1 History of Kiwifruit: Evolution of a Global Crop

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1.1 Introduction

In the *New Zealand Oxford Dictionary* of 2005, kiwifruit are described as having 'fruit with a thin, hairy skin, green flesh and black seeds'. This narrow definition is because the name kiwifruit had originally been devised in New Zealand in 1959 for fruit of the cultivar 'Hayward' of *Actinidia chinensis* var. *deliciosa* (Ferguson, 2020a). 'Hayward' kiwifruit have a hairy skin and brilliant, green fruit flesh. The new name was quickly accepted in export markets and for many years was essentially restricted to 'Hayward' fruit as the world kiwifruit industry was then totally dominated by this cultivar. From 2000 onwards, the name became extended to *A. chinensis* var. *chinensis* when fruit of that variety, with less hairy skins and fruit flesh of different colours, became available in international trade. The name is now sometimes even used for the whole of the genus *Actinidia*, both the fruit and the vines. The name kiwiberry is used for fruit of *A. arguta* and some related species (see Chapter 7).

Actinidia chinensis comes from China. There, the name mihoutao (Fig. 1.1) has generally been used for *Actinidia* fruit, particularly fruit of *A. chinensis*. Mihoutao translates as macaque monkey peach since the ripe fruit are eaten by the monkeys in the mountains (Fig. 1.2). In Chinese botanical literature, mihoutao is usually taken as referring to the whole genus *Actinidia* (mihoutao shu) and *A. chinensis* as zhonghua mihoutao (Chinese mihoutao). Other names have been used in China for *A. chinensis*, but mainly only in restricted areas. The species is variable, particularly in the hairiness of the fruit, as indicated by Chinese names such as yangtao (sun or goat peach) given to variants with smooth, less hairy fruit and mao yangtao for those with hairier fruit (Dunn, 1911; Wilson, 1913).

Early plant collectors in China and botanists were also aware of this natural variation in *A. chinensis* wild populations (Ferguson, 1990a). Fairchild (1913) published a photograph taken by the plant collector E.H. Wilson, labelling it 'A plate of yang taw fruits. One of at least two distinct strains of *Actinidia chinensis* Planch, which have been observed in China'. The fruit shown are clearly hairy, very similar to the 'Hayward' fruit produced by many commercial orchards today.

The consequent, rather convoluted, nomenclatural history of the two main variants ('distinct strains') of *A. chinensis* in mainland China is described in Chapter 3. Currently, they are considered as varieties of the one species, the less

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Fig. 1.1. The simplified Chinese characters for mihoutao (monkey peach). (Photo: The New Zealand Institute for Plant and Food Research Ltd)

Fig. 1.2. Macaque monkey eating a kiwifruit; hence the Chinese name mihoutao or monkey peach. (Photo: Aneesh Thomas, EyeEM)

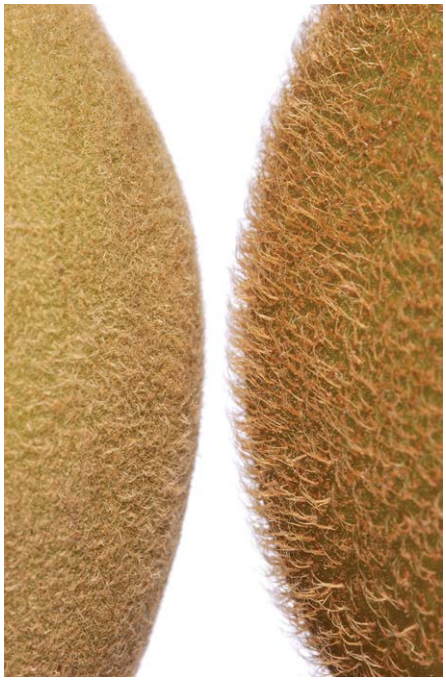

Fig. 1.3. The hairs on the skin of *Actinidia chinensis* var. *chinensis* fruit (*left*) are typically much finer and softer than those on the skin of *A. chinensis* var. *deliciosa* fruit (*right*). (Photo: The New Zealand Institute for Plant and Food Research Ltd)

hairy as *A. chinensis* var. *chinensis* and the hairier as *A. chinensis* var. *deliciosa* (Fig. 1.3). The other obvious difference for consumers is in the colour of the fruit flesh: the fruit flesh of *A. chinensis* var. *chinensis* is usually golden yellow, although occasionally green or sometimes red to varying extents, whereas that of *A. chinensis* var. *deliciosa* is almost always green, but rarely with some red. Other morphological differences between the two varieties are described in Chapter 3, as are their overlapping geographical distributions.

