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Wine Production in the Byzantine Winepresses of Southern Israel: Insights from a Statistical Analysis

Matan Chocron, Oren Ackermann, Ilan Stavi and Boaz Zissu[1]

This paper focuses on various technological aspects of Byzantine winepresses. The Byzantine period presents a unique point in time when the increased demand for wine from the Southern Levant is attested by the introduction of new elements in the architecture and design of the winepress. Whereas past studies have stressed the importance of the introduction of the screw-press, it is shown here that this is but one of numerous features that helped increase the yield. Other elements, such as the addition of a second collecting vat and the integration of fermentation cells contributed significantly to local wine production in the Byzantine period.

Keywords: Byzantine period, simple winepress, complex winepress, statistical analysis, screw press, treading floor, collection vat, fermentation

Introduction

For thousands of years, wine has been an essential part of the diet[2] of the inhabitants of the Levant (Broshi 1985; Safrai 1994; McGovern 2003), and more so in the Byzantine period (fourth–seventh centuries CE). Wine also served as a medicine to cure diseases (Cato, *De Agricultura*:160) and played an important part in rituals of pagans, Jews and Christians. Between c. 3000 BCE and 300 CE, wine was produced in the Land of Israel mostly in small and simple winepresses comprising two main elements, a treading floor and a collecting vat (Frankel 1999), and sometimes an additional intermediate settling vat.

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[1] Dr. Matan Chocron, Israel Antiquities Authority and Martin (Szusz) Department of Land of Israel Studies and Archaeology, Bar Ilan University; Prof. Oren Ackermann, Institute of Archaeology, Ariel University; Dr. Ilan Stavi, Dead Sea & Arava Science Center, Ketura; and Prof. Boaz Zissu, Martin (Szusz) Department of Land of Israel Studies and Archaeology, Bar Ilan University. This research was part of Matan Chocron's Ph.D. dissertation in the Martin (Szusz) Department of Land of Israel Studies and Archaeology, Bar Ilan University, supervised by Oren Ackermann, Ilan Stavi and Boaz Zissu.

[2] *Vitis Vinifera* was an important plant for man. Besides wine, the products of *Vitis Vinifera* are fresh grapes, raisins, vine leaves and *dibs*. Vinegar is also a by-product of the wine industry.

These simple winepresses were found in the vicinity of villages, in or near vineyards, and were used by local farmers over generations. With the rise in demand for wine, Byzantine winepresses were designed to increase production. The understanding of the way these installations functioned has been debated. Some scholars (Hadas 2007; Dray 2015) have suggested that the trodden grapes were left with the must on the treading floor, or in fermentation cells, for primary (alcoholic) fermentation, while the collecting vats were used as temporary containers before the wine was transferred into amphorae for secondary (malolactic) fermentation (Dray 2015). The focus of this paper is on the application of a statistical analysis to better understand wine production in Byzantine winepresses, when new technologies were introduced to match the increase in the demand for wine from the Holy Land.

Wine Production in the Southern Levant

Wine was produced in the late summer, between the months of July and September, when grapes were harvested and brought to the winepress, where they were trodden. The must extracted from the grapes flew from the treading floor to the collecting vat, where it was left to settle for a few days for primary (alcoholic) fermentation. From there, the wine was collected in ceramic jars and stored in a cool place, like caves (Frankel 2009a; Ayalon, Frankel and Kloner 2012).

Winepresses changed over time. The first winepresses to include an intermediate settling vat are dated to the end of the Iron Age, becoming more common from the Hellenistic to the Byzantine period. Another change that occurred at the end of the Iron Age is the use of a beam press with weights. During the Byzantine period, the winepress' architecture, technology and size had greatly advanced (Frankel 1997; Frankel 2009a; Avrutis 2015). The 'developed'[3] winepresses of the Byzantine period comprised new components, such as a direct screw-press, fermentation cells, a directing vat and several collecting vats. At that time, the demand for wines of the Holy Land increased, and wine jars were shipped from the city ports of Gaza and Ashqelon to markets throughout the Byzantine Empire (Mayerson 1985; Kingsley 2001; Pieri 2012).

As of today, thousands of ancient winepresses have been found throughout Israel, mostly during surveys or salvage excavations conducted on behalf of the Israel Antiquities Authority (IAA). These winepresses yielded a wealth of data that allowed for a statistical analysis, a tool only rarely applied in archeological research (Shaus et al. 2017). Such an analysis was recently applied in the study of Byzantine-period winepresses in Israel, which evaluated the ratio between the area of a winepress' treading floor and the volume of its collecting vat (Stavi et al. 2018), suggesting that an unusual ratio—i.e., a large collecting vat in relation to the treading area—attests to a predetermined dual use of the collecting vats

[3] We use here the term 'developed winepress' (see Frankel 2009) rather than 'complex winepress' as it implies progress and development.

as cisterns for runoff water for agriculture. That study, however, did not distinguish between the various types of Byzantine-period winepresses.

Our research aimed at estimating the average ratio (area/volume) for the various types of Byzantine-period winepresses, providing important insights concerning the production capacity of ancient winepresses when other information is missing, e.g., when winepresses were only documented in surveyed, partly excavated or partly preserved contexts (Dar 1981; Turshan and Cox 2015; Frankel and Eisenberg 2018; Seligman 2020).

