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Functionality of early medieval roasters studied using archaeobotany and chromatography: preliminary studies

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Abstract

Roasters are clay, quadrilateral vessels that are found in areas of whole Slavic region. For years, there has been a discussion on their functionality, in which various concepts of their use keep appearing. In this paper we present the results of botanical and gas chromatographic studies carried out on several fragments of roasters that originated in the Sudetes Mountain area and Sudetic Foreland. The analyzed artefacts in total of 26 pieces come from three early medieval sites: Gilów, Jelenia Góra–Grabary and Kamieniec Ząbkowicki. The obtained results allowed to concluding that these were the vessels used for thermal processing of cereal grains in both processes of food processing and food preservation. The results made it possible to move the beginnings of agrarian activity in the Sudetes Mountains by 400 years, earlier than it was thought, which has a key meaning for observation of the economy development in mountainous areas in the early Middle Ages.

Keywords: Roasters, Chromatographic analysis, Botanical studies, Slavic region

Introduction

Clay roasters can be found mainly in the Western and Southern Slavic region and on its borderlands. They have been found in over 200 sites in Poland, the Czech Republic, Germany, Slovakia, Ukraine, Belarus, as well as the Baltic and Balkan countries [1–4] and are considered to be a product typical of Slavs living in Central Europe from the sixth to the tenth century [2, 5–8]. According to some authors, they were also used sporadically between the eleventh and thirteenth century [6, 9, 10]. Linguists and ethnologists also point out to the origin of its name (*prażnica*), identified with the preparation of the so-called roast (*prażmo*), i.e. dried or toasted unripe wheat or rye grains [11]. The prevailing opinion in the literature on the subject is that roasters were mainly used for heating and roasting grain and legumes in order to clean it before grinding or preparing the roast [2, 10–15]. Such usage is also indicated by ethnographic sources: *"The benefits of roasting have been long recognized as it significantly increases the taste of grain, makes it more digestible, changing starch into dextrin and sugar, and also partially transforming protein. It was used to thoroughly dry grain, but also to remove the unpleasant smell from stale grain. Its use was quite extensive."* ([16]–author's own translation).

In the discussion on the function of roasters, some researchers also identified them with hardening metal products [17] or smelting [18]. However, they are mostly associated with the processing of crops, less often of animal-based products. Jaroslav Škojec [10] suggested as many as 10 potential functions they could have. In addition to the above, on the basis of a rich collection of more than 800 roasters from the early medieval site Mikulčiče in Czech Republic, he also distinguished roasters that could be used as portable fireplaces, bread baking forms, malt-making vessels and accessories related to grinding grain.

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The aim of the article is to present the results of chromatographic and botanical studies carried out on roaster fragments from the Sudetes and Sudetic Foreland. No previous research employing these methods has been conducted in the context of the function and use of these vessels. The article aims to be a contribution to a broader discussion on their function. In addition, research on roasters from mountainous areas will provide new information on the economy and processing of agricultural crops in regions where agriculture played a marginal role in the early Middle Ages. Settlement and agriculture are well confirmed in the Sudetic Foreland, but such studies are particularly important for the area of the Sudety Mountain (Jelenia Góra example), considered anecumenical or subecumenical in terms of medieval settlement and agricultural activity before the thirteenth century [19, 20].

The archaeological sites where fragments of roasters were found are located in Gilów (Sudetic Foreland–Niemczańsko-Strzelińskie Hills), Kamieniec Ząbkowicki (Sudetic Foreland–Otmuchów Depression) and Jelenia Góra Grabary (Western Sudetes – Jelenia Góra Valley). All these sites come from the same, tribal period of the Early Middle Ages and they are dated back to the ninth–tenth centuries. A total of 26 pieces of roasters were analyzed from these sites. It is worth pointing out that Sudetic Foothills and Sudety Mountains represent different types of geomorphological conditions, suitable for settlements in lower parts and rather inhospitable in the higher parts of the main Sudetic range.

Roaster form and construction

Roasters are rarely preserved in fragments that allow a complete reconstruction of their form. Researchers draw attention to the fact that often in the absence of characteristic edge and bottom parts, roasters may be confused with fragments of earthen floor and treated marginally in the subject literature [8]. Preserved and reconstructed roasters have the form of a quadrilateral tray with side lengths varying between 30 and 200 cm and a height of 4 to 20 cm [11, 21, 22] (Fig. 1). These shallow, thick-walled containers are made of poorly fired clay, thinned with organic admixture and sand [21]. Usually, their surfaces bear imprints of fragments of leaves and grass blades, grains and small twig fragments.

Another type of such a vessel (called baker) with a round outline was distinguished in the Czech, Slovak, Bulgarian and Balkan sites. According to ethnographers and archaeologists, these forms were used to bake bread. Thus, the nomenclature distinguishes between the tray-shaped roasters and round bakers [11]. So far, none of the latter have been identified among early medieval finds from the territory of Poland.

