CUCURBITS

BOTANY CULTIVATION AND UTILIZATION

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and
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Botany, Cultivation, and Utilization

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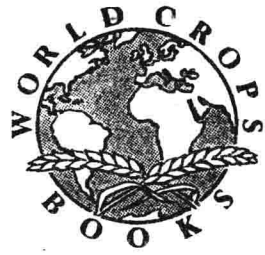

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PREFACE

DURING the course of our day-to-day tasks, we have long felt the need for assembling and critically evaluating the widely scattered literature pertaining to the cultivated Cucurbitaceae. From conversation and through correspondence, it is our conviction that teachers, other investigators, and those with an economic interest in these plants, would also welcome such a treatise. Both of us have spent a large portion of our professional lives engaged in research aimed at increasing man's understanding of the cultivated Cucurbitaceae. By virtue of experience, we feel reasonably competent to assess and synthesize the great mass of descriptive and experimental work reported for these plants. Furthermore, we expect to demonstrate where current information is weakest, and where profitable avenues exist for expanding our knowledge in the future. Our modest goal will have been achieved if the prospective reader, interested in any phase of the cultivated cucurbits, can remove this work from the shelf and find help for the solution of his problem, either in the text or through the extensive list of references.

Many of our colleagues have helped by reading portions of the manuscript critically and giving us the benefit of their comments and suggestions. Those who have aided in this way are: C. F. Andrus, S. F. Blake, G. W. Bohn, V. R. Boswell, H. C. Cutler, O. J. Eigsti, R. G. Grogan, D. H. Hall, L. R. Hawthorn, J. H. Harrington, O. A. Hills, K. A. Kimble, J. E. Knott, W. H. Lange, Jr., L. K. Mann, J. H. MacGillivray, L. L. Morris, C. M. Rick, G. L. Stebbins, Jr., and J. C. Walker.

The reader should not be misled into thinking that persons courteous enough to examine the manuscript must necessarily agree with the authors' viewpoint, or with many of the statements made in the text. For the opinions expressed, and for errors of omission or commission, the authors assume full responsibility.

The senior author is particularly grateful to Professor J. E. Knott, Chairman, Department of Vegetable Crops, University of California, Davis, California, for the use of the facilities of the Department along with the privilege of being a staff member for a period of eight months. Without this friendly co-operation, little could have been accomplished towards the completion of the book. We wish to thank Mrs. Marilyn Stein for preparing the figures, and Messrs. James Perdue and G. A. Sanderson for certain of the photographs.

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INTRODUCTION AND GEOGRAPHIC ORIGIN OF THE CULTIVATED SPECIES

THE Cucurbitaceae are among the more important plant families that supply man with edible products and useful fibres. The cultivated species of this family are not nearly as significant in man's economy as the cereals or the legumes, but in the tropics, subtropics, and milder portions of the temperate zones of both hemispheres, they are crops of more than ordinary importance. For the peoples of these areas, the cultivated Cucurbitaceae have a place in their diet: as sources of carbohydrates when cooked (squash, pumpkin, marrow, chayote), as dessert or breakfast fruits (water-melon, musk-melon), as ingredients of salads (cucumber, gherkin), or as pickles (cucumber, gherkin). There are other minor uses: for example, the fruits of *Lagenaria siceraria* (white-flowered gourd), before the advent of pottery, were indispensable to primitive peoples around the household; the rinds of some mature fruits were used for baskets, jugs, pots, and cutlery; and the fibrous material of *Luffa* (dish-rag gourd) was used for scouring. This last material has also been used in certain oil filters, and for insulation, packing, and other purposes of this nature.

Like many of our crop plants, most of the cultivated species of the Cucurbitaceae have for centuries been associated with man's culture. Several investigators have indicated that it is doubtful whether some of our cultivated plants, e.g. maize, could survive without man's intervention. The same statement is almost certainly true of several species of the Cucurbitaceae. So far as is known, bona fide specimens of the wild counterparts of the cultivated species have never been collected.

