# Commodities carried in amphorae AD 600-1200 – new research from Sicily

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*Summary*

 In this paper we present briefly some of the aspects of trade in amphorae that we intend to confront within the project *‘sictransit’* which began in 2016. This research concerns the people of Sicily and their trade with neighbouring countries in the period 5th to 13th century. The aim of the project is to understand social and economic change through consecutive regimes, broadly characterised as Byzantine, Aghlabid, Fatimid, Norman and Swabian, with special reference to rural and urban contexts. In addition to drawing on research on Sicilian amphorae typology and provenance, we shall be applying organic residue analysis and a variety of other approaches to determine crops and diet.

The work will be undertaken in close collaboration with other analytical and field programmes currently underway in pursuit of the changing diet, demography and agricultural landscapes of Sicily, using plant remains, animal remains, stable isotope analysis and aDNA to compare the predilections of the producers with the form of ceramic containers and their detected contents (Molinari 2013, 2015). In this way we hope to define a more precise context in which commodities are being circulated in amphorae, both within the island and between Sicily and the destinations of its exports and the sources of its imports, across three surrounding seas. The project is a collaboration between archaeology and science departments at the Universities of York, Rome Tor Vergata and Lecce (see also papers by Molinari, Capelli, Orecchioni).

*Systems of supply*

The perceived long term necessity of the transportation of wine, oils and other high value liquid commodities in the Mediterranean recently inspired Bevan (2014) to take an anthropological overview, ranging from the Bronze Age to today's steel shipping containers. The period we are concerned with here is rather shorter and can be considered in five broad phases: (Vroom, this vol.): a Roman (to 300), a Late Roman/early Byzantine (400-700; Karagiorgou 2009, Types I-XX), a 'Dark Age' (700- 900 using globular amphorae; Armstrong 2009; Decker 2016; Vroom 2017), a Fatimid (900-1050; Ardizzone 2010; Arcifa 2010; Sacco 2014) and an early medieval (1050-1300; Vroom, this vol.). As shown by a number of papers in these proceedings, current approaches to tracking Mediterranean trade converge on an impression that the transport of commodities in amphorae is continuous up to the 13th century, but with major changes in the intensity and in the itineraries of supply. In the first millennium AD, Bevan noted a peak in supply between the 1st and 2nd centuries, a dip in the 3rd , an increase in the 5th and 6th and a decline thereafter (Bevan 2014, 394). He endorsed the common-sense idea that the traffic was intended to be continuous and that the apparent decrease was due to the use of less visible containers, in particular wooden barrels (Bevan 2014, 395; Lane 1986, 233-4), to which can be added mule-borne wineskins, at least overland (Decker 2009, 235; Bevan 2014, 397). New discoveries and recent research, among them the Yenikapı, ships, the excavations at Comacchio and the pottery studies carried out at Butrint have affirmed the continuous use of amphorae to some degree up to the 13th century (Kocabaş 2008; Gelichi 2010; Vroom 2017, studying the assemblage at Butrint towers WD1, WD2). While the 8th to 9th centuries remain less obtrusive, they probably do not deserve to provoke the epithet of an 'ice age settling on the Mediterranean' (pace Bowden and Hodges 2012, 233; cf Vroom 2017, 302).

While barrels may be a factor in the visibility of ancient trade, another explanation for the variation in the quantities of amphorae found on sites is that the traffic alters not only in its intensity but in its destinations and routes of supply. There is no obvious reason why former Roman ports or centres such as Ostia, Classe or Butrint should reflect the intensity of Mediterranean trade if they are no longer taking part in it. However, grapes and olives still grow and the likelihood is that they are being picked, pressed and in demand. The revelations of the trade active at Comacchio and in Sicily, and in the Tyrrhenian and Adriatic during the supposedly dead period of the 8-9th century, show that trade has not so much died, as moved somewhere else (Carver 1993; Arcifa 2010; Ardizzone 2010; Gelichi et al 2012; Gelichi & Negrelli 2017). Changes in the supply system reflect changes in demand and changes in procurement, especially in the balance between an imperial command economy and one driven by more private initiative. Whether the globular amphorae and their successors are artefacts of surviving empire or merchant enterprise remains to be seen (cf Decker 2009, 245; Zavagno 2012, 155). Meanwhile the possibility should be entertained that other international agents with new destinations may be driving supply, for example, the monastic network which appears to be at its strongest between the 7-9th centuries and had an expansionist agenda (Gelichi et al. 2012, 200; Carver 2015). These represent transitions that deserve to be mapped, with an expectation of new protagonists and new destinations, and perhaps a more sensitive form of archaeological investigation in which it can be determined how and when a command economy, a spiritual economy, an enterprise economy and a mercantile economy vied for primacy.

