'MILK JUGS' AND OTHER MYTHS OF THE COPPER AGE OF CENTRAL EUROPE

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Abstract: Ceramics were subjected to organic residue analysis from two collections: a series of middle Copper Age (Bodrogkeresztúr) vessels hitherto known as 'milk jugs', curated in the Magyar Nemzeti Múzeum, Budapest, and a collection of early Baden (Boleráz) vessels from the recently discovered settlement of Győr-Szabadrét-domb, in western Hungary. The aim of the analyses was to establish whether or not these vessels, often associated with milk based on typological criteria, were actually used to process, store or serve dairy products. The results of the analyses revealed that no dairy products could be securely identified in the so-called 'milk jugs'. Nevertheless dairy products were identified in other vessel types.

Keywords: Copper Age; dairying; Hungary; lipids; proteins; residue analysis; secondary products

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INTRODUCTION

The Copper Age of Hungary has been identified with an increased emphasis on stock-raising; part of this subsistence practice may have led to an intensification of the use of secondary animal products, such as dairy foods. The main aim of the article is to seek to detect this supposed new emphasis on dairy products in the middle and late Copper Age. A second aim is to investigate whether one of the ceramic type-fossils of the middle Copper Age – the so-called 'milk jug' – was actually used for milk storage, cooking or consumption. A third aim is to conduct a comparative study of a wider range of late Copper Age vessel shapes, including the later version of the 'milk jug', to identify the vessel types associated with eating and drinking of dairy products.

The Hungarian Copper Age has been the object of intensive study since its definition at the Budapest Prehistoric Conference of 1876 (Pulszky 1884). The distinctive styles of copper axes, varying for each phase, were the key early type-fossils for the Copper Age (for history and typology of copper axes, see Patay 1984). Childe was the first to recognize the seeming paradox concerning the middle and late phases of the Hungarian Copper Age – the Bodrogkeresztúr and Baden phases – when he remarked on the simplicity and small scale of the settlements in contrast to the complex metallurgy required to produce such axes (Childe 1939:109–113, 1958; Chapman 1999). In more recent times, the gulf between a dominant mortuary domain and a less developed domestic arena has been recognized throughout the Copper Age (Sherratt 1982–1983; Chapman 1994). Cemeteries rather than settlements are often the main communal focus in the landscape and the main places for structured deposition of whole vessels and striking metalwork (e.g. Tiszapolgár-Basatanya, see Bognár-Kutzian 1963). By contrast, individual family homesteads are thought to be the principal form of very dispersed settlement, but the scale of artefact deposition is very low, rarely leading to more than the discovery of a scatter of sherds and lithics deriving from shallow pits (e.g. Tarnabod and Derecske, see Patay 1974:31). However this is not the whole story: Patay has excavated an exceptional Bodrogkeresztúr site with houses at Tiszalúc. Recent Hungarian rescue excavations in advance of motorway construction have also revealed an unsuspected range of nucleated Copper Age settlements – the result of the scale of the investigation rather than any other factor. This is the case with the largest known settlement of the early Baden – or Boleráz – phase now known in western Hungary, Győr-Szabadrét-domb.

These new discoveries are certain to provoke new ideas about the settlement and social basis of groups previously thought to be small-scale and perhaps mobile, with an emphasis on pastoralism rather than arable farming (Kalicz 1991). One exception to this traditional view was Andrew Sherratt (1981), who developed the idea of an integrated agro-pastoral economy in the late Copper Age, based on the exploitation of secondary animal products – the so-called 'secondary products revolution', now re-titled the 'secondary products scenario' (Sherratt 1997). It was in the late Copper Age that the diffusion from the Near East of five interlinked innovations of ploughing, wheeled transport, horse-riding, woollen textiles and dairying was claimed to have occurred (Sherratt 1981). While it has been suggested that dairying is of a far greater antiquity than the late Copper Age (Bogucki 1984), it is widely believed that cattle dairying was of considerable significance in the Baden period (Hodder 1990; Kalicz 1991; Whittle 1996:123), as illustrated by Whittle's use of the quadruple burial of a human couple and a bovine couple in the Budakalasz cemetery as the symbol of the period (Whittle 1996:Fig. 5.1).

