

BOTANY.—*A new genus, Fortunella, comprising four species of kumquat oranges.* WALTER T. SWINGLE, Bureau of Plant Industry.

The kumquat oranges are of very small size, usually less than an inch in diameter. The two species commonly cultivated differ from other oranges in having a relatively thick, fleshy, sweet and edible peel and in having only 4 to 7 segments, containing a small amount of acid pulp. Besides the round and oval-fruited species common in culture, there is a third species recently introduced into culture from China, and a fourth occurring wild on the Island of Hongkong.

HISTORY OF THE KUMQUAT ORANGES

The kumquat oranges, though described by early Chinese writers on agriculture, remained practically unknown to Europeans until recent times. The kumquat is mentioned in many early Chinese works and described in some detail by Han Yen Chi in his treatise on the oranges, written in 1178. Later works of both Chinese and Japanese authors treat of it fully, often with fairly good illustrations.

The first vague notice of the kumquat oranges in European literature was published by Ferrarius in 1646 in his *Hesperides* and was based on reports made to him by the Portuguese Jesuit, Alvaro Semedo, who lived 22 years in China. His successors, Steerbeck, Volckamer, Risso and Poiteau, and other authors of monumental illustrated works on the citrous fruits, add nothing to our knowledge of the kumquat.

Rumphius in 1741 described and figured the round kumquat in his *Flora Amboinense*. This was the first good account of any kumquat orange to appear in European literature. In 1780 Thunberg assigned the name *Citrus japonica* to the round kumquat, and in 1784 described it more fully in his *Flora Japonica*, still later (in 1800) publishing a fairly good figure of it in his *Icones Plantarum Japonicarum*. Loureiro, in 1790, in his *Flora Cochinchinensis* named the oval kumquat *Citrus margarita*, and also described the round kumquat under the name *Citrus madurensis*.

In spite of Rumphius' and Thunberg's excellent description and illustrations, the kumquat was not known in Europe until 1846, when Robert Fortune, who was collecting in China for the Royal Horticultural Society of London, brought back to England the first kumquat plants. The kumquat did not become generally known on the continent of Europe until much later.

Full descriptions of the round and oval kumquats were published by H. H. Hume,¹ but not until 1912 was a good account of these plants published in Europe, when Dr. L. Trabut² described them and distinguished them from the so-called "chinois" or "chinotto" (*C. Aurantium* L., var.), with which they had been confused by Volkamer and many subsequent European writers. In 1914 Dr. Trabut³ published in Algeria a fuller illustrated account of these plants.

Perhaps because of their relatively late advent into Europe the kumquat oranges have been but little studied by botanists. Apparently no one has questioned the judgment of Thunberg in referring them to the genus *Citrus*.

THE KUMQUATS NOT PROPERLY REFERRED TO THE GENUS *CITRUS*

The question of the true relationship of the kumquats to other citrous fruits was forced upon the attention of the writer, in the course of a survey of the plants related to *Citrus*, by a study of a little known plant of Hongkong, called by botanists *Atalantia Hindsii* (Champ.) Oliv. Good herbarium specimens of this plant, collected by the Wilkes North Pacific Exploring Expedition in 1842 and preserved in the National Herbarium at Washington, D. C., showed the unmistakable facies of a kumquat orange. The thick, rigid leaves, pale and abundantly glandular-dotted below, the angular twigs, small flowers, more or less angular

¹ Hume, H. H. The Kumquats. Bull. 65, Fla. Exp. Sta., pp. 550-566, 3 figs. 1903; also, *Citrus Fruits and their Culture*, 3d ed., p. 18, pp. 53-58, pp. 129-131, figs. 4, 5, 10, 28. 1909.

² Trabut, L. Chinois et kumquat. Rev. Hort. 84: 564-567, figs. 193-195. 1912.

³ Trabut, L. Le kumquat. Bull. Agric. de l'Algerie et de la Tunisie II. 20: 2-11, 4 figs. 1914.

in the bud, and the small prominently glandular-dotted fruits all resembled most strikingly the round kumquat now commonly cultivated in this country.

Later on other specimens of this plant were studied in the herbaria at Kew Gardens and the British Museum, London, and the Muséum d'Histoire Naturelle, Paris; and through the courtesy of the Superintendent of the Botanical and Forestry Department of Hongkong viable seeds of this species were sent to the writer in 1912. A study of the germination, as well as of the foliar, flower, and fruit characters, showed that in reality this plant is a very primitive kumquat. Thereupon the various forms of the common kumquat in culture in Florida, California, and Algeria were studied, as well as the material in the principal herbaria of Europe and America. As a result of this study the writer is convinced that the kumquats should be placed in a new genus midway between *Atalantia* and *Citrus*.