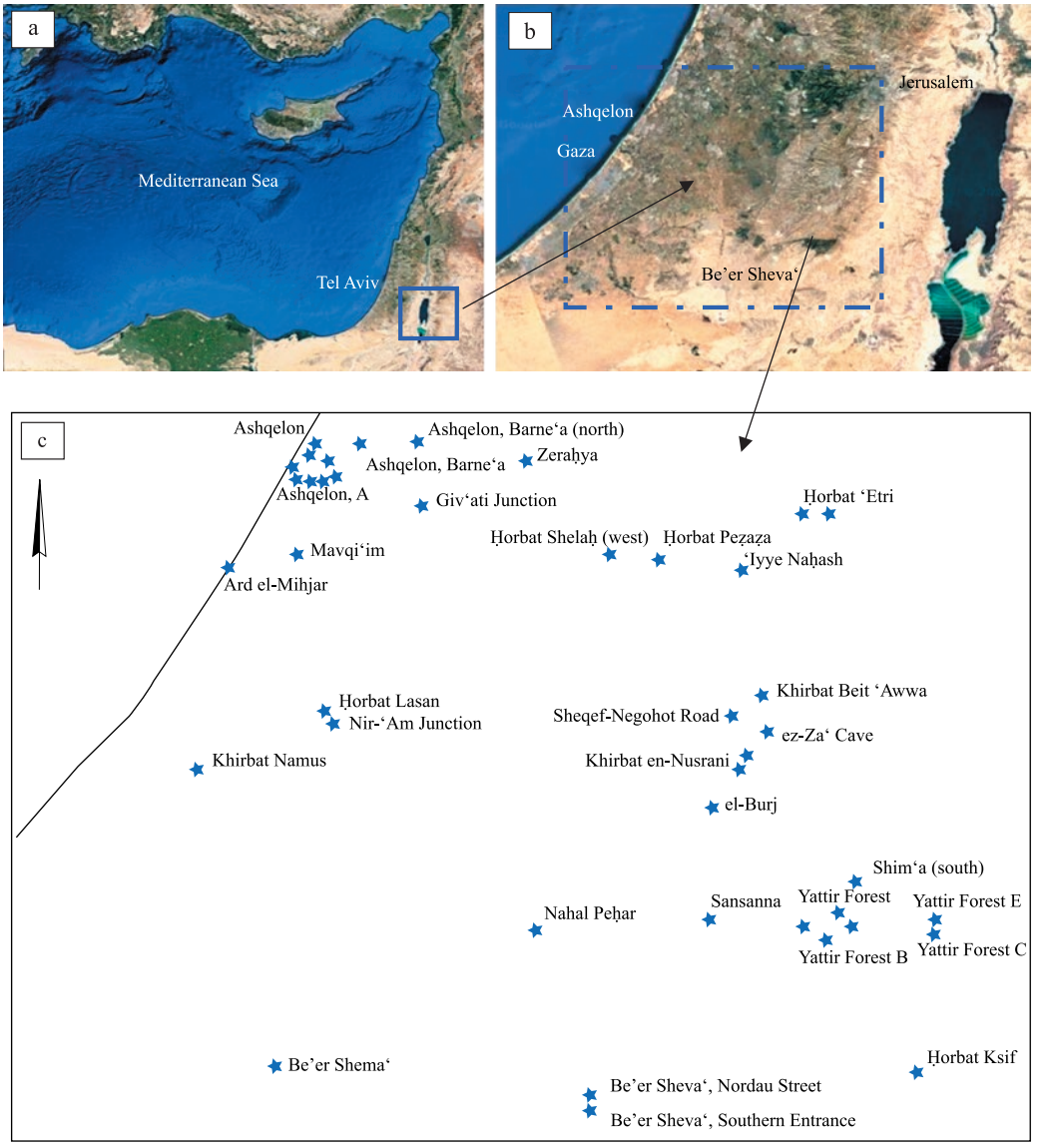

Fig. 1. Satellite images of the Levant (a), the study area (b) and the location of winepresses found in salvage excavations in the area (c).

A total of 55 simple and developed Byzantine-period winepresses were studied, all located in the sub-humid to semi-arid regions of southern Israel (Fig. 1). The winepresses' elements and measurements included in this statistical analysis were assembled from various publications (see below). The main objective of this study was to resolve the debate over how wine was produced in the winepresses, specifically concerning the fermentation process. This was assumed through a statistical analysis of the ratios between the area of the treading floor and the volume of the collecting vat in different types of winepresses: simple, basic-developed, developed with two collecting vats and developed with fermentation cells. The research premise was that the dimensions of the winepress' elements, and the ratio between them, reflects upon the industrial process. Also, this study allowed us to evaluate the impact of the screw-press technology on the annual produce of the winepresses. It is hoped that the statistical analyses introduced below will provide a practical tool for future archeological work.

Database and Methods

The Study Area

The study area spans the sub-humid and semi-arid region of southern Israel, bordered by Ashqelon and Bet Guvrin (Eleutheropolis) on the north, Be'er Sheva' on the south, the Mediterranean Sea on the west and the southern fringes of the Hebron Hills on the east (Fig. 1). This region encompasses the following geographic units: the southern coastal plain, the lowlands (Shephelah), the southern Hebron Hills, and the Be'er Sheva' and Besor Valleys. The outcrop is mostly limestone and chalk in the mountain and hilly areas, and quaternary sediments, like loess, dunes and *ḥamra*, in the valleys (Sneh et al. 1998). The main soil types are brown rendzina, brown and lossial soils (Luvisols, Xerosols and Yerimisols; Dan and Raz 1970; Shapiro 2006). The mean annual cumulative precipitation is 170 mm in the southeast, reaching 500 mm in the northwest. The mean daily temperature is 10–13°C in January and 25–28°C in August (*Israel Meteorological Service* 2020).[4]

In the Byzantine period, the area was intensively populated, especially along the coastal plain, which was settled by the urban cities of Ashqelon, Ashqelon-Mayumas, Gaza, Gaza-Mayumas and Anthedon. The coastal plain was a center of religious, cultural and economic activities (Dan 1984; Bitton-Ashkelony and Kofsky 2004; Faust and Safrai 2015). We chose this area as, despite the relatively dry environmental conditions, agriculture flourished, encompassing many farms, monasteries, winepresses, oil presses, pottery workshops and warehouses (Erickson-Gini, Dolinka and Shilov 2015; Haiman, Argaman and Stavi 2020).