Middle Copper Age pottery

There are two fundamental, systematic studies of the material culture of the middle Copper Age (Bognár-Kutzian 1963; Patay 1974). While the metalwork in copper and gold is given pride of place in both studies, the distinctive ceramics are heavily utilized for relative chronology and the establishment of 'cultural relations'. Most of the pottery types from the Bodrogkeresztúr group consist of a set of bowls, dishes, amphorae, high-pedestalled forms and rare rectangular vessels. But it is the milk jug that Bognár-Kutzian (1963:276–285 and Plate cxxxv: her Type F) identifies as central to the identity of these communities. The term was introduced by Hillebrand (1927:34–35 and 364); the Hungarian term 'köcsög' (1927:34) is translated by the German term 'milchtopfartige Gefäss' (1927:364), without further comment or explanation. Bognár-Kutzian notes that the term continues in use although it is not fully satisfactory (1963:276). Patay (1974) concurs with Bognár-Kutzian that the milk jug is the most important ceramic type-fossil of the middle Copper Age. Milk jugs were buried in most of the middle Copper Age graves and played an important role in mortuary practices (Patay 1974:20). The sizes of milk jugs vary from 10 cm to 30 cm in height but their shape is moderately standardized, with a long vertical neck and a prominent belly. The origins of the type are not known, since it does not occur in the preceding early Copper Age Tiszapolgár group (Patay 1974:21).

Independent discussions with four Hungarian prehistorians about the source of Hillebrand's interpretation of the pottery form as a milk jug produced a unanimous conclusion: it is a shape parallel to milk jugs used in villages in the 1920s, either directly observed by Hillebrand or used at first hand by members of his excavation team. This was partially corroborated by Dr István Csupor, Head of Ceramics at the National Ethnographic Museum, Budapest, who confirmed the following details. In the Carpathian Basin, nineteenth and early twentieth-century milk jugs came in two main forms – a one-handled type with a lid and a two-handled type without a lid; both types were used from the seventeenth century for storing milk and, less commonly, for the production of butter (which was more frequently produced in wooden churns). In the one-handled type, the milk was beaten with a rod that passed through a single perforation in the lid; in the two-handled type the milk was shaken. The two-handled type was not characteristic for the northern Alföld – the area of the Bodrogkeresztúr cemeteries where Hillebrand was working – but rather for south-west Hungary (the Őrség) and Transylvania (where Hillebrand also worked), although occasional examples are known from the Zemplén Mountains (e.g. Gömör). In the twentieth century, the two-handled form was regarded as an archaic form that survived mainly on the peripheries of the Kingdom (I. Csupor pers. com.). The general conclusion must be that the designation 'milk jug' was based on an informal ethnographic analogy drawn from local village life at the time of the Pusztaistvánháza excavations.

Late Copper Age pottery

There is considerable diachronic variability within late Copper Age ceramic assemblages; here most of the attention will be focused on the early, or Boleráz, phase. However, it is worth recalling that later pottery shapes, such as the so-called Baden 'submarine', have good ethnographic and archaeological analogies with vessels used in the making of butter and cheese (Whitehouse 1970; Sherratt 1981). In the Boleráz assemblage at Győr-Szabadrét-domb, the range of general vessel types – bowls, dishes, amphorae and so on – is similar to that of the middle Copper Age but there is a wider distribution of handled forms and a stronger emphasis on necks and carinations, on dishes and amphorae as well as bowls. There is also a range of wider, shallower dishes and plates with good analogies in the late Vinča assemblage (Chapman 1981), whose shapes would be ideal for the production of cream or cheese, through the separation of curds and whey.

THE SITES

Bodrogkeresztúr – middle Copper Age

The eponymous group and the first cemetery to be excavated (Bella 1923; Hillebrand 1923). The cemetery lay on the first terrace of the river Bodrog, at the northern edge of the village. A total of 50 graves were found at a depth of 2 m, yielding a wide variety of finds, including metalwork and many milk jugs (Patay 1961:6–19). Bella (1923:214) reported that milk jugs were found in every grave excavated in the first season. The pottery sampled comprises four milk jugs from four different graves.

Kisvárda – middle Copper Age

A middle Copper Age cemetery of 12 or 13 graves was found by Rómer (1870) on a sand island in the middle of the river Tisza (Patay 1961:37–39). The graves were organized in loose rows, oriented north–south. The only 'milk jug' published from the cemetery (Patay 1961: T. IX/2) was analyzed.

Tiszavalk-Tetes – middle Copper Age

A Bodrogkeresztúr cemetery in the middle Tisza region, with more than 20 graves (Patay 1974: unpublished excavations). A single 'milk jug' from one of these graves was analysed.

