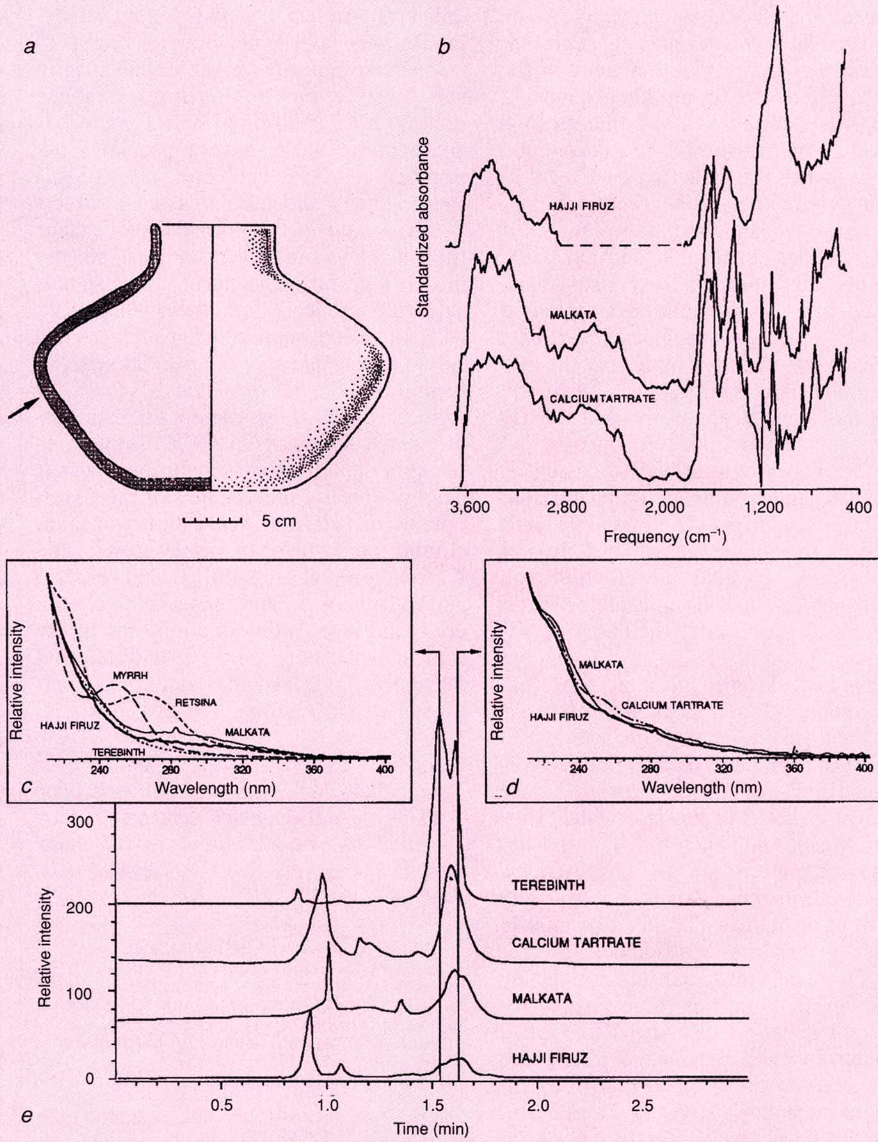
Neolithic resinated wine

SIR — We report here that we have found the earliest chemical evidence of wine. We have analysed a pottery jar from a Neolithic village in Iran's northern Zagros mountains which contained wine, with a *Pistacia* tree resin additive. The jar was produced in about 5400–5000 BC, two thousand years earlier than previous evidence from the earliest civilization of the Near East[1]. Our new evidence belongs to the period when the first permanent human settlements, based on domesticated plants and animals as well as minor crafts such as pottery-making, were being established. It has important implications for the origins of viticulture and viniculture, as well as for the development of modern diet, medical practice and society generally[2].

