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CERAMIC VESSELS AS COOKING POTS.
Use-wear analysis with experimental archaeological methods

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Surpassing mere typological description, pottery analyses have recently been increasingly engaged in evaluating the functional roles of vessels and reconstructing the nuanced ways they could have been used in the past. Therefore, it has become necessary to apply scientific methods and examine, specify, and sometimes re-interpret the current typological framework rooted in traditional denominations and morphological associations. This paper investigates the generic roles of cooking pots, taking, besides morphological characteristics, use-wear traces into account.

The article presents a detailed description of the general methodology applied in a series of cooking experiments in 2022 and one of the open-air cooking methods. The goal of the experiments was to reconstruct and document the transformation pottery vessels undergo during cooking, including the characteristic traces of cooking-related changes induced by high temperatures and contact with fire.

Keywords: experimental archaeology, use-wear analysis, cooking experiment, traces of cooking, pottery typology

FORM AND FUNCTION

The barrel-shaped or globular pot with an everted rim, a pronounced or curved shoulder, a short neck, a flat base, and with or without handles is a distinct type used throughout the entire Bronze Age (Bóna 1975; Kemenczei 1984; Kulcsár 2009). Based on its formal characteristics and ethnographic analogies, Hungarian research has seen such vessels traditionally as cooking implements. Primary publications of archaeological materials rarely and to varying extent mention additional methodological aspects concerning the function of ceramic vessels (Michelaki 2006; Szathmári 2009; Nyíri 2013; Gucsi & Szabó 2018; P. Fischl 2023; Szabó 2023). This approach, however, draws a simplistic – or at least slightly misleading – picture of the potential functional variety of the vessels identified as 'pot', also calling attention away from the possible other functions they sometimes had simultaneously (Csupor & Csuporné Angyal 1998, 58–100; Skibo & Schiffer 2008, 44–51; Szathmári 2009, 296; Nyíri 2013, 167). Furthermore, the morphological approach alone does not take into account secondary use, changes in function, and the related secondary symbolic transformations, which may stem from the object becoming damaged or worn (Rice 1987, 299) or having been entered into a new context (e.g., a burial; see Gucsi 2023, 382). Therefore, it is especially important to consider, besides morphological characteristics, the following aspects when determining a functional category (in this case, cooking pots).

Certain *technological traits* indicate the conscious choices the potter had made with an eye to the planned function of the future vessel. During cooking, cooking pots are exposed to various mechanical impacts (e.g., the vessel being moved and cleaned, its content stirred, etc.) and heat stress to various extent, which may affect certain parts differently. Therefore, the technological choices made by the potter are likely to have been influenced by the future function of the vessel, along with environmental and economic factors and cultural traditions (Sillar & Tite 2000; Kreiter 2006). The selection of raw materials and the tempering (Tite, Kilikoglou & Vekinis 2001; Kreiter 2007, 147–149), the form, the size, and the wall thickness (Braun 1983; Rice 1987, 236–242; Skibo 2013, 101–103), the decoration and treatment of the dry surface before firing (Schiffer 1990; Schiffer *et al.* 1994), and the firing temperature (Müller *et al.* 2013, 5–6;

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Skibo 2013, 101–103) reflect conscious choices in the process of pottery-making. These choices were influenced by, amongst other aspects, the intended cooking function and the cooking techniques employed by the then-future users (Rice 1987, 237; Michelaki 2006, 16; Müller *et al.* 2013, 4–7).

The documentation and interpretation of *use-wear traces* may be a powerful tool in determining the original function of a vessel. Repeated stirring, turning, moving, and cleaning causes a variety of physical damage (e.g. chipping, scratching, abrasion), while direct or indirect exposure to high temperatures and repeated heat shock also induces characteristic changes to certain parts of the vessel (e.g., cracking, spalling, discolouring; Skibo 1992, 105–173; Gucsi 2001, 197; Rösel 2014; Forte, Nunziante-Cesaro & Medeghini 2018, 121–123).

Scientific analysis of organic residues found on the vessel's surface or preserved in deeper layers of the ceramic matrix may provide direct information about whether the object was in contact with food and perhaps even more details (Barnard & Eerkens 2016).

Post-depositional processes such as fragmentation and erosion can primarily influence the quality and quantity of analytical aspects possibly relevant to the functional identification of a complete or incomplete vessel (Forte 2022, 31). Therefore, it is important to reconstruct the phase following the vessel's use life and the potential transformation it has undergone in that phase by a targeted examination of the archaeological context (Brönnimann *et al.* 2020).