Győr-Szabadrét-domb – late Copper Age

The largest settlement yet known of the Boleráz group, the site covers an area of

12 ha, located on a small 2 m-high elevation in the flood-plain 1.2 km north west of the river Rába (Figler et al. 1997). Over 200 pits associated with Boleráz material have been excavated, containing almost 50,000 animal bones, or, on average, more than 230 per feature. Many pits were covered with a flood-plain silt layer, often topped with a layer of in-washed molluscs. Those pits in parts of the site that were not flooded had larger numbers of animal bone fragments.

The zoological remains show a predominance of domestic fauna, with more cattle and caprines than pigs and with little hunting or fowling. Seasonality data from the ruminants and the fish indicate occupation from February through to September, despite the annual spring floods, if not all the year round (Figler et al. 1997:226). This suggests a more 'permanent' occupation than has been argued before for Boleráz settlements (e.g. Kalicz 1991). In addition, ^{14}C dating of the Boleráz occupation indicates a period of 300 years, from 3350 to 3050 cal BC (Figler et al. 1997).

Ten restored or complete vessels were made available for the analysis by the excavator, Dr András Figler.

METHODS

Prior to analysis, samples were prepared first by removing any contaminating surface debris using a scalpel and then collecting ceramic particles (c. 1–3 g) by surface abrasion from the vessel's interior surface. The resulting powdered ceramic was sealed in glass tubes prior to all subsequent analyses. Samples were also taken, where possible, from the vessel's exterior surface to provide negative controls. Replica 'experimental' ceramics used to boil fresh cows' milk and to boil beef were also used as controls; some of these were buried for two years in upland soils (Table 1). Procedural blanks were also included in all subsequent analyses.

Two independent but complementary methods were used for the identification of milk residues (see Craig 2002 for overview). The first method was used to determine the presence or absence of a protein unique to dairy products: α_{s1}-casein. This was achieved using indirectly labelled monoclonal antibodies in a modified enzyme-linked immunosorbant assay designed specifically for removing proteins tightly bound to the mineral surface of the ceramic vessel (Craig and Collins 2000). Ceramics are first dissolved in hydrofluoric acid and liberated proteins are simultaneously captured on a solid matrix. The matrix is incubated with a solution containing monoclonal antibodies that bind to target regions on the captured protein. The antibody used (clone 412–2) targets a specific region of the α_{s1}-casein molecule, that displays structural variation between different mammalian species. In this case, an antibody specific for only the *bovine* form of α_{s1}-casein was used. Each sample was assayed in duplicate or triplicate. The presence of bovine α_{s1}-casein was detected by the addition of a substrate, which changes colour if the enzyme, indirectly linked to the antibody, has bound to its target. The colour change is detected by measuring the absorbance at a specific wavelength using a spectrophotometer. Positives are defined by twice the background absorbance produced by blank extracts under identical conditions.

Table 1. Description of materials analyzed and summary of results.

Site	Lab code	Sample	Context number	Context Description	Vessel Type	Bovine α_{s1} -casein	Lipids Detected
Bodrogkeresztúr	bk-148 –a	interior (body)	pot ID: 148	grave	'milk jug'	–	n/d, heavy contamination (*n*-alkanes, phthalate esters)
	bk-149 -a	Surface Residue	pot ID: 149	grave	'milk jug'	+	n/d, heavy contamination (*n*-alkanes, phthalate esters)
	bk-149 -b	interior (body)	pot ID: 149	grave	'milk jug'	+	C16/C18 FAs*, heavy contamination (*n*-alkanes, phthalate esters)
	bk-153 -a	interior (body)	pot ID: 153	grave	'milk jug'	–	n/d, heavy contamination (*n*-alkanes, phthalate esters)
	bk-153 -b	Exterior (body)	pot ID: 153	grave	'milk jug'	–	n/d, heavy contamination (*n*-alkanes, phthalate esters)
	bk-154 -a	interior (body)	pot ID: 154	grave	'milk jug'	–	C16/C18 FAs*, contamination (*n*-alkanes, phthalate esters)
Tiszavalk-tetes	tt-77193	interior (body)	pot ID: 77193	grave 20	'milk jug'	–	C16/C18 FAs, heavy contamination (*n*-alkanes, phthalate esters)
Kisvárda	ks-001	interior (body)	–	grave	'milk jug'	–	heavy contamination (*n*-alkanes, phthalate esters)
Gyõr-Szabadrét-domb	gs-001	interior (rim)	706	large pit	necked rounded carinated bowl	–	n/d
	gs-002	interior (rim)	276	large pit	'milk jug'	–	C16/C18 FAs, mono-/diacylglycerols
	gs-003	interior (rim)	364	large pit	1-handled necked bowl	–	C16/C18 FAs
	gs-004	interior (rim)	506	large pit	'milk jug'	–	Glycerol, C16/C18 FAs
	gs-005	interior (rim)	651	large pit	small storage jar	–	n/d
	gs-006	interior (rim)	11	large pit	necked jar	–	n/d
	gs-007	interior (rim)	621	large pit	carinated dish	+	C16/C18/C18:1 FAs
	gs-008	interior (rim)	621	large pit	necked carinated dish	+	C16/C18 FAs
	gs-009	interior (rim)	621	large pit	necked jar	–	C16/C18/C18:1 FAs
	gs-010	interior (rim)	26and52	large pit	storage jar	–	C16/C18 FA*, phthalate esters
Experimental 'milk pot'	oc-002a	interior (body)			globular cooking pot	+	
	oc-002b	interior (body)		buried for 2 years	globular cooking pot	+	
Experimental 'beef pot'	oc-004a	interior (body)			globular cooking pot	–	
	oc-004b	interior (body)		buried for 2 years	globular cooking pot	–	
Experimental 'blank'	oc-001a	interior (body)			globular cooking pot	–	
	oc-001b	interior (body)		buried for 2 years	globular cooking pot	–	

