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Hondelink, Merit; Schepers, Mans

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ORIGINAL ARTICLE

The common and the rare: a review of Early Modern Dutch plant food consumption based on archaeobotanical urban cesspit data

Merit M. A. Hondelink[1] · **Mans Schepers**[2]

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Abstract

Past plant food consumption has been studied diachronically and spatially for many Dutch settlements. However, research into the plant food consumption of Early Modern Dutch inhabitants of urban settlements is somewhat underrepresented in the scientific archaeobotanical literature. To fill this knowledge gap, archaeobotanical data from cesspits dating to the period AD 1500–1850 contained in the Dutch Relational Archaeobotanical Database were analysed. First, edible plant taxa were distinguished from medicinal plants and potentially edible weeds. Then, seeds and fruits were distinguished from pollen. Finally, the remains were quantified to form an overview of the plant taxa consumed per urban settlement and, from there, to provide insight into regional and temporal changes in plant food availability and preferences. The combined archaeobotanical dataset, consisting of cesspit material from 51 cities, comprised 97 edible plant taxa. Surprisingly, 20 of these taxa are consistently present in 50–100% of all settlements in the 350 years under study. Based on the archaeobotanical finds from the cesspits, we conclude that the overall plant food consumption of Early Modern Dutch urban inhabitants does not seem to have changed very much over time.

Keywords Archaeobotany · Food consumption · Cesspits · Early modern period · The Netherlands

Introduction

When archaeologists research food items consumed by past societies, they shed light on the inorganic and organic material culture of food-related practices, from production, storage, procurement and preparation to consumption and disposal (Nesbitt and Samuel 1996). As a sub-discipline, archaeobotanical research traditionally focuses on the natural palaeoenvironment surrounding archaeological sites, its influence on human habitation, and vice versa (van Haaster and Brinkkemper 1995, p 117). Archaeobotanical research related to the study of food consumption in general looks at plants of economic and social importance, tracing their provenance and assessing their function and utility. The more specific study of plant food consumption focuses on edible and medicinal plant species.

Past food consumption has been studied diachronically by many archaeobotanists. However, very few scientific archaeobotanical publications deal with food consumption in Early Modern Europe, even though development-led urban excavations have uncovered and sampled plentiful cesspits, latrines and sewers containing evidence of what plants people ate, in the form of human faecal material (Greig 1982; van Oosten 2015; Deforce 2017). For instance, the journal *Vegetation History and Archaeobotany* has published only a dozen articles on Early Modern food-related archaeobotanical research in the past 10 years. In general, the reconstruction of past food consumption in Europe seems to be focussed on prehistory, Roman times and the Middle Ages. Publications that do discuss Early Modern food practices and consumption often discuss this as a follow-on from a discussion on the Middle Ages and focus on a certain region (Knörzer 1984; Vuorela and Lempiäinen 1993; Rösch 1998; Wiethold 2005; Karg

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Merit M. A. Hondelink
m.m.a.hondelink@rug.nl

[1] Groningen Institute of Archaeology, University of Groningen, Poststraat 6, 9712, ER, Groningen, The Netherlands

[2] Centre for Landscape Studies, University of Groningen, Oude Boteringestraat 34, 9712 GK Groningen, The Netherlands

2007; van der Veen et al. 2013), one city in particular (Hellwig 1997; Kooistra et al. 1998; Märkle 2005; van Haaster 2008; Deforce 2010; van Haaster et al. 2012; Brinkkemper 2013; Badura et al. 2015; Speleers and van der Valk 2017), a single plant species (Badura 2003; Wiethold 2005; Deforce 2006; Brinkkemper 2015) or the first evidence of an edible plant (Behre 1992; de Klerk et al. 2015).

Even though each of these studies broadens our understanding of Early Modern food consumption practices, they rarely provide us with an understanding of daily food practices beyond the household or local level. Finds of generative (seeds, fruits, pollen) and vegetative plant parts found in cesspits probably do represent food consumed on a daily basis. However, until now little research has been done to separate the common from the rare. Some rare finds might illustrate species consumed less frequently, for example during feasting. These rare finds are often interpreted as being an indicator for social stratification, and they find their way into publications presumably because they speak more to our imagination than species that are found more commonly. However, we can only discuss what is 'rare' when we know what is common. Overall, what was commonly eaten by people living in the Early Modern Low Countries, after occupation and status biases have been accounted for, remains an educated assumption. In order to properly discriminate between common and rare finds, it is important to have studied a representative number of samples from different locations and, wherever possible, from all layers of society (van Haaster 2008, pp 72–73). Cesspits are present in many urban sites throughout the Early Modern period in the Low Countries. Therefore, to better understand what was actually consumed on a daily basis and how this might have changed through time and space, a review based on archaeobotanical finds from cesspits seems to be an adequate approach. This article aims to provide this review for Early Modern Dutch plant food consumption (hereafter food consumption), based on the edible plants listed in the Dutch national archaeobotanical relational database.

Materials and methods

Selection of the data source

Within the Netherlands, most archaeobotanical research concerning the Early Modern period is carried out as part of development-led excavations. Although the resulting reports are supposed to be openly accessible, most of them are not easy to find. Additionally, student reports are rarely published and thus add to the grey literature. This, unfortunately, impedes further research, as it can be very difficult to find suitable reports for inter- and intra-site comparisons and synthesizing research. To overcome this problem, a relational database for archaeobotanical remains (seeds, fruits and pollen) on the national level was designed by van Haaster and Brinkkemper (1995). The RADAR (Relational Archaeobotanical Database for Advanced Research) data consist of features at the level of the site, chronological dates, archaeological contexts, plant species and plant parts recovered, as well as a list of the publications in which these are mentioned. Archaeobotanists can upload their taxon list after the research has been published and many, though not all, do so. The database provides the necessary information for researchers to be able to interpret both past vegetation and the food habits of past people and research plant-related developments through time and space. At the time of writing this article, RADAR comprises archaeobotanical data from research done in the Netherlands up to and including the year 2012 (henceforth referred to as RADAR-2012).