COOKING TECHNOLOGIES AND EXPERIMENTAL ARCHAEOLOGY

The methodology of experimental archaeology provides a special toolkit to investigate all the above aspects in detail. The complete reconstruction of entire processes, the analysis of extensive sample series, and the independent or joint evaluation of certain variables open the possibility of testing archaeological observations in practice (Forte, Nunziante-Cesaro & Medeghini 2018), thus improving our understanding of the physical properties of ceramics (Tite, Kilikoglou & Vekinis 2001) and certain technological choices (Schiffer *et al.* 1994), which may lead to the introduction of new analytic methods (Evershed 2008), developing a critical approach in the study of archaeological assemblages (Beck *et al.* 2002), and opening a discussion about specific issues, such as various cooking techniques (see this paper).

Save for a couple of exceptions (Gucsi 2001), Hungarian archaeological research has not been engaged in scientific experiments that follow and meticulously document cooking technologies and the changes cooking induces on ceramics. Therefore, in the following section, a session of the series of experiments we conducted is presented in detail to provide insight into the considerable methodological and other potential of the field.

A SERIES OF COOKING EXPERIMENTS

In April and July 2022, a series of experiments were conducted at Majosháza (Pest County) in four sessions. The primary aim was to study the traces of direct and indirect exposure to heat left on four replica vessels and assess to what degree these traces can be used to reconstruct or identify specific cooking methods.

Of the many variables, four aspects were selected and considered in detail.

1. *Form and size of vessels*. The replicas used in the experiment differ in form and size to various extents. Vessel no. 1 is a deep, large bowl, representing a characteristic Early and Middle Bronze Age type; it is a direct replica of a piece from the Budajenő ceramic depot (Gucsi & Szabó 2018, Fig. 30.2). Its wide mouth and slightly curving neck provide easy access to its content, the globular shoulder and belly secure a relatively large capacity (3 litres), while the low design and wide, flat base provide it with stability. Additionally, by grabbing onto the two wide, sturdy band handles arching over the neck one could lift or move the bowl safely (*Fig. 1.1*). Vessel no. 2 represents a cooking pot variant used throughout the entire Bronze Age; this particular vessel, however, was designed after the leading cooking vessel type of the Jobbágyi-Hosszú-dűlő cemetery from the beginning of the Late Bronze Age (Fülöp & Váczi 2014). Despite the narrower mouth, its contents are still easily accessible; the tall, barrel-like body can

Fig. 1. Replica vessels used in the experiments with their volumes and the ingredients of the meals cooked in them

hold three litres. The two relatively wide band handles make it easily transported; however, it must be used more cautiously as it has a relatively high centre of gravity (*Fig. 1.2*). Vessel no. 3 represents a less frequent type with no handles. It has a barrel-shaped body with a characteristic profiled shoulder; its relatively sturdy, low design makes it stable and easy to handle. It has a 1.1-litre capacity (*Fig. 1.3*). Vessel no. 4 (0.5 litres) is a replica of a classic Late Bronze Age, early Urnfield-style jug type. Given its narrow mouth, its contents were not so easily accessed; the inner and outer surfaces are highly burnished, and the outside of the globular body is covered by channelling. It has a large, high-swung band handle, providing a secure grip *(Fig. 1.4)*.

2. *The condition of the vessels.* Only vessel no. 1 (large, deep bowl) of the four was made specifically for the experiment. In line with its formal characteristics and size, vessel no. 4 was used occasionally (max. 20 times) as a drinking vessel and bore no signs of wear. Vessels no. 2 and 3 were transferred from a different experimental context. Originally, these pots were used as goods added to the pyre in experimental cremations in 2017 and 2018, and, having been exposed to high temperatures, have become secondarily burnt partially (vessel no. 2) and fully but moderately (vessel no. 3), respectively (Fülöp 2018).

3. *The contents of the vessels.* Four different types of food were prepared in the four vessels. No. 1: soup – 500 g lentils, 2000 ml water; no. 2: jam – 1500 g strawberry/wild berry; no. 3: porridge – 300 g millet, 750 ml milk; no. 4: porridge – 50 g oats, 300 ml milk. Each vessel was used for preparing the same type of food in different experiments without changing the type and quantity of ingredients.

4. *The context of cooking*. The spatial relationship between fire and vessel determines the cooking technique and is crucial in generating the type and character of use-wear traces. In order to investigate this further, three different cooking environments were designed. 1, a fireplace constructed of bricks with a concrete grate to simulate the cooking technique represented by the portable stoves of the Middle and Late Bronze Age, i.e. replicating the vertical and indirect relationship between the heat source and the cooking vessels (P. Fischl, Kiss & Kulcsár 2001a; 2001b). 2, the second context involved a simple open fire, where cooking vessels were placed right next to the heat source, creating direct but partial contact between the vessels and the fire. 3, in the third context, the replicas were placed directly in the middle of an open fire to simulate direct and complete contact with the heat source.