The two varieties of *A. chinensis* also differ in the place and timing of their initial domestication. The pathways of their domestication are classic examples of domestication by a single introduction of wild germplasm in the case of *A. chinensis* var. *deliciosa* and subsequently by multiple selections from wild germplasm of both *A. chinensis* var. *chinensis* and *A. chinensis* var. *deliciosa*.

The type specimen and the first illustration in the European scientific literature were of *A. chinensis* var. *chinensis* (Fig. 1.4) but it was *A. chinensis* var. *deliciosa* that was domesticated first. Its

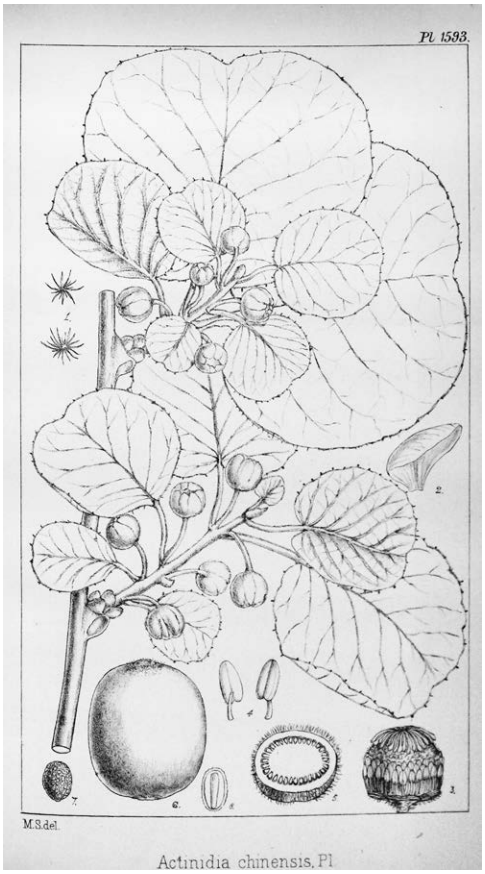

Fig. 1.4. *Actinidia chinensis* var. *chinensis*. The first illustration published in Europe. (From Oliver, 1887)

successful cultivation in New Zealand in the early decades of the 20th century led to the establishment of a new fruit crop using selections descended from a single introduction of seed. This seems to have been largely a matter of luck, although the expertise and efforts of early nurserymen, orchardists and agricultural advisors should not be dismissed. Probably of greatest consequence was the selection of the cultivar 'Hayward', which eventually became the only important fruiting kiwifruit cultivar grown in New Zealand. It was adopted by other countries as they started growing kiwifruit. For many years, the kiwifruit was the cultivar 'Hayward'. 'Most consumers are not even aware that other varieties exist' (Belrose, Inc., 1998).

Half a century after plants of *A. chinensis* var. *deliciosa* first fruited in New Zealand, the success of the expanding New Zealand kiwifruit industry encouraged detailed evaluation of the *Actinidia* germplasm resources in China. Multiple selections from the wild of superior genotypes of both *A. chinensis* var. *chinensis* and *A. chinensis* var. *deliciosa* provided most of the cultivars now grown commercially in China. This was the result of a long-term vision and a well-formulated strategy (Huang, 2022) based on the knowledge that kiwifruit cultivation could be profitable. China brought *A. chinensis* var. *chinensis* into cultivation and thus pioneered the production of yellow-fleshed and red-fleshed kiwifruit.

1.2 The Wild Mihoutao in China

Despite extensive forest clearance, wild *Actinidia* vines are still abundant throughout much of China (Fig. 1.5), even if the distributions of many species are now discontinuous (Huang, 2016). Sporadic attempts were made to cultivate *Actinidia* species, starting about 1200 years ago (Ferguson, 1990b; Cui *et al.*, 2002), but generally, fruit were simply collected from wild plants. Thus, all descriptions in the classic pharmacopoeias (Bencao) and encyclopaedias of the appearance and use of mihoutao as medicine or as fruit for consumption (Fig. 1.6) describe them as being wild plants in the mountains. Thus, the *Bencao Yanyi* [Development of materia medica] compiled by the pharmacist Kou Zongshi between 1111 and 1116 AD (Song Dynasty) described the mihoutao thus: 'The branches are slender and supple, the plant … supports itself by growing over trees. It is found along pathways in the hills, deep in the mountains. The fruit are much eaten by monkeys' (Yan, 1981). European and American travellers in China in the 19th and early 20th centuries confirmed that mihoutao were not then cultivated in China.

