DE GRUYTER OPEN

Acta Bot. Croat. 75 (1), 144–148, 2016
DOI: 10.1515/botcro-2016-0019

CODEN: ABCRA 25
ISSN 0365-0588
eISSN 1847-8476

A comparison of the influences of flotation and wet sieving on certain carbonized legume and cereal remains

Sara Mareković*, Renata Šoštarić

Department of Biology, Faculty of Science, University of Zagreb, Marulićev trg 20/2, HR-10000 Zagreb, Croatia

Abstract – In order to determine the influence of recovery techniques with water (flotation and wet sieving) on carbonized plant remains, a certain amount of wheat, barley, millet, horsebean and lentil macrofossils from archaeological sites was taken and treated with water. Moist recovery was also applied to in-laboratory, artificially, charred barley, millet and lentil samples. After the treatments, the investigated remains were re-counted and the percentages of still recognizable remains for every plant species and for each method were recorded. Comparisons were made of the sensitivities of the investigated species and of the differences in the degree of macrofossil breakup depending on the method of recovery. Our investigation proved that flotation is a less aggressive method than wet sieving and that barley, horsebean and wheat carbonized macrofossils are resistant to moist treatments, while the breakup percentage of lentil and millet (from archaeological sites) is higher than 30%, which should be taken into account when deciding on the (non)use of water recovery in the investigations.

Key words: carbonized plant remains, cereals, flotation, legumes, wet sieving

Introduction

At archaeological investigation sites, botanical (as well as zoological and archaeological) material is often collected together with large amounts of soil and before analysis of that material, it is necessary to conduct a recovery process in order to remove the soil and to make sample analysis easier and faster. The most common recovery methods use water: flotation or wet-sieving (water screening). In water screening, soil is placed on a screen and washed with a water jet. All the particles smaller than the screen mesh are washed through the screen and the larger materials (like botanical findings) are recovered and later analyzed. Flotation is based on the difference in density between organic and inorganic material. In the flotation system, soil is poured into a body of water. Agitation breaks up the soil, allowing light materials (seeds, charcoal) to float and heavier materials (pebbles, potsherds) to sink. Archaeobotanists analyse the organic material collected from sieves with different mesh sizes, to which the water with floating material is directed (Jacomet and Kreuz 1999, Pearsall 2000). Wagner (1982) in his paper introduces the poppy seed recovery test for determining the effectiveness and consistency of any particular botanical flotation system. This is important because it helps investigators to be aware of the recovery rate of found remains in their flotation devices.

The aim of this study is to examine whether the wet sieving destroys carbonized plant remains more than the flotation method and besides that, to investigate whether there is a difference in sensitivity among the species horsebean, lentil, wheat, barley and millet. In our previous studies, we accidentally noticed that the lentil has greater sensitivity to water treatments than wheat and barley grains and therefore our goal was to verify whether this difference is constant and to what extent the difference between the species exists. Tanno and Willcox (2006) hypothesised that the rarity of faba bean finds in their investigation might have been due to their fragility (and devastation during flotation and transportation). Because of the limited access to real archaeological material not previously treated with water, in this study we could not include all the legumes and cereals which could theoretically be found on archaeological sites. But the species that were analyzed in this paper, are certainly some of the most common species found in samples, so we believe that this analysis will give some important answers to archaeobotanists, when the need to make a decision about the right water recovery method for their sample or want to discuss the ratio of different carbonized findings previously water recovered.

* Corresponding author, e-mail: sara.marekovic@biol.pmf.hr

Wright (2005) concluded that the results of archaeobotanical analysis depend on flotation sample size, how the sample is measured and processed and how well the plant material within the sample withstands the rigors of flotation. Some other previous studies have also shown that wet sieving affects plant residues of different species differently, so Hosch and Zibulski (2003) demonstrated in their paper that the number of fragile remains (e. g. cereal chaff remains and *Malus sylvestris* Mill. pericarp fragments) were reduced by increasing wet-sieving intensity, but more or less round and robust remains were scarcely affected. They suggested that a less destructive technique for fragile plant macroremains should be used, although the researchers will need more time for the recovery of the sample. Tolar et al (2010) did an experiment with macroremains found in the Neolithic pile dwelling site of Stare Gmajne, Ljubljansko Barje (Slovenia). They compared three subsamples which were differently rough-handled during the wet sieving and their study showed that some sensitive species were almost completely destroyed and no longer recognizable. This study clearly shows that the proportion of species found in the sample can largely depend on the method of recovery of the sample and that this should be considered when selecting methods and in the interpretation of results. We are aware that the above mentioned studies deal with waterlogged sediments, which are certainly not the same as mineral soils, but there are also some similarities that can help us draw conclusions about recovery techniques.

