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Charred Grain Assemblages from Roman-Period Corn Driers in Britain

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This paper presents a review of the botanical evidence for the function of so-called 'corn-driers' from Roman-period Britain. The charred grain assemblages associated with corn-driers from twenty-one sites have been analysed. The results indicate that these kilns should be regarded as multi-functional structures; both the roasting of germinated grains for the production of malt and the parching/drying of grain in preparation for consumption and storage are functions implied by the botanical evidence. The need for further experimental research is identified.

INTRODUCTION

Corn-driers have been described as the most easily identifiable agricultural structures found in Roman Britain (Morris 1979). Over one hundred examples have been found to date. They all contain a stoking area, flues, and a drying floor. Several types have been distinguished, but structures with a T-shaped flue design appear the most common (Morris 1979). While there is a small number of kilns dated to the first century, and a few more to the second century, the vast majority belong to the third and fourth centuries. Their distribution is restricted to southern and eastern areas of Britain, with a cluster in Humberside forming the northernmost record (Morris 1979). It is difficult to see this distribution as being entirely caused by a bias in recovery as these structures are so easily recognizable, but the different amounts of archaeological work carried out in the south compared to the north may well have influenced the picture to a certain extent.

The presence of charred grain in the flue and stoke-hole areas of these structures probably gave rise to their interpretation as corn-driers (Cocks 1921–22; Goodchild 1943), and this interpretation remained more or less generally accepted until an article by Reynolds and Langley in this Journal in 1979 and a later article by Reynolds in 1981. In these two papers the results of a series of experiments with two reconstructed corn-driers carried out at Butser Ancient Farm were presented. The excavated remains of a rectangular corn-drier from Foxholes Farm, Hertford (Partridge 1976), and the T-shaped corn-drier from Barton Court Farm, Oxfordshire (Miles 1986), formed the models for the reconstructions. The experiments were designed to test the validity of the interpretation of these structures as corn-driers. The conclusion reached was that 'unless the grain is spread so thinly on the floor as to be uneconomic of time and effort, the mechanics of these structures with their solid floors are such that they cannot be considered to be effective for the purpose assigned to them' (Reynolds 1981, 43).

Instead, an alternative function was put forward, suggesting that these structures were used as malting floors. Again experiments were carried out and the resultant malt was found to be quite suitable for the manufacture of ale (Reynolds and Langley 1979; Reynolds 1981). The suggestion that these kilns were used as malting floors concurred with the find of germinated spelt grain at the corn-driers at Catsgore, Somerset (Hillman 1982), and Barton Court Farm, Oxfordshire (M. Jones 1986).

During the last ten years many new samples of carbonized grain found associated with corn-driers have been analysed and evidence is now available from twenty-one different sites. The composition of these samples has provided further information regarding the function of these structures. Most of the information is awaiting publication. This article presents a review of this new evidence.

FUNCTIONS

The exact make-up of the assemblage of charred plant remains found in a corn-drier will vary according to the purpose for which the kiln was used. A detailed list of possible functions based on Morris (1979), Monk (1981), and Hillman (1982), is given here, followed by a description of the type of assemblage such an activity would produce:

1. The drying of whole ears, or even sheaves, especially after a wet summer. It has often been suggested that this practice was necessary in northern and western parts of the country because of the wetter climate and shorter growing season in these areas, and a number of historical references mention this practice.
2. The drying of whole ears of spelt wheat for 'greencorn'. In southern Germany spelt is harvested at the milk-ripe stage and dried or smoked prior to threshing and further processing. The grain is used whole in soups or ground into flour (Körber-Grohne 1987).
3. The parching of fully ripe spikelets of glume wheats (both emmer and spelt) in order to render the glumes brittle and facilitate their removal by pounding and subsequent winnowing. This could also have been applied to free-threshing cereals such as hulled barley or oat, to facilitate the removal of the lemmas, although in the case of barley the grain is usually dried rather than parched prior to dehusking. Once the barley grains are dry, a little moisture is applied to the grains, which are then pounded or milled to remove the hulls (Hillman pers. comm.).
4. The drying of fully processed grain prior to bulk storage, in order to dry the grain sufficiently to prevent spoilage (germination or insect attack), to stop further spoilage of a crop in which some of the grain has started to germinate (e.g. after a wet harvest), or to kill any insects already present. Storage of grain sealed in underground pits does not require the drying of the grain, as the accumulation of carbon dioxide given off by initial germination halts further germination and kills the insects (Reynolds 1974). With storage in large granaries above ground the unwanted germination of the grain and infestation by insects or fungal disease can be prevented by reducing the moisture content to *c.* 11 per cent and the temperature to below 15°C (Gentry 1976; Morris 1979).
5. The drying of fully processed grain to harden it prior to milling. Soft grain can clog up the querns.

6. The roasting of germinated grain to stop the germination process, a method used in the brewing of beer. Malt is produced in the following manner: the grain is steeped in water and then turned out on a floor in a heap or 'couch'. The grain germinates — a process known as 'chitting'. When the modification of the endosperm is sufficient (roughly when the length of the sprouts ('coleoptiles') has reached the length of the grain) the germination process is stopped by putting the grain (now known as 'green malt') into a kiln and roasting it ('curing') with hot air. This produces the malt which forms the main raw material in the manufacture of beer (Brown 1983; Corran 1975).

The processing of cereal crops after the harvest follows a series of well defined stages during which the product (the prime grain) and the various by-products (straw, chaff, and weed seeds) are separated from one another. Carbonized remains of these products and by-products can be recognized as such by their specific composition. These different stages of crop processing and the plant assemblages that they produce, have been described in detail by Hillman (1981). In the description below of the plant assemblages expected to be associated with the different functions of the corn-driers, spelt wheat and barley have been taken as examples. The assemblages are described using Hillman's stages of crop processing.

The drying of whole ears (functions 1 and 2) would, in the case of an accidental fire, produce an assemblage of charred plant remains consisting, in the case of spelt wheat, of approximately equal quantities of spelt grains and glume bases, half as many rachis internodes, straw fragments, and large amounts of weed seeds (Hillman's stage 2), and, in the case of six-row barley, of a ratio of three grains for each internode, straw fragments and weed seeds. The grains would be immature and probably distorted by charring due to their high moisture content at the moment charring took place.