Each vessel was used for cooking on four occasions, once in the first and third contexts (portable stove and full contact with open fire) and twice in the second (partial contact with open fire). Detailed written and photo documentation was prepared before the experiments and after cooking (before and after cleaning the pots). Furthermore, before the first, third, and fourth experiments, the vessels were documented by a Hexagon Aicon SmartScan optical 3D scanner.[3] All four experiments were documented from start to end by notes, photographs, videos, and time-lapse footage. The temperature of the heat hitting the vessel surface and that of the contents were monitored by a Type K thermocouple and a Voltcraft PL-125-T2USB VS thermometer in regular five-second intervals during the entire experiment (*Fig. 4.1b–4b*). The temperature of the vessels' external surface was also measured at shoulder height every five minutes, first at a single point, then at two points during the first experiment and at four points during the remaining sessions with a HoldPeak HP-1500 digital infrared thermometer (*Fig. 4.1a–4a*). The following part presents the third session and the first results.

SESSION NO. 3

The cooking experiment was successful in all vessels. Each pot was placed on a bed of hot embers, and the fire was fed occasionally. The dynamics and duration of cooking depended primarily on the characteristics of the ingredients and the type and quantity of the meals prepared.

The lentils had been soaked for 2.5 hours before cooking, before being boiled in 2 litres of water: it took 46 minutes for 0.5 kg of lentils to be cooked properly. The cooking vessel was placed in the centre of the fire at 332°C (*Fig. 2.1a*). Fifteen minutes later, the lentils produced a layer of foam covering the soup's surface. After another 15 minutes, the foam thickened and began to stick and burn onto the internal wall of the vessel (*Fig. 2.1b*). After another five minutes, the soup started to boil (*Fig. 2.1c*), and finally, 11 minutes later, the lentils were cooked (still covered by a thick layer of foam), and the vessel was removed from the fire (*Fig. 2.1d*).

For the jam, 1.5 kg of defrosted but still cold strawberries was cooked for 1.5 hours. The vessel was placed at the centre of the fire at 413°C (*Fig. 2.2a*). After six minutes of cooking, the strawberry liquid started producing foam, which rose unceasingly and, despite constant stirring and even placing the vessel further away from the heat source, boiled over after 17 minutes (*Fig. 2.2b*). Six minutes later, the lower drops of the boiled-over jam running down the vessel's exterior began to burn onto the surface (*Fig. 2.2c*). Even though 300 ml liquid was removed from the vessel after it had boiled over (which was added back later, in the 52nd minute of the experiment), the foam of the jam rose again in the 40th and 63rd minutes; however, on these occasions stirring prevented it from boiling over. The vessel was removed from the fire following the moderate thickening of the jam in the 90th minute (*Fig. 2.2d*).

The porridge prepared using 700 ml of cold milk and 300 g millet was ready in 20 minutes. The vessel was placed at the centre of hot embers at 465°C *(Fig. 3.3a)*. Three minutes later, the milk began to bubble by the vessel's wall *(Fig. 3.3b)* and, despite constant stirring, boiled over in the 16th minute, temporarily putting out the fire on that side *(Fig. 3.3c)*. Two minutes later, the milk adhering to the vessel's outer side started to get burnt. As the millet soaked up the milk pretty quickly and began sticking to the bottom despite constant stirring, the vessel was removed from the fire a few minutes later (*Fig. 3.3d*).

The oat porridge was prepared using 50 g of oat flakes and 300 ml of cold milk; the process took 21 minutes. The vessel was placed at the centre of hot embers measuring 210°C (*Fig. 3.4a*). The milk began to froth in the 7th minute, first along the vessel walls. After 12 minutes, the entire surface was covered by foam that rose and thickened quickly (*Fig. 3.4b*), and only continuous and vigorous stirring prevented it from boiling over (*Fig. 3.4c*). Six minutes later, the pot was removed from the fire as the porridge was ready and nearly boiling over (*Fig. 3.4d*)

OBSERVATIONS AND USE-WEAR TRACES

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Fig. 2. 1a, Vessel no. 1 at the centre of a fire at 332°C; 1b, food particles sticking and burning to the inside of the vessel; 1c, intensively boiling lentil soup; 1d, the cooked lentil soup. 2a, Vessel no. 2 at the centre of a fire at 413°C; 2b, all efforts were in vain to prevent the foam from boiling over; 2c, burnt jam residue on the outside of the vessel; 2d, the finished strawberry jam