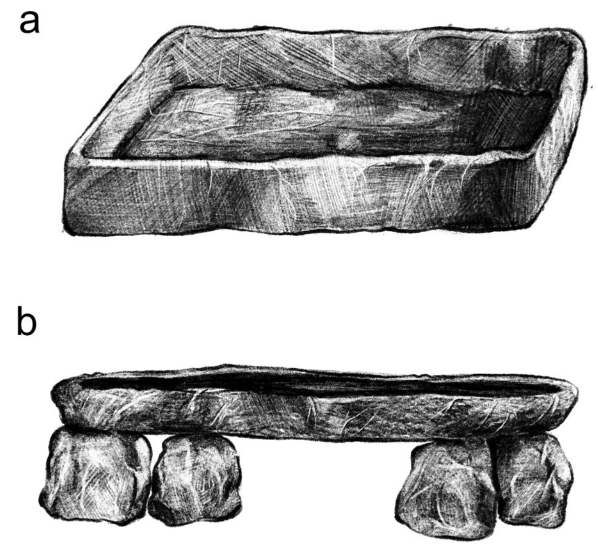

Fig. 1 **a** Form reconstruction **b** Method of placing roaster. (based on [23], drawing by E. Trawińska)

Roasters were situated directly on the ground, in deliberately dug pits, hollows or placed on stones which enabled lighting a fire underneath [23]. Some roasters were moved from one place to another, as indicated by the board imprints on the outer parts of some bottoms and through-holes [8], which made it possible to hold the vessel during transport [8]. Due to their weight and dimensions, they were probably transported short distances within settlements. According to some researchers, the board imprints and holes were made by a pallet during roaster production and are not related to transportation [8].

Material and methods

Materials

Apart from the sites discussed in this paper, several dozen fragments of roasters have been discovered in the Sudeten Foreland and Western Sudety Foothills, namely the following locations: Chwałków (settlement, eighth-ninth century, Ślęża Massif), Koźlice (hillfort, ninth-tenth century, Upper Lusatia), Krzepice (settlement, ninth–tenth century, Strzelińskie Hills), Tylice (hillfort, ninth–tenth century, Upper Lusatia) and Wójcice (settlement, eighth–ninth century, Otmuchów Depression) [24–27]. From the geographic point of view, most of the sites where fragments of roasters were (7 out of 8) are located in hilly areas, adjacent to the dense settlement zone of the lowlands. Only the settlement in Jelenia Góra–Grabary represents the remains of the ninth–tenth century activities in the internal part of Sudetes. The analysis included fragments available in museum inventories, well preserved and from structures with well-established chronology. Additionally, the artifacts had to be stored in dry and ventilated rooms, free from mold. After taking these factors into account, fragments from three archaeological sites were selected for pilot studies: Kamieniec Ząbkowicki, Gilów and Jelenia Góra (Fig. 2). The remaining roasters from the Sudetes were not available for studies or their condition did not allow it.

The first group of the selected roaster fragments was discovered in the ninth–tenth century settlement in Kamieniec Ząbkowicki. As a result of excavations led by Leszek Lenarczyk in 1984 [28–30] 12 structures were uncovered, 8 of them interpreted as remains of log-frame huts. In two of the buildings, a total of 135 roaster fragments were discovered, including 10 in the building designated as structure 11 and 125 in the hut designated as structure 12. The second group of the selected fragments comes from the Gilów stronghold, considered a short-term Great Moravian investment in Lower Silesia [25]. Several dozen roaster fragments were discovered in the Ninth–tenth century complex, in buildings located both within and outside the stronghold walls. Four fragments come from the excavation of the layer located on the borough embankment slope. They were accompanied by scattered, worn-out millstones. The context of these finds indicates that both artifacts were not fit for use and disposed by the dwellers of a nearby hut. Two roaster fragments from Gilów were discovered in building 4, having a much more solid structure than others within the stronghold. Its beams, with the diameter of up to 0.35 m, were placed on a layer of clay isolating the building from the ground. It is one of the few residential structures in Gilów with a hearth, which could have been related to the use of the roaster.

The last of the studied sites is the ninth-tenth century settlement, discovered in 2018 in Jelenia Góra–Grabary. Only 6 roaster fragments were found here, embedded in partially burnt orange clay with numerous charcoals, marked as structure 5 (Fig. 3a). The roaster was located on the edge of a larger building, most probably residential (structure 1). Micromorphological soil studies carried out by Mateusz Krupski allowed for the conclusion that these fragments were located in a heavily ground and mixed layer, most probably thrown out of the original context, similarly to the four fragments from Gilów.

Methods

Seven inventory numbers containing 23 samples were subjected to botanical analysis, three inventory numbers containing one sample each were analyzed with gas chromatography (Table 1).