The parching of fully ripe spikelets of spelt (function 3) would also produce assemblages with approximately equal quantities of grain and glume bases (Hillman's stage 8), but the larger straw nodes and weed heads would have been removed during coarse sieving prior to drying. The grains would be mature and well formed. The drying of fully ripe grains of barley would produce assemblages with barley grains, weed seeds of similar size to the grains and the occasional internode (Hillman's stage 8).

The drying of fully processed spelt grain prior to bulk storage or milling (functions 4 and 5) would produce similar assemblages either of naked spelt grains and only small amounts of glume bases and weed seeds of the same size as the grain (the product of Hillman's stage 12), or of naked grains free of all chaff and weed seeds (the product of Hillman's stage 14). If the grain was dried to halt further spoilage of a crop some germinated grains would be expected. It is difficult to give an exact figure for the percentage of germinated grains in such a case, as no research has been done on this aspect. Here a rather arbitrary figure of less than 15 per cent has been chosen, in the assumption that crops which were spoiled for more than 15 per cent would be consumed straight away, rather than dried for storage. While bulk storage of grain can be in fully processed state, in regions with wet summers the grain is often stored as semi-cleaned spikelets (after Hillman's stage 7) rather than as clean grain, as the presence of the glumes helps prevent spoilage of the grain (Hillman 1981). In this case the assemblage of function 4 would be indistinguishable from that of function 3. In the case of barley the assemblages from fuctions 3 and 4 would be indistinguishable, as

barley stored for fodder would not be dehusked. In fact, hulled barley rather than dehusked barley might have been used for function 5 as well.

The assemblage produced by the roasting of germinated grain (function 6) would consist almost entirely of grains which had germinated prior to charring and large numbers of detached sprouts or coleoptiles. Glume bases and large weed seeds could be present as well if the grain was allowed to germinate in spikelet form. The grains would be mature and well developed, but have a wasted base and concave faces due to germination. The percentage of germinated grains is expected to be more than 75 per cent.

Thus, while the assemblage of function 6 is easily distinguishable from the assemblages of functions 1 to 5, the different drying functions produce more similar assemblages, although functions 1 and 2 should be distinguishable from functions 3, 4, and 5. Functions 4 and 5 will produce assemblages different from function 3 if fully processed grain was used. It may however, be difficult to interpret assemblages in which the percentage of germinated grains is greater than 15 per cent, but less than 75 per cent. In these cases material from function 4 or 6 may have become mixed with other grain. In the case of barley functions 3, 4, and 5 are not distinguishable.

Before looking at the archaeobotanical evidence, it is important to point out two factors which may distort the pattern. First of all, there is documentary evidence that the favourite fuel for all forms of grain parching, and especially malting, was a mixture of straw and chaff together with some wood and/or peat (Hillman 1982). Glume bases of wheat, rachis internodes, awns, straw nodes, and weed seeds are therefore likely to be present in the ashes of the stoke-pit and could have become mixed with the charred grains from the drying floor, thereby complicating the picture. The mixing could have occurred when grain which had trickled down through the floor of the drying chamber (for a discussion of floor construction, see below) was raked out of the flues towards the stoke-pit, or when some of the chaff in the stoke-pit was carried by the draught into the flues underneath the drying floors. In cases where glume bases used as fuel have become mixed with material from the drying floor, it may be impossible to distinguish between functions 3, 4, and 5.

Secondly, charring experiments on grains, chaff, and straw elements of different cereal species have demonstrated that some components (and, to a lesser extent, some species) were more readily carbonized or destroyed than others (Boardman and Jones 1990). Under some conditions the glumes of spelt wheat could burn away before the grain was destroyed. Consequently, the absence of glume bases when grains survive cannot necessarily be taken to reflect the original assemblage. On the other hand, a predominance of glume bases cannot be the result of differential survival, as grain always survives charring as well as, or better than, glumes (Boardman and Jones 1990). The overall preservation and degree of distortion of the cereal grains may offer some means of assessing the likelihood of chaff absence due to differential preservation. Equally, the presence of silicified chaff fragments such as awns and glume tips, can provide information regarding biases in the charred seed assemblage due to differential combustion (Robinson and Straker in press). Despite the fact that both these factors can make the interpretation of the plant assemblages more difficult, the composition of the samples can still be used to limit the range of possibilities. Both factors relate specifically to the distinction between functions 3, 4, and 5.

BOTANICAL EVIDENCE

In the last ten years many new samples of carbonized grain found associated with corn-driers have been analysed and botanical evidence is now available from twenty-one different sites. The composition of these samples has provided some further evidence for the function of these structures. It is important to realize, however, that while these samples each may consist of the rake-outs or cleanings of one or more firings, they are likely to represent only the last usage of the oven, which may not have been typical of the use of the structure throughout its life-span. The botanical evidence available to date has been summarized below and in Tables 1 and 2.

At the excavations at the Old Gaol in **Abingdon**, Oxfordshire, one very small sample from a corn-drier was collected. It contained only sixteen cereal grains (mainly wheat) and fifty weed seeds (M. Jones 1975). The sample is too small to allow a reliable interpretation, but the weed seeds may represent the use of fine-sieving residues as fuel.

From the Roman villa at **Bancroft**, Milton Keynes, Buckinghamshire, a single sample was examined from a late first/early second century corn-drier (Pearson pers. comm.). The sample consisted of a very large number of spelt glume bases, smaller amounts of rachis internodes (some belonging to a free threshing hexaploid wheat), relatively few wheat grains and some weed seeds, as well as detached coleoptiles. The ratio of glume bases to wheat grains is 50:1. While the percentage of germinated grains is only *c.* 20 per cent, the number of detached coleoptiles is twice as high as the total number of grains with a ratio of 247:103. The assemblage is interpreted as evidence for function 6: the roasting of germinated grains for malting. The remains consist of the waste products of this process (detached coleoptiles removed from the roasted grains are re-used as fuel and mixed with glume bases used as fuel), rather than the remains of the accidentally burnt product (sprouted grains), hence the low percentage of sprouted grains (Pearson and Robinson pers. comm.).