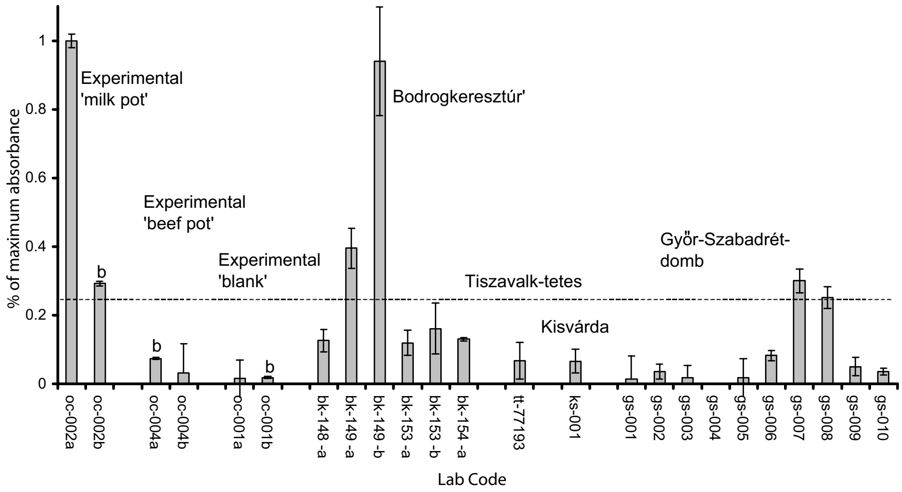

Figure 1. *Results of DACIA against various Copper Age ceramic vessels.*
Each sample was assessed by two replicate immunological assays using a murine monoclonal antibody specific for bovine α_{s1} casein (clone 412–2); the resulting absorbance measurements were detected at 490 nm. Mean values are plotted as % of the maximum absorbance produced by the positive control sample (Oc-002a). The standard deviations (1σ) are shown by the error bars. Control ceramic samples (the six bars on the left) were buried for two years in upland soils in Northumberland, UK where indicated (b). The presence of bovine milk protein is securely defined by twice the absorbance produced by a negative control (empty tube) under identical conditions. The detection limit is indicated by the dashed line. Notably some of the ceramic samples produced absorbance values significantly less than the background and therefore maybe inhibiting the antibody.

Prior to analysis, this antibody was assayed against milks from different species (caprine, ovine, equine and human), the absorbance produced by each of these assays was always less than twice the background demonstrating the antibodies specificity for bovine milk protein. A series of experimental vessels were used as positive and negative controls in each set of analyses (see Table 1, Figure 1).