Two samples from Kamieniec Ząbkowicki have the same inventory number, which is the result of assigning one number to all artefacts from one feature in the late 80's. The archaeobotanical study was carried out on samples of roasters and sediments from Gilów, Jelenia Góra and Kamieniec Ząbkowicki. Three samples were analyzed with gas chromatography: two from Jelenia Góra and one from Gilów. Such a choice was conditional on the consent of the institutions storing the artefacts for research (some of the roasters must have been slightly damaged). The archaeobotanical study was conducted in accordance with generally accepted principles [31–33]. All roaster fragments were measured and described, then, if necessary, cleaned with a soft brush and observed under a

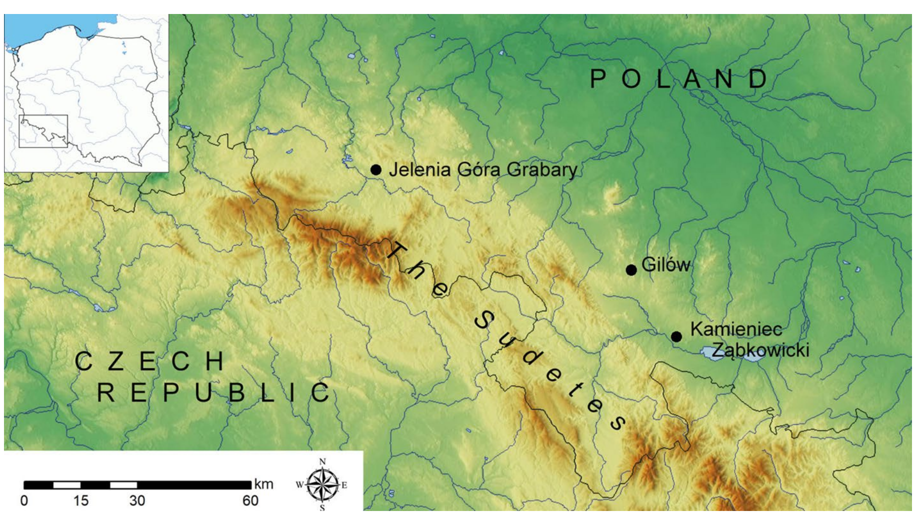

Fig. 2 Map of the sites discussed in the article (background, Openstreetmaps contribution, by E. Lisowska)