Throughout the region, 275 salvage excavations of Byzantine sites were conducted between 1961–2016 and published in *Hadashot Arkheologiyot–Excavations and Surveys in*

[4] https://ims.gov.il/en/ClimateAtlas

Israel.[5] Within these sites, a total of 55 Byzantine-period winepresses were unearthed in 48 excavations (Fig. 1:c). The reasons for focusing on data retrieved from salvage excavations are: (1) the finds comprise a random database, as the location of the sites was determined by development and construction needs and not by a pre-conceived research question; (2) the lion's share of salvage excavations took place in rural areas on the outskirts of ancient settlements (Faust and Safari 2005), which often align with the typical location of winepresses. Conversely, planned excavations tend to focus on central settlement areas, resulting in a notable absence of Byzantine winepresses; however, the data we have is sufficient for undertaking a statistical analysis.

Winepress Database

We established a database for the Byzantine winepresses unearthed in the research area, including a record of the winepresses' dimensions and technology. Special focus was on the following parameters: treading floor area (sq m); collecting vat volume (cu m); the occurrence of a direct screw-press; the number of collecting vats; and the number of fermentation cells.

In most archeological reports, the details of the winepresses were thoroughly described, while in others, some of the details were missing, but these could be deduced from the winepress's drawings. In this article, we consider 41 relatively well-preserved winepresses, categorized into different types (Fig. 2), the two main ones being: simple and

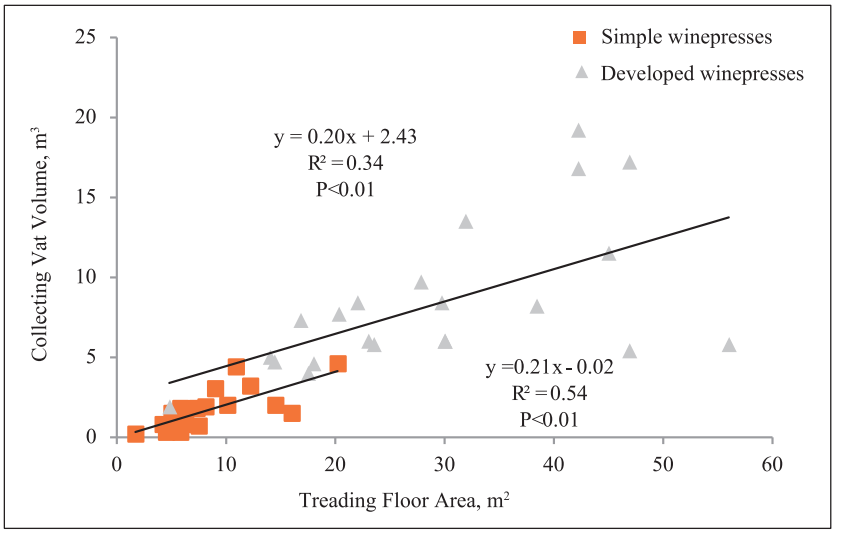

Fig 2. Regression between treading floor area (sq m) and collecting vats volume (cu m), in simple and developed winepresses.

[5] This journal (https://www.hadashot-esi.org.il/) contains preliminary and final reports of almost every salvage excavation conducted in Israel.

developed (see, e.g., Hadas 2008; Frankel 2009; Avrutis 2015). The simple winepress comprised maximum three components: a treading floor, a small settling/sieving vat and a collecting vat. All developed winepresses have a direct screw-press, while they may vary in their components, and therefore, further divided into three subtypes: (1) basic-developed—similar to the simple winepress but with a screw-press; (2) developed—similar to the basic-developed winepress but with two collecting vats; and (3) developed with fermentation cells[6] (Fig. 3), including one or two collecting vats.

We applied a linear regression for assessing the ratio between the treading floor area and the collecting-vat volume, for the entire batch of data, as well as for each type of winepress. For this analysis we used the Microsoft Excel 'data analysis' package.

Results

Our research pointed to a systematicity in the way winepresses were built in late antiquity, including a uniformity in the dimensions and ratios within the simple and developed winepresses. A general correlation was observed between the area of the treading floor and the volume of the collecting vat (Fig. 2): the larger the treading floor, the larger the collecting vat. The statistical analysis revealed that the mean (±SE) area of the treading floors is 19.5 ± 2.3 sq m, with a mean length and width of c. 4.4 m each. The mean (±SE) volume of the collecting vats is 5.3 ± 0.8 cu m.

Simple and Developed Winepresses

About 50% (n = 19) of the winepresses in our database are simple and small. The mean (±SE) area of their treading floors is 8.4 ± 1.1 sq m, and the mean (±SE) volume of the collecting vat is 1.7 ± 0.3 cu m. These winepresses were hewn in the limestone bedrock of the southern Hebron Hills and the calcrete crust (locally known as *nari*) of the southern lowlands (Shephelah). A significant ([7]$P<0.01$) and strongly ([8]$R^2 = 0.54$) positive relation was found between the treading floor area and collecting vat volume for the simple winepresses (Fig. 3). The slope equation is about 0.2, and the intercept is almost zero, meaning that the ratio between the two variables is 1 to 5. That is, a collecting vat of c. 1 cu m for every five-square-meter treading floor, even in small winepresses.