Fig. 3. 3a, Vessel no. 3 at the centre of a fire at 465°C; 3b, bubbling milk by the vessel wall; 3c, milk boiling over; 3d, the finished millet porridge. 4a, Vessel no. 4 at the centre of hot embers at 210°C; 4b, thickening milk froth; 4c, vigorous stirring to prevent boiling over; 4d, the finished oat porridge

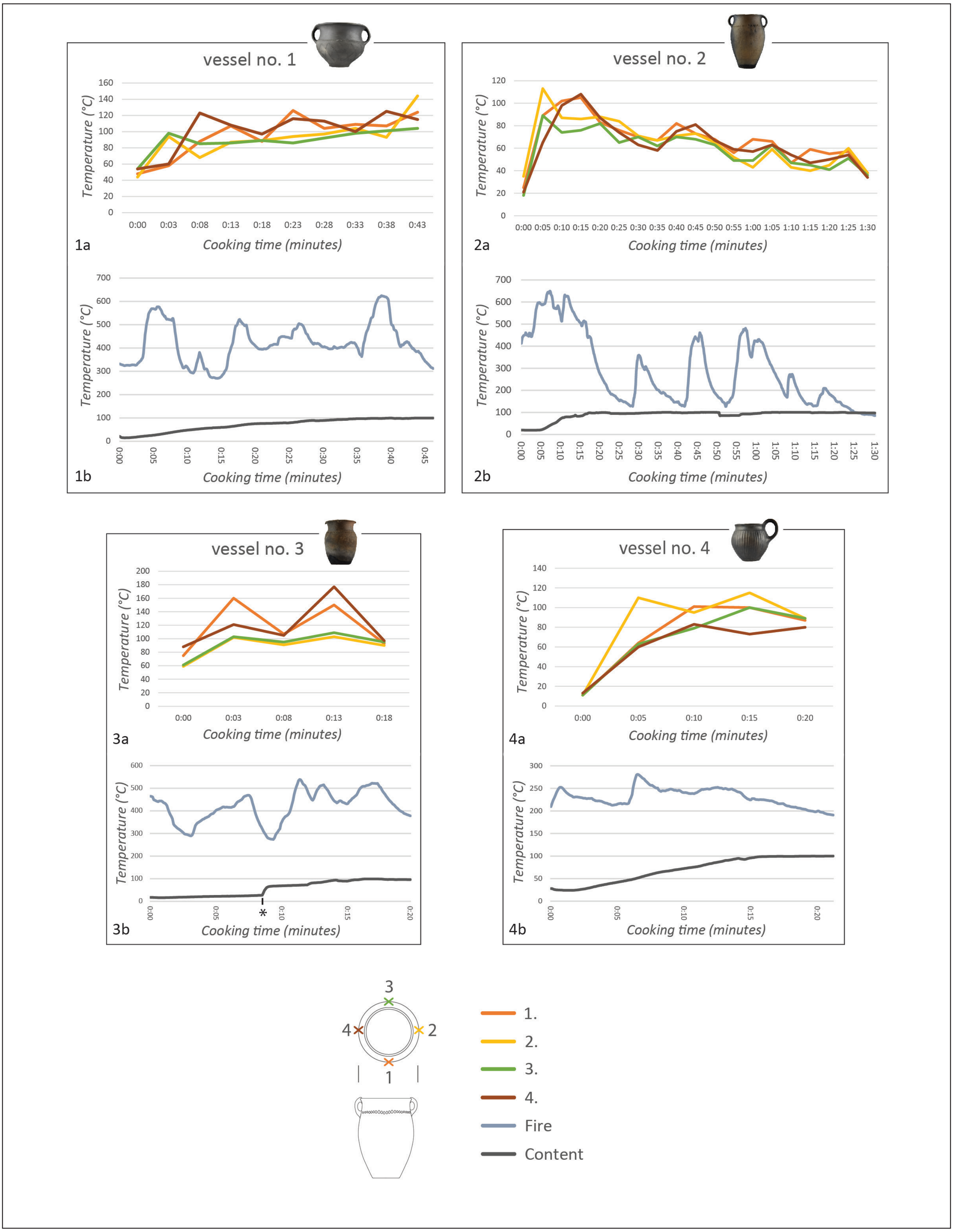

*Fig. 4. 1a–4a, surface temperatures beszúrás: of the cooking vessels measured at four different points during cooking (at 5-minute intervals); 1b–4b, the temperature of the fire and the contents during cooking (measured at 5-second intervals; * – dislocation of the measuring probe caused a sudden change in the temperature curve*

All vessels were placed at the centre of the fire or on a bed of hot embers at a temperature between 210 and 465°C. Due to exposure to such high temperatures, cooking and the vessels' transformation began immediately. The two most characteristic and frequent forms of transformations are discussed below.