The kumquats are the most primitive living true citrous fruits. The Hongkong kumquat, the only species known in the wild state, is the most primitive of the kumquats and consequently the most primitive of the true citrous fruits. That is to say, it is of all known existing species the most nearly like the ancestral form from which the kumquats and the species of *Citrus* originated.

On account of their many and important differences from *Atalantia* and from *Citrus* it is proposed to create a new genus, *Fortunella*,⁴ to include the kumquats.

⁴ *Fortunella*, Swingle, gen. nov. *Citro* affinis, foliis unifoliolatis, staminum numero petalorum quadruplo. A *Citro* differt floribus solitariis vel in paniculis paucifloribus dispositis, numero loculorum ovarii numero petalorum aequali vel paulo majore, ovulis collateralibus in loculo geminis, stigmatate cavernoso ob glandulis oleiferas profundas, foliis venis non prominentibus subtus pallidioribus punctis glandulosis viridibus numerosissimis instructis, alabastro in sectione plus minusve polygono, fructu mesocarpio crassiore, carnoso et eduli. Rami juniores novelli virentes triangulares, vetustiores teretes. Cotyledones in germinatione ut in *Citro* hypogaeae, folia prima ovata subsessilia opposita. Frutices vel arbores humiles.—Species typica, *Fortunella margarita* (*Citrus margarita* Lour.). Colitur Cantone Sinarum.

FORTUNELLA Swingle. Shrubs or small trees; young branches angular, the older ones rounded; spines borne singly at one side of the bud in the axil of the leaf, or wanting. Leaves unifoliate, rather thick, blunt-pointed or even retuse, acute or rounded at the base; veins evident above, scarcely showing beneath; lower surface pale green, densely glandular-dotted; petioles narrowly winged or merely margined, sometimes not articulated with the blade. Flowers borne singly or in few-flowered clusters in the axils of the leaves, hermaphrodite, 5-merous (rarely 4-, 6-, or 7-merous). Flower buds small,

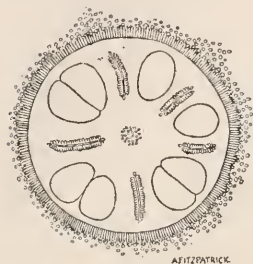


Fig. 1. *F. japonica*.

Cross-section of stigma, showing large oil glands between stylar canals, three of them double, two single. Scale 25.

stalked, containing an embryo pistache green. Germination with hypogeous cotyledons; first foliage leaves broadly ovate, subsessile, opposite as in *Citrus*.

Type species, **Fortunella margarita** (*Citrus margarita* Lour.), cultivated at Canton, China.

The genus *Fortunella* resembles *Citrus* in the general appearance of the stems, twigs, spines, leaves, flowers, and fruits and in having the polyadelphous stamens normally four times as numerous as the petals. It differs from *Citrus* (1) in having an isomerous or hypomerous ovary, normally 3-5-celled (rarely 6 or 7-), not polymerous (8-15- or more celled), (2) in having two collateral ovules in each cell (not 4-12), (3) in having a cavernous stigma containing a few large, deeply immersed, lysigenous oil glands (not asymmetrical and solid or nearly so), (4) in having the under surface of the leaves pale green, nearly veinless and with very numerous, small, deep green glandular dots, (5) in having a sweet and edible, more or less pulpy skin, and (6) in having small more or less angular flower buds.

Fortunella approaches Atalantia and differs strikingly from Citrus in having only two collateral ovules near the top of each cell, whereas Citrus has 4-12 ovules to a cell. Fortunella differs from Atalantia in having twice as many stamens (four times as many, instead of twice as many, as the petals), and in its general agreement with Citrus in twig, leaf, spine, flower, and fruit characters.

The capitate stigmas of all the species of Fortunella contain large oil glands imbedded in their substance, which renders them cavernous.⁵ (See fig. 1.) The stigma of Citrus contains a few scattering oil glands, sometimes one in every space between the radially arranged and expanded styler canals; but these glands are very near the surface and relatively so small that the stigma lacks entirely the cavernous structure characteristic of Fortunella.⁶ The leaves show very many more oil glands on the underside than in any species of Citrus, often ten times as many.

