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Medieval emergence of sweet melons, *Cucumis melo* (Cucurbitaceae)

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• *Background* Sweet melons, *Cucumis melo*, are a widely grown and highly prized crop. While melons were familiar in antiquity, they were grown mostly for use of the young fruits, which are similar in appearance and taste to cucumbers, *C. sativus*. The time and place of emergence of sweet melons is obscure, but they are generally thought to have reached Europe from the east near the end of the 15th century. The objective of the present work was to determine where and when truly sweet melons were first developed.
• *Methods* Given their large size and sweetness, melons are often confounded with watermelons, *Citrullus lanatus*, so a list was prepared of the characteristics distinguishing between them. An extensive search of literature from the Roman and medieval periods was conducted and the findings were considered in their context against this list and particularly in regard to the use of the word 'melon' and of adjectives for sweetness and colour.
• *Findings* Medieval lexicographies and an illustrated Arabic translation of Dioscorides' herbal suggest that sweet melons were present in Central Asia in the mid-9th century. A travelogue description indicates the presence of sweet melons in Khorasan and Persia by the mid-10th century. Agricultural literature from Andalusia documents the growing of sweet melons, evidently casabas (Inodorous Group), there by the second half of the 11th century, which probably arrived from Central Asia as a consequence of Islamic conquest, trade and agricultural development. Climate and geopolitical boundaries were the likely causes of the delay in the spread of sweet melons into the rest of Europe.

Key words: Andalusia, crop diffusion, crop history, *Cucumis melo*, Cucurbitaceae, Khorasan, medieval travelogues, melon, Persia, plant lexicography.

INTRODUCTION

Melons, *Cucumis melo* (Cucurbitaceae), are one of the most widely grown vegetable crops throughout the warmer regions of the world. Ripe melons are prized for their sweetness and eaten raw as a cooling dessert. The consumer demand for sweet melons has stimulated the selection and breeding of hundreds of cultivars belonging to numerous market types, some with local and others with regional or international distribution. The sweet-melon market types that are familiar in Europe, North and South America, Australia and most of Asia are classified into three cultivar-groups (Pitrat *et al.*, 2000; Goldman, 2002; Burger *et al.*, 2006). The muskmelons, or Reticulatus Group, have a reticulate (corky or 'netted') rind and are the most widely grown. The cantaloupes, or Cantalupensis Group, are similar but have a smooth or warted rind and are popular in parts of Europe. Melons of both these groups are usually lobed and furrowed ('sutured'), sometimes prominently, are richly flavoured and aromatic, usually detach from the vine when fully ripe, and normally have a shelf-life of about 1 week. The casabas, or Inodorous Group, widely grown in Central Asia, Turkey and Spain, have a smooth or wrinkled rind, are usually inconspicuously lobed or non-lobed, are neither aromatic nor richly flavoured but achieve the greatest sweetness of all melons; they ripen late, do not detach from the plant, and have a shelf-life of $\geq$1 month.

Melon plants are herbaceous, procumbent, hispid, tendril-bearing annuals having fibrous roots and thriving in fertile, well-drained soils in warm, sunny locations (Rosa, 1924; Whitaker and Davis, 1962; Robinson and Decker-Walters, 1997). They are usually andromonoecious, sometimes monoecious, bearing small, 2–3 cm across, bright yellow flowers that open at dawn and wither during the afternoon. During the morning hours, the flowers are visited by bees seeking pollen and nectar. Some of the pollen carried by bees adheres to sticky stigmatic surfaces of bisexual or pistillate flowers, effecting pollination. Melon plants are naturally self- and cross-pollinating. Depending on environmental conditions and cultivar, flowering begins 35–60 d after sowing. An additional 30–70 d are required from the day of pollination until ripening of the first fruits. Thus, ripening of the first sweet fruits, in the earliest cultivars, can occur as soon as 65 d after sowing but usually requires considerably more time, from 2 weeks to 2 months more.

The fruit flesh of all sweet melon cultivars is bland when immature, becoming sweet only toward the end of fruit ripening (Rosa, 1928). Sweetness of melons can be easily, quickly and objectively assessed by using a refractometer to determine soluble solids content of juice squeezed from the fruit flesh (Thompson and Kelly, 1957). The minimum commercially acceptable soluble-solids content for sweet melons is 9 %, but 11% or more is required for premium markets, and casabas

can have as much as 18 % soluble solids. As they approach maturity, melons increase in soluble solids content and perceived sweetness by accumulating sucrose (Schaffer *et al.*, 1987; Burger *et al.*, 2000). Moreover, sweetness of melon fruit flesh is a function of the length of the sucrose accumulation period, for which there exists considerable genetic variation (Schaffer *et al.*, 2000). The sweetest melons are obtained from cultivars that have a long sugar-accumulating period. The fruits of these melon cultivars ripen late, requiring 85–130 d from sowing to ripening of the first fruits. Thus, for production of the best sweet melons, a long, warm growing season is required, which should be nearly rainfree during late fruit maturation and ripening, as soil wetness and low insolation adversely affect fruit sweetness (Bouwkamp *et al.*, 1978; Wells and Nugent, 1980; Yawalkar, 1980; Kroen *et al.*, 1991; Karchi, 2000). Regions having a semi-arid climate with hot, rainless summers are ideal for production of high-quality sweet melons. Sweet melons are exported in large quantities from these regions into countries having climates less favourable for their production.

The Cucurbitaceae, which encompass over 100 genera, originated in Asia (Schaefer *et al.*, 2009). The genus *Cucumis* has a particularly wide distribution in the wild, from southern and central Africa across southern Asia to northern Australia, and is now recognized as being comprised of 66 species (Sebastian *et al.*, 2010). *Cucumis melo* originated in Asia and its closest relative is *C. picrocarpus* F. von Mueller, which grows wild in Australia (Sebastian *et al.*, 2010). Diverse wild and primitive melons are found on the Indian sub-continent (Chakravarty, 1982; Dhillon *et al.*, 2012; Roy *et al.*, 2012), some of which had been classified as separate species, *C. callosus* (Rottl.) Cogn. & Harms and *C. trigonus* Roxb., until they were shown to be fully cross-compatible with other *C. melo* (Parthasarathy and Sambandam, 1980; Sebastian *et al.*, 2010). Free-living melons have also been observed in northern Australia (Telford *et al.*, 2011), southern United States (Decker-Walters *et al.*, 2002) and north-eastern Africa (Mohamed and Yousif, 2004). The small (3–7 cm in diameter), round fruits of wild and feral melons are bland, bitter, sour or slightly sweet.

