

New Temperate Fruits: *Actinidia chinensis* and *Actinidia deliciosa*

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“The kiwifruit industry is unique among global fruit industries in being so totally dominated by one variety, the Hayward variety. Most consumers are not even aware that other varieties exist.”

(World Kiwifruit Review 1998)

The above statement may accurately represent the current situation but will very soon be out of date. The last 30 years has seen the emergence of the kiwifruit from being a small but increasing crop in one country to being a crop of worldwide significance. The next few years will see the entry of new and quite different *Actinidia* fruit into international trade.

The kiwifruit (*Actinidia deliciosa* [A. Chev.] C.F. Liang et A.R. Ferguson, Actinidiaceae) is one of the very few temperate fruit crops to have been domesticated this century. At the turn of the century it was still just a wild plant in China, but by 1970 it had been developed into a new fruit crop in New Zealand. Today, as we approach the next century, the kiwifruit is an important commercial crop grown in different parts of the world: it has also become uniquely dependent on international trade as the three biggest producer countries export most of the kiwifruit they produce. Total world production now exceeds a million tonnes per year, more than that of well-established crops such as raspberries and currants, and is soon likely to exceed production of strawberries or of apricots (World Kiwifruit Review 1998).

Until recently, the international success of kiwifruit could really be considered as the success of one fruiting cultivar, ‘Hayward’, and associated male (pollenizer) cultivars. World trade has become restricted to this one cultivar and the name ‘Hayward’ could almost be taken as synonymous with “kiwifruit.” Now, however, different cultivars of *A. deliciosa* are being grown; different males of *A. deliciosa* have been selected for the specific climatic conditions of different kiwifruit regions; and a start has been made to the commercial cultivation of different *Actinidia* species with quite distinct fruit.

THE GENUS *ACTINIDIA*

The genus *Actinidia* Lindl. contains about 60 species (Ferguson 1984, 1990). The genus is variable, as are the individual species, and much of this diversity is potentially useful (Ferguson 1990). There is thus great scope for crop improvement through breeding programs (Ferguson et al. 1996). All *Actinidia* species are perennial, climbing or scrambling plants, mostly deciduous although a few from warmer areas are evergreen. All species appear to be dioecious: the flowers on male vines produce viable pollen but lack a properly developed ovary, ovules, or styles; the flowers of female vines appear perfect but the pollen they release is shrivelled and non-viable. Botanically, the fruits of the various *Actinidia* species are all defined as berries in that they are fleshy, they have many seed embedded in the flesh, and they do not split open at maturity. Horticulturally, however, they display great diversity, often in those attributes that are commercially important. The fruit can occur singly, in small bunches of three to five fruit, or sometimes in larger bunches or infructescences containing up to 30 or more fruit (Fig. 1). They vary in size, shape, hairiness, and external color. Some change color as they ripen. The flesh can also vary in color, juiciness, texture, and composition. The fruits of some species are basically inedible or, at best, unpalatable, whereas the flavor of the fruit of other *Actinidia* species is considered by many to be much superior to that of the kiwifruit.

ORIGIN OF PRESENT KIWIFRUIT CULTIVARS

Almost all the kiwifruit cultivars grown in commercial orchards outside of China are descended from two female plants and one male plant, themselves derived from a single introduction of seed to New Zealand in 1904 (Ferguson and Bollard 1990). The provenance of this seed is unknown but it was probably collected

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by E.H. Wilson from Hubei or Sichuan in China. Despite such limited sampling of the gene pool, the first kiwifruit plantings in New Zealand contained considerable variation in the fruit carried by individual plants. Grafted plants were first sold in the 1920s and this allowed the propagation of good strains with large, oval or elongated fruits having bright green flesh but lacking a hard or woody core. Such strains are only one or two generations removed from the original introduction of seed from China.