The rest (n = 22) of the studied winepresses were of the developed type. As the size of these winepresses was much larger than that of the simple ones, their production capacity was greater (Seligman 2020). The mean (±SE) area of the treading floors measured 29.1 ± 2.8 sq m, and the mean (±SE) volume of the collecting vats was 8.3 ± 1 cu m. The

[6] These fermentation cells had treading floor above them.

[7] P value is level of significance. When P value is equal to or less than 0.05, the result is significant, when P value is higher than the result, it is insignificant, and we cannot use it.

[8] R^2 is level of strength of relationship between two variables. R^2 values are between 0 and 1. When $R^2 = 1$, the relationship is very strong, but when $R^2 = 0$, the relationship is very weak.

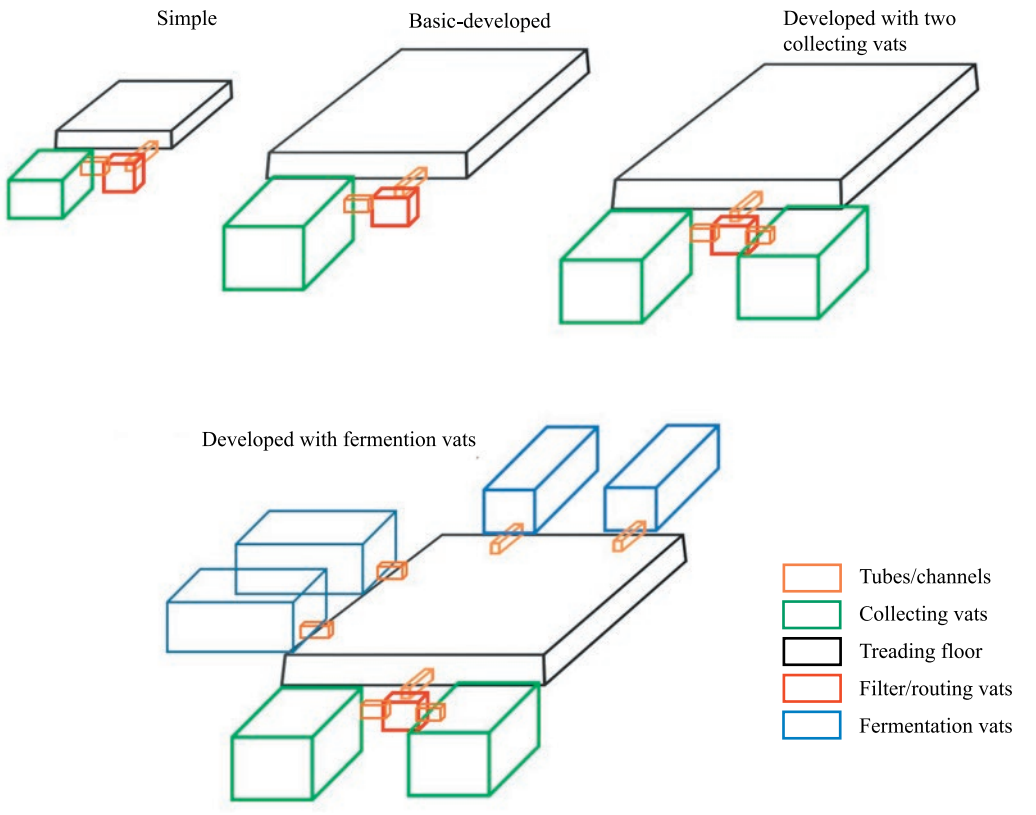

Fig. 3. Types of Byzantine winepresses.

Table 1. Winepresses' Mean Dimensions, according to Type

Type	N	Treading Floor Area (Sq m)		Volume of Collecting Vat/s (Cu m)	
		Mean	Std	Mean	Std
All	41	19.5	2.3	5.3	0.8
Simple	19	8.4	1.1	1.7	0.3
Developed	22	29.1	2.8	8.3	1.0
Basic-developed	7	20.3	3.9	5.5	0.8
Developed with two collecting vats	4	24.9	7.5	9.5	2.7
Developed with fermentation vats	7	35.5	2.7	12.2	1.8

developed winepresses were mostly stone-built, with mortar applied to the soft sediment (*ḥamra*, sand) of the Be'er Sheva' and Besor Valleys and the southern coastal plain (Chocron, Ackermann and Zissu 2019; Table 1). The fit between the treading floor area and the volume of the collecting vats in the developed winepresses (Fig. 2) was lower ($P = 0.34$), but still significant ($R^2 = 0.05$).