Selection of samples

The archaeobotanical data included in this study derive from Early Modern Dutch cesspits (samples dated to between AD 1500 and 1850). Compared with other archaeological and natural contexts, cesspits provide the best samples for analysing past food preparation and consumption, as they include both kitchen waste and consumption waste (Hondelink 2012). Additionally, the organic content of Dutch cesspits is, generally speaking, exceptionally well preserved in many regions due to the high ground water table. Although there are many more contexts available yielding remains of edible plants, this paper focusses solely on cesspits.

The period under study was chosen because it is underrepresented in scientific publications of archaeobotanical research and because a large quantity of data relating to it is available for research, namely in the aforementioned database RADAR. Selection of the sites was based on the availability of data from cesspits in use in the period AD 1500–1850, which we arbitrarily divided into three sub-periods: 1500–1600, 1600–1700 and 1700–1850. Only those cesspits in use within one of these three individual timeframes were included in the current research. Samples whose age range covered more than one sub-period were not included in our analysis, as their inclusion would have hampered comparisons among the three sub-periods. Overall, 34 sites produced useable data (Fig. 1). This resulted in 38 cesspits for the sub-period 1500–1600, 54 cesspits for the sub-period 1600–1700 and 38 cesspits for the sub-period 1700–1850 (Table 1). As can be observed in Fig. 1, the geographical coverage is uneven. There are far more archaeobotanical data from the western, coastal part of the Netherlands than from the rest of the country.

Fig. 1 The location of the Dutch urban settlements with excavation data used, plotted on a modern-day map of the Netherlands

Selection of taxa

Each plant taxon was categorized as either (1) inedible, (2) edible, (3) medicinal, or (4) having other uses. This classification is based on Kalkman (2012) and Wiersema and León (2013), as well as Dodoens (1554) and Blankaart (1698). Only those plant taxa assigned to the second category were selected for further analysis, because we know from the aforementioned sources that they were cultivated, collected, procured and prepared purely for their nutritional value. Based on that same logic, wild and decorative but edible plants, for instance *Bellis perennis* (daisy) and *Viola* sp. (violets), were omitted from the dataset. Plant taxa with medicinal properties were categorized as medicinal if they are harmful when consumed without preparation, such as *Digitalis purpurea* (foxglove), *Hyoscyamus niger* (henbane) and *Solanum nigrum* (black nightshade). Plant taxa with 'medicinal' properties, such as high concentrations of vitamins or other micronutrients, that are edible without preparation, were classified as edible.

Scientific names were verified with the aid of the website of the Plant List (2013). Remains that had been assigned a scientific name that is currently considered non-valid (e.g. *Cassia europaea*) were excluded, as were uncertain identifications (indicated with *cf.*). Identifications only to family, group, genus or type were also mostly excluded. Two exceptions were made. The genus *Citrus* was included, because it is too difficult to distinguish species from one another (van der Meer 2017). Cereals, such as *Hordeum* (barley) and *Triticum* (wheat), were included either as a type (pollen) or genus-level (macro-remains). We argue that this inclusion is justified because most pollen-based cereal records would have to have been omitted from the data otherwise. To ensure that we could easily distinguish between pollen and macro-remains, all cereal pollen finds were (re) named Cerealia. Additionally, we retained the subdivision of macro-remains of *Hordeum* and *Triticum* into subspecies. This makes sense because this level of identification can be achieved by judging morphological features of grain and by-product and because crop selection is based on this particular taxonomic level (Cappers et al. 2016).

With the exception of cereals, taxa identified beyond the species level were registered at the species level in order to make entries to the subspecies or variety level comparable with entries to species level only. For instance, all subspecies and varieties of plum were renamed *Prunus domestica*, because the entries in the database do not always distinguish between ssp. *domestica* and ssp. *insititia* and because the most recent edition of Heukels' flora of the Netherlands (van der Meijden 2005, p 396) has abandoned the subdivision between these two subspecies, arguing that hybridization makes it difficult to distinguish between them. In addition to this pooling, certain species or genera that are deemed difficult to distinguish from one another, especially when not perfectly preserved, were grouped together to sidestep the bias of variable taxonomic determinations. For example, *Prunus avium* and *P. cerasus* (sweet and sour cherry) were pooled together and named *Prunus avium/cerasus*. The same approach was taken to *Malus domestica/Pyrus communis* (apple and pear)—it is assumed that Early Modern apples came from domesticated apple trees. There was a lively practice of horticulture in and just outside cities and villages, as well as an upcoming horticultural industry in different parts of the Netherlands, such as the Boskoop (Sangers 1952)—*Carum carvi/Cuminum cyminum* (caraway and cumin); *Ribes nigrum/rubrum/uva-crispa* (red currant and gooseberry)—complete *Ribes* berries often bear the shrivelled remains of the calyx on top. These calyxes can be used to distinguish the fruits to the species level (Wiethold 2016—*Vaccinium myrtillus/uliginosum/vitis-idaea* (common bilberry, northern bilberry and cowberry); and *Fragaria moschata/vesca* (musk and woodland strawberry). The modern strawberry (*Fragaria × ananassa*), introduced in the 18th century (Roach 1985; Knörzer 1987; Greig 1996), was left out as it is not listed in the RADAR-2012 database.