It should be taken into account that the plant remains can be damaged not only by the mechanical force of water rinsing, but also because of the contact of the carbonized material with the water and during the drying processes, which affects the mechanical structure and cracking of the fragile carbonized structures. Pearsall (2000) describes the work of Jarman et al. (1972), which analyses the percentage of destroyed carbonized macroremains after repetition of the flotation and drying. Their experiment showed that after the first flotation and drying, only 4% of the sample was destroyed. However after the second repetition of the procedure, an additional 56% of the sample was destroyed and the third flotation with drying destroyed the remaining carbonized macrofossils. Badham and Jones (1985) also confirmed that carbonized are far more sensitive than mineralized remains and therefore water screening should be avoided for the sake of finding such remains.

Materials and methods

Species that we have studied are: horsebean (*Vicia faba* L.), lentil (*Lens culinaris* Medik.), wheat (mix: *Triticum turgidum* ssp. *dicoccon* (Schrank) Thell.+ T. *aestivum* ssp. *aestivum* L. + *T. aestivum* ssp. *spelta* (L.) Thell. + *Triticum turgidum* ssp. *dicoccon*/*T. aestivum* ssp. *spelta*), barley (*Hordeum vulgare* L.) and millet (*Panicum miliaceum* L.). For all these species we took 300 well-preserved whole grains from the Late Bronze Age sites Kalnik-Igrišče (Mareković et al. 2015), for both pretreatments that we explored. Additionally, we have treated 180 carbonized lentil seeds from the Roman site Poreč (which was explored in 2008) and 100 horsebean seeds from Bronze Age settlements Nova Bukovica (Šoštarić 2001).

As we had just one additional (beside those from Kalnik-Igriše site) archaeological carbonized sample, for horsebean and lentil species only, in the laboratory we made 6 extra samples with 30 grains for millet, barley and lentil species. Millet and lentils were chosen because they in previous research they showed high rates of destruction during moist treatments, and barley was chosen as the control species, because it had shown great resistance to the treatments. The material was charred in a muffle furnace. The barley and lentil species were heated up to 500 °C, for 3 or 10 minutes. Millet was heated up to 300 °C, for approximately 10 minutes. In our experiment we found the best heating temperature and duration by consulting literature (Wright 2003, Babrauskas 2013) and by using the method of trial and error for each plant species. For each plant we took 3 samples for flotation and another three for wet sieving.

In the flotation treatment we put the macroremains in a container, which was supplied with water via a rubber tube placed in lower part of the container. A steady supply of water caused the carbonized plant remains to move around the container and finally overflow the container on which they were collected in a sieve. The entire procedure lasted between 5 and 10 minutes for each sample.

In the second treatment we put the macroremains on metal sieve, and rinsed it with the water jet from above. The strength of the water stream was regulated to medium strength, and the process lasted for ca 5 to 10 minutes.

Because different soils interact with macrofossils in different ways (some are much more viscous than others, for example), we deliberately did flotation and wet sieving only with carbonized remains, in order to stay focused just on the fragility of the plant remains of every species, regardless of the influence of the soil type.

After rinsing, the macrofossils were left to dry in the open air. Subsequently they were all examined under the microscope, and we counted a number of carbonized remains still recognizable after the wet treatments. We calculated the percentage of recognizable, slightly damaged plant remains for every species and compared for any significant difference between our two treatments and among the different species investigated. Photographs of lentil and barley demonstrate the differences in plant remains before and after treatment, and also show grains or seeds that are either recognisable or unrecognisable (Figs. 1, 2)

The experiment with the plant material carbonized in the laboratory was, because of absence of decomposition after the first moistening, repeated 5 and 10 times to check whether repeated water treatments and drying lead to greater destruction of the material. We wanted to see if the artificially charred remains can show us fragility differences among species similar to those found in genuinely archaeological remains, however much they are more resistant due to their date of origin as well as the absence of pedological and elemental influences that cannot easily be simulated in laboratory conditions.