One of us (M.M.V.) excavated the Neolithic jar (8.81; *a* in the figure), which has an interior yellowish residue, in the 'kitchen' of a square mud-brick building at the site of Hajji Firuz Tepe[3]. The jar mainly contained the calcium salt of tartaric acid, as established by infrared spectrometry (*b* in the figure), liquid chromatography (*c–e*) and a wet-chemical test[4]. Also identified is the yellowish oleoresin of the *Pistacia atlantica* Desf. terebinth tree (*e*), which grows abundantly throughout the Near East[5] and was widely used as a medicine and wine additive in antiquity[6]. The presence of combined tartaric acid/tartrate and terebinth resin has been confirmed for a large group of ancient Near Eastern jars, including Egyptian amphoras with wine dockets[7].

Tartaric acid occurs naturally in large amounts only in grapes, and was converted to the insoluble calcium salt in the calcareous environment of the site. We think that the jar originally contained a liquid, because it has a long, narrow neck and the interior residue is confined to its bottom half. Under normal conditions and at room temperature, grape juice quickly ferments to wine[8]. Because of slow pressing methods in antiquity and high temperatures in the Middle East, fermentation had probably begun before the jar was



Diffuse-reflectance Fourier-transform infrared (IR) spectra (*b*) and high-performance liquid chromatograms (*e*) and ultraviolet (UV) spectra (*c, d*) of methanol extracts of the Hajji Firuz Tepe jar (*a*, arrow marks sampling area) and ancient and modern reference samples. In *b*, calcium tartrate accounts for the IR maxima at 1,613 and 1,561 cm^{-1}, due to the carboxylate group, in the Hajji Firuz sample. Many other absorption bands (for example, 3,596; 3,523; 3,442; 1,385; 1,330; 1,275; 713; 596; 555; and 484 cm^{-1}) match and have similar shapes and intensities. The broad absorption centred at about 3,450–3,400 cm^{-1} results from hydroxyl groups and water of hydration, whereas the inorganic clay band (maximum at 1,032 cm^{-1}) masks characteristic peaks between 1,250 and 800 cm^{-1}, which are visible in an ancient reference sample, a fourteenth century BC wine amphora from the palace of Pharaoh Amenhotep III in Thebes, Egypt[11], at 1,060, 1,005, 955 and 815 cm^{-1}. The same three samples show comparable chromatographs (*e*) and UV spectra (*d*) at a retention time of 1.62 min. The presence of *Pistacia atlantica* Desf. terebinth resin, composed of characteristic triterpenoids[12], in the Hajji Firuz sample is supported by the hydrocarbon peaks at 2,926 and 2,858 cm^{-1} in the IR spectrum (*b*), but more definitively, by the latter's chromatogram (*e*) and those of the ancient and modern reference samples, together with their corresponding UV spectra (*c*) at a retention time of 1.54 min. The *P. atlantica* resin tested was in the form of nodules inside an amphora[13] of the fourteenth century BC merchantman shipwreck at Uluburun. Modern myrrh, also a wine additive in antiquity, and Greek retsina wine, in which sandarac (*Tetraclinis articulata*) resin is the primary additive, show different UV absorptions in the 230–290-nm range (*c*) from that of *P. atlantica*. For sherd extraction and IR analytical procedures, see refs 1, 2. Because of its small sample size (4 mg), the Hajji Firuz IR spectrum was obtained by a micro technique. The liquid chromatograph was run at ambient temperature, using a 25 cm × 4.6-mm silica column, a flow rate of 2.0 ml per min, and an UV detector over the 200–400-nm range. Variation in the retention times of earlier peaks (0.9–1.1 min) on some chromatograms (*e*) is probably due to the different temperatures of individual analyses, as well as interactions in complex mixtures.

filled[9]. The addition of terebinth resin, which is readily soluble in alcohol, served in part to disturb and inhibit the growth of bacteria (*Acetobacter*) that convert wine to vinegar, besides masking any offensive taste or odour[6]. The jar's dense fabric and stoppering further assured the preservation of the wine.

Hajji Firuz Tepe lies within the ancient and modern distributional zone of the wild grape (*Vitis vinifera* L. subsp. *sylvestris*) and *Pistacia* tree varieties, as established by pollen cores from Lake Urmia[10]. Although wild grapes were available seasonally, the wine in the jar might well have been produced from a precursor of the highly successful domesticated type (subsp. *vinifera*), still used to make most modern wine. Many centuries of experimentation, beginning in the Neolithic period, were required to develop a hermaphroditic, more productive grape vine, and to refine the methods of winemaking and storage.