Subsequently, all plant taxa were checked for their listed plant parts, which were renamed when mislabelled (e.g. seeds that were listed as fruits, and vice versa).

Finally, because quantifications in RADAR are not standardized due to the many individual contributors, we

Table 1 List of the Dutch settlements with contexts dated AD 1500–1850 represented in RADAR-2012, together with the number of sites and cesspits per sub-period

Age (AD)	1500–1600			1600–1700			1700–1850		
City	Sites (*n*)	Cesspits (*n*)	Cesspit samples (*n*)	Sites (*n*)	Cesspits (*n*)	Cesspit samples (*n*)	Sites (*n*)	Cesspits (*n*)	Cesspit samples (*n*)
Alkmaar				1	1	2	1	1	2
Amsterdam	3	3	4	4	7	8	8	18	27
Bourtange				1	1	2			
Breda				1	1	1			
Brielle	1	1	1	1	1	1			
Coevoorden				2	2	3			
Delft				1	1	1			
Delfzijl				1	1	1	1	1	1
Eindhoven				1	1	1			
Gorinchem				2	2	6			
Groningen	5	8	13	5	7	8	4	4	9
Haarlem	2	2	4	2	2	5	1	1	1
Harderwijk	1	2	3						
Heiloo							1	1	2
Hoorn	1	1	1	1	1	3	1	1	3
Kampen				1	1	1			
Kuinre	1	1	2	1	1	2			
Leiden	3	4	4						
Maastricht				1	1	4	1	1	2
Middelburg	1	1	1	2	2	4			
Nijmegen	1	1	1	1	1	1	3	4	4
Oldenzaal	1	1	5						
Rotterdam	1	1	3	1	3	3			
's-Gravenhage				2	2	5			
's-Hertogenbosch	6	6	37	2	5	11	1	1	3
Sittard	1	1	3						
Terschelling				1	1	1			
Tiel				1	1	1	1	1	2
Utrecht	1	1	2						
Venlo	1	1	2	1	2	3			
Vlissingen	2	2	5	1	5	7	1	2	2
Zaandam							1	1	2
Zierikzee	1	1	1				1	1	1
Zutphen				1	1	1			
Total	33	38	92	39	54	86	26	38	61

did not make use of the quantity of each taxon listed. Instead, a taxon was quantified as 0 when absent and as 1 when present, per sub-period within each individual cesspit.

Because it is not feasible to discuss all of the edible plant species within the scope of this paper, they are included as supplementary data. Below, only the most common finds are addressed, which are defined as those being present in at least 50% of the cesspits in one or more of the sub-periods. Apart from these most common finds, the singular or 'rare' finds are also discussed, as are relative changes in these common and rare finds through time.

Results

Chronological overview

1500–1850

A total of 94 taxa of edible plants (following the definition above) are listed in RADAR-2012 data, derived from 62 sites that were in use between AD 1500 and 1850. This list of taxa roughly breaks down into four groups, as follows: fruit trees and fruit-producing shrubs (n = 34), vegetables (n = 25), herbs and spices (n = 27) and (pseudo-)cereals (n = 8). The first group concerns fruit trees and shrubs that produce fruits, such as *Prunus domestica* and *Ribes nigrum*/*rubrum*/*uva-crispa*. The second group concerns all different types of vegetables, such as *Spinacia oleracea* (spinach) and *Cucumis sativus* (cucumber/gherkin), and pulses, such as *Pisum sativum* (pea) and *Vicia faba* (broad or faba bean). The group labelled herbs and spices contains both domestic and exotic taxa, for example, *Foeniculum vulgare* (fennel) and *Piper nigrum* (black pepper). The group of (pseudo-)cereals comprises *Hordeum vulgare* ssp. *vulgare* (6-row barley), *Avena sativa* (cultivated oat), *Oryza sativa* (rice), *Secale cereale* (rye) and *Triticum aestivum* ssp. *aestivum*, *T. aestivum* ssp. *spelta*, *T. dicoccon*, *T. durum* (wheats), as well as *Panicum miliaceum* (broomcorn millet), *Setaria italica* (foxtail millet) and the pseudo-cereal *Fagopyrum esculentum* (buckwheat).

Common finds: present in 50% or more of the cesspits per sub-period

The remains of edible plants found in cesspits can be interpreted as direct evidence for consumption in the case of macro-remains (e.g. seeds and fruits) or as indirect evidence for consumption in the case of micro-remains (e.g. pollen). Although the inclusion of pollen can broaden the spectrum of edible plant taxa identified at a site (of cereals, vegetables, herbs and spices in particular), because pollen is not intentionally eaten, it does not necessarily directly represent food consumption. Further research into the presence of pollen of other plants present on edible plants is required to better understand the information pollen provides us about food consumption. In order to enable us to distinguish between direct and indirect indicators for consumption, we tabulated them separately. Table 2 refers to the macro-remains and shows the ubiquity (%) of plant taxa most frequently found (> 50%) in cesspits per sub-period and their potential origin. Table 3 refers to the micro-remains and shows the ubiquity (%) of all pollen finds of edible plant taxa per sub-period.