At **Barton Court Farm**, Abingdon, Oxfordshire, seven samples from two T-shaped corn-driers were analysed. The composition of the plant assemblages was found to vary substantially (M. Jones 1986). The two samples from corn-drier 732 contained fewer glume bases that spelt grains (ratios of *c.* 0.7:1). The very high numbers of weed seeds in the sample near the ash-pit suggests the use of fine-sieving residues (weeds and glume bases) as fuel. The samples either represent a mixture of fully processed grain from the drying chamber with glume bases and weed seeds used as fuel, or spelt spikelets from the drying chamber mixed with weed seeds from the stoke-pit. The relatively high numbers of barley grains (30 to 45 per cent of the total number of cereal grains) suggests that the oven was used to process both barley and wheat, probably on separate occasions. In the five samples from corn-drier 849 the ratios of spelt glumes to grains varied from 0.2:1 and 0.6:1 to 1.5:1 and 2.3:1. It is possible that these glumes and grains originally belonged to the same spikelets but had become separated. It is also possible that the grain had become mixed with various amounts of the remains of the fuel. The ratio of weed seeds to cereal grain was considerably lower than in the samples from corn-drier 732. The samples also contain barley grains (20 to 35 per cent of the total number of cereals). These probably represent the remains of a previous crop being processed. The samples from both corn-driers contained a small number of germinated grains (less than 10 per cent), but as up to 60 per cent of the cereal grains were so badly preserved that the presence or absence of germination could no longer be established, this figure could be higher (M. Jones, pers. comm.). As the percentage of germinated grains is crucial in distinguishing between functions 4 and 6, it is not possible to establish the function of these two corn-driers. The presence of some germinated grains did, however, encourage Reynolds to test the hypothesis that these structures may have been used as malting floors (Reynolds and Langley 1979). The relative proportions of wheat and barley in the samples suggest the presence of residues of more than one usage.

At **Catsgore**, Somerset, nine out of the ten samples from five corn-driers contained spelt grains, almost all of which had germinated, and large numbers of detached coleoptiles, which were interpreted as representing the production of malt (function 6) (Hillman 1982). Seven out of these nine samples also contained spelt glume bases, large numbers of awn fragments, some weed seeds, and small quantities of wood charcoal. These were interpreted as the remains of fuel which had become mixed with the grains when the oven was cleaned out. The tenth sample contained a large amount of wood charcoal, spelt chaff, and only a small number of grains, none of which had germinated. This sample was interpreted as spikelets which were being parched prior to pounding (function 3) mixed with chaff used as fuel, or clean grain which needed further drying prior to storage (function 4) mixed with chaff used as fuel (Hillman 1982).

Six samples were analysed from five corn-driers at **Cawkwell**, Lincolnshire, all dated to the late second to late third century. All were 'cigar-shaped', without evidence for any super-structure (Carruthers 1989). One corn-drier (C) contained fully processed barley, three contained a mixture of barley and wheat (A, D, and E), while one contained mainly spelt glume bases (B). As the grains in corn-driers A, D, and E were badly preserved the exact proportions of barley and wheat are difficult to calculate, but in corn-driers A and E there was more barley than wheat, while in corn-drier D there was more wheat than barley. All three corn-driers appear to contain mixtures of residues of more than one usage. The poor state of preservation of the grain may point to the absence of glume bases due to differential preservation. There was no evidence for deliberate germination of the grain. The assemblages from corn-driers A, C, D, and E point to functions 3, 4, or 5, while the assemblage from corn-drier B only provides evidence for the use of spelt chaff as fuel (Carruthers 1989).

Two very small samples from a T-shaped corn-drier in the Roman Villa at **Chew Park**, Chew Valley Lake, Somerset, contained 14 grains of wheat, some possibly spelt, and three grains of barley (Helbaek 1977). The assemblage is too small to allow an interpretation.

Three samples from a late Roman corn-drier (F12) at site K, Culver Street, **Colchester**, Essex, contained very small quantities of free-threshing grains (bread/club wheat, barley, rye, oats), in addition to one seed of horse bean, and a few weed seeds (Murphy 1985). The samples from the stoke-pit and flue contained very little material (twenty-six and nineteen seeds respectively); the sample from the interior contained 124 seeds. This sample may represent the drying of fully processed grain (functions 3, 4, or 5). However, the fill also produced Late Saxon pottery and it is conceivable that the structure was re-used at this time. Also at Culver Street, Site J, a small pile of charred grain was found in the corner of a room, consisting of germinated grains of spelt wheat and/or emmer and some barley (nine per cent). Almost all the grains had germinated with sprouts extending for about half to two-thirds of the grain length. The sample was interpreted as a deposit of malt, stored ready for brewing, which was charred during the Boudiccan sack of the town (Murphy 1985).

Four samples were analysed from a late 3rd/early 4th century T-shaped corn-drier at the Roman villa site at **Dan-y-Graig**, Glamorgan (Caseldine 1989). One sample (078) came from the flue of the kiln, the remaining three (071/072, 042/1, 042/2) came from an associated 'void' (pit?). Sample 078 consisted largely of cleaned spelt grain, with smaller quantities of barley grains and some emmer, representing the product of Hillman's stage 12. The samples from the 'void' all consisted of fine sieving residues (the cleanings of Hillman's stage 12), of glume bases and weed seeds. The grain from sample 078 is mature with little evidence of germination. The samples from the 'void' contained small numbers of sprouted grains and detached coleoptiles. Due to the poor preservation of the grains in these samples, the exact percentage of germinated grains cannot be calculated. The composition of sample 078 points to function 4, or 5, though function 3 cannot be ruled out due to the possibility of differential preservation of the spelt chaff. While the samples from the 'void' mainly represent evidence for the use of spelt chaff as fuel, they also contain some tentative evidence for function 6 (Caseldine 1989).