In superficial fruit characters Fortunella agrees with the Australian desert kumquat (*Eremocitrus glauca*) in many respects. The seeds are very different, however, and the stem, twig, leaf, and flower characters are so strikingly different that it is not possible to regard these genera as closely related.

There are four species of Fortunella known at present. The two commonly cultivated species, the round and oval kumquats of China and Japan, together with the Meiwa kumquat, comprise the subgenus **Eufortunella**, distinguished by several important characters from the Hongkong wild kumquat for which a new subgenus, **Protocitrus**, is described farther on in this paper.

THE SUBGENUS EUFORTUNELLA

The species of Eufortunella may be distinguished by means of the following key:

Fruits globose, 20-25 mm. in diameter, 4 or 5-celled; seeds small, bluntly rounded at tip; leaves pale and veinless below, blunt-pointed.....2. *F. japonica*.

⁵ This was noticed as early as 1784 by Thunberg (Fl. Jap. 293), who said, "Stigma intus multiloculari," in describing the round kumquat; since then no one seems to have observed this fact.

⁶ Penzig, O. A. J. Studi Botanici sugli Agrumi e sulle Piante Affini, pp. 53-75; atlas, pl. 6. (Ann. di Agr. no. 116). 1887.

Fruits oval or oblong, 5-7-celled; seeds more or less pointed at tip; leaves narrowed toward the tip.

Fruits oblong, 25-33 mm. long, 20-25 mm. in diameter, usually 5 or 6-celled; petiole narrowly margined, not winged; pulp vesicles fusiform. 1. *F. margarita*.

Fruits oval or subglobose, 28-35 mm. long, 22-30 mm. in diameter, 6 or 7-celled; leaves very thick; petiole plainly but narrowly winged at tip; vesicles subglobose or oval. 3. *F. crassifolia*.

THE OVAL KUMQUAT

The oval kumquat has been referred by most botanists to *Citrus japonica* Thunb., which is based on the round kumquat. These two kumquats are certainly very closely related, but as they show constant differences of some taxonomic importance in nearly all parts of the plant, it seems best for the present to consider them as constituting two distinct species.

1. *Fortunella margarita* (Lour.) Swingle.

Citrus margarita Lour. Fl. Coch. 2: 467. 1790.

Citrus aurantium olivaeformis Risso, ex Lo'sel.-Desl. & Michel, Nouv. Duham. 7: 95. 1816.

Citrus aurantium var. *japonica* Hook. f. Curt. Bot. Mag. III. 30: pl. 6128. 1874.

Citrus japonica var. *fructu elliptico* Sieb. & Zucc. Fl. Jap. 1: 35. pl. 15, fig. 3. 1835.

Citrus Aurantium subsp. *japonica* var. *globifera* subvar. *margarita* Engl. in Engl. & Prantl, Pflanzenfam. 3⁴: 199. 1896.

TYPE LOCALITY: Canton, China (in culture).

The type specimen of *Citrus margarita* seems to have been lost, but Loureiro's description is very good and can apply only to an oval kumquat very similar to the one commonly cultivated today in all the warmer parts of the world.

A lectotype (*Swingle*; C. P. B. No. 7955; February 18, 1915), consisting of a branch of an oval kumquat tree growing in a greenhouse of the Department of Agriculture at Washington, has been deposited in the National Herbarium at Washington.

The oval kumquat differs from the round chiefly in the following respects: (1) The leaves are larger, more acute at the base, less pallid and more veiny below; (2) the ovary has usually 4 or 5 cells, very rarely 3 or 6; (3) the fruit is oval, not globose; (4) the style is persistent, not caducous; (5) the seeds are larger and especially longer, with a rougher testa. (Fig. 2.) It differs also in being distinctly more

vigorous and attaining a greater height (10–12 ft.); in the somewhat brighter orange color of its fruits; and especially in the harsher, more biting flavor of the peel, which evidently contains an etherial oil more nearly resembling that of the common orange than does that of the round kumquat.

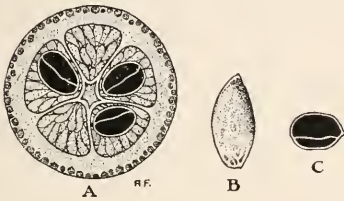


Fig. 2. *F. margarita*. A, cross-section of 5-celled fruit; B, seed; C, seed in cross-section. All natural size.