The first and most prominent sign of direct contact between the fire and the cooking vessel is the pot being covered by soot to some degree. The quantity and quality of the soot depends on the temperature of

Fig. 5. 1, Soot covering almost the entire surface of vessel no. 1; 2, compact, lustrous soot layer on the neck and shoulder of vessel no. 2; 3, grey, yellow-grey oxidised patch on the bottom of vessel no. 3 where it was in direct contact with hot embers; 4, vessel no. 1 before washing after the third cooking experiment, covered by a layer of fine soot; 5, vessel no. 3, washed after the third cooking experiment; 6, vessel no. 2, cleaned after the third cooking experiment, featuring a compact, shiny soot patch; 7, vessel no. 3 before the third cooking session with red and yellow-brown surface; 8, the outer side of vessel no. 3, covered by a black soot layer after cleaning following the third cooking experiment; 9, vessel no. 3, cleaned after the third cooking, with grey and yellow-grey oxidised patches above the base

the fire, the temperature of the vessel surface, and the type of firewood used (Rice 1987, 235; Skibo 1992, 157–171). The first soot patches formed already in the first five minutes of cooking (*Fig. 5.1*), appearing as a black, powder-like layer that started building up immediately when the vessel came in contact with fire and covered most of its external surface. It was easily detached from the surface by touch and could be completely washed off with cold water (*Fig. 5.4–5*). Another similarly characteristic residue type was shiny black soot patches. This kind of soot contains, besides coke, charcoal, and ash, a form of resin that, adhering to the gases produced, precipitates on the relatively cold vessel surface and forms a shiny, compact layer (Skibo 1992, 161–162; Skibo 2013, 91). The process is intensified by the cooling effect of liquids (Skibo 1992, 164). Due to their sheen, patches of such residue were easy to recognise from the 4th–5th minute of cooking on different parts of the vessel (*Fig. 5.2*). In contrast to the powder-like, 'regular' soot, this type was totally resistant to washing in cold water and only lost its sheen at places (*Fig. 5.6*). Another variant of this residue has no sheen but likewise strongly adheres to the vessel surface and is also resistant to a cold wash (*Fig. 5.7–8*). This high durability may be a good basis for interpreting pottery finds with similar traces.

The clearest sign of ceramic vessels being exposed to high temperatures is the presence of oxidised patches. Interestingly, this only occurred sporadically, and at certain areas, mainly because the formation of oxidised patches requires the soot to have been burnt off completely at a temperature of around 400°C; moreover, later, with a decrease in temperature, soot may start forming again and potentially covers previously oxidised areas (Skibo 1992, 159–161; Forte, Nunziante-Cesaro & Medeghini 2018, 130). Several factors influence reaching the threshold where carbon-rich materials can burn away. One of the main obstacles is a fundamental characteristic of open fire: uneven and rapidly changing heat, determined primarily by the presence or absence of flames, as illustrated perfectly by the undulating temperature curves consisting of the data points measured at the base of the vessels (*Fig. 4.1b–4b*). Food type and cooking method also play a significant role, as liquids constantly cool the surface (Skibo 2013, 91–92). As indicated by the low temperatures measured at shoulder height, the upper part of the vessels remained relatively cool throughout the experiments (*Fig. 4.1a–4a*). Therefore, oxidised patches only formed on the lower parts, constantly exposed to high temperatures. The most characteristic example of this is vessel no. 3 (with millet porridge), on which oxidised patches were already present in the sixteenth minute of cooking (*Fig. 5.3*). After removing it from the fire, a 3–5 cm wide, grey and yellow-grey zone, partially oxidised to varying degrees, could be observed above its base (*Fig. 5.9*).

CONCLUSIONS

Depending on the find context and the condition of the artefact, most of the use-wear traces discussed above is relatively easy to observe in the archaeological material. Experiments like the one presented above are important as they provide a good base for reconstructing the ways and contexts where particular use-wear traces could have been formed or created. However, making this approach an efficient tool requires larger experiments, well-considered research questions, and a uniform and well-thought-out documentation protocol. Therefore, besides the interpretation and comparative evaluation of the other three sessions, we plan to conduct similar cooking experiments in the near future. We aim to develop a new methodological tool which, completing morphological typology, enables us to identify the presumably broad spectrum of actual cooking pots in the archaeological material of settlements and even amongst grave finds (Gucsi 2023, 381).

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