Nine samples were collected from a possible corn-drier at **Dorchester**, County Hall excavations, Dorset (Ede forthcoming). The interpretation of this oval shaped feature as a corn-drier was based on the similarity of its appearance to the post-Roman corn-driers at Poundbury (Monk 1987b). However, the sides and bottom of the feature did not show signs of burning, and the stones found inside the feature were also not burnt (Ede forthcoming). Of the nine samples, four contained very few plant remains. The remaining five samples contained clean grain, virtually no chaff and few weed seeds, with the exception of sample 5350 which contained more weeds than grains. In all samples barley was the dominant crop, but emmer/spelt and bread wheat were also present, varying from 2 to 40 per cent, indicating that the samples consist of a mixture of more than one drying event. There was no evidence of sprouted grain. The samples suggest that the feature (if it was a corn-drier) was used for functions 3, 4, or 5.

Table 1: Summary of the Data

Name	*Site*	*Date*	*Crop*	*% Germinated*	*No. of Ident.**	*Use of Chaff Charred*	*Silicified*	*Reference*
Abingdon	n.r.	n.r.	wheat/barley	—	76	—	—	Jones M. 1975
Bancroft villa	Roman villa	1/2C	spelt	20%	5000+	fuel	—	Pearson pers. comm.
Barton Court Farm	R/B set.	4C	spelt/barley	<10%	5000+	?fuel	—	Jones M. 1986
Catsgore	R/B set.	4C	spelt	95%	6000+	fuel	—	Hillman 1982
Cawkwell	R/B set.	2/3C	barley/spelt	<1%	10,000+	?fuel	—	Carruthers 1989
Chew Park	Roman villa	4C	wheat/barley	—	17	—	—	Helbaek 1977
Colchester	Roman town	4C**	bread wheat/ barley/rye	—	169	—	—	Murphy 1985
Dan-y-Graig	Roman villa	3/4C	spelt	—	5000+	fuel	fuel	Caseldine 1989
Dorchester	R/B set.	3/4C	barley/wheat	—	4000	—	—	Ede forthcoming
Farmoor	R/B set.	3/4C	spelt	—	445	fuel	—	Jones M. 1979
Fengate Farm	R/B set.	4C	spelt	n.r.	1341	—	—	Murphy 1984
Foxholes Farm	R/B set.	3/4C	emmer/spelt	—	211	—	—	Monk 1982
			barley	—	850	—	—	
Hibaldstow	R/B set.	4C	spelt	90%	5000	—	—	Straker 1978
Leicester	Roman villa	n.r.	spelt	n.r.	246	fuel	fuel	Jones G. 1982
Mucking	R/B set.	3C	spelt	95%	3000+	—	—	Van der Veen 1988a
Poxwell	R/B kiln	n.r.	spelt	7%	624	—	—	Jones G. 1983
Tiddington	R/B set.	2–4C	spelt	<30%	37,000	fuel	—	Moffett 1986
Upton St Leonards	R/B set.	3/4C	spelt/bread wheat	—	n.r.	—	—	Clark 1971
Wasperton	R/B set.	4C	spelt	n.r.	n.r.	fuel	—	Bowker 1987
		***	barley	—	n.r.	—		
Welton Wold	R/B set.	1–5C	spelt/barley	2%	6000+	fuel	fuel	Straker 1986
Wendens Ambo	R/B set.	2/3C	spelt/bread wheat	—	2329	—	—	Jones G. *et al.* 1982

Key: n.r. = not recorded.
* = charred awn and lemma fragments and all silicified chaff excluded.
** = the structure was a typical late Roman type, but its fill included Late Saxon pottery, possibly indicating re-use at this time.
*** = the pottery could range in date between the second and fourth centuries, but the latter date would be preferred by the archaeologist.

Site	*Context*	*Crop: Spelt Function*	*Barley Function*	*Spelt/Barley Function*	*Free-threshing Cereals Function*	*Reference*
Abingdon	39/42	—	—	—	—	Jones M. 1975
Bancroft villa	343/2(3)	6	—	—	—	Pearson pers. comm.
Barton Court Farm	732, 849	—	—	3, 4, 5, or 6	—	Jones M. 1986
Catsgore	316, F674 F444, F278 }	6	—	—	—	Hillman 1982
	F424	3, 4, or 5	—	—	—	
Cawkwell	A, D, E	—	—	3, 4, or 5	—	Carruthers 1989
	C	—	3, 4, or 5	—	—	
	B	—	—	—	—	
Chew Park	n.r.	—	—	—	—	Helbaek 1977
Colchester	F12	—	—	—	3, 4, or 5	Murphy 1985
Dan-y-Graig	078	4, 5, (or 3?)	—	—	—	Caseldine 1989
	071/72, 042	6?	—	—	—	
Dorchester	F116	—	—	3, 4, or 5*	—	Ede forthcoming
Farmoor	L1002/2	—	—	—	—	Jones M. 1979
Fengate Farm	341	3, 4, 5, or 6	—			Murphy 1984
Foxholes Farm	F172	4, 5, (or 3?)**	—	—	—	Monk 1982
	F64	—	3, 4, or 5	—	—	
Hibaldstow	n.r.	6	—	—	—	Straker 1978
Leicester	305, 309, 310 427, 199, 290 }	—	—	—	—	Jones G. 1982
Mucking	C.D. III	6	—	—	—	Van der Veen 1988a
Poxwell	n.r.	4, 5 (or 3?)	—	—	—	Jones G. 1983
Tiddington	301, 4	3, 4, 5, or 6	—	—	—	Moffett 1986
	184, 515	6	—	—	—	
Upton St Leonards	n.r.	—	—	—	—	Clark 1971
Wasperton	F1025, F831	3, 4, or 5	—	—	—	Bowker 1987
	F1906	—	3, 4, or 5	—	—	
Welton Wold	Phase 2b	—	—	3, 4, or 5	—	Straker 1986
	Phase 3	—	—	3, 4, or 5	—	
	Phase 4	—	—	3, 4, or 5	—	
Wendens Ambo	04804, 09901	4, 5, (or 3?)***	—	—	—	Jones G. *et al.* 1982

Key: n.r. = not recorded.
* = samples contain some bread wheat as well.
** = sample contains both emmer and spelt.
*** = samples contain spelt and/or bread wheat.

At **Farmoor**, Oxfordshire, a sample from a T-shaped corn-drier was dominated by glume bases of spelt wheat. The ratio of glume bases to grains was *c.* 5:1. Some awn fragments of oat and wheat and a very small number of weed seeds were also found. The composition of the sample suggests that it represents the use of spelt chaff to kindle the fire in the corn-drier (M. Jones 1979).