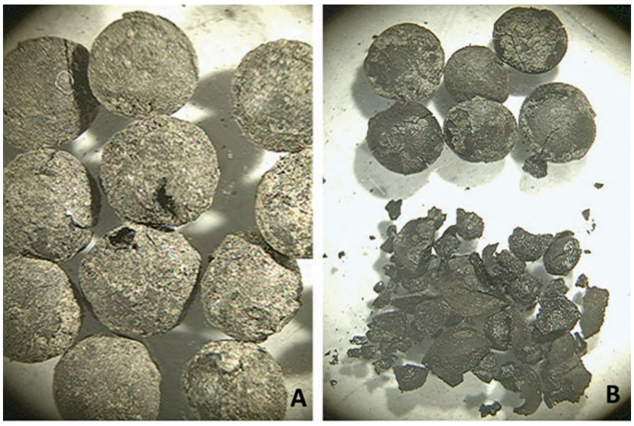

Fig. 1. The lentil seeds from the site Kalnik-Igrišče: A) before the treatment, B) upon wet sieving: the recognizable lentil remains are on the top and unrecognizable ones on the bottom of figure.

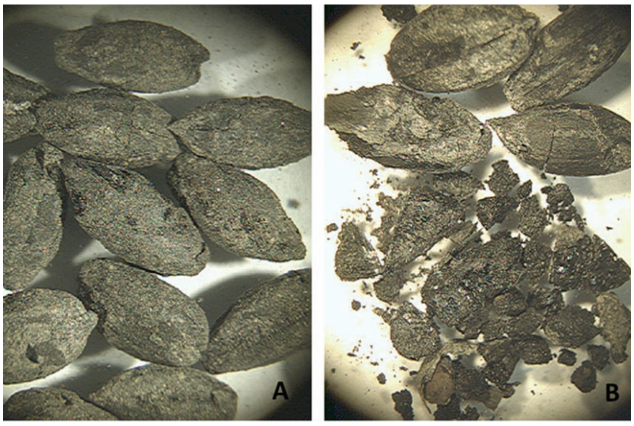

Fig. 2. The barley grains from the site Kalnik-Igrišče: A) before the treatment, B) upon wet sieving: the recognizable barley remains are on the top and unrecognizable ones on the bottom of figure.

Statistical analysis of the obtained data was performed with the software package Statistica (ver 8), manufacturers StatSoft Inc., USA. The aim was to check statistically whether there is a difference in the proportion (percentage, labelled p1) of recognizable seed after the flotation and the proportion (percentage, labelled p2) of recognizable seed after the wet sieving treatment. Beside that we wanted to see whether there are significant differences among species in the same pretreatment.

For this purpose, we set the null hypothesis H0: p1 = p2 and the alternative hypothesis H1: p1 ≠ p2. We tagged with n1 the total number of seeds before the flotation and with n2 the total number of seeds before the wet sieving treatment. The value of the test statistics is calculated with the following formula:

$$z = \frac{\mathrm{p1} - \mathrm{p2}}{\sqrt{p' \cdot (1 - p') \cdot \left(\frac{1}{\mathrm{n1}} + \frac{1}{\mathrm{n2}}\right)}}$$

where

$$p' = \frac{\mathrm{n1} \cdot \mathrm{p1} + \mathrm{n2} \cdot \mathrm{p2}}{\mathrm{n1} + \mathrm{n2}}$$

Beside the value of the test statistic z we needed also the corresponding p-value which is calculated as follows:

– p = P{Z ≥ z} if alternative hypothesis is in this form H1 : p1 − p2 > 0,
– p = P{Z ≤ z} if alternative hypothesis is in this form: p1 − p2 < 0,

where Z is a random variable with a standard normal distribution. P-values were counted with the probability calculator in the software package Statistica. Calculated p-values are compared with the level of significance α = 0.05 = 5% (α is the maximum probability that we will make mistakes, if we reject the null hypothesis, i.e., maximum probability that we will reject the null hypothesis if it is correct – so called error of the first kind) and one of the following two conclusions is made:

– if p < α we reject the null hypothesis and at the level of significance α we accept the alternative hypothesis H1,
– if p > α we conclude that we do not have enough arguments to support the decision to reject the null hypothesis.