*Variations in Contents*

If the economic framework is changing to accommodate more diversity, it would not be unreasonable to expect some diversity in what is being carried. It can be noted that amphorae diagnostic of successive phases of supply often have a different shape, which may have a practical explanation: as for example an increase in amphora length reflecting an increase in the size of ships (Bevan 2014, 388). At Yenikapı cargo ships varied in size from 9m long (YK12, C14 672x870 cal.; its cargo of globular amphorae partially intact) to 22.5m long (YK3, C14 668x840 cal.; conveying marble). They were found with 20 other wrecks in layers dated to the 10-12th century (ie a century later), and the grading of the cargo vessel contingent as a whole as small, medium or large is aligned to length of voyage (local or long-distance) rather than cargo (Kocabaş 2008; Kocabaş 2012, 320). The long life of ships and their diversity of use may mean that any correlation between type of ship and type of amphorae will be elusive. Inscriptions on amphorae are not only rare, but discreetly sited, and probably not universally comprehensible. This implies that a primary function of amphorae form was the easy recognition of what was in them. If this is so, then some variation in their contents can also be supposed. The conventional forms of the 1-6th century are assigned to wine, oil and fish sauce, so it is possible that globular represents the preferred shape for 8/9th century wine. But it is also possible that wine from different sources is being signalled by different shaped containers, then as now (Vroom 2017, 297). This would be harder to argue for the 10/11th century forms for which the prime movers are likely to have been Muslim and a new range of contents anticipated. At the least, it would not be prudent to assume that all amphorae were used to transport wine and that the economic case is closed.

A point of departure for new research is provided by the variety of alternative contents already evident from some of the better documented regions. Michael Decker shows that while LR4 ('Gaza jars') mainly contained Gaza wine, 'papyri inform us that the *gazation* carried a range of products, including grain and nuts.' Similarly, while large scale wine-presses and dozens of LR5 production centres are known in the territory of Ascelon, LR5 also served as a multi-purpose jar 'whose typical contents could include fish brine, dried figs and olive oil, as well as wine'. The range of such trade is reckoned to be extensive: while LR4 have been found in 84 sites in Israel, and LR5 at 180 sites in Byzantine Palestine, LR4 and 5 have turned up at a further 123 sites around the Mediterranean (Decker 2009, 239).

*A Commodity revolution?*

For subsequent centuries, we may recall that the Comacchio finds included evidence for oil, wine, spices, salt, incense, silk, fish and salted eels (Brogiolo 2011, Fig 85, after Gelichi; McCormick 2012). The Abbey of Corbie had a toll-free concession issued in its favour in 716 by Chilperic II for the annual passing through the warehouses of Fos-sur-Mer of a wide variety of commodities, including 10,000 pounds of oil, 30 modii of fish sauce, 30 pounds of pepper, 150 pounds of cumin, 2 pounds of cloves, 1 pound of cinnamon, 2 pounds of spikenard, 50 pounds of dates, 100 pounds of figs, 100 pounds of almonds, 30 pounds of pistaccios, 100 pounds of olives, 150 pounds of chick peas, 20 pounds of rice, 10 pounds of orpiment as well as supplies of leather and papyrus (Loseby 2000, 178). By the 11th century, the *Geniza* documents record the transportation of dyes, olive oil (and soap made from it), fruit, nuts and cheese (from Sicily); and from the Orient, pepper, cinnamon, indigo, perfume (Goldberg 2012, 98). None of these commodities were necessarily conveyed in amphorae: fourteenth-century documents record the conveyance of sugar and cinnamon in boxes, and cereals in sacks (Bevan 2014, 399) and fresh fruit was arriving in medieval England (see below). But cargo survival in ship-wrecks suggest that amphorae were still the most common weather- and damp-proof container on offer. In and amongst its jars, the Tantura F wreck contained carobs and olive pits and fish bones (Barkai & Kahanov 2007, 26-7).