A sample from an oven at **Fengate Farm**, Weeting, Norfolk, contained mainly charred grains, glume bases, and rachis internodes of spelt wheat. Some, though not all grains had sprouted before carbonization and sprouts of varying lengths up to 6 mm were present (Murphy 1984). Unfortunately, the exact percentage of germinated grains was not recorded, but it was less than 75 per cent. The ratio of glume bases to wheat grains is 1.5:1, i.e., there are slightly more glumes than would be expected from complete spikelets. The relatively low percentage of sprouted grain and the wide variation in sprout length were taken as probable evidence against malting. Well-controlled malting would be expected to produce more even germination (Murphy 1984). Thus, although this deposit could represent malted spelt accidentally charred during parching, the possibility that sprouting occurred accidentally in the ear or in storage, and that the spelt was then dried in the oven to prevent further spoilage cannot be excluded (Murphy 1984). The composition of the sample is not conclusive and could refer to functions 3, 4, 5, or 6. The glume bases, or at least some of them, could represent the use of chaff as fuel.

At **Foxholes Farm**, Hertford, two samples were collected from the upper and lower fill of the stoke-hole of a corn-drier and two sub-samples from an associated pit (Monk 1982). The samples from the stoke-hole (F172) contained small amounts of emmer and spelt grain, and virtually no chaff or weed seeds. The samples represent fully processed wheat grain (the product of Hillman's stage 14) and may represent the drying of grain prior to bulk storage or milling (functions 4 or 5). As the possibility of differential survival (i.e. glume bases are more readily destroyed than grains) cannot be ruled out, the samples could originally have consisted of spikelets which were being parched prior to dehusking (function 3). The two sub-samples from the pit (F64) consisted almost entirely of barley grains and represent a fully processed crop. The grain may have been accidentally charred in the corn-drier and later deposited as waste into the nearby pit (Monk 1982). The composition of the sample points to functions 3, 4, or 5.

One sample from a corn-drier in **Hibaldstow**, Lincolnshire, produced a very large number of spelt grains. There were no chaff fragments, and only a few weeds, mainly seeds of roughly equal size to cereal grains (e.g. *Bromus mollis/secalinus, Avena* sp., *Agrostemma githago, Raphanus raphanistrum*) (Straker 1978). The composition of the sample is consistent with fully processed spelt grain (Hillman's stage 13). Most of the grains were germinated, but the sprouts were of different lengths. The unevenness of the germination could mean the sample represents a spoiled crop, but the very high percentage of germinated grains (90+ per cent) makes an interpretation of deliberately sprouted grain for the production of malt (function 6) much more likely.

At a Roman villa at Norfolk Street, **Leicester**, four samples were collected from a T-shaped corn-drier and another two from small hearths cut into the corn-drier (G. Jones 1982). Of the four samples from the corn-drier, one was too small (less than fifty identifications) to allow an interpretation, two contained large quantities of silica remains of lemmas, awns, and non-basal glume fragments pointing to the use of chaff for fuel; and the fourth sample, from the stoke-pit, consisted largely of glume bases of spelt. The ratios of glume bases to grains (36:1), and weed seeds to cereals (6:1), in this sample point to the use of fine-sieving residues (Hillman's stage 12) for fuel. A few germinated embryos were found, but in insufficiently large numbers to indicate that the oven was used in the malting process (G. Jones 1982). Unfortunately, the exact percentage of germinated grains was not recorded. Of the two samples from the hearths, one (no. 199) had roughly equal numbers of grains and glume bases, but the very small number of seeds (fifty-seven in total) makes the sample unreliable. In the other sample glume bases of spelt predominated. The ratio of glume bases to wheat grains was 3.3:1. This sample appears to consist of a mixture of chaff, possibly used as fuel, and some grain of unknown origin. The samples from this site indicate that chaff was used as fuel in the corn-drier, but they do not provide information regarding its function.

A small sample of carbonized grain was analysed from an L-shaped corn-drier at **Mucking**, Essex. The sample was dominated by germinated grains of spelt wheat. Detached coleoptiles and spelt glume bases were also present in large numbers. Most of the weed seeds belonged to large-seeded species (*Bromus mollis/secalinus, Avena* sp.). The ratio of glume bases to wheat grains is 0.6:1, and 95 per cent of the grains were sprouted. The sample was interpreted as evidence for malt production (Van der Veen 1988). The virtual absence of wood charcoal suggests that no mixing with fuel had taken place. The glume bases are, therefore, unlikely to represent remains of fuel. It is more likely that the spelt was deliberately germinated while still in spikelet form. The sample composition points to malting, function 6.

One sample from a corn-drier at **Poxwell**, Dorset, contained an abundance of well-formed grains of spelt wheat, but no chaff, weed seeds, or wood charcoal (G. Jones 1983). The grain represented fully processed spelt (the product of Hillman's stage 14). As only seven per cent of the grain was germinated the sample could not represent malt production. Instead, its composition suggests that the oven was used for the drying of grain to prevent further spoilage, prior to bulk storage (function 4). However, the differential survival of glume bases and grains could mean that the sample originally consisted of spelt spikelets, ready for parching (function 3).