Results

The results of treatment comparisons made on macrofossils collected from archaeological sites and afterwards on those carbonized in the laboratory are shown in Figs. 3–5.

Horsebean collected from the Kalnik-Igrišče site showed the least sensitivity to treatments and as many as 91% of specimens were recognizable after both pretreatments. Horsebean is followed by barley grains, preserved 85% after flotation and 82.3% after wet sieving. Wheat also proved to be a resistant macrofossil, because both treatments preserved almost three quarters of the grains in a recognizable form (75.3% after flotation and 74.7% after wet sieving) (Fig. 3).

During flotation as well as during wet sieving the remains most destroyed were the carbonized remains of the lentil, as only 68.7% of these remains (Kalnik-Igrišče) and 35% (Poreč) were recognizable after flotation, and, that percentage decreased after wet sieving to 52% (Kalnik-Igrišče) and 22.2% (Poreč) (Figs. 4, 5).

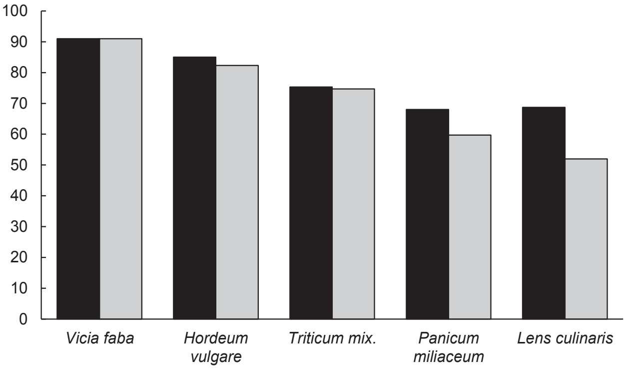

Fig. 3. Comparison of percentage of recognizable macrofossils after flotation (black bars) and wet sieving (grey bars) on the site Kalnik-Igrišče.

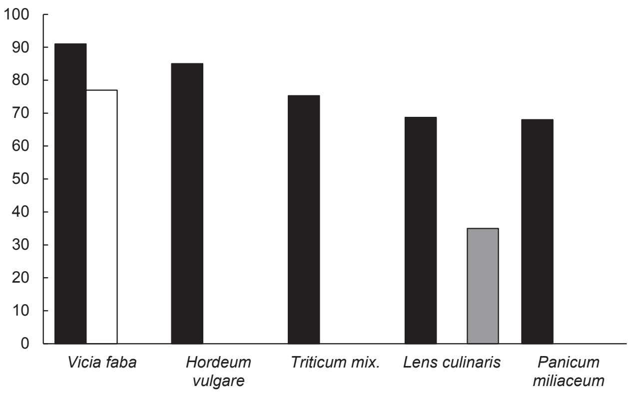

Fig. 4. The percentage of recognizable carbonized remains after flotation. Black bars represent the results from the site Kalnik-Igrišče, grey bar shows the results from Nova Bukovica and the white one from Poreč site.

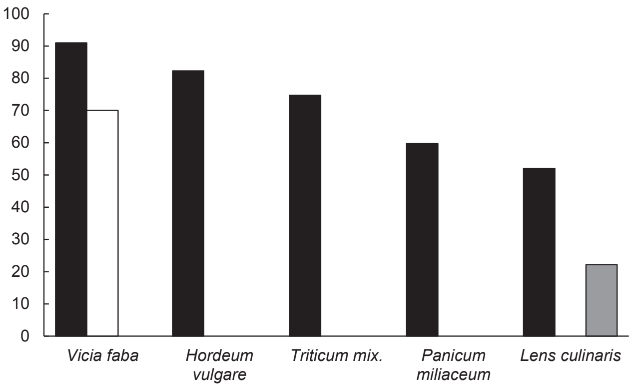

Fig. 5. The percentage of recognizable carbonized remains after wet sieving. Black bars represent results from the site Kalnik-Igrišče, the white bar result from Nova Bukovica and the grey bar the result of the lentil from Poreč site.