Macro-remains 1500–1850

Table 2 shows the 29 plant taxa of which seeds and fruits were present in 50% or more of the cesspits during one or more sub-periods. *Ficus carica* (fig) is the most common throughout the three sub-periods, closely followed by *Malus/Pyrus* and *Vitis vinifera* (grape). *Brassica nigra* (black mustard) is also well represented in all three sub-periods. The presence of *Foeniculum* decreases slightly over the course of time, as does that of *Mespilus germanica* (medlar), *Vaccinium* spp., *Linum usitatissimum* (flax) and *Humulus lupulus* (hop).Whilst the presence of *P. avium/cerasus* declines in the sub-period 1600–1700, it rises again in the sub-period 1700–1850. The same goes for *P. domestica* (plum), *Corylus avellana* (hazelnut), *Ribes* spp. and *Juglans regia* (walnut). Fruits of *Rubus fruticosus* (blackberry) are found less often in 1700–1850 than in the previous sub-periods, whilst instances of *R. idaeus* (raspberry) fruit finds increase over the course of the time considered, as do instances of *Fragaria moschata/vesca*, *Morus nigra* (mulberry), *Coriandrum sativum* (coriander), *Brassica napus/rapa* (rapeseed), *Vicia faba*, *Piper nigrum* and *Sambucus nigra* (elderberry).

The fragmented fruits of *Fagopyrum* are often found in the cesspits, although their presence decreases over time. The same can be stated for the chaff of *Panicum miliaceum*. Instances of *Secale* and *Triticum* diminish during the sub-period 1600–1700, although they increase again during the sub-period 1700–1850. This trend applies to the macro-remains of cereals in general, of which mostly charred grain kernels and bran fragments were found. The only cereal macro-remain present in over 50% of the cesspits that increases over the course of the centuries is *Oryza*.

Micro-remains 1500–1850

Table 3 shows all selected plant taxa represented by pollen finds, per sub-period. The most frequent pollen finds are those of cereals (*Hordeum* and *Triticum*), even though their presence diminishes over the course of the centuries. Other cereals, such as *Secale* and the (pseudo-)cereal *Fagopyrum*, are also present. The presence of *Secale* strongly diminishes after 1600, whilst that of *Fagopyrum* declines in the middle sub-period and increases during the third sub-period. Many other taxa show a similar trend, for instance *Anthriscus cerefolium* (chervil), *Beta vulgaris* (beet), *Vaccinium* spp., *Coriandrum*, *Foeniculum*, *Ribes* spp. and *Juglans*.

In contrast, *Sambucus* and *Carum carvi/Cuminum cyminum* are found more often in the sub-period 1600–1700 compared with the other two sub-periods.

The presence of other taxa increases over the course of the centuries, such as *Humulus*, *Pisum*, *Capparis spinosa* (capper), *Juglans*, *Borago officinalis* (borage), *Pimpinella anisum* (anise), *Spinacia oleracea*, *Mespilus germanica*,

Table 2 Ubiquity > 50 (%) of plant macro-remains found in the cesspits under study (at least in one of the sub-periods considered) and potential origin: as kitchen by-products (KBP) after food processing (such as juice pressing); concentrated as consumption refuse (CR) after ingestion and digestion; originating from a secondary fill or garden waste (GW)

Plant taxa	Remain	AD 1500–1600	AD 1600–1700	AD 1700–1850	KBP	CR	GW	Category	Food unit
Cerealia	Fruit	83	73	71		+		1	S
Corylus avellana	Fruit	72	58	71	+			1	S
Fagopyrum esculentum	Fruit	83	73	71	+			1	S
Humulus lupulus	Fruit	56	38	36	+		+	1	S
Juglans regia	Fruit	61	50	64	+			1	S
Oryza sativa	Chaff	44	54	57	+			1	S
Panicum miliaceum	Chaff	67	54	50	+			1	S
Piper nigrum	Fruit	33	38	57		+		1	S
Prunus avium/cerasus	Fruit	78	73	86	+			1	S
Prunus domestica	Fruit	67	77	86	+			1	S
Secale cereale	Fruit	78	62	71		+		1	S
Triticum aestivum	Fruit	56	15	29		+		1	S
Coriandrum sativum	Fruit	56	62	57	+	+		2	S
Foeniculum vulgare	Fruit	67	65	50	+	+		2	S
Sambucus nigra	Fruit	39	54	57	+	+		2	S
Vitis vinifera	Seed	89	92	93	+	+		2	S
Brassica napus/rapa	Seed	33	42	57		+		3	S
Brassica nigra	Seed	83	77	79		+	+	3	S
Linum usitatissimum	Seed	56	46	36		+		3	S
Malus domestica/Pyrus communis	Seed	89	88	93	+	+		3	S
Mespilus germanica	Seed	61	62	50	+	+		3	S
Vicia faba	Seed	44	38	50		+		3	S
Ribes nigrum/rubrum/uva-crispa	Seed	72	69	86	+	+		4	S
Vaccinium myrtillus/uliginosum/vitis-idaea	Seed	72	58	50	+	+		4	S
Ficus carica	Fruit	100	85	100		+		5	C
Fragaria moschata/vesca	Fruit	67	77	79	+	+		5	M
Morus nigra	Fruit	67	69	64		+		5	M
Rubus fruticosus	Fruit	89	73	64	+	+		5	C
Rubus idaeus	Fruit	44	77	79	+	+		5	M

The taxa are ordered alphabetically within categories of potential ovule numbers; category 1: number of potential ovules n = 1, 2: n = 2–5, 3: n = 6–10, 4: n = 11–50, 5: n > 50

Food units are categorized as: *S* single fruit, *M* multiple fruit, *C* compound fruit