At **Tiddington**, Warwickshire, twenty-six samples from four T-shaped corn-driers were analysed (Moffett 1986). Two of the ovens (301 and 515) were dated to the second century, the other two (184 and 4) to the late third or fourth centuries (though one (4) only tentatively). Virtually all samples were dominated by glume bases of spelt and weed seeds (ratios of glume bases to wheat grains vary from 5:1 to 60:1). They can all be interpreted as evidence for the use of fine-sieving residues (Hillman's stage 12 sievings) for tinder and fuel (Moffett 1986). In most samples a few germinated grains were found, but they never formed more than 30 per cent of the total number of grains, and often much less. It is difficult to interpret these samples as evidence for the roasting of deliberately germinated grains for the production of malt, as in that case many more germinated grains would be expected. However, most samples also contained detached coleoptiles, and in some cases these were considerably more numerous than the germinated grains. This points to an under-representation of germinated grains, which is quite feasible, as charred remains of fully germinated grains do fragment easily and then become difficult to recognize. The coleoptiles could also represent remains of fuel residues. After the roasting of the germinated grain the malt is sieved to remove the rootlets (Brown 1983). Any detached coleoptiles would probably be removed at the same time. These could then be thrown back into the fire. The composition of the samples has been interpreted as pointing to the use of the ovens for the production of malt (function 6) in two cases (corn-driers 515 and 184), and either malt production or the drying or parching of badly spoiled grain (function 6 or 3, 4) in the case of corn-driers 301 and 4. In all cases there was extensive evidence for the use of fine-sieving residues (chaff and weed seeds) as tinder or fuel (Moffett 1986). There were square pits associated with each corn-drier; they may have been used to steep the grain. In corn-drier 515 a few of the germinated grains were stuck together in such a way as to suggest that they had been charred while still in the spikelet. This would indicate that spikelets rather than dehusked spelt grains were used for malting (Moffett 1986), a phenomenon also recorded at Mucking (see above).

At **Upton St Leonards**, Gloucestershire, a sample from a T-shaped corn-drier contained charred grains and chaff of spelt wheat, some bread/club wheat, and a large range of weed seeds (Clark 1971). Only a list of species present and no actual numbers of identifications was given. Consequently, no interpretation can be offered.

At **Wasperton**, Warwickshire, fifty-nine samples from three corn-driers were collected (Bowker 1987). The composition of the samples from two of the corn-driers (F1025 and F831) points to the use of spelt glume bases as fuel. The samples near the stoke-hole were dominated by chaff. In contrast, the samples from the cross-flue (near the drying chamber) were dominated by cereal grains (spelt and some barley). Although all features contained a few germinated grains and detached coleoptiles, they occurred in insufficient numbers to represent malted grain (Bowker 1987). It is more likely that they represent the parching or drying of a partially spoiled crop (function 3 or 4). Unfortunately, the exact percentage of germinated grains was not recorded. The third corn-drier (F1906) contained different assemblages. The samples were all dominated by barley grains. One seed of horse bean was also found. There was very little evidence for germinated grains (Bowker 1987). The composition of these samples points to the use of this corn-drier for the parching or drying of barley grain (functions 3 or 4).

At **Welton Wold**, Humberside, nineteen samples from four corn-driers were analysed. The site was occupied from the late first to the early fifth centuries and corn-driers were associated with each of the four phases of occupation (Straker 1986). The samples from the first corn-drier (phase 2A) were too small to allow a reliable identification. Those from the second (phase 2B) consisted of a large amount of spelt glume bases, roughly equal quantities of wheat and barley grains, and weeds, the latter mostly seeds of *Bromus subgenus Eubromus* and *Avena* sp. The ratio of glume bases to wheat grains is *c.* 2:1. Only two per cent of the grains were germinated. The samples were interpreted as either clean spelt and barley grain mixed with fuel (glume bases), or spelt spikelets and barley grains mixed with fuel. The presence of large amounts of silicified cereal chaff (awn fragments, glume beaks etc.) in the stoke-pit of this oven also points to the use of chaff as fuel. The composition of the samples suggests that the corn-drier was used for functions 3, 4, or 5. The samples from the third corn-drier (phase 3) contained barley and wheat grains, wheat glume bases, and some weeds. The ratio of spelt glume bases to grains was *c.* 1:1, while there were twice as many barley grains as wheat grains. The samples represent a mixture of residues from the drying of fully processed barley grain and the parching or drying of spelt spikelets (functions 3, 4, or 5). The samples from the fourth corn-drier (phase 4) also consisted of a mixture of barley and wheat. There were virtually no glume bases of spelt in these samples, but this could be due to differential preservation. The composition of the samples points to the drying of barley (functions 3, 4, or 5) and the parching or drying of wheat (functions 3, 4, or 5). The relative proportions of barley and wheat suggest that the samples contain a mixture of residues from more than one usage.

All four samples from a late Roman corn-drier at **Wendens Ambo**, Essex, were dominated by grains of wheat (spelt and/or bread wheat) (G. Jones *et al.* 1982). Two samples were too small to allow a reliable interpretation (thirty-two and forty-seven seeds respectively). The remaining two samples consisted of fully processed wheat and were interpreted as representing the drying of grain prior to storage (function 4) (G. Jones *et al.* 1982). The absence of glume bases could be due to differential preservation and, consequently, function 3 cannot be ruled out.

Thus, to summarize (Table 1 and 2), out of the twenty-one sites from which charred grain assemblages have been analysed, none has provided evidence for either functions 1 or 2 (the drying of whole ears), and none has provided conclusive evidence for function 3 (the parching of wheat spikelets or hulled barley grains), although on at least ten sites this function was one of the possibilities. On four sites (Dan-y-Graig, Foxholes Farm, Poxwell and Wendens Ambo) the assemblages pointed to functions 4 and 5 (the drying of fully processed grain prior to storage or milling), but see below for a discussion on the matter of differential preservation of chaff and grain. On eight sites it was not possible to distinguish between functions 3, 4, and 5. Five sites (Bancroft villa, Catsgore, Hibaldstow, Mucking and Tiddington) provided evidence for function 6 (the roasting of deliberately germinated grain for malt). On two sites it was not possible to distinguish between functions 3, 4, 5, and 6, while on five sites the assemblage was too small or the sample composition did not provide sufficient information to establish the corn-drier function. On eight sites there was firm evidence for the use of spelt chaff as fuel, and on three sites (Dan-y-Graig, Leicester and Welton Wold) the use of chaff as fuel was confirmed by the presence of large quantities of silicified chaff (mainly awn fragments and glume beaks). On most sites spelt wheat was the dominant crop, but at Cawkwell, Foxholes Farm and Wasperton clean barley was found, while at Barton Court Farm, Cawkwell, Dorchester, and Welton Wold a mixture of spelt and barley was found, which was probably a combination of residues from more than one firing event. At Colchester a mixture of barley, bread wheat and rye was present.