The results show that in all cases, except for the horsebean sample from the site Kalnik-Igrišče, carbonized material is destroyed more by the wet sieving method. The biggest difference in destruction beyond recognition, is evident on the lentil (16.7% and 12.8%) and millet (8.3%) sample.

The results show that for the horsebean sample from both sites, we cannot claim there is a significant difference (if we use the level of significance α = 0.05) between the flotation and wet sieving treatments. For wheat and barley, there are no very strong arguments for stating that the proportions (percentages) of recognizable seeds differ according to the treatment. In both lentil samples it has been proven that (by the level of significance α = 0.05) wet sieving damages the carbonized remains more than flotation. At the level of significance 0.05, we accepted the hypothesis that the proportion of recognizable millet seeds is greater after flotation than after wet sieving. The samples of millet, lentil and barley experimentally carbonised in a furnace are much more resistant and less prone to destruction real archaeological material.

The experiments with the laboratory-carbonized, material showed that the disintegration of the plant remains, with both recovery methods and regardless of the number of repetitions, was the biggest in millet samples. Barley samples were the most resistant and barley grains remained undamaged during all flotation and wet sieving procedures (Tab. 1).

The number of repetitions of the procedures done on the millet and lentil samples, increased the decomposition of the grains, and the samples were more damaged after wet sieving, than after flotation.

As for the flotation process and the wet sieving of laboratory-carbonised material (lentils, barley, millet), we cannot (at the level of significance α = 0.05) prove a statistically significant difference in the destruction of the material beyond recognition, regardless of the number of repetitions of procedures (1, 5 and 10).

However, when the sensitivity of millet is compared with that of barley, it can be proven (at the level of significance α = 0.05) that sensitivity is significantly bigger when flotation is repeated 10 times, and with wet sieving after the first repetition. Therefore it became apparent that wet sieving is a more aggressive procedure and affects the carbonized remains of millet more than flotation.

When we compared the sensitivity of the lentil in relation to barley, we came to the conclusion that their sensitivities are not statistically significantly different (at the level of significance α = 0.05) after flotation or wet sieving, even after ten repetitions.

The sensitivity of millet compared to that of lentil is statistically significantly different (at α = 0.05) only after the tenth repetition of wet sieving.

Discussion

Laboratory samples of carbonized lentil, millet and barley clearly showed that recent material, carbonized in a furnace, is more resilient and less prone to disintegration than real archaeological material. In previous investigations it has been already noted (Pearsall 1980, King 1987, Goette et al. 1994, King 1994,) that it is not easy to get lab samples

Tab. 1. The comparison of the preservation percentage of carbonized macrofossils obtained by methods of repeated flotation and wet sieving.

No. of repetitions	Lentil		Barley		Millet	
	Flotation	Wet sieving	Flotation	Wet sieving	Flotation	Wet sieving
1 x	100 %	100 %	100 %	100 %	97.77 %	96.67 %
5 x	100 %	99.44 %	100 %	100 %	96.67 %	93.33 %
10 x	98.89 %	98.33 %	100 %	100 %	94.47 %	86.67 %

(corn) the structure and properties of which identical or at least satisfactorily similar to those found in real archaeological samples. Brady (1989) investigated the impact of flotation on the preservation of laboratory samples of carbonized wood and concluded that there is no significant difference in the conservation of mass during flotation, regardless of the differences in the density of the wood in different plant species, which can also be result of greater resistance of wood in the case of laboratory-carbonized material. Therefore we presume that although it is impossible to get accurate numerical data on the rate of destruction of some plant species in wet recovery treatments on the basis of studies done on laboratory carbonized material, it is possible to conclude which species are more sensitive and which method is more aggressive.