Modern diets include many foods and beverages used in Neolithic times[11] which have rarely been identified chemically. Wine was a highly desirable grape product, because of its unique dietary and medical benefits and psychotropic effects. The identification of resinated Neolithic wine is particularly significant, because of this beverage's impact on social customs, religions and economies throughout the world[2].

Patrick E. McGovern
Donald L. Glusker
Lawrence J. Exner
Museum Applied Science Center for Archaeology (MASCA), University of Pennsylvania Museum, Philadelphia, Pennsylvania 19104-6324, USA
Mary M. Voigt
Department of Anthropology, College of William and Mary, PO Box 8795, Williamsburg, Virginia 23187-8795, USA

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When batterer becomes murderer

SIR — I reported in Scientific Correspondence an estimate of the probability x that a batterer was the murderer of his mate when she is known to have been murdered by somebody[1]. The probability x must be an increasing function of the degree of battery. If one defines a representative batterer as someone who averages one assault per year, one can estimate x relative to such a batterer. Threats of death and other aggressive behaviour are tantamount to assaults, but let us leave something to the discretion of the jury! This communication is not concerned specifically with the O. J. Simpson case, where there are mountains and valleys of further evidence.

Unfortunately, my earlier estimate[1] of x was much too low because it was based on an incorrect statement made by the distinguished lawyer Alan Dershowitz in a television interview in March 1995. (He repeated the statement in another interview recorded on 2 April 1996.) He said that less than a tenth of 1 per cent of batterers go on to murder their wives. He did not say at the time that this fraction is really the batterer's probability of murder per assault. For a representative batterer it is approximately the probability of murder per year, which is much less than the probability of his committing murder sooner or later. I have found that Dershowitz[2] had made the same mistake, but his raw data are presumably reliable[3].

On page 101 of his recent bestselling book[4], Dershowitz writes, "We knew we could prove, if we had to, that an infinitesimal percentage — certainly fewer than 1 out of 2,500 — of men who slap or beat their domestic partners go on to murder them." He used this and similar estimates to argue that battery should be regarded as inadmissible evidence. But on page 104 he mentions that, in 1992, there were 1,432 murders among 2–4 million assaults. So our representative batterer's probability of murder is about 1/2,000 per year. His probability of going on to murder is an order of magnitude larger, hardly "infinitesimal". Even if Dershowitz's estimate had been right, one could equally argue that the knowledge that an accused was the husband of the victim should be inadmissible because husbands very seldom murder their wives!

Let G mean that the accused is factually guilty (committed the crime in, say, 1994). Let M mean that the woman was murdered by somebody in 1994. Let Bat mean that she had been battered by her mate about once per year for several years. Let the given information be M and Bat. We would like to estimate $x = P(G|M \text{ and } Bat)$, where the vertical stroke is the standard notation for 'given' or 'conditional upon'.

Our conclusion will be that, for a standardized batterer, x is approximately 0.9 instead of the 0.5 I estimated earlier. Both my earlier contribution and this one use the odds form of Bayes's theorem[5–8]. The odds corresponding to a probability P can be defined as $P/(1-P)$. The theorem gives

$$\frac{O(G|M \text{ and } Bat)}{O(G|Bat} = \frac{P(M|Bat \text{ and } G)}{P(M|Bat \text{ and not } G)} \quad (1)$$

The left side is the Bayes factor (in favour of guilt provided by the evidence M, given Bat). Its numerator is x, and its denominator is about 1/2,000 because the year of the murder is specified. The numerator of the right side is 1, and we now estimate its denominator.

There are about 25,000 murders per year in the US population of about 250,000,000 (p. 964 of ref. 9), giving a probability of 1/10,000 of being murdered in a given year. But approximately a quarter instead of a half of murdered victims are female (p. 283 of ref. 3), so being female reduces this probability to 1/20,000. Thus:

$$P(M|Bat \text{ and not } G) = P(M|\text{not } G) \approx 1/20{,}000 \quad (2)$$

Therefore, the right-hand side of equation (1) is about 20,000. This, then, is the Bayes factor in favour of true guilt and

$$O(G|M \text{ and } Bat) \approx 20{,}000/2{,}000 = 10 \quad (3)$$

so the corresponding probability is approximately 0.9 as I claimed.

(Some refinements and more details are given in an unpublished technical report, available on request.)

I. J. Good
Department of Statistics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0439, USA

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