Cucumis melo has been cultivated for several thousand years (Robinson and Decker-Walters, 1997). Cultivated melons exhibit much fruit diversity, ranging in size from 5 cm in diameter to $\geq$10 kg, in shape from oblate, spherical, oval, pyriform, fusiform, to extremely long and serpentine, with or without stripes, and lobes and furrows ('sutures') or wrinkles or warts, highly aromatic or not at all, with relatively thin or thick fruit flesh that at maturity is orange, green, cream or white and that remains bland or becomes sweet or sour (Burger *et al.*, 2010).

The cucumber-like, elongate melons, Adzhur (Chate) Group, and the extremely long snake melons, Flexuosus Group, are featured in 3000-year-old Egyptian depictions (Janick *et al.*, 2007). Mediterranean mosaics and reliefs dating to Roman times depict snake melons. Snake melons are the most often-mentioned cucurbit in classical literature, being the Greek *sikyos*, Latin *cucumis*, and Hebrew *qishu'im*, indicating the esteem with which they were held by various cultures of Mediterranean antiquity. They are extensively grown in the Old World tropics and sub-tropics to the present day, but are not well-adapted to temperate climates. These melons are harvested when immature and consumed as raw, cooked or pickled vegetables (Chakravarty, 1966; Pandey *et al.*, 2010; Paris, 2012). The snake and adzhur melons have a bland flavour very much like cucumbers, *C. sativus*, and like them are eaten when immature. They do not become sweet, even when fully ripe.

Round melons, harvested when ripe, have been grown at least since Roman times, but in antiquity and the medieval period they are less frequently mentioned and depicted than snake melons and adzhur melons (Janick *et al.*, 2007; Paris *et al.*, 2009, 2011). Their secondary popularity contrasts sharply with the esteem with which sweet melons are regarded today. Of the Roman melon, De Candolle (1886, p. 262) wrote, 'It was probably of indifferent quality, to judge from the silence or the faint praise of writers in a country where gourmets were not wanting'. Sturtevant (Hedrick, 1919, p. 203) had the same opinion: '... yet the admiration of the authors of the sixteenth century for the perfume and exquisite taste of the melon, as contrasted with the silence of the Romans, who were not less epicurean, is assuredly a proof that the melon had not at that time, even if known, attained its present luscious and perfumed properties ...'.

Sweet melons of the Cantalupensis Group are recorded as having arrived in Italy in the late 15th century (Hedrick, 1919; Pitrat *et al.*, 2000; Jeffrey, 2001; Goldman, 2002). Indeed, demand for sweet melons was so immediate that, by 1518, images of fruits of both cantaloupes and muskmelons appeared in festoons in a lavish home near Rome known today as the Villa Farnesina (Janick and Paris, 2006). Their cultivation rapidly expanded to much of Europe and then to the Americas. The objective of the present work is to determine when and where the truly sweet melons were first developed.

METHODS

The Cucurbitaceae exhibit much parallel variation among species and genera (Vavilov, 1951). Melons, *Cucumis melo* L., are most often confused with watermelons, *Citrullus lanatus* (Thunb.) Matsum. & Nakai, as the mature fruits of both are large and often sweet. However, there are traits that are common in melon and rare in watermelon, and vice versa (Rosa, 1924; Whitaker and Davis, 1962; Robinson and Decker-Walters, 1997; Maynard, 2001).

The leaf laminae of melons are rounded cordate, rarely segmented, but those of watermelons are pinnatifid, rarely entire (Table 1). Perfect or pistillate flowers of melons occur in axils of the first one or two leaves of shoots but in watermelons they occur apically, usually at every seventh or eighth leaf axil. Melon cultigens vary greatly in fruit shape, from oblate to extremely long, they can be pointed or necked at one or both ends and of irregular appearance, and can have a large circular stylar scar from which the stylar end may protrude as a 'cap' (Table 1 and Fig. 1), but watermelons are limited to slightly oblate to spherical to oval to oblong, sometimes slightly pyriform, but of a regular appearance. The fruit surface of melons can be lobed, with shallow or deep furrows (often referred to as 'sutures'), reticulate ('netted'), roughened, warted or wrinkled, but the fruit surface of watermelons is smooth,

TABLE 1. *Characteristics differentiating melons from watermelons (after Whitaker and Davis, 1962; Robinson and Decker-Walters, 1997)*

Characteristic	Melon, *Cucumis melo*	Watermelon, *Citrullus lanatus*
Lamina shape	Cordate	Pinnatifid
Tendrils	Unbranched	Branched
Plant sexuality	Usually andromonoecious	Usually monoecious
Staminate flowers	Clustered	Solitary
Pistillate (or hermaphroditic) flowers	At basal axils	At apical axils
Fruit shape	Oblate, globular, spherical, oval, oblong, cylindrical, serpentine, acute, necked, fusiform, pyriform, irregular	Globular, spherical, oval, oblong
Fruit stylar end	Sometimes protrudes, scar often ≥2 cm diameter	Not protruding, stylar scar usually ≤2 cm diameter
Fruit peduncle end	Does or does not abscise	Does not abscise
Fruit surface	Reticulate, warted, wrinkled, rarely smooth	Smooth
Fruit lobes and furrows ('sutures')	Non-lobed to prominently lobed and deeply furrowed	Almost always non-lobed, sometimes shallowly lobed and furrowed
Fruit striping	Usually indistinct	Usually distinct
Fruit 'rind'	Thin (exocarp only)	Thick, ≥ 2 cm (exocarp + mesocarp)
Ripe fruit exterior hue	Usually yellow or orange	Almost always green
Fruit interior	Flesh + seed cavity	Seeds within flesh
Fruit flesh wetness	Moist (less wet)	Watery (very wet)
Flesh colour	Orange, green, cream, white	Red, pink, orange, yellow, white, rarely green
Seed colour	Tan, yellow	Black, brown, gray, red, purple, green, yellow, tan, or white and can have patterns of two colours
Seed hilum end	Pointed	Blunt

even slick, or at most shows mild lobing. Striping of the exterior is usually indistinct in melons but usually bold in watermelons. The exterior colour of melons almost always turns from green to yellow or orange as they ripen but almost always remains green in watermelons. The 'rind' of melons is the thin (<1 cm) exocarp but in watermelons is comprised of the green exocarp and the thick (usually 2–3 cm), white, firm, wet mesocarp. In most cultigens of muskmelons and cantaloupes, and some non-sweet melons, an abscission forms between the peduncle and the ripening fruit, resulting in detachment of the fruit, at its full physiological maturity, from the plant. This does not occur in watermelons. The fruit flesh of melons is the mesocarp layer, and the endocarp