1.3 Domestication and Cultivation of Green-fleshed Kiwifruit, *Actinidia chinensis* var. *deliciosa*

1.3.1 The first plants outside China

The first serious attempts to cultivate *A. chinensis* were not in China but in other countries. At the

Fig. 1.5. Wild kiwifruit or mihoutao. *Actinidia chinensis* var. *deliciosa* growing over trees in Sichuan, China. (Photo: The New Zealand Institute for Plant and Food Research Ltd)

Fig. 1.6. An early Chinese illustration of the mihoutao (*Actinidia chinensis*). The text quotes the *Bencao Gangmu* of Li Shizhen (1518–1593): mihoutao are common in the mountains of Jiangxi, Huguang (largely modern Hubei and Hunan) and Henan and peasants collect the fruit to bring to town to sell in the markets. (From Wu, 1848)

end of the 19th century and during the early years of the 20th century seed and plants of *A. chinensis* were sent to Europe, the USA and New Zealand (Ferguson and Bollard, 1990; Ferguson, 2004). Some introductions, all apparently unsuccessful, were of *A. chinensis* var. *chinensis*; most introductions of *A. chinensis* var. *deliciosa* were only marginally more successful.

In 1904, a London nursery firm, James Veitch & Sons Ltd, advertised plants for sale of what we now know as *A. chinensis* var. *deliciosa*. The seed from which the plants had been raised had been collected by E.H. Wilson (Fig. 1.7). The advertisement said that the vine produced 'edible fruits having the size of walnuts, and the flavour of ripe gooseberries' (James Veitch & Sons, 1904). This seems to be the first time that the flavour of kiwifruit was likened to that of the European gooseberry and is possibly the origin of the former name in English, 'Chinese gooseberry'. The first plants sold by James Veitch & Sons all proved to be male (Fig. 1.8). Eventually, after further introductions of female plants, fruit was occasionally produced in Britain and the USA, but in those countries, *A. chinensis* var. *deliciosa* came, for many years, to be valued mainly as an ornamental plant.

Fig. 1.7. The plant collector E.H. Wilson at the time of his trips to China. (From Anon., 1905)

Fig. 1.8. Staminate flowers of *Actinidia chinensis* var. *deliciosa* from a plant obtained in 1905 from James Veitch & Sons and raised from seed gathered in Hubei, China, by E.H. Wilson. (From Sprague, 1914)

1.3.2 The first plants in New Zealand

One successful introduction of *A. chinensis* var. *deliciosa* seed to New Zealand in 1904 ultimately led to the establishment of a new fruit crop (Ferguson and Bollard, 1990; Ferguson, 2004). In 1903, Isabel Fraser (Fig. 1.9) had visited her sister Katie Fraser, a missionary teacher at Ichang (now Yichang), Hubei Province, China. Ichang was the overwintering base for E.H. Wilson on his plant-collecting trips to China. In 1900, he had introduced the fruit of *A. chinensis* to the foreign residents of Ichang '... with whom it found immediate favour' (Wilson, 1913). When Isabel Fraser returned to New Zealand, it is very likely that her seed of *A. chinensis* var. *deliciosa* came directly or indirectly from Wilson. The fruit from which the seed had been extracted probably originated not from around Ichang itself but from further inland in Sichuan.

The seeds were given to Alexander Allison, a farmer in Whanganui, New Zealand. He successfully raised both male and female plants, and by 1910 his vines were producing fruit (Ferguson and Bollard, 1990). These are the first known

Fig. 1.9. Isabel Fraser. After visiting her sister in Ichang, China, in 1903, she returned to New Zealand in 1904 with seed of *Actinidia chinensis* var. *deliciosa*. (From Anon., 1910)

fruit of *A. chinensis* var. *deliciosa* to be produced outside China. Nurserymen became interested and by 1917 plants were being sold to the public under the name 'Chinese gooseberry', a name that was used for the next 40–50 years. A commercial orchard of 14 vines was established in Whanganui in the late 1920s followed by a larger orchard there of about 60 vines. Fruit were being sold in other parts of New Zealand by the mid-1930s. This was the small beginning of a new commercial fruit crop (Fig. 1.10).

1.3.3 Cultivar selection

For many years, New Zealand orchardists were simply encouraged to propagate female Chinese gooseberry strains with large oval or elongated fruit. One selection with large oval fruit was named 'Hayward' after its selector Hayward Wright (Fig. 1.11), an Auckland nurseryman; another was named 'Bruno' after Bruno Just, another nurseryman (Mouat, 1958). These and other selections can be traced back to one male and two female vines (Ferguson and Bollard, 1990) descended from the original *A. chinensis* var. *deliciosa* seed that had arrived in New Zealand in 1904, a very narrow genetic base for a developing industry.