‘Hayward’

‘Hayward’ was selected from a small number of seedlings, possibly only 40, likewise only a couple of generations from the original seed, and likewise descended from those two female and one male plants. ‘Hayward’ eventually became the cultivar of choice because its fruit were larger, had a better appearance, and their flavor was considered by many to be superior. These qualities meant that the fruit of ‘Hayward’ were preferred by consumers in both New Zealand and overseas to that of other kiwifruit cultivars then available. Initially, ‘Hayward’ had been planted on only a small scale and most early exports of kiwifruit from New Zealand were of other cultivars. However, “the customer is always right”: the clear preference by consumers and marketers, especially in the developing markets in the US, for ‘Hayward’ kiwifruit meant that by the mid 1960s new kiwifruit plantings in New Zealand were almost exclusively of ‘Hayward’ and by 1975, only ‘Hayward’ fruit were accepted for export. ‘Hayward’ may have been less easily managed and less productive than some of the other kiwifruit cultivars but these disadvantages were convincingly outweighed by the qualities of the fruit. Perhaps most important for the New Zealand growers was the remarkably long storage life of ‘Hayward’ fruit, as this allowed the development of a kiwifruit industry based on exports by ship to distant markets.

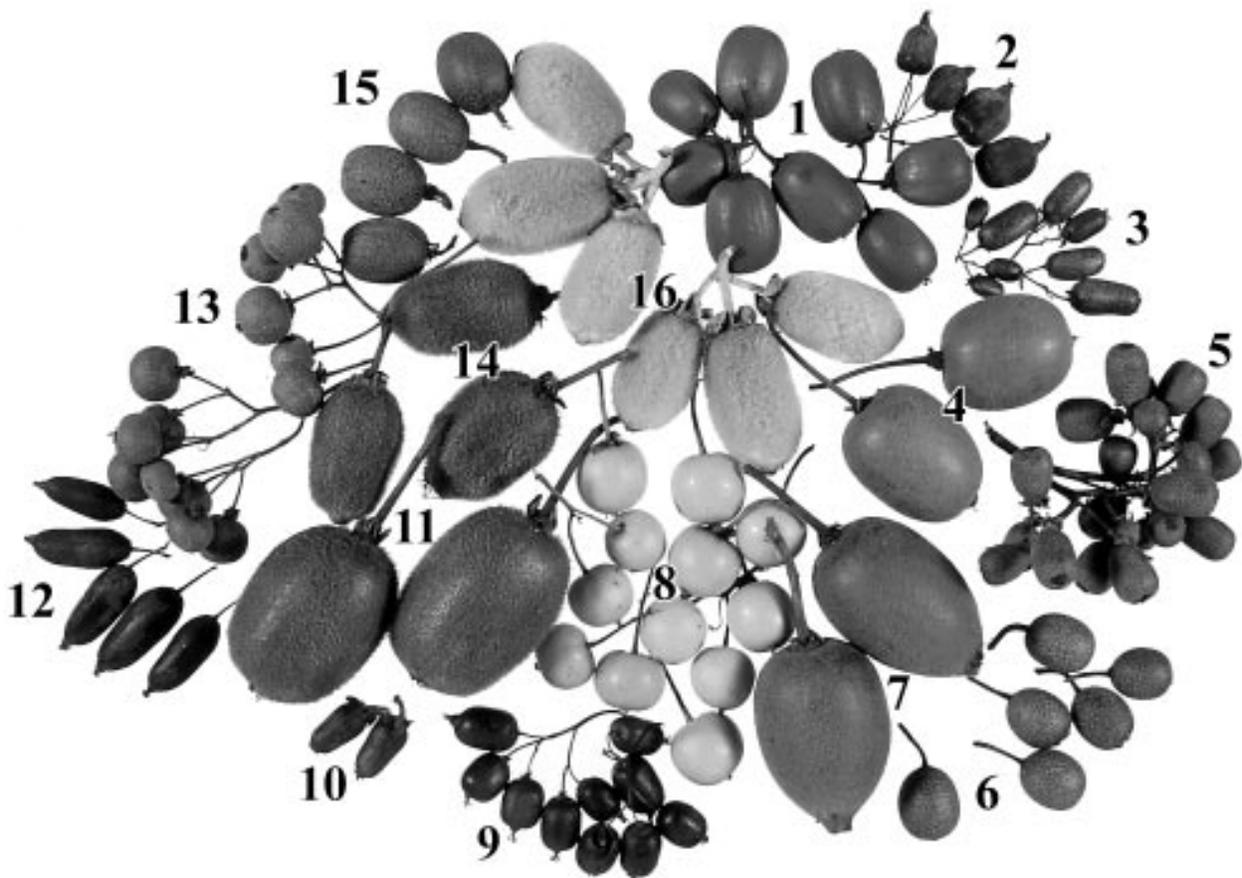


Fig. 1. Fruit diversity in *Actinidia*, with the commercial kiwifruit, *A. deliciosa* ‘Hayward’ for comparison.

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|--------------------------|---------------------------------|--|--------------------------|
| 1 <i>A. rufa</i> | 5 <i>A. latifolia</i> | 9 <i>A. arguta</i> | 13 <i>A. guilinensis</i> |
| 2 <i>A. melanandra</i> | 6 <i>A. indochinensis</i> | 10 <i>A. fulvicoma</i> | 14 <i>A. setosa</i> |
| 3 <i>A. glaucophylla</i> | 7 <i>A. chinensis</i> ‘Hort16A’ | 11 <i>A. deliciosa</i> ‘Hayward’ | 15 <i>A. chrysantha</i> |
| 4 <i>A. chinensis</i> | 8 <i>A. macrosperma</i> | 12 <i>A. arguta</i> var. <i>purpurea</i> | 16 <i>A. eriantha</i> |