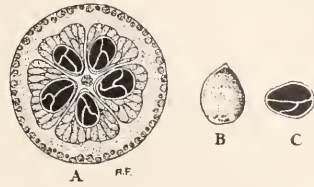


Fig. 3. *F. japonica*. A, cross-section of 5-celled fruit; B, seed; C, seed in cross-section, showing polyembryony. All natural size.

THE ROUND KUMQUAT

2. *Fortunella japonica* (Thunb.) Swingle.

𠄎 𠄎 *Chin Kan*, vulgo Fime Tatsbanna. *Malus Limonia*, fructu pumilo aureo, medullâ dulci. Kaempf. *Amoen. Exot.*, fasc. 5, 801. 1712.

Limonellus madurensis Rumph. Hort. Amboin. 2: 110. pl. 31. 1741.

Citrus japonica Thunb. Nov. Act. Upsal. 3: 199. 1780.⁷—*Fl. Jap.* 292. 1784.—*Icon. Pl. Jap.* 2: [pl. 5]. 1800.

Citrus madurensis Lour. *Fl. Cochin.* 2: 467. 1790.

Citrus inermis Roxb. *Fl. Ind.* 3: 393. 1832.

Citrus microcarpa Bunge, *Mém. Acad. Imp. Sci. St. Petersb.* 2: 84. 1833.

Citrus japonica var. *fructu globoso* Sieb. & Zucc. *Fl. Jap.* 1: 35. pl. 15, fig. 2. 1835.

Citrus Aurantium subsp. *japonica* var. *globifera* Engl. in Engl. & Prantl, *Pflanzenfam.* 3: 199. 1896.

TYPE LOCALITY: Japan (in culture).—Native in China.

⁷ The original publication of this species by citation is on p. 199 as follows:

“*Kin Kan*, vulgo Fime Tats
banna, p. 801.

Citrus Iaponica.”

Under the heading Characters of New Species it is given as follows, on p. 208:
“*Citrus japonica*:

petiolis alatis, foliis
acutis; caule fruticoso.”

The species is published by the citation on page 199, inasmuch as Kaempfer identifies the plant not only by giving the Chinese characters never applied to any other plant but also the Japanese common name and a short latin phrase sufficient to distinguish it from any other *Citrus*.

The differences between the round and oval kumquats have already been enumerated under the latter species. (See figs. 2 and 3.)

No type specimen of this species exists, but the specimen figured by Thunberg probably is to be found in the Upsala Museum and may after critical examination prove suitable to be considered a lectotype.

The plants grown in Japan, United States, Europe and North Africa are almost all grafted and consequently show great uniformity.

THE MEIWA, A NEW KUMQUAT, POSSIBLY OF CHINESE ORIGIN

About 1896 or 1897 a new kumquat appeared in Japan, apparently imported from China. It seems to have been listed at first as the Chinese large-fruited kumquat, but soon came to be known as the spotted Meiwa kumquat,⁸ and soon simply as the Meiwa kumquat.⁹

This variety is very prolific, even small shrubs bearing an abundance of fruit. The leaves are decidedly different from those of any other kumquat, being much thicker and folded on the midrib so as to be V-shaped in cross-section. The fruits are slightly oval, often nearly globose, decidedly larger than those of the round kumquat, and distinctly broader at the equator than those of the oval kumquat.

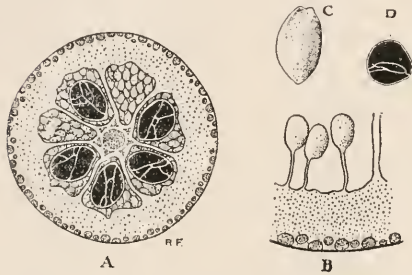


Fig. 4. *F. crassifolia*. A, cross-section of 7-celled fruit; B, oval pulp vesicles, growing into cell from inner wall of ovary; C, seed; D, seed in cross-section. A, C, and D, natural size; B, scale $1\frac{1}{2}$.

They show in cross-section 5, 6 or 7 segments, with one or two seeds in each segment. (Fig. 4.) Upon close study these differences seem to necessitate the recognition of the Meiwa kumquat as a new species.¹⁰

⁸ Hidaka, Kwaji Yen, in *Nippon yen gei zatto shi* (Bull. de la Soc. d'Horticulture du Japon) 23: 44. May, 1911.

⁹ Some nurserymen give also a variety *Nei wa*; others consider these synonymous, preferring *Meiwa*.