FIG. 1. Casaba melons (*Cucumis melo*) at a Richmond Hill market in Queens, New York (Andres, 2004). The melons are almost entirely yellow, wrinkled, roughened, and somewhat lobed. The fruits are generally round but acute and slightly necked at the peduncle end and have a large, circular stylar scar. Photograph © October 2000 by Thomas C. Andres. Used with permission.

consists of the placenta and seeds, neatly arranged in rows, within a central cavity. The fruit flesh of watermelons is the endocarp, the seeds are distributed within it, seemingly randomly to the casual observer. The flesh of melons is best described as moist and that of watermelons as watery or wet. The fruit flesh colour of melons can be orange, green, cream or white and the fruit flesh of watermelons can be red, pink, orange, yellow, white or, rarely, green. Melon seeds can be light tan or yellow but watermelon seeds can have a variety of colours and colour patterns. Thus, there are a large number of features that can potentially distinguish between *Cucumis melo* from *Citrullus lanatus*.

The features starkly distinguishing melons from watermelons prove to be especially important for obtaining an accurate understanding of sweet melon history as, in antiquity and through the medieval period, descriptions of food crops are not highly detailed (Dalby, 2003*b*). Usually, the foods themselves are not described but are discussed in relation to their supposed effects on the body or their pharmacological value.

Besides the lack of descriptions of food crops, there are other stumbling blocks to arriving at an accurate assessment of the history of each. These are the terminologies used in different contexts, times, languages and geographic areas. For example, the word 'sweet' can be synonymous with sugary but can also mean not bitter, not sour, or not salty. Moreover, what might have been considered sweet in ancient times might not be considered sweet today, due to subsequent development or introduction of cultigens with greater sweetness. The adjective 'red' has been used variously to include orange, purple and brown, and 'yellow' to include orange. Although red fruit flesh is non-existent in *Cucumis melo*, in some literature from the Renaissance to the present day the flesh colour of melons is described as 'red' or 'pink'. Also, the word 'melon' in American English can be used to refer to either or both *Citrullus lanatus* and *Cucumis melo* (Goldman, 2002), and the same situation occurred in medieval Latin (Paris *et al.*, 2009). In Arabic, *battikh* usually is watermelon but can refer to melon or be inclusive of both (Watson, 1983; Aguirre de Carcer, 1995; Nasrallah, 2007). Conceivably, the word for watermelon in biblical Hebrew

(*avattihim*, Numbers 11:5) and Hebrew, Greek (*pepon*) and Latin (*pepo*) of the Roman period could have been similarly duplicitious; on the other hand, in all three languages, writings of the classical period include a new word that clearly designates round, ripe melons (see below). The modern Persian word for sweet melons is *kharbuza* (Haim, 1992), but in medieval Yemen, *kharbiz* often meant watermelon (Amar and Qafah, 2011) and, in Turkish, the word *qarpouz* (*karpuz*) is watermelon whilst *qavoun* (*kavun*) is melon (Viguier, 1790). Thus, correct interpretations of the literature require familiarity with characteristics that differentiate among related taxa but also require judicious consideration of the literary context, time and place (Dalby, 2003*b*). The analysis presented here will not encompass all records which include duplicitious names, such as *melones* and *battikh*, but will focus on those from which the taxonomic identity as *Cucumis melo* can be inferred, based on the descriptors presented in Table 1.

MELONS OF THE ROMAN PERIOD (TO CE 500)

The *pepon* of classical Greek literally refers to a sun-ripened fruit and usually specifically referred to watermelon, *Citrullus lanatus* (Liddell and Scott, 1948; Andrews, 1958; Grant, 2000). Dioscorides, in *On Medical Matters* (1st century CE), wrote that the rind of the *pepon* is to be applied on top of the head of a child suffering from heat stroke or on the forehead for running eyes (Beck, 2005). Clearly, Dioscorides was prescribing watermelon, *Citrullus lanatus* (Table 1), as its thick, watery rind would have the desired damping and cooling effects. Galen, in *On the Properties of Foodstuffs* (2nd century), wrote that the *pepon* was cold and wet and that the *melopepon* was less cold and less wet, having a milder effect on the body than the *pepon* (Grant, 2000; Powell and Wilkins, 2003).

Pliny, in his Latin-language *Natural History* (Book 20, 6:11) (1st century), described the *pepo* as very refreshing (Janick *et al.*, 2007) and the *melopepo* as a new introduction, a quince-shaped, aromatic yellow fruit that detached from the plant when ripe. The *melopepo*, undoubtedly, was *Cucumis melo*, as this is the only cultivated Old World cucurbit having a fruit which detaches from the vine spontaneously and the yellow colour, indicative of fruit ripeness, is common in *C. melo* but rare in *Citrullus lanatus* (Table 1). Quintus Gargilius Martialis (3rd century) wrote that the *pepone* are good to eat if one takes the trouble of removing the rind and pits (Maire, 2007), the need for removing the pits again suggesting watermelon.

The *melopepon*, as *melafefon*, was discussed in the context of Jewish Law, in compilations of rabbinical Hebrew-language commentaries known as the *Mishna* (2nd century) and *Tosefta* (3rd century). From the commentaries, it is apparent that the *melafefon* was used when ripe; however, it is absent from a discussion of the probably more common fruits that were eaten raw when ripe, the *avattihim*, table grapes, figs and pomegranates (*Mishna*, Ma'asrot 2:6) (Janick *et al.*, 2007).