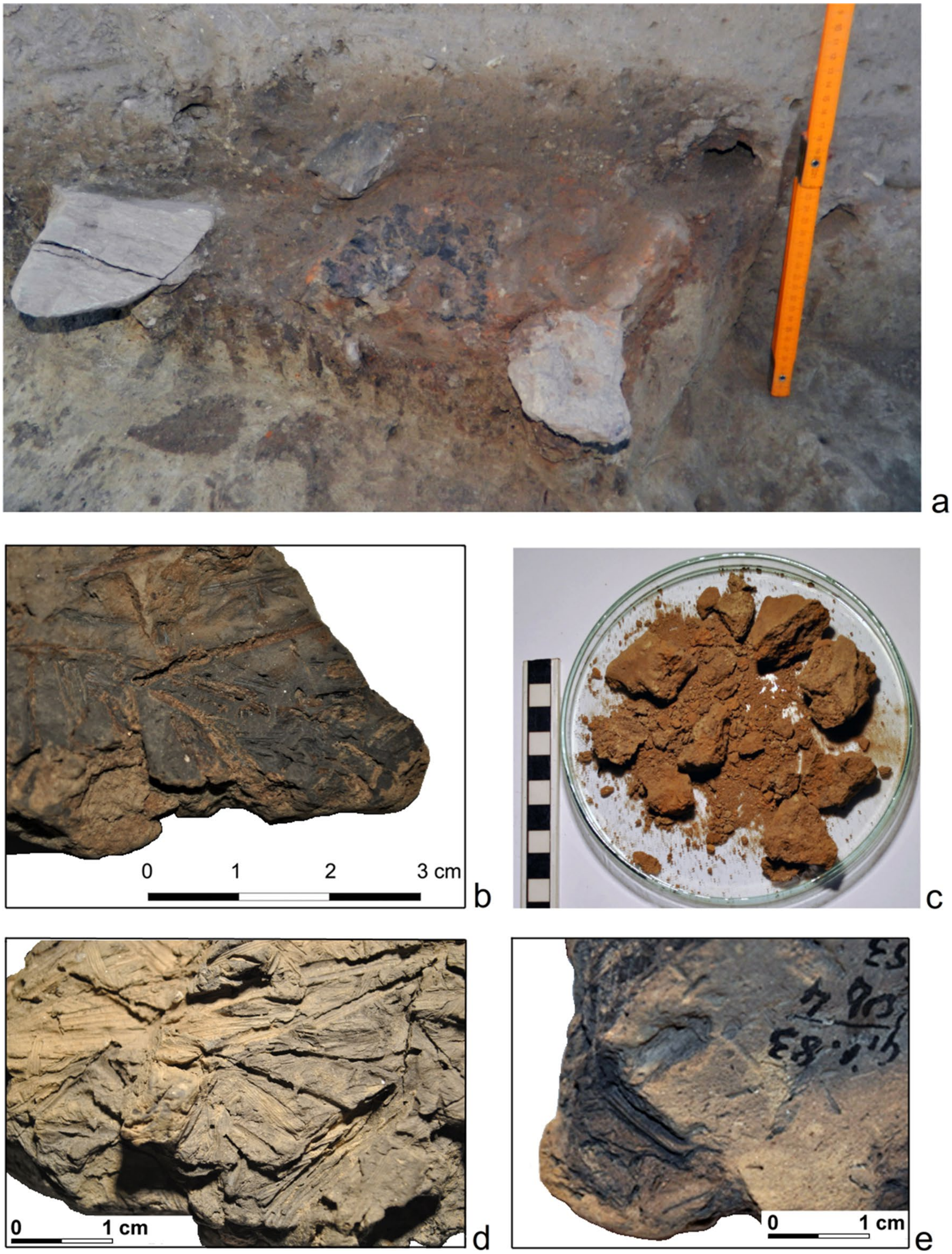

Fig. 3 Roasters: **a** Roaster in situ, Jelenia Góra–Grabary site **b**, **e** Roaster fragments from Gilów **c** Roaster fragments from Jelenia Góra–Grabary site **d** Roaster fragment from Kamieniec Ząbkowicki (photos by A. Sady; E. Lisowska)

Table 1 List of examined samples

Sample name	Inventory number	Archaeological site	Feature	Excavation manager (year)	Analysis type	Number of examined fragments
BotKam1	MOW/A/19/19:11	Kamieniec Ząbkowicki	Trench II/1984; feature no. 12	L. Lenarczyk (1984)	Botanical	1
BotKam2	MOW/A/19/19:11	Kamieniec Ząbkowicki	Trench II/1984; feature no. 12	L. Lenarczyk (1984)	Botanical	2
BotGil5	2002	Gilów	Trench II/80–82 (2002), refuse dump	K. Jaworski (2002)	Botanical	4
BotGil6	79c/82	Gilów	Trench I/82, feature 4	J. Kaźmierczyk, K. Bykowski (1982)	Botanical	1
BotGil7	83a/82	Gilów	Trench I/82 feature 4	J. Kaźmierczyk, K. Bykowski (1982)	Botanical	3
GilGC-MS4	I/1982–88	Gilów	Trench I/82–88	J. Kaźmierczyk, K. Bykowski (1982)	Gas chromatography	1
BotJGG4	Sample2/18	Jelenia Góra	Trench I/2018, feature 5	E. Lisowska (2018)	Botanical	6
BotJGG6	Sample3/18	Jelenia Góra	Trench I/2018, feature 5	E. Lisowska (2018)	Botanical	6
JGGGC-MS5	37/2018	Jelenia Góra	Trench I/2018, feature 5	E. Lisowska (2018)	Gas chromatography	1
JGGGC-MS6	48/2018	Jelenia Góra	Trench I/2018, feature 5	E. Lisowska (2018)	Gas chromatography	1
Total examined fragments						26

stereoscopic microscope (magnification 7 to 45×). All observed traces were recorded. The fragments were not broken during the analyses; thus their results pertain to imprints visible on the surface, or fragment edges.

Samples with traces collected inside the fragments were initially segregated without washing (sludging) under magnification. Several pieces of charcoal were isolated and analyzed further in terms of their origin. The fragments were measured before observation (longest dimension). A stereoscopic microscope was used for initial observation, followed by the analysis of anatomical structure details under a metallographic microscope (Olympus BX53M). The charcoals were observed in three planes: transverse, tangent and radial. Identification keys were used for marking [34, 35].

Preparation of samples for chromatographic analysis consisted of weighing out about 5 g of the material, which, after grinding, was extracted in a Soxhlet apparatus in a mixture of dichloromethane and methanol (2:1 v/v) for 4 h. The extracted lipid fraction was evaporated to dryness on a rotary evaporator. The resulting residue was dissolved in 2 mL of hexane. 0.5 mL of the solution was transferred to a glass vial and evaporated under a stream of nitrogen. The analytes included in the lipid fraction were derivatized by adding 100 µL of the mixture of N,O-bis(trimethylsilyl)trifluoroacetamide and trimethylchlorosilane (100:1 v/v). The process was carried out for 30 min at the temperature of 75 °C. The vials were then supplemented with 300 µL hexane and subjected to gas chromatography-mass spectrometry (GC–MS) analysis.