Olea europaea (olive), *Portulaca oleracea* (common purslane), *Prunus domestica* and *Sorbus* sp. (rowan). Pollen of *Syzygium aromaticum* (cloves) is frequently found in cesspits (Table 3). The species belongs to the Myrtaceae, and its pollen is rather difficult to distinguish from that of *Myrtus communis* (myrtle) and *Pimenta dioica* (allspice) unless using SEM (Jankovská 1995; Thornhill et al. 2012a, b; Deforce et al. 2019, p 439). Archaeobotanists are inclined to identify this pollen type as cloves, for three reasons. First, cloves are the dried flower buds of *S. aromaticum*, which contain a large amount of pollen, and eating cloves would have resulted in a relatively large amount of pollen being ingested and subsequently deposited with the faeces. In contrast, *Myrtus* and *Pimenta* were consumed in the form of leaves and/or berries and the fruits, respectively, which would have had a relatively smaller amount of pollen adhering to them that could potentially have been deposited after ingestion and digestion (Deforce et al. 2019, p 439). Second, the historical literature speaks in favour of *Syzygium* as the producer of this type of pollen found in cesspits, especially as the Dutch East India company, the Verenigde Oost-Indische Compagnie, had a monopoly on the *Syzygium* trade commencing in the course of the second half of the second sub-period (van Zanden 1993; Knaap 2004). Thirdly, cookbooks from the 16th, 17th and 18th/19th century contain many recipes containing *Syzygium*, though *Myrtus* and *Pimenta* are almost never mentioned. Certain plant taxa present in the first two sub-periods disappear from the pollen record during the sub-period, such as *Carthamus tinctorius* (safflower), *Petroselinum crispum* (parsley), *Castanea sativa* (chestnut),

Table 3 Ubiquity (%) of plant micro-remains found in the cesspits under study in alphabetical order

Sub-period (AD)	1500–1600	1600–1700	1700–1850
Anethum graveolens	6	4	
Anthriscus cerefolium	33	31	29
Apium graveolens	6	4	
Beta vulgaris	22		7
Borago officinalis	6	8	14
Capparis spinosa	11	8	14
Carthamus tinctorius	17	8	
Carum carvi/Cuminum cyminum		4	
Castanea sativa	6	4	
Cerealia	56	35	36
Coriandrum sativum	6		7
Fagopyrum esculentum	17	15	21
Foeniculum vulgare	6		14
Humulus lupulus	17		21
Juglans	11	4	14
Mespilus germanica			7
Olea europaea			7
Petroselinum crispum	11	4	
Pimpinella anisum	6	12	21
Pisum sativum	17	8	21
Portulaca oleracea			7
Prunus		4	7
Ribes nigrum/rubrum/uva-crispa	6		
Sambucus nigra	6	12	7
Secale cereale	28	8	7
Sorbus			7
Spinacia oleracea	6	12	29
Syzygium aromaticum	28	31	36
Vaccinium myrtillus/ uliginosum/vitis-idaea	22	8	14
Vicia faba	28	19	29
Vitis vinifera	6		

Anethum graveolens (dill), *Apium graveolens* (celery) and *Vitis vinifera* (grape).

Similarities and differences

Only a limited number of plant taxa represented by seeds and fruits are also represented by pollen, namely *Ribes* spp., *Vicia faba*, *Fagopyrum*, cereals, *Coriandrum*, *Vaccinium* spp., *Sambucus*, *Foeniculum*, *Vitis*, *Humulus*, *Mespilus germanica* and *Secale*. Many of the species represented solely by pollen finds are edible plants of which the leaves, flowers or flower buds were consumed. These vegetables, herbs and spices were consumed for their vegetative plant parts and leave no trace in the macrobotanical record, as they are harvested before the plant starts to form seeds and fruits. They correlate well with the species addressed by Deforce et al. (2019). When comparing the results of the presence of edible plant species represented by both the macro- and micro-remains, we see some fluctuation in the ranking of the presence of plant taxa through time. These fluctuations are smaller for macro-remains than for micro-remains.

There is another interesting trend. When we look only at the macro-remains, it is obvious that, despite fluctuations, quite a number of plant taxa are present in similar percentages of ubiquity throughout the course of the period under study. This does not hold for the micro-remains, however. This discrepancy may be the result of the fact that fewer pollen samples than macro-remain samples have been analysed. Future research may shed light on this potential difference in incidence.

Rare finds or singular finds

A fair number of plant taxa are represented in all three sub-periods in both increasing and decreasing quantities. Twelve species were found only once in the selected sub-periods

(Table 4). These are: *Fagus sylvatica* (beech), *Physalis alkekengi* (Chinese or Japanese lantern), *Coffea arabica* (coffee), *Berberis vulgaris* (common barberry), *Salicornia europaea* (common glasswort), *Lepidium sativum* (garden cress), *Atriplex hortensis* (garden orache), *Melissa officinalis* (lemon balm), *Lens culinaris* (lentil), *Lactuca sativa* (lettuce), *Rosmarinus officinalis* (rosemary) and *Sinapis alba* (white mustard).

These are by no means only exotic and rare species, as might be suggested by them being listed as singular finds. Some of these taxa were present in cesspits dating to overlapping sub-periods. Due to the strict demarcation of the sub-periods under study, these finds from overlapping sub-periods were omitted. A number of the singular finds are archaeophytes and would have been expected to be found more frequently. Some other species, such as lettuce, would definitely have been part of the Early Modern diet, as is evidenced by historical recipes. All but *Coffea* (native to Ethiopia) grow naturally in the Netherlands, but we know from historical records that coffee was imported in bulk and consumed by large numbers of the general public during the late 17th and 18th century (Jobse-van Putten 1995, pp 107–108; Meerman 2015, p 98). The ship lying on the seabed off the coast of Texel carrying containers with coffee testifies to this (Kuijper and Manders 2009).

