat malting trial with a typical modern white malt. The extract on the emmer is surprisingly high considering that about 50% of the corns were sheathed in ear material. The total nitrogen content of the emmer wheat malt is considerably higher than malted modern wheat or barley varieties. The free amino nitrogen level indicates lower levels of proteases in wheat. The generally lower level of enzymes is shown in the low diastatic power and alpha amylase activity.

Different brewing methods

Many ancient Egyptian residues contain heavily channelled starch granules, indicating extensive enzyme attack during germination, together with pristine-looking starch. This suggests that ancient Egyptian beer may have been made with both malt and unsprouted grain. Many of these residues also contain a solid, glassy-looking matrix. This matches with the appearance of grain or grist which has been moistened and heated. The presence of fused starch with completely unaltered starch in the same residue also suggests that grain was treated in different ways before being mixed together for beer *(figure 9)*.

Such a two part system would be a good way to brew if processes such as temperature cannot be closely regulated. This could be similar to the traditional decoction mashing process which probably developed as a way of achieving consistent temperatures without the aid of accurate thermometers. The malted grain would have contained active enzyme capable of breaking down starch into fermentable sugars.

Unlike the conventional view of ancient Egyptian brewing, bread plays no role at all in such a sequence.

There is enough evidence to indicate that the ancient Egyptians used a variety of techniques to kiln their germinated grain and to process unsprouted grain destined for brewing. Samples examined to date range from air dried through to heavily roasted material. The roasted, malted grain would have provided a pleasant flavour. Although this greatly complicates the task of interpretation, it would certainly create beers of different character. This might account for many of the named types of ancient Egyptian beer.

Recreating the ancient recipe

Now that we have come this far, the most intriguing question of all is: what did ancient Egyptian beer taste like? The combination of archaeological evidence and modern brewing expertise makes it possible to attempt an answer. The evidence which has been obtained, especially from the residues, but from all archaeological data, leads to the method outlined in Figure 10 to recreate the taste of New Kingdom ancient Egyptian beer.

The need for modern standards of hygiene precludes the use of ceramic vessels, papyrus sieves and large numbers of workers to prepare the beer. Instead, we will modify the recipe to make use of the modern brewing facilities available at Scottish Courage's pilot brewery in Edinburgh.

Undoubtedly, the character of these beers would have been strongly influenced by the addition of fruit or spices as flavouring. There is evidence of ingredients other than cereals in some of the residues and although they have not been definitely identified yet, this evidence gives some clues to the flavourings that were used. Our interpretation of these will be incorporated in the modern brewing trials.

The opportunity to brew ancient Egyptian beer using authentic ingredients and modern equipment provides the next exciting challenge.

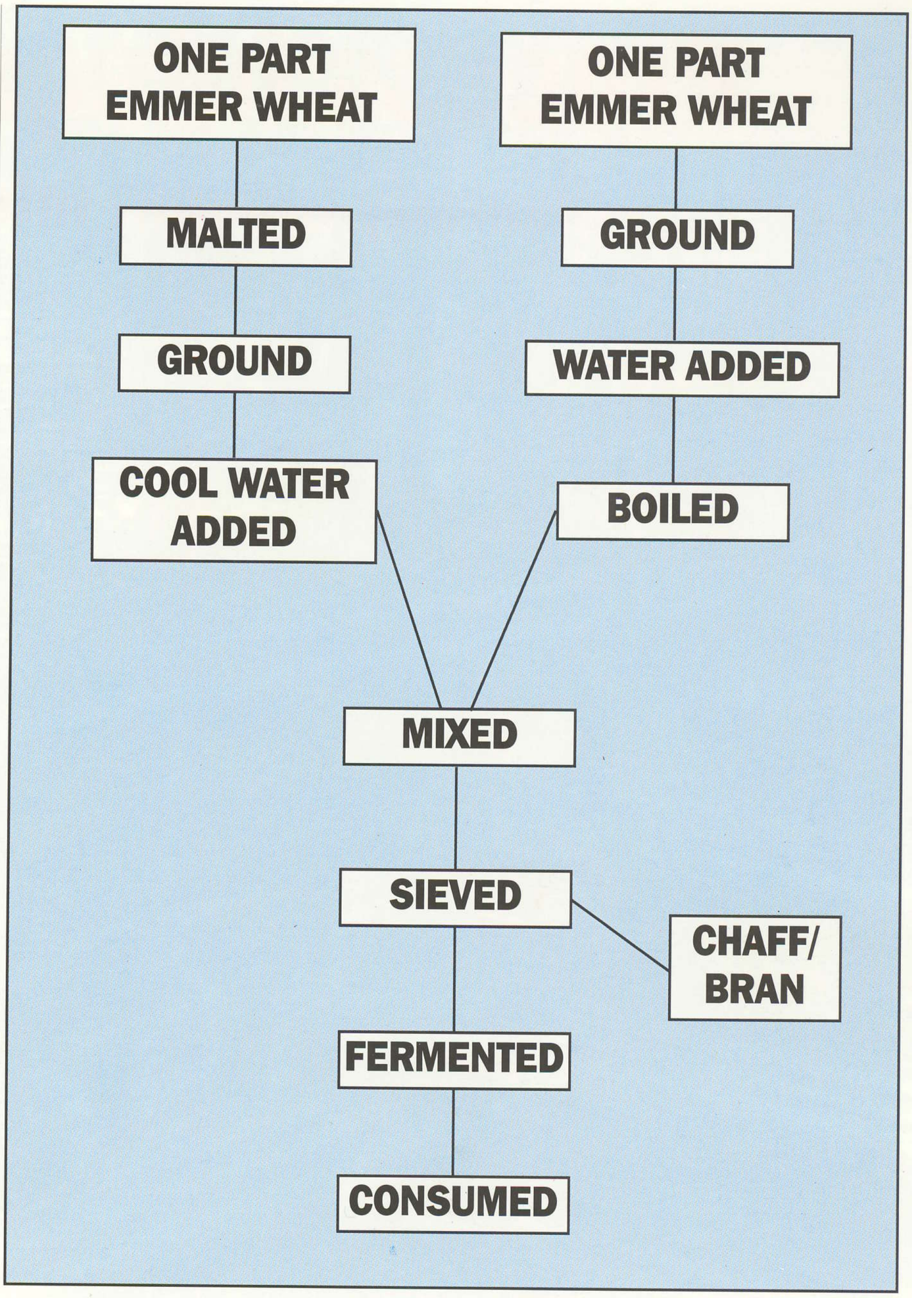

Figure 10: Schematic diagram showing a suggested reconstruction of ancient Egyptian beer brewing

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