DISCUSSION

The results raise a number of different issues, both botanical and archaeological, which will be discussed in this section. First of all, it is necessary to consider the impact of

differential combustion on the composition of the botanical assemblage. As has already been mentioned above, there is evidence that under certain charring regimes chaff fragments such as glume bases, can burn away completely while the grains remain more or less intact (Boardman and Jones 1990; Robinson and Straker in press). Consequently it has become impossible to rely exclusively on the composition of the charred plant assemblage when distinguishing between functions 3, 4, and 5. While the assemblages from Dan-y-Graig, Foxholes Farm, Poxwell, and Wendens Ambo all point to functions 4 and 5, we cannot rule out the possibility that the glume bases were simply burnt away and that the assemblages originally consisted of spelt spikelets rather than clean grain. It may be possible to assess the likelihood of chaff loss by determining the thermal history of the grains by techniques such as Electron Spin Resonance. ESR spectroscopy has been successfully applied to archaeobotanical remains in the past (Hillman *et al.* 1983 and 1985), and its application to selected corn-drier assemblages is greatly needed, especially in association with further experimental work on the differential combustion of cereal components.

A second, important botanical point concerns the need to dry the grain prior to storage or milling. This practice has been recorded for the Western Isles of Scotland, Orkney, Shetland, and Ireland (Fenton 1978, Scott 1951). These are all areas with high levels of annual rainfall and a short growing season, where the cereal harvest (barley and/or oats) often had to take place late in the season and during wet weather. While in southern and eastern Britain there will have been years during which the harvest was brought in wet and unripe, this would have been the exception rather than the rule. Throughout the centuries farmers in southern England have dried grain by standing it in sheaves or laying it out on barn floors rather than using purpose-built driers (Reynolds and Langley 1979). Apart from the differences in climate, the historical descriptions also refer to slightly different crops (barley and oats instead of spelt and some barley in the Roman period). Spelt wheat is usually (though not absolutely necessarily) parched prior to pounding, second winnowing and sieving, to render the glumes brittle and facilitate their removal. If the crop was harvested under dry conditions there would probably be no need for further drying after the parching and removal of the glumes (Hillman and Robinson pers. comm.). Experimental work to test this hypothesis is urgently required.

As it is both difficult to distinguish between assemblages resulting from functions 3, 4, and 5, and unclear to what extent there would have been any need for functions 4 and 5 after parching (function 3), it seems appropriate to redefine these functions together under a single broader title: the preparation of grain for consumption and storage (parching/drying). The assemblages from this more general function are clearly distinguishable from those of functions 1, 2, and 6.

This analysis of charred grain assemblages associated with the corn-driers indicates that these ovens should not be regarded as single-function structures. Both the roasting of deliberately germinated grain for the production of malt *and* the preparation of grain for consumption and storage (i.e. parching/drying) are functions clearly implied by the botanical evidence. Both these functions are associated with similar flue designs: T-shaped corn-driers. The results highlight the need for further experimental work with corn-driers. The experiments carried out at Butser Ancient Farm were aimed to test their ability to dry barley grain. The present results indicate a need for a repetition of the experiments using spelt wheat, to test their ability to parch spelt spikelets rather than to dry grain, and to test whether further drying of the grain after parching and removal of the glumes is actually required.

The conclusion reached by Reynolds and Langley, that these structures could not function as corn-driers was based largely on the impermeability of the floor (Reynolds and Langley 1979; Reynolds 1981). The evidence from Foxholes Farm (one of the reconstructed corn-driers) pointed to the use of a solid floor made from wooden planks covered with a chalk and soil slurry, and a stone slab floor was found at Atworth (Shaw-Mellor and Goodchild 1942; Reynolds 1981). The conclusion reached after the experiments was that 'such solid floors are very poor conductors of heat and rather than allowing hot air to rise through the grain, they simply warm the lowest levels and cause moisture exchange from one level to another' (Reynolds 1981, 37). Ironically, the charred plant assemblages from neither Foxholes Farm or Barton Court Farm (the two corn-driers reconstructed and used in the experiments) could be interpreted as pointing to function 6 (malting). Few structural details of corn-drier floors have been preserved archaeologically, but the surviving evidence points in some cases to the use of double floors, the heat being channelled through the flue into the space between the two floors, heating the upper floor (as at Atworth (Shaw-Mellor and Goodchild 1942)), and in other cases to the use of a single floor, the heat being channelled through the flue and the hot air either deflected from the back of the cross flue into the drying chamber by means of a hood at the back wall of the cross flue, or drawn into the drying chamber from the end of the cross flue by means of chimneys or vents in the roof or walls of the drying room (Morris 1979). While the archaeological evidence appears to suggest that these ovens either heated a floor area or channelled hot air into the drying chamber, the ethnographic references to corn drying and malt production, in contrast, all refer to channelling the hot air *through* a permeable floor surface, such as straw, wooden slats, sacking, hair cloth, wire frames, or pieces of pierced cast-iron plates on which the grain is put, so that the hot air is passed through the grain (Brown 1983; Fenton 1978; Mathias 1959; Monk 1987b; Scott 1951). Evidence for permeable floors will be difficult to find archaeologically, but a careful reassessment of the structural evidence for corn-drier floors appears necessary, though it falls outside the scope of this article.

Experiments are also required to measure the degree of uniformity of sprout length in germinated spelt grains and the number of germinated grains as a percentage of the total assemblage at the moment of roasting. Several authors have used the relatively low percentage of germinated grains and/or the lack of uniformity in sprout length as indicators against deliberate and controlled germination for malt (Bowker 1987; Hillman 1982; G. Jones 1983; Moffett 1986; Murphy 1984). In this article arbitrary figures of more than 75 per cent for deliberate germination and less than 15 per cent for accidental germination have been used. However, the technique of producing a uniform germination might be a fairly recent development with the selective breeding of barley cultivars specifically for the brewing industry and rigorous sample selection by the brewers (Briggs 1978). Could some of the assemblages with low percentages of germinated grains in fact represent poorly germinated grain for malting?