Michael Decker is convinced that many of the new agricultural techniques and crops that have been attributed to 9-10th century innovations by Islam were already developed in Late Byzantine times: he includes irrigation, qanats, the *noria* wheel and *saqiya* gearing, and by implication some of the new crops, notably rice, itemised in Andrew Watson's 'Green Revolution' (Decker 2009, 199, 201, 259). Hypothetically, these included oranges, lemons, sugar cane and other fruits and vegetables (Watson 1983; Chiarelli 2011, 213-222). The Islamic introduction of some of these have also been re-examined in the recent systematic and intensive research conducted under the aegis of the AGRUMED project. (Fiorentino, Zech-Matterne 2017). AGRUMED endorsed the origins of citrus fruits in east Asia and showed from texts that citrus fruits were known and perhaps cultivated in Archaic Greece and Roman Italy, although palaeobotanical finds are few, and in general ‘evidence is still too sparse to trace a reliable history of its spread (Fiorentino, Zech-Matterne 2017, 12, Fig 2; Pagnoux, ibid. p95). Current research by Edward Treasure of Durham University has found none of the 'revolution' crops in 10/11th century Spanish strata that were well preserved by burning and produced hundreds of identifiable taxa (pers. comm.). But, as these researchers would agree, individual presence or absence of plant remains in particular places is not a decisive argument for an industry elsewhere. In Sicily, oranges, lemons and sugar cane were grown in the hinterland of Palermo from the 10th century, the date that sherds of sugar-refining pots occur in excavations in the city and the beginning of the extensive cultivation of lemons in the ‘Conca d-Oro’ (Molinari 2015, 210; Barbera et al. 2015, 7). Even if lemons had grown in Roman gardens elsewhere, there is little doubt that this was an important moment in the industrial development of a sophisticated trade in foodstuffs, first from east to west and then from south to north. Sugar cane was introduced into the Iberian peninsula in the 11th century, and by the later Middle Ages merchandise books record up to to ten grades of sugar commanding high prices. Dried fruit and fresh fruit are being sent to England, including oranges, lemons, pomegranates and apples, and whole peppercorns were found on the *Mary Rose* (sank Portsmouth 1545) (Gutiérrez 2000, 103).

From the point of view of trade, the key question is not when the lemon arrived, but when citrus products began to be cultivated, processed and exported as profitable commodities. This is of importance for Sicily, where the obvious affluence and economic influence of the Fatimid regime suggests new resources and a new mechanism for generating profit. And among these initiatives, prominent candidates must be the arrival and commodification of new cultivars. Proof of the upsurge of such an industry relies partly on new discoveries of industrial processing areas, especially in Palermo. But proof of export lies rather in the hands of those who determine the contents of the new forms of amphorae that are being manufactured at the same time. It may be surmised that the high value products are sugar and the kind of fruit that sugar may be used to conserve. That such 'conserves' were reaching Northern Europe at a later date, and in special containers, is again suggested by later medieval evidence related by Alejandra Gutiérrez : “A frequent find on European excavations is the *bote,* *albarello (arbanello)* or concave-sided jar. These vases could have been used as containers for exotic foodstuffs, such as spices, honey, syrup or sugar-preserved fruits. The containers would have been covered with a piece of cloth or parchment and then tied with a piece of string around the rim. As imported foreign goods, preserves of this type were exclusive and available only to those who could afford them.” (Gutiérrez, A 2011, 307). It is thus possible that the high-value product we are seeking is some kind of marmalade, a commodity very welcome in northern countries offering an alternative to fermented fruit as a source of Vitamin C during long winters.

The aim of current research is therefore not only to provide scientific endorsement of what was carried in amphorae, but to discover whether there is a change or expansion in the range of commodities in demand, and, if so, whether such a change led to changes in trade agreements and an increase in wealth for the relevant producers. Such wealth is indicative of economic forces that can be every bit as potent as physical or religious conquest. However it can also be harder to detect. The problem of course is that sugar and most of its associated foodstuffs are soluble in water and so unlikely to survive in the walls of amphorae, especially in shipwrecks. Analytical chemical approaches of appropriate sensitivity have yet to be developed; and given the questions already raised on the sources of the products, even the standard determinations of lipids in amphorae have yet to reach the levels of specificity and validation we require. These are the challenges that lie ahead.

*Organic Residue analysis; problems and prospects*

Despite many years of studying amphorae, there is virtually no evidence of their contents in all but a few, exceptionally well-preserved contexts. Analysis of amorphous organic residues can potentially reveal contents and can be applied to sherds from a range of contexts and even following curation in museums. Linked with knowledge of sites of amphorae production and origin, this potentially allows assessment of the direction and volume of commodities traded.

Organic residue analysis (ORA) relies on the biomarker concept (Evershed, 2008). The identification of contents once present in ancient containers is based on the detection of molecular compounds (biomarkers) traceable to commodities of interest , absorbed into the walls of ceramic containers and resistant to the processes of biological and chemical decay. Generally, as biomolecules degrade, assigning their origin becomes more uncertain, provoking a more general and less specific assessment of contents. The identification of commodities used by past societies is therefore a trade-off between specificity and stability of the molecular compounds derived from natural products. As generally robust and water-insoluble molecules, lipids (i.e. fats, oils and waxes) meet this requirement and have been largely studied for the past 30 years (e.g. Craig et al., 2013; Debono Spiteri et al., 2016; Evershed et al., 2008). The majority of these studies have focused on lipid rich animal products, such as dairy fats and oils from aquatic species, but also beeswax [(Regert et al. 2001)](https://paperpile.com/c/2GSJF2/diBL), and some specific plant oils can be readily identified, including castor, brassica, palm fruit and palm kernel oil (Colombini et al., 2005; Copley et al., 2001, 2005; Pecci et al., 2010; Steele et al., 2010). Although olive oil has been claimed as detected in several amphorae, its specific identification remains challenging as the molecular profile of most degraded plant oils tend resemble olive oil. In contrast, plant resins (e.g. Pinaceae, pistacia) preserve well and are easily identifiable adhered to the surface or absorbed within ceramic artefacts, particularly amphorae (Pecci et al., 2017; Romanus et al., 2009; Stern et al., 2003, 2008b).