Discussion

Understanding patterns

The overview of edible plant taxa derived from the RADAR-2012 dataset has provided some unexpected results. A total of 33, 39 and 26 sites were eligible for analysis per sub-period. Percent ubiquity of archaeobotanical finds from cesspits at these sites show plant species consumed, both directly (seeds and fruits) and indirectly (pollen). Within archaeobotanical research, it is stated that certain edible plant species are rarely found in cesspits, because the plant parts consumed leave no trace in the archaeobotanical record. The best known of these 'absent' species belong to the group of vegetables, herbs and spices (Kooistra and Brinkkemper 2016). When single cesspits are analysed, these species indeed seem not to be ubiquitous. However, when multiple cesspits are analysed from a site and pollen research is included, the number of vegetable species present increases significantly.

Survival in the archaeobotanical record

Post-depositional processes acting on plant remains

The preservation of plant remains is determined by both pre- and post-depositional processes. Pre-depositional processes primarily relate to food preparation, food consumption and food digestion (Butler 1990; Holden 1990; Carter and Holden 2000; O'Meara 2014). Several post-depositional processes hamper the preservation of deposited plant material that is a precondition for archaeobotanical research. Post-depositional processes are also referred to as taphonomy, although a generally accepted definition of this term is still lacking. Archaeobotanists are aware of the complexity of these processes, and many studies have been dedicated to this topic (for an overview, see Fuller 2006).

Once plant tissues become part of the archaeobotanical archive, they normally decay within a few years unless external factors impede this process. The three most common modes of preservation in Dutch cesspits are waterlogging, mineralisation and charring prior to deposition, with waterlogging being the most common. The mode of preservation

Table 4 The 12 species represented by singular finds, including plant part and possible preparation methods

Taxon	Plant name	Native species	Plant part	Possible preparation methods
Fagus sylvatica	Beech	Yes	Cupule	De-seeding, roasting
Coffea arabica	Coffee	No	Seed	Roasting, grinding
Berberis vulgaris	Common barberry	Yes	Seed	–
Salicornia europaea	Common glasswort	Yes	Seed	–
Lepidium sativum	Garden cress	Yes	Seed	–
Atriplex hortensis	Garden orache	Yes	Fruit	Threshing
Physalis alkekengi	Chinese or Japanese Lantern	Yes	Fruit	–
Melissa officinalis	Lemon balm	Yes	Fruit	–
Lens culinaris	Lentil	Yes	Seed	Boiling, pulverizing/mashing
Lactuca sativa	Lettuce	Yes	Fruit	–
Rosmarinus officinale	Rosemary	Yes	Fruit	–
Sinapis alba	White mustard	Yes	Seed	Grinding

A '-' indicates that no preparation would have been needed to render the food edible matters greatly, because the types of food plants recovered during excavation are strongly correlated to the types of preservation encountered (van der Veen et al. 2007, p 185; Colledge and Conolly 2014). Fruits, vegetables, herbs and spices are most often preserved due to waterlogging or mineralization, whilst whole grain kernels of cereals and seeds of pulses are most often preserved due to charring. Nuts and oil-rich seeds, as well as seeds and fruits from fibre plants, can be preserved due to either waterlogging or mineralization (van der Veen et al. 2013, p 157). Under waterlogged conditions, cereals and pulses are underrepresented compared with whole grain kernels and seeds. This bias can be remedied in part by also considering cereal bran, which preserves well in waterlogged conditions and is identifiable with proper identification keys (e.g. Körber-Grohne 1991). The *testa* of pulses are more difficult to recognize and identify (Butler 1990). Charred plant material preserves very well once it becomes part of the content of a cesspit, and uncharred plant material preserves by waterlogging or by becoming mineralized. Because this study is restricted to cesspits, modes of preservation can be expected to be similar between sites and between sub-periods. The reduction in plant material from what was originally deposited will therefore also have been the same throughout the period under study. The analysis of a large dataset such as this one, confined to Early Modern Dutch cesspits, is therefore suitable for a comparative study that is aimed at revealing general patterns in past food consumption.

Potential seed production

Assuming that plant remains from cesspits will have preserved equally well throughout the three demarcated sub-periods, we can compare between sub-periods and interpret the (lack of) change in presence of taxa throughout the 350 years under study and know that the differences are 'real'. To judge the meaning, in terms of human consumption, of the seeds and fruits in an archaeological context, we first have to take into account their number in relation to the food unit that is consumed. This can be done by evaluating the potential seed production and possible clustering of fruits. In seed plants (spermatophyta), the seed develops from an ovule and becomes enclosed by a fruit in the flowering plants (angiosperms). The potential number of seeds produced by a plant depends on the number of ovules and the effectiveness of pollination and fertilization. With respect to fruit clustering, three types of fruits can be distinguished: single fruits, multiple fruits and compound fruits. A simple fruit develops from a single flower with a more or less isolated position in the infructescence. A multiple fruit develops from one flower with multiple pistils; in the ovary of each pistil, one or more seeds ripen. A compound fruit develops from several flowers that are united within the infructescence, each with its own pistil (Cappers and Bekker 2013, p 12).

Assessing the potential seed production by quantifying the number of potential ovules is especially useful when we want to assess the significance of the percent ubiquity of multiple or compound fruits in past diets. Food plants with such fruits may be overrepresented numerically in comparison with their dietary importance in the archaeobotanical record in general, because the fruits are consumed as a single food unit even though they consist of multiple fruits and therefore multiple seeds.