GC–MS analysis was performed using a 6890 N Network GC System gas chromatograph connected to a 5973 Network Mass Selective Detector quadrupole mass spectrometer (Agilent Technologies) equipped with an HP–5MS column (30 m × 0.25 mm × 0.25 µm). A 1 µL sample was injected at the temperature of 250 °C. The carrier gas was helium with a flow rate of 0.9 mL/min. The chromatograph oven temperature program was as follows: starting temperature 60 °C (0 min); temperature increase by 12 °C/min; final temperature 300 °C (0 min). The quadrupole mass spectrometer was operated in the electron ionization (EI) mode. The ion source temperature was 230 °C and the detector temperature was 150 °C. During the analysis, a solvent delay of 4 min and a scan of the mass to charge ratio (m/z) 50–550 were used.

Qualitative analysis of fatty acids and archaeological biomarkers was carried out on the basis of Wiley mass spectra library and NIST08. All acids were determined as trimethylsilyl derivatives. The quantitative analysis of fatty acids was performed using the internal normalization method.

Results of botanical tests

Kamieniec Ząbkowicki

The material from this site consisted of roaster fragments with the maximum dimensions of 8.5 × 5.6 × 3.6 cm, 8.7 × 6 × 3 cm and 12.4 × 8 × 3 cm, brown and dark gray (Fig. 3d). All fragments showed elements of mineral admixture and clear traces of organic admixture. Most of them were incalculable and difficult to accurately determine imprints of straw, i.e. fragments of leaves and blades of undefined cereals or wild grass (*Cerealia* indet./Poaceae indet.). Among the intersecting imprints of these elements, the presence of grain imprints was discerned that allowed for identifying three imprints of barley (*Hordeum vulgare*), one imprint of probably barley (cf. *Hordeum vulgare*), one imprint of (probably) millet (cf. *Panicum miliaceum*) and one imprint of (probably) oats (cf. *Avena sp.*). Moreover, three impressions of unspecified cereal grains (*Cerealia* indet.) and one imprint of an unspecified grain ear fragment (*Cerealia* indet.) were found. Burned grains of barley were also found in two of the prints.

Gilów

Four roaster fragments obtained during excavations in 1982 and four fragments from 2002 (Fig. 3b, e) were selected for the analysis. They measured from 2 to 10.3 cm, and were light brown-gray, dark gray and orange. Relatively few traces of plant admixture were visible on their surface and one of the fragments did not contain any. The preserved traces consisted of flat, elongated and ribbed straw imprints (*Cerealia* indet./Poaceae indet.) (Fig. 3b).

Jelenia Góra–Grabary

During the segregation of the sediment samples (BotJGG4), four pieces of charcoal were separated, with dimensions of 9, 12, 13 and 18 mm. Preliminary evaluation under a magnifying glass showed that they all originated from coniferous trees. The microscopic analysis of the anatomical structure confirmed the presence of small pits in the cross fields visible in the radial section. No resin channels were observed. These features indicated that the examined fragments probably come from silver fir (cf. *Abies alba*). Similar features were visible on the fragments of the other separated coals. In this case, three fragments measuring 12, 15 and 23 mm were analyzed. Probably these fractions originally belonged to one larger roaster fragment, which broke into 12 smaller lumps, which made it impossible to notice specific species of crops or grass on its surface (Fig. 3c). No plant residues were observed in the sediment sample (sample BotJGG6).

Results of chromatographic analyses

Different groups of organic compounds were determined in lipid extracts by gas chromatography, including mainly aliphatic and aromatic hydrocarbons (e.g. tetradecane, nonadecane), organic acids and alcohols (like hexadecanol, octadecanol or eicosanol). A variety of determined compounds and their derivatives may be the result of decomposition of the organic substance with which the examined samples were in contact. Fatty acids and biomarkers were the most important groups of the determined compounds.

An exemplary chromatogram for sample JGGGC-MS5 is shown in Fig. 4.

The fatty acid percentages for each sample are shown in Table 2.

The samples essentially contained saturated acids from caproic acid C6:0 to stearic acid C18:0. Only in sample GilGC-MS4 the presence of two unsaturated acids was detected: oleic C18:1 and linoleic C18:2. The absence of unsaturated acids in sample JGGGC-MS5 and sample JGGGC-MS6 is not common, usually palmitoleic C16:1 and oleic C18:1 acids are present [36, 37]. The highest amount of acids were determined in sample GilGC-MS4—12 different acids, the lowest in sample JGGGC-MS6—only 3 acids. Palmitic acid C16:0 was the dominant acid in samples JGGGC-MS5 and JGGC-MS6, while stearic acid C18:0 was the most abundant in sample GILGC-MS4. Pentadecanoic acid C15:0, which is considered an indicator of bacterial activity, was determined only in sample JGGGC-MS5. Such a significant difference is puzzling and may indicate a different purpose and perhaps the origin of the examined vessel fragments. However, based on the presence of acids, it is not possible to directly infer the source of the studied organic residues. as acids are present in almost all types of plant and animal materials. Therefore, for the purposes of this publication the discussion on the results is based on the study by Eerkens [38], who selected the proportions characteristic of various types of food on the basis of experimental studies. The calculated proportions and their interpretation are presented in Table 3.