Watermelons are depicted in mosaics from Greece and northern Africa dating to Roman times. A 4th-century mosaic from Tunisia shows oblate melons that are striped yellow and green, the yellow colouration indicative of fruit ripening (Janick *et al.*, 2007).

A Latin-language cookbook from late Roman times (approx. CE 400) in the name of Apicius has a preparation for spiced raw *pepones et melones* (Flower and Rosenbaum, 1974). The Roman agricultural writer Palladius (4th century) described seed treatments that were supposed to make *cucumeres* (snake melons) become *dulcis* and make *melones* become aromatic and *suave* (Cabaret-Dupati, 1844); this prescription was repeated in the *Geoponica* (10th century) for *melopepones* (Owen, 1806). However, snake melons, *cucumeres*, cannot attain the level of sweetness that is characteristic of modern sweet melons and therefore the *melones* and *melopepones*, while agreeable, very likely did not possess the sweetness that is customarily expected of modern melons. These Roman round melons, the *melopepones*, are thought to have been of the Adana Group, named after a locality in a fertile plain of southern Turkey (Cizik, 1952; Janick *et al.*, 2007). Adana melons are round to oval and fairly large, but with thin, rather dry, mealy flesh low in sugar content (Cizik, 1952; Pitrat *et al.*, 2000).

MEDIEVAL MELONS (CE 500–1500)

Latin and Byzantine Europe

De Observantia Ciborum, an early 6th-century book on foods attributed to a Pseudo-Hippocrates, lists *cucumere* (snake melons) first among the vegetables. The *pepone* (watermelons), here too, are listed among other fruits that are eaten raw when ripe, pomegranates, grapes and figs, but there is no mention of *melopepones* or *melones* (Mazzini, 1984). A contemporary from what is now north-eastern Italy, the physician named Anthimus (Grant, 2007), wrote a manuscript of the same title, in which he mentioned *cucumeres* and *melones*. As the latter were said to be eaten ripe and better the flesh mixed with its own seeds, it appears that this author used the word *melones* for watermelon, not melon (Table 1). Paul of Aegina (approx. 690), following Galen, wrote that the *melopepon* is less cold and humid than the *pepon*, having the same effects on the body but to a lesser degree (Adams, 1834). The *pepones*, but not the *melopepones* or *melones*, are mentioned in the *Capitulare de Villis et Curtis Imperialibus* (approx. 800) of Charlemagne (Fleischmann, 1919). Round-fruited *C. melo*, then, were not mentioned in any original context by these early medieval European authors, apparently because they were considered insignificant.

Walahfrid Strabo of southern Germany wrote a poem on gardening, *Hortulus* (approx. 840) (Payne and Blunt, 1966). In it, the *pepones* were viney plants, the fruits round to rather slender, nut-shaped or oval, and yellowish, aromatic, hollow inside and flavourful. The yellow colour and hollow interior indicate *Cucumis melo*. However, there are no superlatives indicating that these *pepones* were particularly sweet and, thus, they were likely of the Adana Group. Four centuries later, Albertus Magnus of Germany, in his *De Vegetabilibus* (approx. 1260) (Jessen, 1867), described the *citrulus* as a kind *pepo* that had a smooth green exterior, which would indicate *Citrullus lanatus*, and the *pepo* was commonly yellow with an uneven surface, composed of regular semi-circles in relief, indicative of *Cucumis melo* (Table 1). Plainly, to both

German authors, the *pepo* was primarily *Cucumis melo*, and the word *melopepones* was not familiar. To Albertus Magnus, *cucumer* was *Cucumis sativus* and *citrulus* was *Citrullus lanatus* but to his Italian contemporaries, they were *Cucumis melo* and *Cucumis sativus* (cucumber), respectively (Paris *et al.*, 2011). Thorndike (1945) observed that there was little exchange among groups of medieval European botanists, probably dictated by geographical, political, academic or ecclesiastical limits.

The *pepon* and *melopepon* are mentioned in an early Byzantine Greek book of foods, *De Cibis* (approx. 670) with regard to their supposed effects on the body (Ermerins, 1840; Dalby, 2003*a*). They are listed as foods that moisten in *De Alimentis* (mid-10th century) (Ideler, 1842; Dalby, 2003*a*). In the *Syntagma* of the physician Simeon Seth (latter half of the 11th century), a dietetic calendar (approx. 1100), the *Peri Trophon Dynameos* (approx. 1100), and the *Prodromic Poems* (approx. 1160), *peponia* (also *pepones*, *peponas*) are mentioned, but not *melopeponia* (Brunet, 1939; Hesseling and Pernot, 1910; Delatte, 1939; Dalby, 2003*a*). In the *Syntagma* and the *Peri Trophon Dynameos*, some of the *pepones* are said to be sweet, the same as for mulberries, apples, pomegrantes and plums (Delatte, 1939).

Late medieval herbals, beginning with the *Tractatus de Herbis* (approx. 1300), depict oval to elongate melons, but all appear to be vegetable melons, not sweet melons (Paris *et al.*, 2011). One exemplar of the horticultural health manual *Tacuinum Sanitatis*, Bibliothèque nationale de France ms. Nouv. Acq. Lat. 1673 (approx. 1390), has an image, on folio 38v, of oval, wrinkled, casaba melons (Inodorous Group) (Cogliati Arano, 1976; Paris *et al.*, 2009). Unlike an image of watermelon that is labelled *Melones dulces* (folio 37r), this melon is labelled *cucumeres et cetruli*, suggesting that it was not recognized as sweet by the local population. Another exemplar, Vienna Cod. Ser. N. 2644 (approx. 1400), shows a large, spherical, yellow, aromatic melon, labelled *Melones indi et palestini* (fol. 22r); yet another exemplar, Rome Casanatense 4182 (approx. 1400), shows a similar image, but it is labelled *Melones insipidi* (fol. 36r). Evidently, these images were depicting melons of the Adana Group. There are no images showing a *Cucumis melo* that is labelled with the adjective *dulces* (Paris *et al.*, 2009).