The Cucurbitaceae consist of about ninety genera and 750 species almost equally divided between the New and Old World tropics. Seven genera are common to both hemispheres. A few species have ranges extending well into the temperate regions of the northern and southern hemispheres but all species are frost-sensitive. Most of them are climbing or prostrate annuals, or occasionally perennial herbs, and usually monoecious ; * but there are andromonoecious † and dioecious ‡ forms as well. The phylogenetic position of the family is in dispute; rarely

* With stamens and carpels in separate flowers on the same plant.
† With staminate and hermaphrodite flowers but no pistillate ones.
‡ Unisexual, with staminate and pistillate flowers on separate plants.

do any two authorities agree as to where it should be placed with respect to other families and orders. Until much more is known about the floral anatomy, embryology, cytology and comparative morphology of this large and homogeneous family, it would appear unprofitable to speculate about its position in relation to other dicotyledonous families.

WATER-MELON (*Citrullus vulgaris* Schrad.*)

There is much evidence (De Candolle, 1882) that the water-melon is indigenous to tropical Africa, whence there are reports that it has been found in the wild state on both sides of the Equator. If these reports are true, it probably occurs in the drier, open areas of the tropics adjacent to the Equator. David Livingstone (De Candolle, 1882) is reported to have seen districts where the entire countryside was literally covered by water-melon vines. The aborigines and several kinds of wild animals were eagerly devouring the fruit.

The water-melon has evidently been cultivated for centuries by the peoples bordering the Mediterranean Basin. The Berbers of North Africa, the early Egyptians, and the Spanish, all have names for the plant —which fact indicates it was known to their earlier cultures. A Sanskrit name testifies to its early introduction into Asia.

Pangalo (1930, 1944, 1955) has made extensive studies of Asiatic water-melons. On the strength of these studies, in both field and herbarium, he was convinced that *C. vulgaris* is indigenous to India. While Pangalo's conclusion may very well be the correct one, it is not the only inference that can be drawn from his data. The authors would like to suggest that what Pangalo has actually discovered is a strong secondary centre of diversification of the genus in India. The many well-documented historical records which indicate that the water-melon comes from Africa cannot be lightly disregarded.

CUCUMBER, GHERKIN, MUSK-MELON (*Cucumis* spp.)

CUCUMBER (*Cucumis sativus* L.)

The cucumber is listed as indigenous to India by De Candolle (1882). The chief evidence offered for this viewpoint is the finding of *Cucumis hardwickii* Royle, a cucumber-like plant, at the foot of the Himalayas in India. In most respects, *C. hardwickii* is similar to *C. sativus*, except that the exterior of the fruit is smooth, and the flesh is extremely bitter. De Candolle states that Sir Joseph Hooker collected specimens of *C. hardwickii* along the southern foot of the Himalayas, and quotes him as saying, in effect, that *C. hardwickii* falls well within the range of variability

* Authorities for Latin names of plant and animal species and lower taxa are commonly given only on introduction of the entity or, if it is treated specially (as in this case), in the heading to such treatment. Ed.

of *C. sativus*. There is no critical evidence to disprove an alternative suggestion that *C. hardwickii* is a 'weedy' form of *C. sativus* escaped from cultivation, rather than the putative ancestor of this species.

While there is no conclusive evidence that the cucumber is from Asia, there are scraps of evidence that are highly suggestive. The cucumber, with seven pairs of chromosomes and several distinct morphological characters, stands apart from other members of the genus *Cucumis*, which have twelve pairs of chromosomes and are indigenous to tropical Africa. The angular stems, and the harsh, scabrous texture of the foliage, along with the comparatively large, triangular-lobed leaves (the middle lobe is sharply acute), are clearly unusual in *Cucumis*. Professor O. E. White of the University of Virginia has studied *C. sativus* in Burma. He informs us that this species is extremely variable, both vegetatively and in fruit characters, in this area. This could be a well-developed secondary centre, however, with little or no relation to the primary centre of distribution.

De Candolle (1882) makes the statement that the cucumber has been cultivated in India for at least three thousand years. The source of this statement is not given, but evidently the cucumber must have been known in this area for a very long time. From India it spread to China, and even earlier and more rapidly to the West, where it was much appreciated by the Greeks and the Romans.

WEST INDIA GHERKIN (*Cucumis anguria* L.)