In modern Britain only barley is used for the brewing of beer, though other cultures are known to use cereals such as millet and sorghum. Historical evidence seems to indicate that in western Europe barley has always been the most important cereal in the brewing industry, but there are, nevertheless, frequent references to the use of other cereals, such as wheat, rye, and oats. For example, in Domesday Book it is mentioned that at St Paul's Cathedral, London, the canons brewed 67,814 gallons of ale from 175 quarters each of barley and wheat, and 708 of oats (Corran 1975). And in a herbal quoted by Corran (1975) directions were given for brewing beer: 'They take wheat, barley, spelt, rye, or oats, either one kind (for good beer can be prepared from all these cereals) or two or three together . . .'. Reviewing the various regional beers the same book says: 'English beers are also extraordinarily good, especially English ale brewed from wheat' (Corran 1975, 48–49).

Corn-driers are largely a Roman phenomenon (but see Monk, forthcoming, about Medieval driers). They have not (yet?) been found on Iron Age sites, but start in the first century, and are particularly common during the third and fourth centuries. Neither of the two functions for which archaeobotanical evidence is now available (i.e. the preparation of grain for consumption and storage (parching/drying) and the roasting of germinated grains for malt) require specific structures such as corn-driers. Throughout the prehistoric period these activities will have been carried out within each household, in small quantities throughout the year, taking grain out of storage as and when it was required. The presence of corn-driers seems to suggest a different scale of processing. The state in which grain was put into bulk storage (clean or as spikelets) probably varied according to the size of the production unit and the purpose of storing: storage for household consumption throughout the year and storage of seed corn was probably in spikelet form, while storage before or after long distance transport, taxation, and sale to military or urban units, is more likely to have been in the fully processed state. The processing of grain in corn-driers is more likely to have been necessitated by this second need for storage. Carbonized grain from a Roman granary at South Shields Roman fort did, in fact, produce evidence for the storage of cleaned grain (Van der Veen 1988b), and two grain storage deposits from Roman London also consisted of fully processed grain (Straker 1984). The parching, dehusking and drying of large quantities of grain prior to long distance transport and bulk storage would have required a scale of processing very different from that used in individual households and this is likely to have necessitated purpose-built structures.

The increase in the scale of agricultural operations during the Roman period is also reflected in the first appearance of large watermills, compared to the hand-operated rotary and bee-hive querns of earlier periods. Three watermills are known from the area along Hadrian's Wall: at Chesters, Haltwhistle and Willowford (Spain 1984), suggesting that the Roman military were supplied with grain rather than flour. At the Roman villa at Chew Park, Somerset, a large millstone was found in the stoke-pit of the corn-drier (Rahtz and Greenfield 1977), and at Heronbridge, Cheshire, Littlecote Park Villa at Ramsbury, Wiltshire, and Barton Court Farm, Abingdon, Oxfordshire, there are tentative associations between corn-driers and watermills or, at least, large millstones (Spain 1984).

Evidence from insect analyses also points to an increase in the scale of grain transport and storage. The damage to grain by grain weevils and beetles apparently became a serious problem during the Roman period (Buckland 1978; Kenward 1979). The absence of any evidence of serious crop loss by insect infestation prior to the Roman period may possibly be explained by the fact that during the Iron Age and earlier periods grain was stored in much smaller units, usually only for domestic use; much less bulk transport took place, and grain was, at least in parts of England, stored in sealed underground pits, where the rapid accumulation of carbon dioxide proves lethal to the insects (Buckland 1978). The appearance of corn-driers during the Roman period, often on low-status sites, also gave rise to the hypothesis that they represented the response of British farmers to seasonal cash-flow problems brought about by the expanding monetary economy in the later Roman period (M. Jones 1981 and 1982). To summarize, the phenomenon of corn-driers during the Roman period would appear to have arisen from an increase in the scale of agricultural production, and in the scale of processing, transport and storage of grain. Their regional distribution may, to a certain extent, reflect this development in Britain, though the varying amounts of archaeological work carried out in different parts of the country will have biased this distribution.

On thirteen out of the twenty-one sites the crop associated with the corn-driers was spelt wheat. On an additional four sites spelt wheat was present, but mixed with barley. On only three sites was barley present as a pure crop. On one site, Colchester, a mixture of free-threshing cereals was present (bread wheat, barley, rye, and one horse bean), but no spelt. This feature did contain some Saxon pottery and the fill may therefore be of rather later date than the corn-drier (Murphy 1985). Corn-driers dated to the Medieval period have all been associated with free-threshing cereals. Oat was the most common crop at Ballinaraha, Co. Tipperary, Ireland (Monk 1988), Drogheda, Co. Louth, Ireland (Monk forthcoming), Collfryn, Llansantffraid Deuddwr, Powys (Jones and Milles 1984), Chalton Manor Farm, Hants. (Monk 1981), and Ewanrigg, Cumbria (Huntley 1988), while at Kilferagh, Co. Kilkenny, Ireland (Monk 1987a), and Poundberry, Dorset (Monk 1987b), bread wheat and barley were also present as separate crops. At Hereford grains of a free-threshing wheat together with smaller amounts of barley and oats were recorded (Arthur 1985). At none of these sites was there any evidence for the production of malt; no germinated grains were found. Not only is the range of cereals associated with medieval kilns different from those dated to the Roman period, but they also vary in structural design. A further discussion of the evidence from these later kilns is outside the scope of this article. The results of experimental work with post-Roman corn-driers and a review of their botanical evidence is in progress (Monk forthcoming).

CONCLUSION

The charred grain assemblages found associated with Roman-period corn-driers indicate that these structures were used for more than one purpose. Both the roasting of germinated grains for the production of malt *and* the preparation of grain for consumption and storage (parching/drying) are functions implied by the botanical evidence. In both cases the principal cereal crop used was spelt wheat. So far, no evidence has been found for the drying of complete ears of grain to ripen them when harvested wet. The botanical evidence suggests that further experimental work is necessary to clarify a number of different points: the ability of corn-driers with solid floors to parch spelt spikelets, the need for drying spelt grains after they have been parched to remove the glumes, and the ease of germination of spelt spikelets and spelt grains for the production of malt and the uniformity (or lack thereof) of sprout lengths. While it is recognized that the application of techniques such as Electron Spin Resonance spectroscopy to charred grain assemblages could never become routine, it is highly desirable that the thermal history of certain selected grain assemblages from corn-driers is determined in order to assess the likelihood of chaff loss due to differential combustion. A more thorough analysis of the structural evidence for solid floors in corn-driers is also urgently required.

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