South-western and Central Asia

The earliest evidence for the existence of sweet melons comes from a vast Central Asian region known as Khorasan, a territory which extended over lands that are in modern Turkmenistan, Uzbekistan, Afghanistan, Tajikistan and north-eastern Iran (Anon., 2012), and from Persia, another vast ancient territorial expanse, situated to the west and south of Khorasan, extending over the rest of modern Iran and eastern Iraq. A large medical compendium consisting of 360 chapters, the *Paradise of Wisdom*, was compiled by ‘Ali ibn Sahl al-Tabari and completed in 850 at Samarra (modern Iraq) (Meyerhof, 1931). The compiler was a native of Maru (Khorasan, modern Turkmenistan), and had lived in Tabaristan, Persia (north-central modern Iran), bordering the Caspian Sea. Meyerhof noted: ‘Rare or remarkable names of remedies or technical terms are specially mentioned . . .’ and, according to him, in the chapter on vegetables, there is an allusion to *quniya*, which he understood to be an elongate form of melon.

The *Syriac Book of Medicines* is another compilation, the first part of which dates to the early 6th century (Budge, 1976). In a later part of unknown date but perhaps from the latter half of the 9th century, during the flowering of translations from Greek into Syriac (Prioreschi, 2001), there is a statement that the *gunya* should be avoided during the month of Nisan (usually falls from late March to late April).

An Arabic translation of Dioscorides’ *On Medical Matters* was edited, approx. 990, by Al-Husayn ibn Ibrahim al-Natili in Samarqand (Khorasan, modern Uzbekistan); the original was lost but a copy, produced there in 1082, has survived as Leiden University Or. ms. 289 (Sadek, 1983; Witkam, 2007). Some of the plant illustrations in this herbal are derived from earlier Greek manuscripts but others have an eastern-style iconography (Collins, 2000). On folio 88v there is an illustration of a viney plant, highly stylized into a candelabra effect typical of eastern iconography, that sports eight large, bright yellow fruits that are round except for a large protruding stylar end (Fig. 2). The illustration is labelled *qawoun*, in a handwriting different from that of the main text, which opens on the previous folio with an explanation that the *qawoun* are the *battikh*. Melon, *Cucumis melo*, in modern Uzbekistan is *qovun* (Mavlyanova *et al.*, 2005) and in neighbouring Turkmenistan is *gawun* (Esen, 2008).

A philological and lexicographical *Book of Plants* was written by Abu Hanifa Ahmad al-Dinawari in the 2nd half of the 9th century. The author resided in Dinawar, Persia (west-central modern-day Iran), and studied in Isfahan

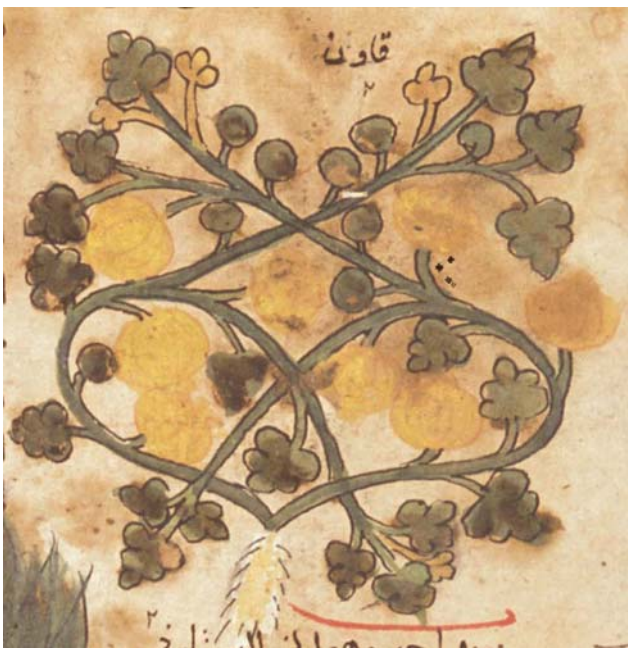

FIG. 2. Depiction labelled Qawoun (melon, *Cucumis melo*), on folio 88v, Leiden University ms. Or.-289, Kitab al-Hasha’ish fi Hayula al-‘Ilaj al-Tibbi (Arabic translation of Dioscorides’ *De Materia Medica*, edited by Abu ‘Abdallah al-Natili, approx. 990) and copied in Samarqand, 1082 (Sadek, 1983; Witkam, 2007). Used with permission.

(central Iran), Basra and Kufa (modern Iraq). He had several major written sources of information, all dating to the early 9th century, although he also gathered some oral information on his own (Breslin, 1986). He wrote that the *battikh* are a kind of *yaqtin*, which are herbaceous viney plants, especially cucurbits. He also wrote that *kharbiz* is a Persian word for *battikh*. In modern Iran, *kharbuza* designates sweet melons, *Cucumis melo* (Haim, 1992), especially the large, elongate ones.

Muhammad Abu al-Qasim ibn Hawqal, a Kurdish native of what is now south-eastern Turkey, travelled extensively around the Islamic Empire. He described in his travelogue, in 955, elongated *battikh* that were *qabih al-mandar*, of ugly appearance, but *ghaya fi al-halawa*, infinitely sweet, very good to eat (Kramers and Wiet, 1964). They were grown in the village of Ardahar (Persia), present-day north-western Iran bordering Armenia, Azerbaijan and Turkey. These *battikh* were comparable in quality to 'the renowned *battikh* of Khorasan'. In Maru, Khorasan (modern Turkmenistan), around 970, he noticed that the *battikh* were sliced and dried 'for export to numerous places of the world, and I do not know of any other place where such a thing might be possible'. Shams al-Din al-Muqaddasi, who travelled around the Islamic Empire for 20 years beginning in 966, wrote: 'There is a meat of Bukhara (Khorasan, modern Uzbekistan) that is incomparable, as is a kind of *battikh* called *al-saf*' (*al-saq* in another version) (De Goeje, 1991; Collins and Al-Tai, 1994).

Al-Biruni was a native of Khorasan who wrote a pharmacological book in the early 11th century. Quoting ibn Masawaih (mid-9th century), he wrote that the famous *battikh* called *al-Ma'muni*, named after an early 9th-century 'Abbasid ruler in Baghdad (Nasrallah, 2007), were very sweet and red; thus, they likely were a cultivar of watermelon. He also wrote, however, that there was a kind of *battikh* called *miloun* (melon) that was not as cold, wet and diuretic as the others. These *miloun* were actually *qitha* (vegetable melons) that became 'transformed' during the summer (Said, 1973).