The native country of the so-called 'West India gherkin' has been a botanical puzzle for well over a century. As a result of a brilliant piece of scientific detective work, Meeuse (1958) has offered a reasonable solution to the problem, with acceptable supporting data. Most of the early botanists were inclined to believe that this species was of American origin, as it appeared to be an endemic plant in many areas of the New World. Then Naudin (1859*a*) pointed out that the other species of *Cucumis* are African in origin, and suggested that it could have been introduced into the Americas by the slave trade. Sir Joseph Hooker made practically the same suggestion, except that he thought it might be a cultivated and modified form of an African species. Its distribution in the Americas coincides very closely with areas where there was a brisk slave trade. The status of the problem remained unchanged for about a century until Meeuse (1958) reinvestigated the entire question at the National Herbarium in Pretoria, South Africa. He found in Africa a wild species of *Cucumis*, *C. longipes* Hook., that has many morphological features in common with *C. anguria*. Furthermore, Meeuse found that *C. longipes* will cross readily with *C. anguria*, and both the F_1 and F_2 generations are highly fertile. His conclusions are aptly stated and so important for the solution of this problem that they seem best produced verbatim:

1. 'The West India or Bur Gherkin, *Cucumis anguria* L., is a cultigen descended from a non-bitter variant (mutant) of an African wild

species, described as *Cucumis longipes* Hook., which normally has bitter fruits.

2. 'The original stock reached the New World over 300 years ago, most probably through the early slave trade between West Africa and the West Indies, the actual introduction being more or less accidental.

3. 'The slight morphological difference between the cultivated *C. anguria*, and its ancestral form *C. longipes*, can easily be explained by a combination of its isolation and a certain amount of selection by man during a period of about 300 years.'

Bohn & Whitaker (unpublished) can confirm Meeuse's work in part. These investigators crossed the two species, *C. anguria* and *C. longipes*, and found the F_1 to be fertile. The F_2 progenies from the cross have not yet been grown, but there is hardly any doubt that they will perform as Meeuse has reported.

MUSK-MELON (*Cucumis melo* L.)

The place of origin of this large and polymorphous species, *C. melo*, has never been satisfactorily resolved, and the prospects for obtaining fresh data that will shed light on the problem are not very bright. We do know that the forty or more non-cultivated species of *Cucumis* are indigenous to the tropics and subtropics of Africa; no substantial evidence is on record to show that *C. melo* is an exception. De Candolle (1882) says that Sir Joseph Hooker received specimens, from a collector in Guinea, of plants growing along the banks of the Niger river. The collector reported that the fruits are eaten by the natives and have an odour not unlike that of a fresh green melon. Another collector (Thonning) found these plants in sandy soil in Guinea. The fruits were ovoid and about the size of a plum. These specimens were identified as *C. melo* by a competent systematist and authority on the Cucurbitaceae (Cogniaux).

There are a number of observations which, considered *en masse*, indicate that *C. melo* was introduced into Asia at a comparatively late date. There is no Sanskrit name for the musk-melon, but the later Tamil culture did have a name for the fruit of this species. De Candolle (1882) and Sturtevant (1919) both feel that musk-melons were either unknown to the Greeks and the Romans, or were of such poor quality as to be little used.

There are undoubtedly well-developed secondary centres of origin of *C. melo* in India, Persia, southern Russia, and China. The genes for resistance to powdery mildew (Pryor *et al.*, 1946) have all occurred in collections from India. Likewise, such primitive characters as longitudinal splitting of the fruit at maturity, soft and mushy character of the flesh, and large leaves on stout petioles, frequently occur in collections from this area.

Fitting the few facts together, we are suggesting that *C. melo*, after being introduced into Asia at a comparatively recent date, exploded

with variability in a congenial environment under the guidance of man. This would account for the large number of subspecies that have come into existence in a relatively short time.

Dish-rag or Loofah Gourd (*Luffa cylindrica* Roem.)

The 'dish-rag' or 'loofah' gourd is either cultivated or grows as an 'escape' in practically all of the tropical regions of the world. This is one reason why it is very difficult or even impossible to pinpoint with accuracy the indigenous area of the species. The best clue we have is that the four or five other species of *Luffa*, with one exception, are from tropical portions of Asia. Pending the emergence of convincing evidence to the contrary, we can assume, with some confidence, that *L. cylindrica* is indigenous to tropical Asia—probably India.

De Candolle (1882) points to several lines of evidence which suggest that *L. cylindrica* is a comparatively recent addition to the existing array of cultivated plants. For example, (*a*) there is no Sanskrit name for this plant, (*b*) according to Breitschneider, it has been cultivated in China for a relatively short time, and (*c*) there is very little variation in either vine or fruit—a trait not generally true of plants with a long history of cultivation.