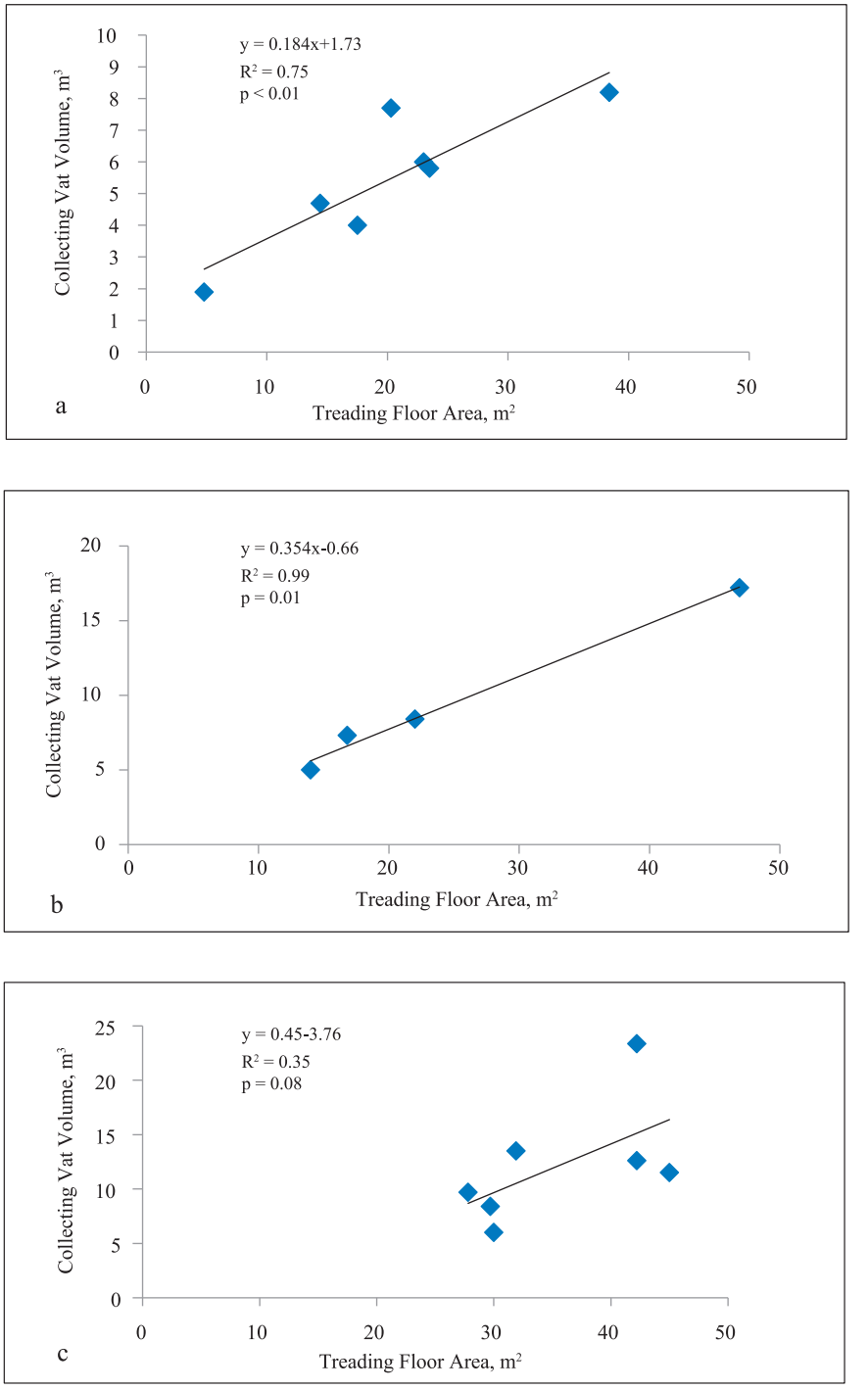

Fig. 4. Relationship between treading floor area and collecting vat volume in developed winepresses: basic-developed (a); developed with two collecting vats (b); and developed with fermentation vats (c).

Considering these results, we performed regression tests for the three different subtypes of the developed winepresses (see above). The results point to an even better fit for the basic-developed and developed winepresses with two collecting vats than that of the simple ones (Fig. 4:a, b); however, the fit between the treading floor area and the volume of the collecting vats in winepresses with fermentation cells was lower and marginally significant (Fig. 4:c).

Developed Winepress with a Direct Screw-Press and an Extra Collecting Vat

The slope equation of both the basic-developed (with screw-press) and simple winepresses is similar (0.18 and 0.21, respectively), while the cutting coefficient of the basic-developed winepresses is much greater than that of the simple winepresses (1.73 and -0.02, respectively). Thus, the volume of the collecting vat in the basic-developed winepresses is equal to the product of the slope and the area of the treading floor plus ~1.73 cu m. Based on this formula, the volume of a collecting vat in a simple winepress with a treading floor area of 20 sq m would be c. 4 cu m, and the volume of a collecting vat in a basic-developed winepress with screw press, comprising a treading floor of the same size would be c. 5.4 cu m, i.e., c. 35% greater than that of the simple one.

It would seem that the presence of two collecting vats in a winepress would negatively affect the fit between the area of the treading floor and the volume of the collecting vats. However, the results proved the opposite, as the fit was even higher for such winepresses (Fig. 4:b). The slope coefficient for these winepresses is almost double (0.35) that of the winepresses with a single collecting vat (simple and basic-developed types: 0.21 and 0.18, respectively). Winepresses with the same size of treading floor (20.4 m) had a collecting-vat volume of 7.8 cu m, i.e., 95% more than that of the simple winepresses and 44% more than that of the basic-developed winepresses.

Discussion

Wine Production in Simple Winepresses

The debate over the function of the treading floor and collecting vat of the simple winepresses put forward a theory that the treading surface had also been used for fermentation and the collecting vat served as a temporary vat before loading the wine into the amphorae for secondary fermentation (Dray 2011); this theory, however, was rejected by Ayalon et al. 2012, who questioned the logic of hewing such large vats to be used only as temporary containers. For example, in the southern Shephelah, a simple winepress was found with a large collecting vat (4.6 cu m, depth 1.2 m; Ganor and Klein 2012). If Dray's theory were correct, the volume of a collecting vat in a simple winepress would have been expected to remain constant no matter the size of the treading area. Our results, however, point to a significant positive correlation between the area of the treading floor and the volume of the collecting vat, and as such, support the conservative theory that wine was fermented in the collecting vat.