Ibn Butlan, a native of Baghdad and who had travelled around the Near East, in his tabularly arranged *Rectifying Health by Six Causes* (approx. 1060), listed *battikh hindi* (Indian *battikh*), *battikh miz* (insipid *battikh*) and *battikh hilu* (sweet *battikh*) (Elkhadem, 1990). While there is no further description, Ibn Butlan noted that the best sweet *battikh* were from Samarqand (Khorasan).

Over 200 years later, Shams al-Din al-Dimashqi, in his *Cosmography* (approx. 1300), described the *battikh asfar* (yellow *battikh*) of Nablus (Palestinian Authority, biblical Shekhem) as being 'sweeter than all other kinds of *battikh*' (Le Strange, 1890). The traveller Ibn Battuta also wrote (approx. 1330) of the melons of Nablus as good and delicious (Defremery and Sanguinetti, 1968) and the yellow *battikh* of Dehli (India, approx. 1340) as very sweet. In a book dedicated to the governor of the town of Zefat (Galilee, Israel) between 1372 and 1376 (Lewis, 1953), the *battikh asfar Sultani* (Sultan's yellow *battikh*) is described as grown in the town of 'Akko (coastal Galilee), the attribution to the sultan would imply the largest, best-appearing or sweetest. Ibn al-Shihna, in his description of Halab (Aleppo, Syria) (approx. 1480) wrote of a *battikh asfar* known as the *Samarqandi* that was not native to the region; he described it as especially delicious when grown in a few villages around Damascus but around Cairo, even though it achieved a high degree of sweetness, it was too soft and watery (Sarkis, 1909). The yellow colour of these *battikh* indicate that they were melons, *Cucumis melo*.

Andalusia and North Africa

Ibn Habib, a physician from Andalusia (southern and central Iberian peninsula), in his *Compendium of Medicine* (approx. 850), echoed Galen's description (approx. 180) of the *pepo*, watermelon (Grant, 2000), by stating that the *battikh* are cold and humid (Alvarez De Morales and Giron, 1992). The *Cordoban Calendar* (2nd half of the 10th century) listed *battikh al-hindi* and *dulla'* as synonyms for watermelons (Pellat, 1961). Ibn Bassal, in his *Kitab al-Filaha* (*Book of Agriculture*, approx. 1080), named *battikh sindi* instead of *battikh hindi* and *dulla'*, stated that there were a number of kinds of *battikh* and that the sugary kind would achieve highest quality in dry, non-irrigated soils (Millas Villacrossa and Aziman, 1955). Such conditions in the field would benefit sweetness in both melons and watermelons.

An Andalusian contemporary of Ibn Bassal, Abu al-Khayr of Seville (Al-Khattabi, 1990), approx. 1100, gave numerous names for kinds of *battikh*, including some from the east, *kharbiz* and *khadaf*; the last two are in Al-Dinawari's lexicography (Breslin, 1986). Seemingly echoing al-Biruni (Said, 1973), he wrote that *battikh* were *qitha* (vegetable melons, *Cucumis melo*) that were allowed to turn yellow and ripe (Al-Khattabi, 1990). Some of the names Abu al-Khayr gave to yellow melons, though, seem to be of his original recording. Significantly, these names included *Sukkari* (sugary), *Mi'niq*, because they had a long neck, and '*Aqabi*, because one end has the angular shape of the beak of a bird of prey; these were known as the *miloun* (melon). A distinctly different kind, the *Armini* (Armenian), had a smooth but thin yellow skin, thick, soft flesh, pleasant aroma and sweet flavour (Al-Khattabi, 1990). These descriptions of *battikh* with acute ends or thin yellow rinds, although terse, do indicate *Cucumis melo*. Ibn al-'Awwam, approx. 1180 (Clément-Mullet, 1866; El Faïz, 2000), wrote that there were melons that had a long neck, were rough to the touch, and aromatic with a sugary flavour when allowed to yellow and ripen on the vine. For some other kinds of melons, the sweetness is implied but not stated specifically. One was described as bent, with a long neck and a belly, and aromatic. Another had the shape of a cushion, was ash-coloured, and rough to the touch, and a third was described as having a neck, a large base, conical, and peppered with small spots.

Nasiri Khosraw, a traveller from Maru, Khorasan, who wrote in Persian, mentioned *kharbuza*, melons, as among the fruits and vegetables he saw in Old Cairo in December, 1048 (Schefer, 1970). Maimonides (approx. 1200), writing in Egypt, noted that there were round and oblong *battikh*. Of the latter, some were called *milouniya* and the Egyptians called them *battikh asfar* (yellow *battikh*) (Rosner, 1995). 'Abd al-Latif al-Baghdadi (approx. 1200) wrote that it was rare to find melons in Egypt that had a sugary flavour, true and perfect, but they were often rotten and spoiled and their taste dominated by a certain watery insipidness (Silvestre de Sacy, 1810). An exotic, introduced, necked melon preferred

by the local inhabitants was referred to as the melon of Khorasan or of China. This melon was said to be small, yellow when ripe, but could not have been very sweet, at least as grown in Egypt, as it was described as eaten with sugar.

DISCUSSION

Our search has not revealed any indication of the presence of sugary melons, *Cucumis melo*, comparable in quality to modern sweet melons, around the Mediterranean Basin in classical times, to CE 500. Writings and depictions from this era indicate that round, ripe melons were a fairly well-known crop, but they had minor importance as compared with snake melons (Janick *et al.*, 2007). Mentions of round melons are not frequent in the literature of Latin Europe in the ensuing centuries, either, and we can confirm that there are no superlatives in the literature which would indicate the presence of sugary melons prior to the late 15th century (De Candolle, 1886; Hedrick, 1919). However, approx. 1390, a melon resembling the white Portuguese casaba 'Branco' was illustrated in northern Italy. Its label *Cucumeres et cetruli* indicates, though, that it was considered to be a kind of vegetable melon (Paris *et al.*, 2009). Probably the climate of northern Italy was not suitable for casaba melons, as they are late to ripen and accumulate sugar, requiring a long, hot growing season.