The second technique was used to identify the lipid components of the absorbed residue. Lipids were extracted and analysed by high temperature gas chromatography (GC) or gas chromatography mass spectrometry (GCMS): see Heron and Evershed (1993) for review. Whilst this method is suitable for characterizing fresh dairy products, principally by their fatty acid and triacylglycerol (TAG) composition, over time many of these compounds are either lost completely or else their distribution is significantly altered. Laboratory

Notes for Table 1
+ or – for 'bovine α_{s1} casein' was assessed by two replicate immunological assays using a murine monoclonal antibody specific for bovine α_{s1} casein (clone 412–2); the resulting absorbance measurements were detected at 490 nm; n/d = none detected. FAs = fatty acids detected (16:0 = palmatic acid; 18:0 = stearic acid; C18:1 = octadecenoic acid). FA = fatty acids were only detected upon extraction of the vessel by alkaline saponification. Experimental pots were buried for two years in acid upland soils where indicated.*

experiments have shown that dairy fats degrade, so as to resemble adipose fats more closely (Dudd and Evershed 1998) presenting a significant problem for the identification of the former in archaeological samples. This was overcome by measuring the stable carbon isotope ratio of the most prominent saturated fatty acids (with carbon chain lengths of 16 [16:0; palmatic acid] and of 18 [18:0; stearic acid]) using gas chromatography combustion isotope ratio mass spectrometry (GC-C-IRMS. Dudd and Evershed 1998; Dudd et al. 1999). The relative proportion of light (^{12}C) and heavy (^{13}C) carbon atoms – the carbon isotope ratio ($\delta\ ^{13}C$) – in these molecules can be used to determine their origin. Adipose fats from non-ruminant animals have similar isotope ratios for both acids but, in ruminant adipose fats, the 18:0 fatty acid contains 1 – 3‰ less ^{13}C than the 16:0 component; it is therefore said to be isotopically 'lighter' or 'depleted'. Significantly, this difference is even more pronounced in ruminant milk fats. The absolute isotope ratios of these fatty acids in milk are a function of the animal's diet, but in all cases the $\delta\ ^{13}C$ of the 18:0 fatty acid in modern reference ruminant milks is between 3.3 and 7‰ lighter than the 16:0 component (Copley et al. 2003; Craig et al. in press); this difference is commonly expressed as $\Delta^{13}C$, where $\Delta^{13}C = (\delta^{13}C_{18:0}) - (\delta^{13}C_{16:0})$.

RESULTS

The results of the lipid analysis are summarized in Table 1 and Figure 2. The results of the protein analysis are summarized in Table 1 and Figure 1.

Each of the four milk jugs analysed from the middle Copper Age site at Bodrogkeresztúr was heavily contaminated with plasticizers and series of saturated hydrocarbons. As no contamination was detected in the procedural blanks that were processed identically and concurrently with the samples, the contaminating compounds are most likely derived from their storage in the museum or from the conservation process. A similar range of contaminants was observed on the vessel exterior, which also indicates that the presence of these compounds is not related to pottery use. However in addition to the contaminants, small amounts (<5 μg per g of ceramic) of the major 18:0 and 16:0 fatty acids could be identified in samples taken from the interior of two of the vessels. These ceramic samples were then re-extracted by alkaline saponification to release higher quantities for analyses by GC-C-IRMS (see Stern et al. 2000; Craig et al. 2004). The results are shown in Figure 2. Both of these milk jugs had $\Delta^{13}C$ values greater than –3.3‰, indicating, contrary to our expectations, that they were not derived from remnant milk fats. Nevertheless, the milk protein bovine α_{s1}-casein was identified in one of these samples, both within the ceramic matrix and in the surface residue (Figure 1). The discrepancy in these findings may be reconciled by envisaging a scenario where small amounts of dairy products were mixed with much higher amounts of non-dairy fats during either a single use or throughout the artefacts' 'use history'. However, contamination with modern milk (proteins) during curation or over the many years that material was stored, although unlikely, cannot be ruled out and may explain the strong positive reaction with the anti-