Diversity of Byzantine Winepresses

A lower (R^2 0.54 versus 0.34) positive fit was found for the developed winepresses in relation to the simple ones, which may be explained by their nature. While the simple winepresses of the Byzantine period are quite homogeneous and hardly changed throughout most of antiquity, the developed winepresses are heterogeneous and reflect changes in the wine production of late antiquity. Avshalom-Gorni, Frankel and Getzov (2008) distinguished between different types of developed winepresses in the different regions of Israel, and Chocron (2021) found that the closer a winepress is to the markets (large cities and harbors), the larger and more advanced it is. Lewit (2012) considered that in the Levant, winepresses with a direct screw-press were built in places which are close to their owners' residence, where cheap working labor is available.

Efficiency in Byzantine Developed Winepresses

It has been posited that one of the most significant advances in wine production in antiquity was the introduction of the screw-press (Frankel 1997; 1999; Burton and Lewit 2019). The screw-press was used to increase production by squeezing the grapes' skins after extracting the must by treading (Frankel 2016). The screw-press marks the transition from local production to mass production, as is evidenced from the economic success, especially in wine export. However, as of yet no research was undertaken to compare the scope of production in the simple winepress versus that accomplished in the developed winepresses. Our study offers, for the first time, an estimation based on a statistical analysis of the advantage of the screw-press in the annual produce of wine, suggesting that winepresses with a direct screw-press[9] produced an average of 35% more wine annually than the simple winepresses.

We consider that the importance of the screw-press as a technological innovation has been overemphasized, probably due to its centrality in the developed winepresses of the Byzantine period and in relation to the other components, which are architectural-structural, as well as to its mentioning in the written Jewish literature, e.g., in the Tosefta and the Jerusalem Talmud (see Frankel 1999), and its depiction on mosaics throughout the Levant (Renan 1864; Saller and Bagatti 1949; Piccirillo 1993). Also, Roman[10] sources dealing with the pressing technology of wine and oil, such as Cato, Plini and Hero, list the presses in an order, in which the beam press usually appears first and the screw-press last, leading researchers (Lewit and Burton 2019; Burton and Lewit 2019) to assume that this order was chronological, reflecting a progress of technology.

Our study focused on the architectural elements of the winepresses, including the additional collecting vat and the fermentation cells with treading floors above them. These elements increased the efficiency of the winepresses by increasing the yield of wine and giving the producer more flexibility in producing different types of wines at the same time.

[9] Basic developed winepress without fermentation cells.

[10] The direct screw reached the Levant only in the Byzantine period.

The statistical analysis revealed that the ratio between the treading area and the collecting-vat volume in winepresses with two collecting vats was almost double that of the simple winepresses. The extra vat in the Byzantine-period developed winepresses almost doubled the production capacity compared to the simple winepresses of the earlier periods and c. 50% more than in the basic-developed winepresses with a screw.

The fit between the area of the treading and the volume of the collecting vats is higher in the basic-developed and developed winepresses with two collecting vats than in the simple winepresses. This may be due to the fact that the former winepresses were built rather than rock-cut, and therefore, the builders could precisely calculate the desired ratio between the treading floor area and the collecting vat volume. Thus, while the developed winepresses were built on soft sediment and were not limited by the nature and quality of the bedrock, the simple winepresses were usually rock-hewn and therefore, their dimensions and depth must have taken into consideration the nature and quality of the bedrock (i.e., strength, fissures; Hirschfeld 1983).

The low fit (low R^2 and high P value) between the area of the treading floor and the volume of the collecting vats for developed winepresses with fermentation vats implies a different winemaking process. We consider that in these winepresses, the treading and the primary fermentation process did not take place only in the central treading floor and the collecting vats, respectively. This understanding contradicts Frankel's theory considering this type of winepresses. The fermentation cells in our study were vaulted-roofed, with mosaic floors above them,[11] which were connected to the vats below them through a narrow perforation (Haiman 2009; Israel and Erickson-Gini 2013). Therefore, it seems that the fermentation cells were used for treading, while the vats were used for collecting the must and for the fermentation process (see Dray 2015).

Contra to Dray, we consider that the treading took place both in the central floor and in the floors above the fermentation vats. Also, we are of the opinion that the primary fermentation process took place both in the fermentation cells and in the collecting vats. More specifically, we propose here that red wine was fermented in the fermentation vats and white wine was fermented in the collecting vats.

Considering these results and our proposition, it is clear that the regression analysis should include the area of the treading floor above the fermentation and the volume of the fermentation cells. Unfortunately, in our study, most of these floors (roofs) and part of the fermentation cells did not survive. Therefore, this analysis was not included in our research. In the future, more extensive research should take this aim.

The formulas obtained from the statistical analysis presented above allow for an estimation of the area of the treading floor or the volume of the collecting vats when one of these elements is missing. Archaeological surveys in agricultural-mountainous areas

[11] The roof above the fermentation cells was divided by walls which were used to divide between the different production cycles.

Fig. 5. Partly unearthed winepress in the Judean Mountains (photography: B. Zissu).

usually report many treading surfaces of ancient winepresses, whose area may be calculated; however, the collecting vats are usually filled with soil/debris and therefore, their volume is unknown (Frankel 2009b; Fig. 5). Also, in some salvage excavations, for various reasons, the winepresses are either partially exposed or partly survived (see, for example, Peretz and Michael 2017; Erickson-Gini 2022).