The calculated fatty acid proportions indicate plants as the main source of origin for the studied residues. Sample GilGC-MS4 and sample JGGGC-MS5 were likely in contact mainly with seeds and nuts. This is consistent with the archaeologists' assumption as to the essential function of roasters as vessels for heating and roasting cereal grains. Sample JGGGC-MS6 is difficult to interpret due to the low number of determined acids. However, it should be remembered that relying solely on such proportions raises some doubts. As already mentioned. fatty acids are ubiquitous, found in both plant and animal products [36–38]. This is especially true of palmitic acid C16:0 and stearic acid C18:0. Many studies show that significant amounts of these two acids in organic residues may result from the

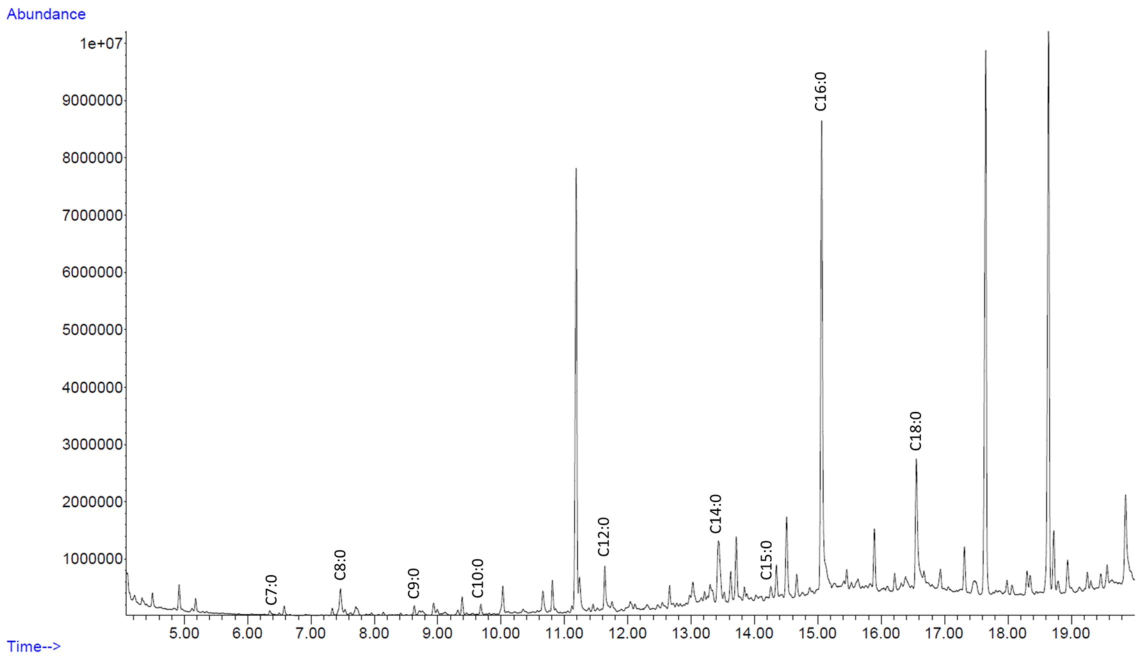

Fig. 4 Chromatogram for sample JGGGC-MS5: C7:0–enanthic acid, C8:0–caprylic acid, C9:0–pelargonic acid, C10:0–capric acid, C12:0–lauric acid, C14:0–myristic acid, C15:0–pentadecanoic acid, C16:0–palmitic acid, C18:0–stearic acid (by J. Kałużna-Czaplińska, A. Rosiak)

Table 2 Fatty acids content (in %) in examined samples

No	Acid name			Sample name		
	Systematic	Common	Acronym	GilGC-MS4	JGGGC-MS5	JGGGC-MS6
1	Hexanoic acid	Caproic acid	C6:0	0.01		
2	Heptanoic acid	Enanthic acid	C7:0	0.02	0.02	
3	Octanoic acid	Caprylic acid	C8:0	0.08	0.13	
4	Nonanoic acid	Pelargonic acid	C9:0	0.13	0.17	0.02
5	Decanoic acid	Capric acid	C10:0	0.10	0.18	0.01
6	Dodecanoic acid	Lauric acid	C12:0	0.81	1.00	
7	Tetradecanoic acid	Myristic acid	C14:0	1.86	2.25	
8	Pentadecanoic acid	–	C15:0		0.53	
9	Hexadecanoic acid	Palmitic acid	C16:0	7.52	11.59	1.45
10	Heptadecanoic acid	Margaric acid	C17:0	0.51		
11	cis,cis-9,12-Octadecadienoic acid	Linoleic acid	C18:2	0.59		
12	cis-9-Octadecenoic acid	Oleic acid	C18:1	0.82		
13	Octadecanoic acid	Stearic acid	C18:0	12.02	4.13	

conversion of unsaturated to saturated acids. e.g. by the degradation of oleic acid C18:1 to stearic acid C18:0.