¹⁰ *Fortunella crassifolia* Swingle, sp. nov. A speciebus ceteris *Fortunellae* differt foliis crassioribus, canaliculatis, in sectione V-formibus, cellulis paliformibus in 4-6 stratis dispositis, fructibus majoribus ovoideis, 5-6-7-ocularibus, vesiculis ovoideis vel ellipsoideis nec fusiformibus.—Habitat in China?, cult. in Japonia et America.

3. *Fortunella crassifolia* Swingle, sp. nov.

A dwarf tree or a shrub, often thornless, sometimes with short stout spines 3–10 mm. long; twigs slender, 2.5–5 mm. in diameter, angled when young, dark green, often tufted at the ends of the branches. Leaves lanceolate or ovate-lanceolate, 4–9 (usually 6–8) cm. long, 1.5–4 (usually 2–3.5) cm. broad, tapering toward both ends, often rather sharply, rarely rounded and emarginate at the tip, the base cuneate (especially when not articulated with the tip of the petiole), sometimes more or less broadly rounded; margin entire below the middle and sometimes nearly to the tip, but usually obscurely crenate in the upper third or half; leaves very thick and rigid, folded along the midrib so as to be more or less U- or V-shaped in cross section, on the upper surface glossy dark green, or more or less yellowish green, with veins scarcely visible, paler on the under surface, dotted with very numerous dark green oil-glands and obscurely veined; petioles 7–10 mm. long, at base subcylindric, 1–2 mm. in diameter, the tip narrowly winged, 2.5–4 mm. wide, often not articulated with the blade, the winged petiole then merging imperceptibly into the cuneate base of the leaf. Flowers occurring singly or in pairs in the axil of the leaf, buds at first 5-lobed at the tip, later more or less 5-angled in cross section. Fruits broadly oval or ovate in outline, 25–35 by 25–28 mm., usually 5–7-celled with one or two seeds in a cell, some of the cells usually without perfect seeds. Seeds oval, 9–12 by 5–7 by 4–6 mm., blunt-pointed at both ends; testa larger than the embryo and more or less wrinkled at the projecting ends; embryos often several, green.

Type in the U. S. National Herbarium, no. 694952, consisting of a fruiting branch taken from a cultivated plant in the greenhouse of the U. S. Department of Agriculture, Washington, D. C., *Swingle* (C. P. B. No. 7496-C), February 17, 1915. Merotype,—flowering branch, *M. Kellerman*, February 23, 1915. Additional specimens from nurseries at Port Arthur and Alvin, Texas, are in the U. S. National Herbarium.

This species, although differing in many important characters from the two commonly cultivated species of kumquats, may nevertheless on more thorough study prove to be of hybrid origin or else a mutation. The precocious and abundant fruiting and the presence of many good seeds in the fruits would seem, however, to indicate that it can scarcely be a hybrid between two very distinct species. Besides, it is not easy to see what species could have been hybridized to produce such a form.

In many ways the Meiwa kumquat shows a marked intensification of the characteristics of the true kumquats. Such intensification may result from hybridization or from mutation but may also be the result of long continued, slow, evolutionary change. In any case, the present form doubtless merits a distinctive name, such as is given commonly to

hybrids between well marked species and to stable forms of mutative origin.

The very thick and rigid leaves of the Meiwa kumquat show 4 or 5 or even more layers of palisade tissue on the upper side of the leaf. The other two species show only 2 or 3 layers of palisade.

THE SUBGENUS PROTOCITRUS

The Hongkong kumquat, *Fortunella Hindsii*, differs from the round kumquat (*F. japonica*), the oval kumquat (*F. margarita*), and the Meiwa kumquat (*F. crassifolia*) in a number of morphological characters, some of them of decided taxonomic significance in this group. It may be regarded as constituting a new subgenus:

PROTOCITRUS Swingle.¹¹ Differs from *Eufortunella* (1) in having the ovary hypomerous (3 or 4-celled, not 5-celled); (2) in the ovary wall of the mature fruits having on the inside between the stalks of the pulp vesicles a number of minute, wart-like, pale yellow, cellular masses (fig. 5); (3) in having the dissepiments of the fruit dry, and the peel thin and not very fleshy; (4) in having shorter, broader, more brachytic flowers; (5) in having leaves with the veins more prominent on both faces, and less pallid below.