When growers in other countries were inspired to emulate the New Zealand kiwifruit growers, it is not surprising that they too chose to grow 'Hayward'. In California, initial plantings were based on 'Chico', an early importation from New Zealand and later recognized as being indistinguishable from 'Hayward'. The commercial plantings in Europe were also of 'Hayward'. This reliance of a fruit industry on a single cultivar in most parts of the world is most unusual, possibly unique. Such reliance does have advantages: it facilitates standardization amongst suppliers from different countries. There are, however, also disadvantages in that standardization can lead to greater competition in individual markets and makes branding more difficult. Furthermore, experience with fruits such as apples has shown that different cultivars are not necessarily competitive but may allow market segmentation. Another consideration is that any monoculture is undesirable in principle.

Other Fruiting Cultivars of *A. deliciosa*

The special qualities of 'Hayward' make it likely that it will be an important cultivar for many years to come. Indeed, it has become the standard against which customers will assess any new cultivars. 'Hayward' is, however, by no means perfect (Ferguson et al. 1990), and there is room in the marketplace for other kiwifruit cultivars.

Numerous selections have been made in China from wild-growing populations of *A. deliciosa*. Few of these have yet proved themselves and 'Hayward' has been taken back to China and is now widely cultivated there. The best known of the Chinese selections is 'Qinmei', selected from the Qinling Mountains, Shaanxi. It has been enthusiastically promoted in China and has been extensively planted, perhaps more extensively than justified by its qualities. The fruit are a reasonable size but have only a mild flavor and a comparatively short shelf life. None of the new Chinese selections of *A. deliciosa* has yet been grown on a commercial scale outside of China.

'Koryoku', a seedling produced by open pollination of 'Hayward', is being grown on a limited scale in Japan, mainly because it reaches harvest maturity earlier and because the fruit, when ripe, are considered to be sweeter.

Top Star® is a bud mutation of 'Hayward' which has smooth, essentially hairless fruit (Bergamini 1991). The reduced vigor of the vine allows for easier management and less summer pruning. Plantings of Top Star® have been established in Italy but the reduction in management costs is too small and the fruit are unlikely to receive sufficient a market premium to justify the reworking of existing 'Hayward' orchards.