In addition to fatty acids, the studies also showed the presence of biomarkers that can facilitate conclusions on the origin of residues [39–42]. Even in low concentrations, they can clearly indicate the type of a studied residue [36]. Several compounds were determined in the studied samples. Sample GilGC-MS4 contained phenylacetic acid of the phenolic acids family, whose presence may indicate the processing of plant-based foods, and benzene, a phthalic acid confirming the probability of thermal treatment of dishes (products) [43].

Three compounds, determined in sample JGGGC-MS5, indicate waxes: benzoic acid esters [44], olefin-17-Pentatriacontene [45] and 1-Heptatriacotanol, a

Table 3 Proportions of fatty acids in the examined samples

Proportions of fatty acids	Sample name		
	GILGC-MS4	JGGGC-MS5	JGGGC-MS6
(C15:0 + C17:0)/C18:0	0.04	0.13	0.00
C16:1/C18:1	0.00	0.00	0.00
C16:0/C18:0	0.63	2.81	0.00
C12:0/C14:0	0.44	0.44	0.00
Probable source of residues (min. 3 compatible proportions)	Seeds and nuts, berries	Seeds and nuts	Just 3 determined fatty acids

long-chain alcohol that often occurs in beeswax or vegetable waxes [46]. This may suggest that the roaster was in contact with some beeswax product. A derivative of cholestane was also determined in this sample.

Sample JGGGC-MS6 among the studied compounds contained carotenoid–rodopine (rhodopine), 1–monolinoleoylglycerol consisting of a single chain of fatty acid (linoleic acid), glycerol, which is the end product of digestion in animals, and cholesterol—a lipid from the steroid group, a compound characteristic of animals [36]. The presence of these compounds may indicate a mixed, plant-animal origin of organic residues. For the first time, chromatography was used to analyze the organic residues from the early medieval roasters. However, when comparing the results with the analyses of other historical vessels e.g. from the western part of the Prussian territory [37]; Podlasie Province [47] or Pomeranian Voivodeship [48], they seem to be similar. This indicates that clay vessels, including medieval ones, were mainly used to stored or prepared plant material.

Discussion

The use of two complementary methods in identifying the functions of early medieval roasters allowed for the establishment of several important conclusions. Thanks to archaeological studies we can state that roasters were produced from clay with a large amount of organic admixture in the form of vegetative parts of cereal plants and grasses (*Cerealia* indet./Poaceae indet.). The domestic nature of their production indirectly indicates the presence of these plants in the vicinity. They were produced directly in the settlement by its inhabitants, because they were too heavy for further distribution. Roasters were thick-walled containers and lack of finesse in their manufacture and high degree of wear result in finding them mainly in fragments [1, 49]. An additional factor affecting the degree of fragmentation of these artefacts may also be connected with site taphonomy as well as firing conditions. From the observations and botanical analyses of the traces of plant admixture carried out so far, it can be assumed that the fragility of the vessels could also be influenced by quite abundant, in some cases, plant admixture, and voids in the surface resulting from burning out the plant tissue. Due to their thick walls, roasters did not heat up too quickly and kept warmth well, which made them appropriate for drying or roasting grains [1]. During heating the voids were filled with warm air, which was then evenly distributed within the vessel. The presence of fine charcoals in the sediment samples can be explained by the fact that roaster fragments are very often found within houses or huts in or near hearths [1]. Some authors also theorize about using roasters as portable heat sources [8], so the fragments of burnt wood preserved in the vessel fill are most likely the remains of material used in the hearth. In this case of the studied roasters it was coniferous in origin, probably fir.

Chromatographic studies with the use of a gas chromatograph combined with a mass spectrometer allowed to establish that the basic substance in contact with the internal walls of roasters are acids of plant origin, probably the result of heating seeds and nuts. This is also confirmed by the biomarkers found in the roaster, indicating the plant origin of the studied residues. In the case of one roaster from the site in Jelenia Góra–Grabary, biomarkers also directly indicated thermal treatment of animal origin substances.