1.3.4 The development of management practices

Successful introduction is only the first step in the development of a new commercial crop. Growers must learn how to manage the plant, select best forms of the plant and succeed in producing profitable crops that can be harvested at the optimal time, stored, if necessary, then marketed (Ferguson and Bollard, 1990). The management techniques being developed (Fig. 1.12) were initially specific to the conditions in New Zealand.

1.3.5 The consequences of fruit exports

Chinese gooseberries began to be planted in different parts of New Zealand to provide fruit for local consumption. Storage experiments indicated that export of the fruit by sea to overseas markets on the other side of the world was a realistic possibility. Initially, export was

Fig. 1.10. Whanganui, New Zealand: fruit from the first commercial kiwifruit orchard in the world. (From Whelan, 1935)

Fig. 1.11. Hayward Wright with canes of his large-fruited selection of *Actinidia chinensis* var. *deliciosa*, later named 'Hayward' in his honour. (From Rice, 1930)

Fig. 1.12. Innovation in vine management. A 21st century orchard in the Bay of Plenty, New Zealand. The aim is to separate replacement canes from the fruiting canopy below. (Photo: The New Zealand Institute for Plant and Food Research Ltd)

a means of using fruit surplus to local requirements. 'Hayward' fruit reached the markets in better condition than did fruit of the other cultivars then grown (Ferguson and Bollard, 1990). As exports became more important, the clear preference of the overseas markets encouraged new plantings of 'Hayward' or reworking of existing orchards to 'Hayward'. By 1975, only 'Hayward' fruit were being recommended for export. The following year, exports exceeded local consumption for the first time. In 1965, the total area of Chinese gooseberry orchards in New Zealand was about 100 ha; this increased to about 1000 ha in 1975 and to 15,000 by 1985. It was the adoption of 'Hayward' that allowed the successful expansion of an industry producing fruit primarily for export.

1.3.6 A change of name – kiwifruit

The name Chinese gooseberry was used in New Zealand until the first exports of fruit to the USA. A new name was then considered necessary (Ferguson, 2020a). 'Kiwifruit' was chosen in 1959 because the bird, the kiwi (*Apteryx*), is the national emblem of New Zealand, and the people of New Zealand are commonly known as kiwis (Fig. 1.13). By 1970, all exports of kiwifruit from New Zealand went under that name. The international success of exports meant that the name became accepted, and as other countries started growing kiwifruit, they too adopted the new name.

1.3.7 Cultivation of kiwifruit spreads to other countries

Sustained promotion of kiwifruit in California, Europe and Japan encouraged orchardists in those places to consider growing kiwifruit. While kiwifruit may have been novel, a demand for the fruit had been created and New Zealand orchardists had shown that kiwifruit could be cropped profitably. Interest was also stimulated by publicity in horticultural journals and

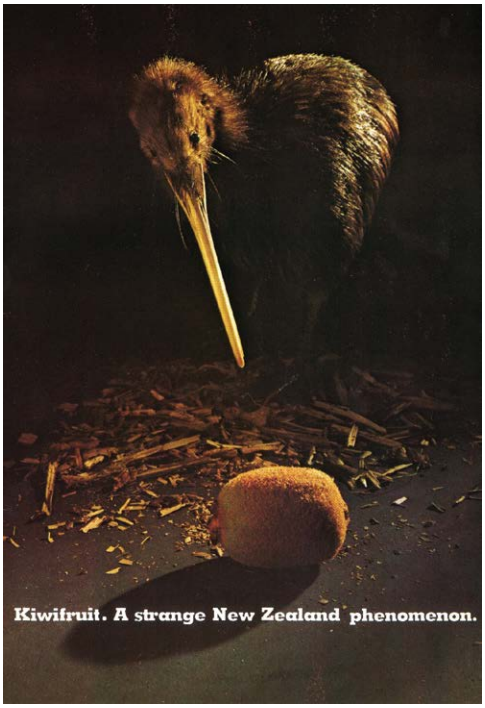

Fig. 1.13. A new name: kiwifruit. Cover of the advertising booklet *Kiwifruit: A Strange New Zealand Phenomenon*. ([New Zealand] Kiwifruit Export Promotion Committee, 1979)

nursery catalogues. Kiwifruit went from being a crop peculiar to New Zealand to one of increasing worldwide distribution. The cultivars selected in New Zealand were accepted and the management practices adopted. As 'Hayward' was becoming the only green-fleshed kiwifruit cultivar grown in New Zealand, it soon predominated elsewhere.