'Tomua' is a selection recently released in New Zealand (Muggleston et al. 1998). It is the first female kiwifruit cultivar from New Zealand not derived solely from the 1904 introduction of seed. It comes from a cross between 'Hayward' and males from an accession of *A. deliciosa* seed, originally collected in the Qinling Mountains and introduced into New Zealand in 1975. As far as we know this was the second ever introduction of *A. deliciosa* seed into New Zealand. This accession was notable for flowering early in the season and the fruit, although small, also maturing early. The aim of the cross was to combine the size and fruit quality of 'Hayward' with this early fruit maturation. 'Tomua' has large fruit of good, sweet flavor but of limited storage life: its main advantage is that, depending on location, the fruit can be harvested up to a month earlier than 'Hayward' fruit and yet, when ripened, are very acceptable to consumers. (Tomua means "early" in Maori. This fruiting cultivar should not be confused with the old pollenizer cultivar, 'Tomuri'; tomuri means "late" in Maori.) 'Tomua' is therefore complementary to 'Hayward', filling a special if restricted market niche by allowing the export of kiwifruit from New Zealand earlier in the season.

In some areas with warmer winters, e.g., southern California, 'Hayward' crops poorly because its winter chilling requirements are not satisfied. Adequate crops are instead obtained by using some of the older New Zealand selections, e.g., 'Abbott' or 'Allison', or newer selections, e.g., 'Tewi' (from the Canary Islands) or 'Vincent' (from Orange County, California), but these generally have fruit of mediocre quality (Meyer 1992; Ferguson 1997) and cannot compete commercially when 'Hayward' fruit are regularly available. 'Donné' was specifically selected for the warmer climatic conditions of South Africa.

Male (Pollenizer) Cultivars of *A. deliciosa*

Most male cultivars have been selected to coincide in flowering with 'Hayward', the predominant fruiting cultivar. Effective pollination, seed set, and full-sized fruit require coincident flowering of males and females but weather conditions during spring have a major effect on the time of flowering of males, relative to that of 'Hayward'. Different males are therefore being selected for the different growing countries. A series of males has been selected in New Zealand for 'Hayward' from seedlings derived from the 1904 seed introduction. Appropriate males, e.g., 'Autari', have also been selected in Italy for local growing conditions (Testolin et al. 1995) and these plants are probably also originally derived from the 1904 seed accession into New Zealand. The 'Californian Male' or 'Chico Male' appears to have come from a separate E.H. Wilson introduction of seed from China.

Males, 'King' and 'Ranger', have now been selected for 'Tomua' as it flowers several weeks ahead of 'Hayward'. These males are from the cross that produced 'Tomua'.

Market Diversification Through Cultural Practices

'Hayward' kiwifruit appear to appeal to special or discerning customers, particularly in Europe. In New Zealand, much more emphasis is now being placed on sustainable methods of production, especially with minimal use of insecticides and fungicides. Organically-produced kiwifruit are now being marketed separately and currently return a 70% premium to growers over conventional first-class fruit.

Actinidia chinensis Planch.

Of all the various *Actinidia* species, *A. chinensis* is most like the kiwifruit, *A. deliciosa* (Fig. 2). Indeed, until about 15 years ago, *A. chinensis* and *A. deliciosa* were classified together in the one species. There are good botanical reasons for separating the two species, but more important for horticulturists, their fruit are distinctly different. In wild plants of *A. chinensis*, the fruit are generally much smaller, more rounded, and less cylindrical than those of cultivated kiwifruit and initially it was feared that fruit size would be too small for commercial development. However, there is considerable variation in fruit size and shape and the fruit of good selections of *A. chinensis* can approach or even exceed the average size of 'Hayward' fruit. The fruit is almost hairless at maturity, and what hair remains is usually much shorter and finer than kiwifruit hair, more like the fuzz of a peach. Flesh color can vary greatly from bright green, shading through lime green to a clear, intense yellow. Possibly the most attractive fruit are those in which the inner pericarp flesh is red, the outer yellow. More important, the flavor of good selections of *A. chinensis* is thought by many to be much better than that of 'Hayward'. The fruit are sweeter, more aromatic with a flavor reminiscent of some subtropical fruit.