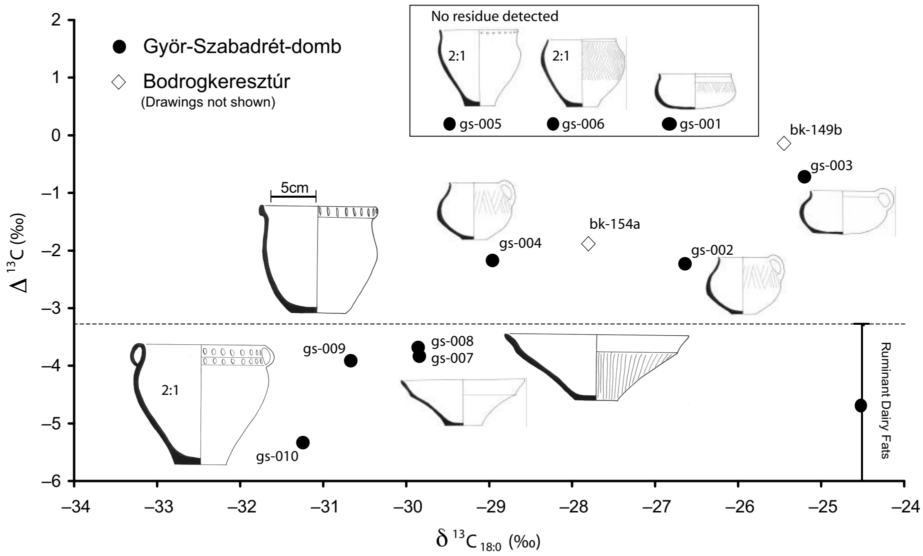

Figure 2. *Plot of the difference in the $\delta^{13}C$ values of 18:0 and 16:0 fatty acids ($\Delta^{13}C$ value) against the $\delta^{13}C$ value of the 18:0 fatty acid extracted from various Copper Age ceramic vessels. $\Delta^{13}C$ of pottery extracts which plot below the dashed line (i.e. <3.3‰) indicate the presence of ruminant milk. $\Delta^{13}C$ values between –1‰ to –3‰ are indicative of ruminant adipose fats; whereas values > –1% are typical of non-ruminant lipids; such as porcine or fish fats. Fatty acids methyl esters (FAMEs) were prepared prior to analysis by GC-C-IRMS by methylation of saponified solvent extracts or after direct alkaline saponification of the potsherd. FAMEs were analysed using a Hewlett Packard 5890 gas chromatograph attached to a PDZ Europa Geo isotope ratio mass spectrometer using a 30 m × 0.32 mm I.D. fused-silica column coated with BPX70 stationary phase. Temperature program = 130°C (2 min); 130°–190°C at 4°C/min; 190°C (2 min). The values were corrected for the derivitization. Extracts were run at least in triplicate with analytical precision of ±0.3‰. The range and mean $\Delta^{13}C$ values obtained from a modern ruminant milk samples (n=8) are shown. These data are from Craig et al. (in press) and are derived from bovine, ovine and caprine samples fed on a range of pastures and fodders. The modern samples have been corrected for contamination with post-industrial carbon (Friedli et al. 1986) and are consistent with values obtained by Copley et al. (2003).*

casein antibody (Figure 1). An external sample of this vessel was not available to make this distinction.

The middle Copper Age milk jugs from Kisvárda and Tiszavalk-Tetes tested negative for bovine α_{s1}-casein. The presence of milk other than cows' on these vessels or extensive protein degradation could equally explain this finding. Lipids were extracted from the Tiszavalk-Tetes jug and analysed by gas-chromatography. Very small amounts of fatty acids (<1 μg per g of ceramic) were identified amongst a complex mixture of contaminating molecules, including plasticizers (phthalate esters) and soil derived components (hydrocarbons, alcohols). In this case, alkaline saponification did not produce enough lipids on which to make single compound measurements.

Appreciable amounts of lipids (0.5–1 mg per g of ceramic) dominated by mid-chain fatty acids were identified by GCMS in seven of the ten vessels from the late

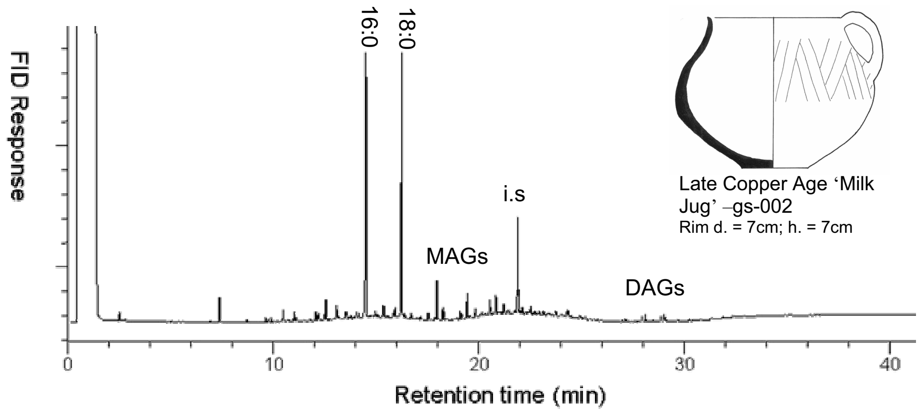

Figure 3. *Total gas chromatograph of partly degraded animal fat extracted from 'milk jug' – gs-002. (Drawing of complete pot shown in inset.)*
Lipids were extracted with chloroform/methanol (2:1) and derivitized with N,O-*bis(trimethylsilyl) trifluoroacetamide containing 1% v/v chlorotrimethylsilane. The resulting trimethylsilyl derivatives were analysed on a Hewlett Packard 5890 gas chromatograph with a 15 m × 0.32 mm, bonded-phase fused-silica capillary column coated with DB-1HT stationary phase. Temperature programming was from 50 to 350°C at 10°C min^{-1}, after a 2 min isothermal hold at 50°C. Peaks were identified by comparison with known standards and by mass spectrometry. 16:0 = palmatic acid; 18:0 = stearic acid; i.s. = internal standard (20µg n-tetratriacontane); MAGs = monoacylglycerols; DAGs = diacylglycerols.*