Possible early indications for the existence of sweet melons are found in Arabic writings of the 9th century. Al-Dinawari's botanical lexicography has *kharbiz* for *battikh* (Breslin, 1986) and the Persian *kharbuza*, in modern Iran, designates sweet melons (Haim, 1992). The *quniya* mentioned by 'Ali al-Tabari (Meyerhof, 1931) and the *gunya* of a late supplement to the *Syriac Book of Medicines* (Budge, 1976) apparently referred to the melons of Khorasan, as the label *qawoun* is given to the melon illustrated in the 11th-century Samarqandian copy of Dioscorides' herbal (Fig. 2). Sweet melons in modern Uzbekistan are *qovun* and in modern Turkmenistan are *gawun*. However, the mere use of the words *kharbiz*, *quniya*, *qawoun* and *gunya*, while suggestive, does not necessarily indicate that the melons back then were comparable in sweetness to those enjoyed today.

Writings dating to the mid-9th century allude to wonderful *battikh* from Central Asia. Some of these *battikh* were shipped all the way to Baghdad and named after the caliph Ma'mun (Bosworth, 1968; Said, 1973; Nasrallah, 2007; Amar and Lev, 2011). These particular *battikh*, apparently, were watermelons and not melons, as they were described as having red flesh and Baghdadian kitchen preparations (approx. 950) called for slicing off the rind, even as much as half of the thickness of the fruit, to leave only the central fruit flesh, the sweetest part (Nasrallah, 2007). Evidently, Ibn Hawqal, in his 10th-century travelogue (Kramers and Wiet, 1964), was describing very different *battikh*, ones that were 'infinitely sweet' but ugly. The sweetness of both melons and watermelons could be given such a superlative but, when comparing genetic variation for fruit appearance of melons and watermelons (Table 1; Esquinas-Alcazar and Gulick, 1983; Stepansky *et al.*, 1999; Mavlyanova *et al.*, 2005; Sensoy *et al.*, 2007; Esen, 2008; Solmaz and Sari, 2009), only some cultigens of the former have fruits that are fusiform, necked, acute or of an unsymmetrical shape and have a dull-coloured, rough, or uneven surface, and thus characteristically and saliently 'ugly'. Ibn Hawqal compared the sweetness of the ugly melons from north-western Iran with the finest melons of Khorasan. The cutting and drying of melons in Khorasan mentioned by Ibn Hawqal was also observed in the late 13th century by Marco Polo (Bergreen, 2007) and is still practiced there commercially (Mavlyanova *et al.*, 2005; Esen, 2008; McCreight *et al.*, 2010). In another travelogue, an incomparable kind of *battikh* from Khorasan is said to be referred to as *al-saf* (De Goeje, 1991; Collins and Al-Tai, 1994), which is reminiscent of *al-asfar* (yellow). The 1082 copy of Al-Natili's translation (approx. 990) of Dioscorides' herbal (Sadek, 1983) illustrates the *battikh*, synonym *qawoun*, as melons (Fig. 2), not watermelons, suggesting that melons were more familiar in the environs of Samarqand. Ibn Butlan (approx. 1060) probably was referring to melons when he wrote that the best sweet *battikh* were from Samarqand (Elkhadem, 1990) even though the illustrated European versions of his work show the *melones dulces* as striped, oblong watermelons (Paris *et al.*, 2009). To the present, Central Asia has the greatest diversity of sweet melon cultigens (Vavilov, 1951; Slomnicki *et al.*, 1968; Mavlyanova *et al.*, 2005; Esen, 2008; McCreight *et al.*, 2010). These include muskmelons and cantaloupes that ripen in mid-summer, are aromatic, have good quality but a short shelf-life, and casabas that ripen late, are not aromatic, of high quality and have a long shelf-life, as well as other melons that cannot be readily classified into these groups.

The first description of sugary melons in Europe is from the south-western end of the continent, Andalusia, which has a semi-arid climate, and was written in the late 11th century by Abu al-Khayr of Seville (Al-Khattabi, 1990). To him, the typical *battikh* were *qitha* (vegetable melons) that were allowed to ripen and turn yellow, thus *Cucumis melo*. The sugary *battikh* described by Abu al-Khayr had narrow, acute peduncle ends, which is a characteristic rather frequently encountered among casaba melons (Fig. 1) and, therefore, the casaba (Inodorous Group) was probably the first sweet melon cultivar-group to be grown in Andalusia. The sugary melon described a century later by Ibn al-'Awwam (Clément-Mullet, 1866), necked with a rough surface, aromatic, turning yellow when ripe, and needing to ripen fully on the vine to become sugary, is not easy to identify with a particular cultivar-group. The necking of the fruit would favour a casaba, the roughness of its surface could allude to netting (muskmelons), warting (cantaloupes) or wrinkling (casabas), and the aroma would favour a muskmelon or cantaloupe. Another melon described by Ibn al-'Awwam, that was necked, conical and spotted, was very likely a casaba. The casabas are the sweet melons most diverse and common in the Iberian peninsula today (Esquinas-Alcazar and Gulick, 1983).

The disjunct sweet melon-growing regions, Central Asia and Andalusia, in texts of the 9th to 12th centuries, may be a reflection of the relatively small number of writers who chose to describe fruits and vegetables to any extent whatsoever but, also, may be a reflection of reality. A number of plants arrived in Mediterranean lands from the east via the Sabean Lane – a maritime trade route from the western Indian subcontinent (modern Pakistan), along the south coast of Persia and

Arabia, then northwards via the Red Sea to Egypt – then via short overland journey to the Mediterranean coast, then by sea westward to Andalusia, completely across the Islamic Empire from its most eastern to its most western extents (O'Leary, 1964; Harvey, 1975). Physical and political barriers can result in a disjunct distribution of foods over vast distances (Zubaida and Tapper, 1994). Later writings, from the late 13th to late 15th centuries, place sweet melons in western Asia/eastern Mediterranean, within the present-day boundaries of Israel, Syria and the Palestinian Authority (Le Strange, 1890; Sarkis, 1909; Lewis, 1953; Defremery and Sanguinetti, 1968).

Watson (1983) contended that sweet watermelons, *Citrullus lanatus*, first arrived in the Mediterranean Basin via the Sabean Lane. There is, however, some evidence suggesting that sweet watermelons had already been selected by Mediterranean civilizations of antiquity (Wasylikowa and van der Veen, 2004; Janick *et al.*, 2007; Cox and van der Veen, 2008; Amar and Lev, 2011). Sweet melons, *Cucumis melo*, would be a crop that first reached the westernmost Mediterranean from Central Asia, as a result of Islamic conquest, trade and agricultural development.