A. chinensis has already proved itself in China. The Chinese collect large quantities of *Actinidia* fruit from the wild, and they generally consider the fruit of *A. chinensis* to be superior to those of *A. deliciosa*. Most of their *Actinidia* selections from the wild are of *A. chinensis* and some of the better selections are now being planted extensively. The fruit produced is so far purely for local consumption

Chinese Cultivars of *A. chinensis* Being Grown Outside of China

Material of some of the better Chinese selections of *A. chinensis* have been available through Japanese nurseries from 1989 onwards. Cultivar names are often confused because Japanese importers have given the cultivars new names and yet other names have been given when material was subsequently imported into Europe. The female selections available include: 'Lushanxiang' (syn. '79-2', 'ACC 226', 'Elizabeth', 'First Emperor', 'K189', 'Yellow Joy'); 'Jiangxi 79-1' (syn. 'Koushin', 'Kosuei 79-1', 'Lushan 79-1', 'Red Princess'); 'Kuimi' (syn. 'F.Y. 79-1', 'ACC 211', 'Apple Sensation', 'Kamitsu', 'Turandot', and, possibly, 'K191'); 'Jinfeng' (syn. 'FT79-3', 'Golden Yellow', 'Kinpo').

These selections have been grown in Italy, New Zealand, and the US. The only commercial production outside of China appears to be in

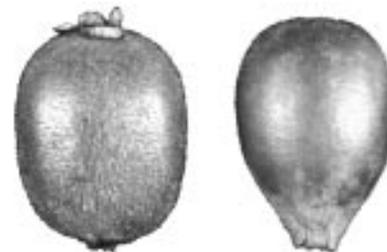


Fig. 2. The old and the new: *A. deliciosa* 'Hayward' (left), the present kiwifruit of commerce, and *A. chinensis* 'Hort16A' (right), to be sold under the name ZESPRI™ GOLD kiwifruit.

California, with ‘Lushanxiang’, ‘Jiangxi-79-1’, and ‘Golden Yellow’ fruit having been sold in the Los Angeles market since 1995. There is obviously keen demand by consumers with growers receiving \$US16 per 3.0 kg tray.

Cultivars of *A. chinensis* Selected Outside of China

Seed of *A. chinensis* was first introduced to New Zealand in 1977, and research workers there were soon convinced that this species had the greatest commercial potential of any of the *Actinidia* species other than the kiwifruit itself. The first New Zealand bred cultivar of *A. chinensis* has been formally released and full-scale marketing will commence in the 1999 harvest season. In 1987 a cross was made between plants from two accessions of *A. chinensis* with the aim of combining fruit size, good flavor, and yellow flesh. One seedling was identified in 1991 as having particularly good fruit which have a very characteristic, pointed shape, quite different in appearance to ‘Hayward’ fruit. The skin is covered with very soft downy hair, which is easily rubbed off. The flesh is a bright yellow when fruit are harvested at the right maturity and the flavor is much preferred by most consumers to that of ‘Hayward’ fruit. This selection has been registered under the PVR name of ‘Hort16A’ and will be marketed under the commercial name ZESPRI™ GOLD Kiwifruit. (ZESPRI™ is the name of the marketing subsidiary of Kiwifruit New Zealand, the successor to the New Zealand Kiwifruit Marketing Board.)

Although the fruit of ‘Hort16A’ are recognizably kiwifruits (i.e., are considered by most consumers to be related to ‘Hayward’ kiwifruit) they will need to be handled differently, especially as the fruit skin is more tender and more easily damaged than that of ‘Hayward’ kiwifruit. The ancestors of the plant come from different parts of China and ‘Hort16A’ will probably differ from ‘Hayward’ in its climatic requirements and in its response to management practices. Furthermore, the kiwifruit is hexaploid whereas ‘Hort16A’ is diploid and flowers almost a month earlier: diploid males of *A. chinensis* have therefore had to be selected as pollenizers. Two such plants, ‘Meteor’ and ‘Sparkler’, have so far been registered.