Copper Age settlement at Győr-Szabadrét-domb. Contamination was only observed in one of these samples. A typical gas chromatograph of an endogenous lipid residue is shown in Figure 3. The most abundant lipid species in this sample are stearic acid (C18:0) and palmatic acid (C16:0) with lesser amounts of monoacylglycerols and diacylglycerols. These components are the major decomposition products of triacylglycerols, the main component of natural fats and oils. The relatively large abundance of stearic acid observed in these sherds indicates the presence of degraded animal fats rather than plant lipids, which only contain minor amounts of this compound (*c*. <5 mole %) relative to palmitic acid. Isotopic analysis of both these acids using GC-C-IRMS (Figure 2) reveals a diverse number of sources for the lipids in these vessels. The $\Delta^{13}C$ values of the 'milk-jugs' analysed were more consistent with ruminant adipose fats rather than milk fats. However, several of the other vessel types did show evidence of milk, with $\Delta^{13}C$ values of less than –3.3‰. Two of these vessels, both carinated dishes, produced positive results against the anti-bovine α_{s1}-casein antibody, indicating the presence of cow's milk (Figure 1). Substantial mixing of products in these pots is likely as the $\Delta^{13}C$ demonstrate considerable heterogeneity throughout the assemblage.

DISCUSSION AND CONCLUSIONS

In this article, the authors set out to investigate whether or not the function of one of the best-known pottery 'types' in the Copper Age of Central Europe – the middle Copper Age milk jug – matched its name. The name was derived from ethno-historical parallels of the vessel form, specifically its long neck and prominent belly. Identifying the use of these vessels was important not only in the context of Copper Age ceramics, where the milk jug is treated as an important type-fossil, but also in the current debate in European prehistory over the prevalence and intensity of dairying practices.

Our expectations that milk jugs would contain traces of milk were not fulfilled. Out of eight examples, milk protein was identified in only one vessel and this could not be verified by complementary lipid analysis. These results place serious doubt on the functional identification of this type of vessel as a milk jug. However, this vessel type was not devoid of organic residue completely, as fats most likely derived from ruminants were identified in two of the Győr-Szabadrét-domb handled cups. Similar ruminant-derived residues were identified on another example from Bodrogkeresztúr, whilst yet another Bodrogkeresztúr 'milk jug' contained a residue that was most likely derived from a non-ruminant source.

Intriguingly, however, milk *was* identified in the other types of vessels: two carinated dishes, a necked jar and a large storage jar. This confirms the use of dairy products in half of the Boleráz vessel types investigated. Possible other uses of Győr-Szabadrét-domb 'milk-jugs' include the storage or consumption of mixed ruminant and non-ruminant animal fats.

One of the many archaeological strategies that has evolved to extend our understanding of vessel function (and ultimately activities occurring at archaeological sites) is the inference of function from form (Rice 1987). One of the principal sources of information for such an inference is analogy, whether modern, historical, ethno-historical or ethno-archaeological (Kramer 1985). We propose that independent scientific testing of functional inference should be built into research strategies to provide a wider suite of comparanda for assessment of formal analogy. Another example is the claimed identification of the function of a distinctive Adriatic Neolithic ceramic type as a 'salt pot' (Chapman 1988): analytical methods are now under review to test for the survival of salt-derived products in ceramics.

In relation to our first aim, the failure to support a dairying function for milk jugs does not falsify the claims for intensification of secondary products in the central European Copper Age (Sherratt 1997) but it does challenge the supposition based on formal analogies inherent in the dairy products aspect of the secondary products scenario. What the current data does is to falsify Hillebrand's claim that Bodrogkeresztúr 'milk-jugs' were used for dairying products. Since we have not yet tested other middle Copper Age vessel shapes, it cannot be currently demonstrated that the intensification of dairying took place in this period. However, we can point to a new and expanded range of *late* Copper Age vessel types in which dairy products were processed – the carinated dish, one-handled necked bowl, one-handled jug, necked amphora and two-handled amphora (Figure 2). These vessels combine to represent a sizeable part of the Boleráz ceramic assemblage and have many formal parallels in other late Neolithic/ Copper Age assemblages. It is also noteworthy that two examples of what are termed 'jugs' contained no signals, as was the case with one other necked bowl. Thus, our third aim of documenting dairying in the late Copper Age was realized.