Certainly some of these lipid-rich products, such as plant and fish oils, are high energy, high value commodities that could have been traded across the Mediterranean in antiquity. Resins were undoubtedly used to line and seal Mediterranean amphorae but were important commodities in their own right from at least the Bronze Age [(Stern et al. 2003)](https://paperpile.com/c/2GSJF2/Cyb3). In contrast, fruits (whether citrus or vine) are generally lipid depleted and contain sugars, low molecular weight organic acids and phenolic compounds and therefore present a novel analytical challenge. First, most of these compounds are water soluble, and easily leached from archaeological artefacts, except in arid or frozen environment. This solubility in water also leads to their outward loss or inward migration, as contaminants, from the soil to the potsherds after burial. Second, these compounds are ubiquitous in nature, and therefore often lack the required specificity needed for identification. Third, unlike animal and plant lipids, analysed for thirty years with the same robust protocol of extraction and detection (Evershed et al., 1990, 1994; Mottram et al., 1999), no standard protocol exists for the analysis of other molecular compounds. For wine detection no fewer than nine extraction procedures and five analytical techniques have been tried (Barnard et al., 2011; Garnier et al., 2003; Garnier and Valamoti, 2016; Guasch-Jané et al., 2004; McGovern et al., 2013, 1996, Pecci et al., 2017, 2013; Romanus et al., 2009). The extraction of the decay products of citrus fruits has rarely been attempted.

Even so, despite some undeniable improvements, the identification of wine is still subject to debate. Clearly it seems that spot tests and the infrared spectroscopy, however quick, easy and cheap are wholly inappropriate for detecting degraded residues and complex mixtures as often encountered in the archaeological record (Stern et al., 2008). Separation techniques, such as gas or liquid chromatography, need to be coupled with detection using mass spectrometry. Even when such approaches are applied, conflicting results can arise, as shown by the content of Canaanite amphorae aboard the Uluburun shipwreck from Southern Turkey, said to contain either wine or *Pistacia* resin (McGovern and Hall, 2016; Stern et al., 2008). Others have questioned the specificity of the biomarkers (tartaric acid, its salts and syringic acid) for wine [(Steele 2013)](https://paperpile.com/c/2GSJF2/fqrx) even when such identifications seem highly probably based on their context.

Thus, while ORA has generally proven very efficient for studying the use of archaeological pottery, determining the content of trade amphorae in the Mediterranean remains a big challenge because:

* Burial contexts are not particularly favourable to the preservation of organic matter, especially the preservation of plant specific but sensitive compounds
* A large diversity of commodities and their degradation products must be considered. Most of these commodities have been rarely identified in archaeological pottery, and there is no consensus in the biomolecular archaeology community concerning the characteristic biomarkers.
* Mixing of commodities and recycling of amphorae are likely to have occurred, leading to a complex molecular signal that is difficult to interpret.

In order to bring greater precision to the identification and origins of organic residues, and broaden the range and possible taxa present, five main tasks will be addressed by the *SicTransit* project:

* Use of classical ORA approaches to detect plant oils and fish products.
* Development of new methods of analysis to enlarge the range of molecular compounds (polyphenols, wax esters, triacylglycerols) that can be reliably detected
* Analysis of the same potsherd with various methods (extraction and detection) to accumulate data on various molecular compounds and to compare the analytical potential of each method.
* Analysis of modern plant products to better understand their composition and identify possible biomarkers
* Analysis of the surrounding sediments as often as possible to rule out possible contamination from the soil.

*Amphorae biomolecules uncorked -* One final thought should be given to the potential for identifying other biomolecules in amphorae, such as proteins and DNA, which have been successfully achieved for the identification of osseous and botanical remains. Both DNA and proteins offer far greater specificity than lipids and are beginning to be increasingly applied to the identification of plant remains ([Palmer et al. 2012)](https://paperpile.com/c/2GSJF2/o9O2%2BhiIq) allowing species and even varieties to be distinguished, including wine [(Cappellini et al. 2010](https://paperpile.com/c/2GSJF2/o9O2%2BhiIq)). A drawback is that these molecules are generally soluble and easily degraded in the burial environment unless somehow to protected, such as within a seed coat or bound to bone mineral. One possibility is the protection offered by entrapment in resins lining the amphorae walls, which may offer a hydrophobic and stable environment for longer term preservation.

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