This study showed that the carbonized grains of lentils and millet are sensitive and therefore samples that contain these grains should preferably be spared wet sieving. Carbonized remains of beans, wheat and barley after both treatments keep a preservation percentage greater than 70% and therefore we believe that they are sufficiently robust and their presence should not be a reason for avoiding wet sieving. Therefore, we propose that, before the water recovery, a preliminary insight into the diversity of plant remains from each site, should be acquired. If the sample contains carbonized lentils and millet, and it is possible to conduct sieving without water, wet recovery techniques should definitely be avoided. However if the soil around the sample is so compact that it demands the use of water, we recommend avoiding wet sieving, because it will do more damage to sensitive carbonized material than flotation.

If wet sieving has already been conducted or must be used to accelerate the recovery process, we certainly suggest researchers should consider the fact that the decomposition of lentils may be greater than 45% and the decomposition of millet greater than 40%. That fact should be noted in order to obtain a more accurate proportion ratio of found taxa.

In conclusion, our study is in agreement with previous reports of Badham and Jones (1985) that the wet sieving is a more aggressive method than flotation and that it should be used only when the sample does not contain many fragile remains.

References

Babrauskas, V. 2013: Temperatures in flames and fires. Retrieved February 10, 2013 from http://www.doctorfire.com/flametmp.html

Badham, K., Jones, G., 1985: An experiment in manual processing of soil samples for plant remains. Circaea 3, 15–26.

Brady, J. T., 1989: The influence of flotation on the rate of recovery of wood charcoal from archaeological sites. Journal of Ethnobiology 9, 207–227.

Goette, S., Williams, M., Johannessen, S., Hastorf, C. A., 1994: Toward reconstructing ancient maize: Experiments in processing and charring. Journal of Ethnobiology 14, 1–21.

Hosch, S., Zibulski P., 2003: The influence of inconsistent wet-sieving procedures on the macroremain concentration in waterlogged sediments. Journal of Archaeological Science 30, 849–857.

Jacomet S., Kreuz S., 1999: Archäobotanik – Aufgaben, Methoden und Ergebnisse vegetations-und agrargeschichtlicher Forschung. Eugen Ulmer, Stuttgart.

Jarman, H. N., Legge, A. J., Charles, J. A., 1972: Retrieval of plant remains from archaeological sites by froth flotation. In: Higgs, E. (ed.) Papers in economic prehistory, 39–48. Cambridge University Press.

King, F. B., 1987: Prehistoric maize in eastern North America: An evolutionary evaluation. Dissertation, University of Illinois.

King, F. B., 1994: Variability in cob and kernel characteristics of North American maize cultivars. In: Johannessen, S., Hastorf, C. A. (eds.) Corn and culture in prehistoric New World, 35–54. Westview Press, Boulder, Colorado.

Mareković, S., Karavanić, S., Kudelić, A., Šoštarić, R., 2015: The botanical macroremains from the prehistoric settlement Kalnik-Igrišče (NW Croatia) in the context of current knowledge about cultivation and plant consumption in Croatia and neighboring countries during the Bronze Age. Acta Societatis Botanicorum Poloniae 84, 227–235.

Pearsall, D. M., 2000: Paleoethnobotany, a handbook of procedures. Academic Press, San Diego.

Pearsall, D. M., 1980: Analysis of archaeological maize kernel cache from Manabi Province, Ecuador. Economic Botany 34, 344–351.

Šoštarić, R., 2001: Carbonized plant remains of the prehistoric locality in Nova Bukovica on the site Sjenjak. Prilozi Instituta za arheologiju u Zagrebu. 18, 79–82.

Tanno, K., Willcox, G., 2006: The origins of cultivation of *Cicer arietinum* L. and *Vicia faba* L.: early finds form Tell el-Kerkh, north-west Syria, late 10th millennium B.P. Vegetation History and Archaeobotany 15, 197–204.

Tolar, T., Jacomet, S., Velušček, A., Čufar, K., 2010: Recovery techniques for waterlogged archaeological sediments: a comparison of different treatment methods for samples from Neolithic lake shore settlements. Vegetation History and Archaeobotany 19, 53–67.

Wagner, G., 1982: Testing flotation recovery rates. American Antiquity 47, 127–132.

Wright, P. J., 2003: Preservation or destruction of plant remains by carbonization?. Journal of Archaeological Science 30, 577–583.

Wright, P. J., 2005: Flotation samples and some paleoethnobotanical implications. Journal of Archaeological Science 32, 19–26.