Over- or underrepresentation of plant species

When studying the taxa listed in Table 2, it may be tempting to assume that they were consumed most often, and therefore comprised a major part of the Early Modern diet. However, this is not necessarily the case. For instance, it could very well be that species producing a large quantity or robust (i.e. well-preserving) fruits and seeds are best represented in cesspits. Therefore, plant species producing many and/or robust diaspores may be overrepresented when we assess past food consumption through the archaeobotanical research of cesspits. To ascertain if the taxa represent species that produce a large number of diaspores, we also tabulated the number of potential ovules per food unit (Table 2).

Twelve of the taxa contain no more than one potential ovule, which means that they only have one seed in a single fruit (Spjut 1994). Four taxa contain an average of 2–5 potential ovules. Six taxa contain an average of 6–10 potential ovules. Two taxon groups contain an average of 11–50 potential ovules. Finally, five taxa are characterized by an average of 50 or more potential ovules. Table 2 shows that most taxa present are part of category 1, containing one potential ovule per fruit or food unit. However, when we compare the presence of each category by site, a different picture emerges. Even though most taxa are part of the first category, they are present in far fewer sites percentagewise. A clear difference can be observed between category 5 and all other categories. On average, the taxa in category 5 are present in 75% of all sites, whereas the taxa in the other categories are present in lower percentages (68% in category 4, 60% in category 3, 65% in category 2 and 61% in category 1). Whereas the taxa containing 50 or more potential ovules are present in most sites, this is not the case for other taxa. Other multiple and compound fruits, such as pomegranate, tomato and cucumber, while also present in the RADAR-2012 data, are present in fewer sites. This indicates that sheer number of potential ovules and thus potential seed count does not necessarily correspond to a greater presence in cesspits. But because these fruits contain more seeds and fruits per food unit, the chance of finding a seed or fruit from this category is of course higher.

However, conclusions cannot be drawn from the correlation between these frequently present taxa and their role in the Early Modern diet as long as the impacts of seed robustness and of pre- and post-depositional processes have not been studied in more detail.

Plant use and food preparation

Most food items are prepared in one way or another before consumption. With regard to food, excavations of cesspits typically yield two types of findings: kitchen by-products, and consumption refuse in the form of faeces. Kitchen by-products consist of plant parts that are discarded while preparing a food item into a dish. Conversely, consumption refuse consists of plant parts that have been intentionally consumed but have survived digestion to form part of the excrement. Historical recipes mention, if often rather vaguely, which preparation methods were applied. The method of preparation can leave traces on plant remains, which in turn can be analysed to distinguish between kitchen by-products and consumption refuse or faecal matter (Hondelink 2012, 2013). Preparation methods partly explain why some food plants are rarely found in certain archaeobotanical contexts.

Plant foods that typically produce kitchen by-products are vegetative plant parts that enclose the edible fruit (such as the chaff of cereal grain kernels), the large inedible parts of single fruits (such as the hard inner part of stone fruits, being the endocarps), and large inedible seeds (such as those of *Mespilus germanica*). Plant foods that typically end up in human faeces are the small but hard parts of multiple and compound fruits. They are consumed in large quantities, are only partly fragmented by chewing, and preserve easily. Especially multiple fruits that consist of a cluster of stone fruits (such as bramble) are therefore omnipresent in cesspits. Only the soft, outer part of the small stone fruit is digested, and the many endocarps (often inaccurately designated as 'seeds') become concentrated in a cesspit. A well-represented compound fruit is the fig. In this case, the soft edible tissue (axis) supports hundreds or even thousands of fruits (often inaccurately called 'seeds'). Only the soft tissue is digested, and most of the fruits become concentrated in the cesspit.

Finally, there are also food plants that could provide evidence for either kind of pathway, such as the odd stone fruit that is swallowed and digested instead of removed before consumption, grape pips that are swallowed instead of spat out, and apple or pear cores that are eaten instead of discarded. Cereals can also be interpreted as providing both kitchen by-products and consumption refuse, depending on the plant part recovered. They can be interpreted as a kitchen by-product (or even the by-product of the previous threshing) in the case of chaff, rachis fragments and charred fruits, or as consumption refuse in the case of (mineralized) fragmented fruits and bran.

Traditionally, *Brassica nigra* is interpreted as a weed that grows in rural areas and floodplains (Weeda et al. 1987). Cesspit finds of *B. nigra* seeds could thus also be considered garden waste. However, the presence of *B. nigra* seeds in cesspits is interpreted as consumption refuse, because the seeds can be consumed as a condiment either whole or ground and because the seeds are used in relatively small quantities in food preparation. Other wild plant species that are generally interpreted as weeds were probably used for culinary purposes in the past as well (Behre 2008; van Amerongen 2016). Bulk finds can be another indication of the culinary use of wild plants, for example, the bulk find of thousands of *B. nigra* seeds in Poitiers, Vienne, France (Pradat et al. 2015). For the Netherlands, there are also recorded bulk finds of wild plant seeds that are interpreted as having been stored for consumption, for instance, the seeds of *Sinapis arvensis* (wild mustard) found in medieval Ouddorp, Zeeland, The Netherlands (Schepers 2010). The same goes for finds of *Raphanus raphanistrum* (wild radish) seeds and fruits from early Roman Saksenoord, Friesland, the Netherlands, whose dispersal units were also interpreted as having been collected in the wild for culinary usage.