Selection of sugary sweet melons by ancient farmers would have required a climate allowing expression of sweetness (Thompson and Kelly, 1957; Yawalkar, 1980). The cloudy, rainy summers over much of Europe, for example, are ill-suited but the climactic conditions occurring over much of Central Asia, the Middle East, and around the Mediterranean Sea, especially the hot, rainless summers, are favourable. Melons are traditionally grown in these regions without irrigation or with carefully timed supplemental irrigation (Esen, 2008). Ibn Bassal, approx. 1080, wrote that the sugary *battikh* would lose their sweetness if grown in sites having wet soils or if they were irrigated (Millas Villacrossa and Aziman, 1955). Even in semi-arid climates, sub-optimal cultural conditions such as ill-timed irrigation, poorly drained soils, and prevalence of pathogens can adversely affect fruit quality of even the potentially finest melons (Davis *et al.*, 1965).

The ability of melon fruits to accumulate sucrose is conferred by a major recessive gene, *su* (Burger *et al.*, 2002). As melon plants have a rather strong tendency to cross-pollinate, a plant bearing sweet melons, if grown in the vicinity of a plant bearing bland melons, will foster some progeny having bland melons. Maintenance of the sucrose-accumulation trait, year after year, would have been quite problematic in much of the Middle East and Mediterranean Europe, as the cucumber-like melons have been widely grown in those regions for millennia (Janick *et al.*, 2007; Paris, 2012). Nasiri Khosraw saw *kharbuza* in Old Cairo in December 1048 (Schefer, 1970); the Khorasani melons of Egypt described as eaten with sugar by 'Abd al-Latif al-Baghdadi a century and a half later (Silvestre de Sacy, 1810) may have been degenerate offspring resulting from serendipitous hybridization between melons of Khorasan and the local cucumber-like melons. Ibn al-Shihna, near the end of the 15th century, wrote that the *Samarqandi* melon was delicious and very sweet, but apt to lose its uniformity and quality when grown in Syria and Egypt (Sarkis, 1909). Possibly, successful isolation and propagation of sweet melons in Central Asia was expedited by an early introduction there of cucumber. *Cucumis sativus* and *C. melo* are not cross-compatible (Whitaker and Davis, 1962; Robinson and Decker-Walters, 1997) and Central Asia is geographically close to the centre of origin of cucumber, the Indian subcontinent (Bisht *et al.*, 2004; Sebastian *et al.*, 2010). *Cucumis sativus* is also more cool-tolerant than *C. melo* and has replaced traditionally grown cucumber-like melons in many areas (Paris *et al.*, 2011, 2012).

Sweet melons were introduced into Italy and neighbouring countries, indeed into much of Europe, reportedly from Armenia, in the late 15th century (Pitrat *et al.*, 2000; Jeffrey, 2001; Goldman, 2002). The old Turkish word for melon, *qavoun* (Viguier, 1790) (modern *kavun*), is obviously closely related to the Uzbek and Turkmen *qovun* and *gawun*, indicating that Central Asian melons diffused into Turkey overland and not via expansion of Arabic-speaking people. The travelogue of Ibn Hawqal (Kramers and Wiet, 1964) indicates that sweet melons were already present in north-western Iran, near the border with modern Armenia, Azerbaijan, and south-eastern Turkey, by the mid-10th century. A close resemblance between some traditional sweet melon cultivars from Hungary and from Turkey has been documented (Szamosi, 2009; Szamosi *et al.*, 2010), offering support for an additional though more gradual, northerly and mostly overland route of diffusion of melons into Europe. Apparently, there were several introductions of sweet melons into Europe during the early Renaissance. Both, muskmelons and cantaloupes are depicted (1515–1518) in the Villa Farnesina, and the depictions are realistic, showing imperfections of the fruits (Janick and Paris, 2006). Many of the melons are cracked, puckered open, a feature that is indicative of excessive soil wetness. Most modern melon cultivars are produced under irrigation, in order to obtain higher yields per unit area. These cultivars have been selected for resistance to cracking and for achieving acceptably high sucrose and soluble solids content, even if grown under full irrigation or in areas having summer rains.

Melons from Central Asia are the ultimate germplasm source of the sweet melons which are so widely grown and highly valued throughout much of the world today. The sweet melon germplasm of Central Asia is highly diverse (Slomnicki *et al.*, 1968; Jeffrey, 2001; Mavlyanova *et al.*, 2005; Esen, 2008; McCreight *et al.*, 2010) and is well represented in collections maintained by a number of gene banks (Pitrat, 2008). Not all combinations of fruit-quality traits found in Central Asian germplasm, however, have been fully introgressed into sweet melons grown in other regions. Notably, there are melons in Central Asia that are very large, sweet and flavourful, that can be kept in cold storage for months (Mavlyanova *et al.*, 2005; Esen, 2008), yet these are not grown in other regions to any great extent. Evidently, there are ill-defined climactic, soil or cultural factors that adversely affect the quality of these melons elsewhere, offering a challenge to breeders to develop such melons with improved adaptation to other environments.

CONCLUSIONS

Lexicographies dating to the 9th century suggest the presence of sweet melons, *Cucumis melo*, in Central Asia. The earliest description of sweet melons is found in a mid-10th-century travelogue of this region. A surviving late 11th-century copy

of a late 10th-century herbal from Khorasan, Central Asia indicates that round-fruited, ripe melons were familiar in that region. Central Asia, specifically Khorasan and Persia, is likely to be the cradle from which sweet melons emerged. The sharply continental climate, with its high insolation and dry summers, offered a most favourable environment for successful selection and propagation of sweet melons. Manuscripts derived from the late 11th century and 12th century indicate the presence of sweet melons in Andalusia, probably casabas brought there from Central Asia as a result of Islamic conquest. Sweet melons that were adapted to the climatic conditions prevalent elsewhere in Europe appear to have been introduced there later, near the end of the 15th century, by a mostly overland route from Central Asia, and selected for increased adaptation to cooler, wetter environments.

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