Many of the large-fruited Chinese selections of *A. chinensis* are tetraploid. A cultivar of *A. chinensis*, also suggested to be tetraploid, has been selected in France. ChinaBelle® has fruit averaging between 80 and 100 g, and it too has yellow flesh (Blanchet and Chartier 1998). A pollenizer, PolliChina®, has also been selected.

CULTIVATION OF OTHER ACTINIDIA SPECIES

Two other *Actinidia* species have fruit of obvious commercial potential: these are *A. arguta* (Sieb. et Zucc.) Planch. ex Miq. and *A. kolomikta* (Maxim. et Rupr.) Maxim. The potential of *A. arguta* has been discussed at length for more than 80 years, but it is only over the past few years that it has shown any signs of being anything more than just a novel or experimental crop. The fruit is about the size of a European gooseberry or grape, with a skin that is smooth and polished, completely hairless and generally palatable (Fig. 3). The flesh is sweet but the best feature is the unique, “sophisticated” flavor. Good selections of *A. arguta* show that this species has the potential to be much more than just a crop for those areas that are too cold for kiwifruit cultivation.

Small commercial plantings of *A. arguta* have been established in Canada, France, Germany, Italy, New Zealand and the United States, with local selections being promoted. These have been selected for size, for color (red or green skins), sweetness and flavor. The most widely planted, about 25 ha in Oregon, is what has been identified as the cultivar ‘Anna’ (correct name ‘Anansnaya’), but this material seems not true to label (R. Meyer pers. commun.).



Fig. 3. Fruit of *A. arguta*. The fruit are small (about 10–20 g), but good selections have a fine, sweet flavor and the skins are smooth, hairless, and edible.

Fruit of *A. arguta* has had a good reception in the San Francisco and Los Angeles markets, fetching remarkably high prices, and increasing amounts of both fresh fruit and processed products are being exported.

The true 'Ananasnaya' is possibly a hybrid of *A. arguta* and *A. kolomikta* (Evreinoff 1949) selected many years ago by Michurin. *A. kolomikta* is a particularly cold-hardy *Actinidia* species with small but sweet fruit, very rich in vitamin C. It is of very limited commercial potential except for very cold areas.

THE NEW ZEALAND TRADITION OF NEW FRUITS AND NEW FRUIT CULTIVARS

The success of the kiwifruit is basically attributable to the inherent qualities of the fruit, to its appeal to the consumer and to its ease of handling. This appeal to the consumer—which is due to the beautiful green flesh, the flavor, the texture and the high content of vitamin C—has played an essential part in the kiwifruit's popularization. Sustained and imaginative marketing has undoubtedly also helped the successful marketing of 'Hayward' fruit. New kiwifruit cultivars will require similar promotion.

It is less certain why it was in New Zealand that kiwifruit should have first been developed as a commercial crop. Chance was undoubtedly important as was the possession of a particularly good cultivar. However, even an outstandingly good cultivar such as 'Hayward' does not necessarily result in the development of an industry unless growers are aware of its potential: 'Hayward' was sent to California in 1935 but its true worth was not appreciated until the first shipment of New Zealand kiwifruit to the United States quarter of a century later. The New Zealand tradition of innovation in fruit growing was also probably important.

New Zealand has only a small population and its fruit growing industries have therefore become largely reliant on exports. As a consequence, the industries are particularly aware of customers' needs and of the desire for novelty. Some of our novelty crops such as horned melons (kiwanos), tamarillo, and feijoas have remained novelties. Much of the success of the New Zealand apple industry is due to its reliance on new or novel cultivars with 'Royal Gala'/'Gala' and 'Braeburn', both of local origin, now making up more than half of all the apples exported. The 'Hayward' kiwifruit is a good example of a novel crop that has "made good" and has become established throughout the world. It is our hope that 'Hayward' will be joined by other, equally successful new *Actinidia* cultivars.

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