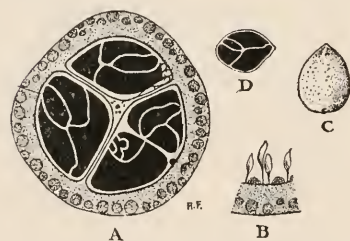


Fig. 5. *F. Hindsii*. A, cross-section of 3-celled fruit, one cell having 2 seeds, another showing a few pulp vesicles; B, fusiform vesicles and verruciform tissue growing into cell from inner wall of ovary; C, seed; D, seed in cross-section, showing polyembryony. A, B, scale 2; C, D, natural size.

The two most important characters distinguishing the subgenus *Protocitrus* from *Eufortunella* are the few-celled ovary and the dimorphic *emergencen* from the ovary wall of the fruit, viz.: ordinary pulp vesicles

and verruciform tufts of loosely aggregated more or less colored cells. (Fig. 5, B.)

¹¹ *Protocitrus* Swingle, subgen. nov. A *Eufortunella* differt ovarii hypomeribus (3-vel 4- nec 5-ocularibus) parietibus dorsalibus locularum fructus maturi verrucosis, verrucis e cellulis luteolis compositis, dissepimentis membranaceis non succosis, exocarpio tenuiori minus succoso, floribus brevioribus latioribus, foliis subtus viridioribus, venis conspicuioribus.

The Hongkong kumquat, which, as already indicated, is the sole species of the subgenus *Protocitrus*, may be described, as follows:

Fortunella Hindsii (Champ.) Swingle.

Sclerostylis Hindsii Champ. Hook. Journ. Bot. III. 3: 327. 1851.

Atalantia Hindsii Oliver ex Benth. Fl. Hongkong. 51. 1861.—
Journ. Linn. Soc. 5, Suppl. 2: 26. 1861.

A spiny shrub or small tree; twigs slender, angled when young; leaves oval-elliptical, tapering sharply at both ends, dark green above and faintly venose, paler and venose below; petioles winged, often merging into the lamina of the leaf without a separative joint. Flowers short, broad, not opening very widely; pistil very short; style shorter than the ovary; stigma large, cavernous; ovary 3 or 4-celled; ovules 2 in a cell. Fruits small, 1.5–2 cm. in diameter, subglobose, bright orange red when ripe, the color of a tangerine orange; pulp vesicles very few, small, fusiform; seeds thick, oval or ovate in outline, plump, 9–11 by 7–8 by 5–6 mm., pistache green in section.

TYPE: Hongkong, *R. B. Hinds*, without number, 1841; a much branched twig with spines, leaves, fruit pedicels, and one young fruit.¹² (Mounted on the same sheet are two twigs collected by Wright.) Herb. Kew.

The Hongkong wild kumquat grows commonly on the dry hills about Hongkong and on the mainland of China opposite.

Much other material from Hongkong and some from Kaulung, on the mainland opposite Hongkong, has been examined by the writer in the collections at Kew, British Museum, Muséum d'Histoire Naturelle, Gray Herbarium, and U. S. National Herbarium. Living plants grown in the greenhouses of the Department of Agriculture from seeds from Hongkong have permitted a comparison of this plant at all stages of growth with the other species of *Fortunella*.

UTILIZATION OF THE KUMQUATS IN BREEDING NEW TYPES OF CITROUS FRUITS

In connection with the attempt to breed hardy citrous fruits the attention of the writer was directed some years ago to the kumquat oranges, which are particularly remarkable for their very small size

¹² A label in Bentham's (?) writing, reading "*Atalantia monophylla* DC. Hong Kong, Hinds, 1841," is pasted across the base of the twig, which shows it to be without doubt the specimen cited by Bentham (Lond. Journ. Bot. 1: 480–481. 1842). Some of the petioles of this twig exhibit the curious imperfections in the articulation with the blade characteristic of this species; so it is possible to identify this specimen beyond question.

and for having a relatively thick, sweet, and edible peel. These diminutive fruits, borne on correspondingly dwarfed trees or shrubs, have been found to possess in very high degree winter dormancy, which is so essential to hardiness in citrous fruits grown in the variable climate of Florida and the Gulf States. Recently the kumquat oranges have also been found to be remarkably resistant to citrus canker, the most dreaded of all the diseases affecting citrous trees in the United States. Indeed, many investigators have not succeeded in finding any canker infection on kumquat oranges, and believe them to be immune. Furthermore, hybrids between the two commonly cultivated species of kumquat, the oval and the round-fruited, on the one hand, and the common lime on the other, have proven not only to be very resistant to cold, but to possess a considerable degree of resistance to citrous canker.