In connection with the above findings, one should agree with most concepts concerning the use of roasters as containers for thermal treatment of plant products, and in some cases plant and animal products. However, the hypotheses connecting these vessels with metal hardening or smelting processes [17, 18], forms for baking bread or producing malt, as well as identifying them as accessories related to grain grinding [10] were not confirmed. The hypothesis about their use as portable hearths is also uncertain, as in such case we would only discover acids produced by heat treatment of various species of shrubs and trees. Perhaps a larger-scale study will allow for expanding the range of roaster usage.

Gas chromatography was performed for early medieval roasters for the first time, and preliminary results open a wide range of possibilities for analyzing such artifacts from sites covering the entire Slavic region. Conducting the above study on artifacts excavated in the Sudetes also allowed for moving the beginnings of agriculture in the early Middle Ages in Central European mountainous areas by almost 400 years. Based on C14 results (Fig. 5) as well as the analysis of pottery manufacturing style typical of late ninth and tenth century, the site in Jelenia Góra–Grabary confirms the existence of the settlement in the Sudety Mountains in such an early period.

Thanks to the discovery of grains, straw as well as the unpublished palynological analyzes carried out by M. Malkiewicz from the Institute of Geological Sciences of the University of Wroclaw, we now know that the soil cultivation process in this area began as early as in the ninth century, and not in the thirteenth century, as previously thought [19, 20]. This is also confirmed by the early medieval settlements and strongholds discovered in recent years, recorded during planned and rescue excavations in the Sudetes [51]. Such sites were detected in the Central Sudetes within Kłodzko Valley and the Stołowe Mountains, in the Eastern Sudetes. New botanical evidence comes from the hillfort in Opava-Kylešovice [52]. It can be clearly seen that the cultural landscape of the Sudety mountains during the older phases of the Early Middle Ages (ninth–tenth centuries) includes settlement enclaves, which were self-sufficient in the production and processing of the basic agricultural products. An additional argument for such an early, medieval activity is the iron coulters discovered in Jelenia Góra–Grabary, Gilów and several other archaeological sites in Sudetic Foreland and Upper Lusatia [25].

Conclusion

Botanical and gas chromatographic studies were carried out on several fragments of roasters that originated in the Sudetes Mountain area and Sudetic Foreland. Thanks to the archaeological research, it can be concluded that roasters were made of clay with a large amount of organic admixture in the form of vegetative parts of cereal plants and grasses. They were used as containers for thermal treatment of plant products, and in some cases probably also for plant and animal products. Plant material, probably seeds and nuts, was the main material with which the examined fragments of roasters were in contact. This is evidenced not only by the presence of fatty acids, but also by the presence of biomarkers characteristic of this type of material.

The application of modern analytical techniques (such as gas chromatography combined with mass spectrometry) in archaeological studies not only helps to confirm the previously stated hypotheses, as in the case of the discussed roasters, but also provides the opportunity to obtain new information on historical objects. New information combined with archaeological knowledge and practice contributes to a better understanding of the habits and lives of our ancestors.

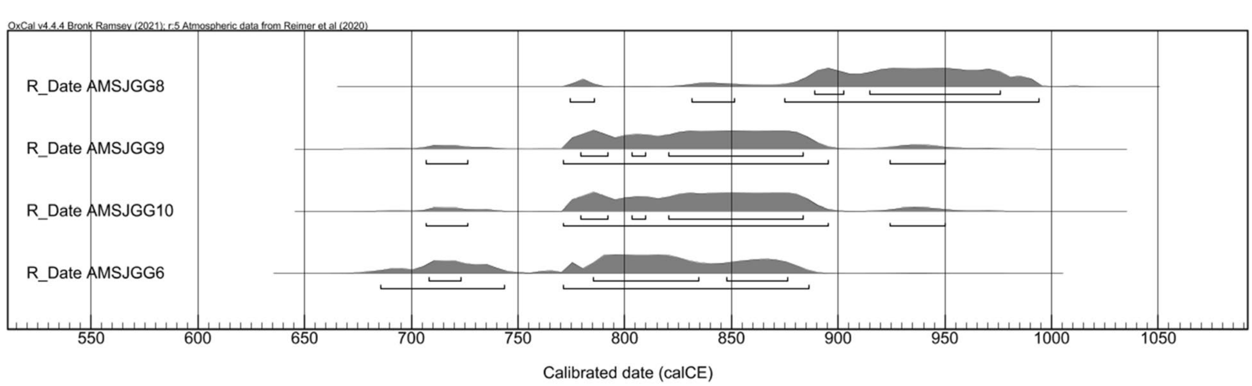

Fig. 5 AMS radiocarbon dating results of charcoal samples from Jelenia Góra–Grabary site. Calibrated with the OxCal v4.2.3. software [50]. Produced by M. Furmanek

Abbreviation
GC-MS: Gas Chromatography–Mass Spectrometry.

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Declarations

Competing interests
The authors declare that they have no competing interests.

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