White-flowered Gourd (*Lagenaria siceraria* (Mol.) Standl.)

Lagenaria siceraria is found, at the present time, throughout the tropics and subtropics of the world either as a cultivated plant or 'camp follower'. With the present distribution, and a mass of conflicting evidence from archaeological and historical sources, it is not easy to reach a reasonably conclusive decision with respect to the origin of this monotypic species. The evidence falls into two categories: (*a*) archaeological, and (*b*) that from plant distribution.

The archaeological evidence for the presence of *L. siceraria* in the Americas, prior to 1492, is abundant and firmly documented. At a site known locally as Huaca Prieta, on the north coast of Peru, Whitaker & Bird (1949) have identified and recorded a large mass of materials of *L. siceraria*. Most of these had been used for containers of various sorts, e.g. work baskets, water bottles, dippers, jars, dishes, etc. Many fragments were found that had evidently been used as scoops or ladles. Some of the forms with long necks were used as fish-net floats. Others were used as rattles for ceremonial purposes, and still others were made into whistles. The best information on this culture suggests a date of 4000–3000 B.C. The material from Huaca Prieta is probably from the earliest culture yet known in South America, but *L. siceraria* seeds and rind fragments have been recovered from a long list of sites in South America, all of them pre-Columbian in age. Yacovleff & Herrera (1935) have

listed *L. siceraria* seeds and fragments from a number of sites. Ames (1939) has identified as *L. siceraria* a small gourd-bottle from a pre-Columbian grave at Paracas. Whitaker (1948) has identified *L. siceraria* materials in the collection of Professor Max Uhle from a number of sites excavated along the south coast of Peru. This collection consists of an impressive array of well-preserved containers of various sorts, such as work baskets, food containers, and water bottles. Table I summarizes this information for South America.

A similar picture emerges from a study of the plant materials found in archaeological sites in North America. In a sequence of eight cultures of artifact complexes excavated from three caves near Ocampo, Tamaulipas, Mexico, fragments of *L. siceraria* were found in all of the eight cultural levels at this site (Whitaker *et al.*, 1957). The earliest culture (Infiernillo) has been dated by radiocarbon methods at 7000—5500 B.C.

TABLE I.

ARCHAEOLOGICAL SITES, LOCATIONS, AND CHRONOLOGIES OF FRAGMENTS OF *Lagenaria siceraria* RECOVERED IN SOUTH AMERICA; ALL SITES ARE IN PERU (*from* WHITAKER, 1948)

Site	Location	Dates
Huaca Prieta	North coast	4000–3000 B.C.
Paracas (Cavernas)	Central coast	A.D. 400–500
Paracas (Neocropolis)	Central coast	A.D. 700–800
Nazca	South coast	A.D. 700–800
Ica Valley	South coast	A.D. 900–1200
Ancon	Central coast	A.D. 900–1200
Chincha	Central coast	A.D. 1300–1400
Chancay	Central coast	A.D. 1300–1400

TABLE II.

ARCHAEOLOGICAL SITES, LOCATIONS, AND CHRONOLOGIES OF FRAGMENTS OF *Lagenaria siceraria* RECOVERED IN NORTH AMERICA (*from* WHITAKER, 1948; SMILEY, 1951; AND MARTIN *et al.*, 1952)

Site	Location	Dates
Ocampo	Tamaulipas, Mexico	7000–5500 B.C.
Newt Kash	Kentucky, U.S.A.	A.D. 800–900
Walker Gilmore	Nebraska, U.S.A.	A.D. 1000
Tularosa Cave	New Mexico, U.S.A.	800 B.C.–A.D.1200
Canyon Creek Ruin	New Mexico, U.S.A.	A.D. 1323–1347
Upper Tonto Ruin	New Mexico, U.S.A.	A.D. 1346
Guasave	Sinaloa, Mexico	A.D. 100

In Table II we have listed a few of the sites from which material of *L. siceraria* has been recovered in North America. It is evident from Tables I and II that *L. siceraria* has been cultivated in the Americas over a long period of time. There is no question but that it was widely diffused and employed for many purposes before the Europeans arrived in 1492.

There is little doubt that *L. siceraria* has been cultivated in the Old