Conclusions

A positive significant fit was found between the area of the central treading floor and the volume of the collecting vat(s), supporting the traditional theory put forth by Frankel (2009a) that grape juice was mostly fermented in the collecting vat(s), with the exception of the developed winepresses with fermentation cells. In this unique type, the primary fermentation process occurred in the fermentation cells surrounding the treading area and in the collecting vats. The analysis presented above showed that the screw-press increased the scope of wine production in the Byzantine winepresses by one-third, while the addition of a second collecting vat almost doubled the produce. Moreover, based on our research, it

is evident that the main advancement of the Byzantine-period winepresses was due to their architectural elements (fermentation cells and extra collecting vats) and not only to the direct screw press.

References

Avrutis V.W. 2015. *Wine Presses at the Nesher-Ramla Quarry: A Thousand Years of Winemaking*. Haifa.

Avshalom-Gorni D., Frankel F. and Getzov N. 2008. A Complex Winepress from Mishmar Ha-'Emeq: Evidence for the Peak in the Development of the Wine Industry in Eretz Israel in Antiquity. *'Atiqot* 58:47–67 (Hebrew; English summary, pp. 65*–67*).

Ayalon E., Frankel R. and Kloner A. 2012. Wine Production in Eretz Israel in Antiquity: Advancement in Research or a Completely New Approach? *Cathedra* 145:15–36 (Hebrew; English summary, p. 213).

Bitton-Ashkelony B. and Kofsky A. 2004. *Christian Gaza in Late Antiquity* (Jerusalem Studies in Religion and Culture 3). Leiden–Boston.

Broshi M. 1985. *Wine in Ancient Israel*. Tel Aviv (Hebrew).

Burton P. and Lewit T. 2019. Pliny's Presses: The True Story of the First Century Wine Press. *Klio* 101:543–598. https://doi.org/10.1515/klio-2019-0041.

Cato Marcus Porcius. *De agri cultura* (W.D. Hooper trans.; Loeb Classical Library). London 1934.

Chocron M. 2021. *Winepresses in the Semi-Arid Desert during the Byzantine Period: Typological, Geographic and Economic Aspects*. Ph.D. diss. Bar-Ilan University. Ramat Gan (Hebrew; English summary, pp. I–IV).

Chocron M., Ackermann O. and Zissu B. 2019. Byzantine Wine Presses in the Semi-Arid Environment from the Southern Hebron Mountains to the Southern Coastal Area. *JSRS* 28:117–137 (Hebrew; English summary, p. 60*).

Dan Y. 1984. *The City in Erez-Israel during the Late Roman and Byzantine Periods*. Jerusalem.

Dan Y. and Raz Z. 1970. *Soil Map Units of Israel in the Scale of 1:250,000.* Jerusalem (Hebrew).

Dar S. 1981. *Settlement Pattern of Western Samaria in the Periods of the Second Temple, Mishna, the Talmud and the Byzantine Period*. Ph.D. diss. Tel Aviv University. Tel Aviv (Hebrew; English summary).

Dray Y. 2011. The Complex Winepress at Ḥorbat Siv: Analysis and Interpatation. *'Atiqot* 65: 89–92 (Hebrew; English summary, p. 70*).

Dray Y. 2015. The Wine Making Process in the Improved Byzantine Wine Press. In A. Diler, K. Şenol and Ü. Aydinoğlu eds. *Olive Oil and Wine Production in Eastern Mediterranean during Antiquity (International Symposium Proceedings 17–19 November 2011, Urla, Turkey)*. Izmir. Pp. 191–199.

Erickson-Gini T. 2022. Ashqelon, er-Rasm. *HA–ESI* 134 (December 18). https://www.hadashot-esi.org.il/report_detail_eng.aspx?id=26249&mag_id=134 (accessed March 24, 2024).

Erickson-Gini T., Dolinka B.J. and Shilov L. 2015. A Late Byzantine Industrial Quarter and Early Islamic-Period Finds at Ḥorbat Be'er Shema. *'Atiqot* 83:209–248.

Frankel R. 1997. Presses for Oil and Wine in the Southern Levant in the Byzantine Period. *DOP* 51:73–84. https://doi.org/10.2307/1291762

Frankel R. 1999. *Wine and Oil Production in Antiquity in Israel and Other Mediterranean Countries* (*JSOT*/ASOR Monograph Series 10). Sheffield.

Frankel R. 2009a. Introduction. In E. Ayalon, R. Frankel and A. Kloner eds. *Oil and Wine Presses in Israel from the Hellenistic, Roman and Byzantine Periods* (BAR Int. S. 1972). Oxford. Pp. 19–24.

Frankel R. 2009b. Some Wine Presses in Western Galilee. In E. Ayalon, R. Frankel and A. Kloner eds. *Oil and Wine Presses in Israel from the Hellenistic, Roman and Byzantine Periods* (BAR Int. S. 1972). Oxford. Pp. 1–18.

Frankel R. 2016. Oil and Wine Production. In G.L. Irby ed. *A Companion to Science, Technology, and Medicine in Ancient Greece and Rome* II. Newark. Pp. 550–569.

Frankel R. and Eisenberg M. 2018. The Hippos Winery Complex. In M. Eisenberg. *Hippos-Sussita of the Decapolis: The First Twelve Seasons of Excavations 2000–2011* II. Haifa. Pp. 56–73.

Faust A. and Safrai Z.E. 2005. Salvage Excavations as a Source for Reconstructing Settlement History in Ancient Israel. *PEQ* 137:139–158.

Faust A. and Safrai Z.E. 2015. *The Settlement History of Ancient Israel: A Quantitative Analysis*. Ramat Gan (Hebrew).