Consumption and deposition of plant parts

A fair number of the edible food plants that are represented less frequently in cesspits are those whose seeds and fruits are less robust or less likely to be deposited in general (e.g. vegetables whose edible parts are obtained before the plant sets seed). Furthermore, food preparation (e.g. the grinding of peppercorns), consumption (chewing and digestion), and disposal, as well as the presence of microorganisms, soil composition and water level, will determine the presence of plant remains in consumption refuse and their preservation in the cesspit.

Singular finds

A dozen taxa contained in RADAR-2012 that are present at other sites or contexts for the period under study are absent from the study dataset. An explanation for the relative absence of these 12 taxa in 350 years of cesspit use can be found in the type of plant part used for consumption and the cooking techniques that have to be applied (Table 4). The lack of soft tissue analysis of vegetative plant parts present in cesspits likely introduces a serious bias. The benefits of this type of analysis are evident when it is included in the research (Karg 1991; Tomlinson 1991; van der Veen 2007).

In the case of *Atriplex hortensis*, *Lactuca sativa*, *Lepidium sativum*, *Melissa officinalis* and *Rosmarinus*, it is the leaves that are normally eaten. In case of *Salicornia europaea*, it is the stems that are consumed. These plant parts rarely leave a trace in the archaeobotanical archive, unless soft tissue is recovered, as they are commonly consumed before the plant has started producing seeds. As can be seen in Table 4, it is not these vegetative plant parts that have been retrieved from the archaeobotanical samples, but, rather, the seeds and fruits. As the latter are not the preferred plant part used for consumption, they are generally interpreted as indirect evidence, but evidence nonetheless, for the consumption of these species.

Seeds and fruits are found most often, because they generally preserve well unless they are prepared for consumption in some taphonomically detrimental way, for example by grinding (such as in the use of *Piper nigrum*, *Coffea arabica* and *Sinapis alba*). Seeds of *Lens culinaris* preserve poorly, as do seeds of most protein-rich pulses. They are often digested completely, and they digest easily. Only when they come into contact with heat or fire or when they become mineralized do they preserve. With *Fagus*, normally it is the non-edible cupule, tough and woody, that is found in archaeobotanical samples. Within the context of a cesspit, this would suggest that the cupules were thrown away as a kitchen by-product, as only the nutlets are consumed. Another interpretation, in light of this solitary find, is that the *Fagus* cupule was deposited in the cesspit as part of garden waste. This leaves us with the single seed find of *Berberis vulgaris*, a shrub native to Europe that grows on the edge of forests. These berries can be eaten raw but are very sour, so they are often used for making jam, also because the fruits have a high concentration of pectin. Even if these berries were eaten in only small quantities, *Berberis* seeds should still be present in archaeobotanical contexts. The seeds are relatively small and have few identifiable characteristics (they measure 4.6 × 1.7 mm; see Cappers et al. 2012). It is possible that they remain largely unidentified because we do not yet recognize them (Greig 1996, p 219).

Conclusions

Datasets of archaeobotanical samples from cesspits contained in the RADAR database (updated to 2012) were analysed to reconstruct Early Modern Dutch urban food consumption. Consumed food items can be disposed of during or after food preparation, as kitchen by-products, or after consumption, as human faecal matter. Both kinds of material contain subfossil plant remains which are generally interpreted as, respectively, indirect and direct evidence for past food consumption. In order to interpret and reconstruct past food consumption trends, they have to be compared with a contemporary general trend in food consumption and/or compared with a diachronic local study. It is important to hold at least one of the variables, the type of archaeological context, constant—as has been done in this paper. The data analysed for this study provided detailed diachronic information about plant consumption in 34 different urban settlements within the Netherlands, based on the macro- and micro-remains from 98 cesspits from the period AD 1500–1850, which was divided into three sub-periods for analytical purposes, 1500–1600, 1600–1700 and 1700–1850. The plant taxa that are present in > 50% of the sites in each of these three sub-periods show relatively few changes in ranking between the sub-periods.

Potential ovule production, clustering of fruits in food units, and plant usage were analysed to assess if these plant taxa were overrepresented solely because of the number of seeds and fruits produced or if they indeed formed a majority of floral food items consumed. An increase in potential seed production was shown not to correspond with an increase in the percent ubiquity of subfossil plant taxa found in sites, although percentagewise the frequency of their presence was higher. Post-depositional processes influencing the chances of recording a taxon during archaeobotanical analysis—that is, preparation and preservation—have to be studied in greater detail and deserve further attention in future research. The 12 plant species represented by singular finds are not interpreted as 'rare', for one or more of three reasons. First, some are present in sub-periods omitted from the selection because of overlaps in dating. Second, their absence from the archaeobotanical datasets may have been caused by post-depositional processes, such as grinding or pounding. Third, their absence may relate to the lesser preservation qualities of their vegetative plant parts, such as leaves and roots.

A comparison of the results of macro- and micro-remain analysis shows that quite a variety of edible plants only become visible when pollen analysis is carried out. These taxa mostly represent plants of which the vegetal plant parts are consumed. More information is to be gained when pollen research is included in studies aiming to reconstruct past peoples' dietary practices.

Despite these critical notes, this review shows that there is a large potential for improving the dataset by further archaeobotanical research and more attention for the detailed registration of plant parts in general and potential preparation marks in particular. A more accurate picture of Early Modern Dutch food consumption and of past Dutch food consumption in general will be obtained by further integrating future data into RADAR and by supplementing this with data from primary historical sources pertaining to food consumption, such as cookbooks and herbaria.

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