Two further points should be emphasized – the first concerning further investigations, the second museum policy. It is desirable that the investigations are extended in three directions:

1. a wider range of Copper Age milk jugs
2. other examples of vessels shown to contain milk in Boleráz contexts
3. other vessel types purportedly linked to dairying, such as the so-called Baden 'submarine' – a vessel form compared to the supposed milk churns of the Palestinian Copper Age Ghassulian ceramic assemblage (Sherratt 1981).

The second point concerns the post-excavation treatment of pottery. It is standard practice in several major museums in Central and Eastern Europe to remove calcareous concretions on the surface of the pottery by washing in an acid solution (usually hydrochloric acid). While it is recognized that detailed study of the surface treatment and decoration of the vessel is often impossible without some form of cleaning, museum archaeologists and conservators should be aware that in certain cases this can make scientific analysis of lipids and proteins particularly difficult. Equally the introduction of modern organic contaminates during conservation can hamper the identification of the original vessel contents. This study has shown that, despite extensive treatment with acids, the milk jugs from the Magyar Nemzeti Múzeum can still produce a weak lipid signal. None the less, there is a high probability that acid hydrolysis will have destroyed much of the original ancient biomolecular evidence, especially more labile biomolecules such as proteins and DNA. Museum colleagues are asked to take this problem into account in future treatment of their artefacts.

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BIOGRAPHICAL NOTES

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ABSTRACTS

«Pots de lait» et autres mythes de l'âge du cuivre en Europe Centrale
Oliver E.Graig, John Chapman, András Figler, Pál Patay, Gillian Taylor and Matthew J.Collins

Résumé: Une analyse de résidus organiques fut effectuée sur les céramiques de deux séries, à savoir une collection de récipients de l'âge du cuivre moyen (Bodrogkeresztùr), jusqu'ici connus sous le nom de «pots de lait» et conservés au musée Magyar Nemzeti de Budapest ainsi qu'une collection de récipients du début de la période de Baden (Boleràz) et provenant du village récemment découvert de Győr-Szabadrét-domb, en Hongrie occidentale. Le but de cette analyse est de savoir si oui ou non ces vases, qui, d'après leurs caractères typologiques sont souvent associés au lait, étaient effectivement utilisés pour traiter, conserver ou servir des produits laitiers. Les résultats de l'analyse montrèrent qu'aucun produit laitier n'a pu être identifié avec certitude dans les soi-disant «pots de lait». Néanmoins, des produits laitiers furent reconnus dans d'autres types de récipients.

Mots clés: âge du cuivre, analyse de résidus, lipides, protéines, produits laitiers, produits secondaires, Hongrie

"Milchkrüge" und andere Mythen der mitteleuropäischen Kupferzeit.
Oliver E.Graig, John Chapman, András Figler, Pál Patay, Gillian Taylor and Matthew J.Collins

Die keramischen Gefäße zweier Sammlungen wurden einer Analyse organischer Rückstände unterzogen. Dabei handelte es sich um eine Serie mittelkupferzeitlicher (Bodrogkeresztúr) Gefäße, die bislang unter dem Begriff "Milchkrüge" bekannt geworden sind, aus den Beständen des *Magyar Nemzeti Múzeum Budapest* sowie eine Kollektion von Behältnissen der frühen Badener Kultur (Boleráz) aus der kürzlich entdeckten Siedlung von Győr-Szabadrét-domb in Westungarn. Das Ziel der Analysen war, festzustellen, ob diese Gefäße, die oft aufgrund typologischer Kriterien mit Milch in Verbindung gebracht werden, tatsächlich für die Herstellung, Lagerung oder den Ausschank von Milchprodukten genutzt wurden. Die Ergebnisse der Analysen zeigten, dass sich Milcherzeugnisse nicht mit Sicherheit in den sogenannten "Milchkannen" identifizieren ließen. Dennoch wurden Milchprodukte in anderen Gefäßtypen nachgewiesen.

Schlüsselbegriffe: Kupferzeit, Analyse von Rückständen, Lipide, Proteine, Milchwirtschaft, Nebenprodukte, Ungarn