Ganor A. and Klein A. 2012. Ḥorbat Peẓaẓa. *HA–ESI* 124 (December 12). https://www.hadashot-esi.org.il/Report_Detail_Eng.aspx?id=2135&mag_id=119 (accessed March 24, 2024).

Hadas A. 2007. Biological, Biochemical and Physical Aspects of Operating Antique Winepresses. *JSRS* 16:144–162 (Hebrew; English summary, pp. XV–XVI).

Hadas A. 2008. A Proposed Classification System for Ancient Winepresses. *JSRS* 17:151–161 (Hebrew; English summary, pp. XVI–XVII).

Haiman M. 2009. Ḥorbat Shelaḥ (West). *HA–ESI* 121 (November 17). https://www.hadashot-esi.org.il/report_detail_eng.aspx?id=1251&mag_id=115 (accessed March 24, 2024).

Haiman M., Argaman E. and Stavi I. 2020. Ancient Runoff Harvesting Agriculture in the Arid Beer Sheva Valley, Israel: An Interdisciplinary Study. *The Holocene* 30:1196–1204. https://doi.org/10.1177/0959683620913917

Hirschfeld Y. 1983. Ancient Wine Presses in the Park of Aijalon. *IEJ* 33:207–218.

Israel Y. and Gini-Erickson T. 2013. Remains from the Hellenistic through the Byzantine Periods at the 'Third Mile Estate', Ashqelon. *'Atiqot* 74:167–222.

Kingsley S.A. 2001. The Economic Impact of the Palestinian Wine Trade in Late Antiquity. In S.A. Kingsley and M. Decker eds. *Economy and Exchange in the East Mediterranean during Late Antiquity (Proceedings of a Conference at Somerville College, Oxford, 29th May, 1999).* Oxford. Pp. 44–68.

Lewit T. 2012. Oil and Wine Press Technology in Its Economic Context: Screw Presses, the Rural Economy and Trade in Late Antiquity. *Antiquité Tardive* 20:137–149.

Lewit T. and Burton P. 2019. Wine and Oil Presses in the Roman to Late Antique Near East and Mediterranean: Balancing Textual and Archaeological Evidence. In A. Squitieri and D. Eitam eds. *Stone Tools in the Ancient Near East and Egypt: Ground Stone Tools, Rock-Cut Installations and Stone Vessels from Prehistory to Late Antiquity*. Oxford. Pp. 97–110.

Mayerson P. 1985. The Wine and Vineyards of Gaza in the Byzantine Period. *BASOR* 257:75–80.

McGovern P.E. 2003. *Ancient Wine: The Search for the Origins of Viniculture.* Princeton–Oxford.

Piccirillo M. 1993. *The Mosaics of Jordan* (ACOR Publications 1). Amman.

Peretz I. and Michael N.D. 2017. Netivot, Ḥorbat Bohu. *HA–ESI* 129 (May 10). https://www.hadashot-esi.org.il/report_detail_eng.aspx?id=25205&mag_id=125 (accessed March 20, 2024).

Pieri D. 2012. Regional and Interregional Exchanges in the Eastern Mediterranean during the Early Byzantine Period: The Evidence of Amphorae. In C. Morrisson ed. *Trade and Markets in Byzantium*. Washington, D.C. Pp. 27–49.

Renan E. 1864. *Mission de Phénicie.* Paris.

Roll I. and Ayalon E. 2009. A Byzantine Wine Press at Kh. Duran (Rehovot). In E. Ayalon, R. Frankel and A. Kloner eds. *Oil and Wine Presses in Israel from the Hellenistic, Roman and Byzantine Periods*. Oxford. Pp. 265–268.

Safrai Z. 1994. *The Economy of Roman Palestine.* London–New York.

Saller S.J. and Bagatti B. 1949. *The Town of Nebo (Khirbet el-Mekhayyat) with a Brief Survey of Other Ancient Christian Monuments in Transjordan* (SBF Collectio Maior 7). Jerusalem.

Seligman J. 2020. Were the Central Negev Settlements Suppliers or Importers of Gaza Wines? *JRA* 33:249–270.

Shapiro M.B. 2006. Soils of Israel. *Euroasian Soil Science* 39:1170–1175.

Shaus A., Sober B., Faigenbaum-Golovin S., Mendel-Geberovich A., Levin D., Piasetzky E. and Turkel E. 2017. Statistical Inference in Archaeology: Are We Confident? In O. Lipschits, Y. Gadot and M.J. Adams eds. *Rethinking Israel: Studies in the History and Archaeology of Ancient Israel in Honor of Israel Finkelstein*. Winona Lake. Pp. 389–401.

Shtober-Zisu N. and Zissu B. 2018. Lithology and the Distribution of Early Roman-Era Tombs in Jerusalem's Necropolis. *Progress in Physical Geography: Earth and Environment* 42:628–649.

Sneh A., Bartov Y., Weissbrod T. and Rosensaft M. 1998. *Geological Map of Israel, 1:200,000* (Israel Geological Survey; 4 sheets). Jerusalem.

Stavi I., Chocron M., Filin S., Arav R., Ackermann O. and Zissu B. 2018. Intentional, Dual Purpose of Ancient Wine Presses, as Cisterns for Runoff Water Harvesting in Drylands. *Holocene* 28:1107–1112.

Turshan N. and Cox M. 2015. Ya'amun Main Wine Press from Roman to the End of Umayyad and Early Abbasid Periods in Northern Jordan. *Mediterranean Archaeology and Archaeometry* 15/3:131–139.