This spread of kiwifruit around the world can be illustrated by the evolution of the Italian kiwifruit industry (Ferguson and Bollard, 1990; Testolin and Ferguson, 2009; Testolin, 2015; Costa *et al*., 2018). Experimental plantings were established in 1966/67 but the first commercial plantings came about five years later. At first, many female cultivars such as 'Abbott', 'Bruno' and 'Monty' were introduced as well as 'Hayward', but 'Hayward' quickly dominated. Many initial plantings failed or produced low fruit crops because growers were inexperienced and lacked knowledge or because marginal land was used. Once more suitable areas were chosen and growers became more aware of the plant's requirements, the industry developed rapidly, almost doubling in area every two years (Costa *et al*., 1992). Initially, the small quantities of marketable fruit returned very high prices to orchardists, and this encouraged more planting. Another advantage was that, at that stage, 'Hayward' was substantially free of disease.

The management techniques, support structures and methods of training and pruning were largely those developed in New Zealand (Testolin and Ferguson, 2009; Testolin, 2015) (Fig. 1.14). However, in New Zealand, the bulk of kiwifruit orchards (> 80%) is in one part of the country, the Bay of Plenty. Kiwifruit cultivation in Italy extends throughout the length of the country with more diverse environmental conditions. Therefore, some management practices had to be modified (Costa *et al*., 2018). The most striking difference between the two countries is the structure of the industries, particularly in marketing. The New Zealand industry is unusually unified with most exports under the control of one marketing organization, Zespri Group Limited. The Italian kiwifruit industry is much less tightly organized with multiple exporters.

In 1978, there were about 600–800 ha of kiwifruit planted in Italy, increasing to ~10,000 ha in 1988 and 27,000 ha in 2008, before decreasing to 24,500 ha in 2020 (Costa and Testolin, 2022). At one stage, kiwifruit production in Italy exceeded that of New Zealand, but from 2015 to 2020, there was a decline in annual production from 575,096 tonnes to only 305,356 tonnes, despite the total area of plantings remaining essentially unchanged (Costa and Testolin, 2022). 'Hayward' remains the most widely grown kiwifruit cultivar in Italy. Towards the end of the 20th century other *A. chinensis* var. *deliciosa* cultivars owned by nurseries or consortia began to be planted and, more recently, cultivars *of A. chinensis* var. *chinensis*.

There are extensive kiwifruit orchards in Chile and in northern hemisphere countries such as France, Greece, Iran, Portugal and the USA (see Chapter 2). In all these countries, 'Hayward' still predominates. 'Hayward' is even important in China, the original home of kiwifruit.

Fig. 1.14. A protected (covered) kiwifruit orchard in Emilia-Romagna, Italy, just after budbreak in spring. (Photo: U. Palara, Italy)

1.4 Domestication and Cultivation of *Actinidia chinensis* var. *chinensis* and *A. chinensis* var. *deliciosa* in China

1.4.1 First kiwifruit orchards

In 1957, the Beijing Botanic Garden, Chinese Academy of Sciences, grew plants of *A. chinensis* var. *deliciosa* raised from seed collected in the Qinling Mountains, Shaanxi, and followed this in 1961 with plants of *A. chinensis* var. *chinensis* from seed collected in the Funiu Mountains, Henan (Huang *et al*., 2003). These seem to be the first modern attempts to cultivate kiwifruit in China. This was also the start of the domestication of *A. chinensis* var. *chinensis*, even if the first plantings were valuable mainly for scientific research.

The first small commercial kiwifruit orchards in China were established around 1980 in Chibi County, Hubei, and then in Dujiangyan, Sichuan. The cultivars used (*A. chinensis* var. *deliciosa*) and orchard management techniques adopted were based on those used in New Zealand. Possibly the first ever commercial orchard in China, indeed the world, of *A. chinensis* var. *chinensis* was established around 1980 by transplantation of wild vines to an orchard in Xixia, Henan.

1.4.2 Evaluation of wild *Actinidia* germplasm in China

The success of kiwifruit in New Zealand stimulated Chinese horticulturists to initiate a national germplasm survey of wild *Actinidia* resources. The immediate aim was to develop cultivars by selection of superior genotypes to replace the cultivar 'Hayward' (Cui *et al*., 2002; Huang and Ferguson, 2007; Huang, 2012, 2016; Huang and Zhong, 2018). The ultimate aim was a Chinese kiwifruit industry that was

competitive with international kiwifruit industries. The plan also emphasized the development of orchard, storage and marketing techniques suited to Chinese conditions, of processed products and possible medical uses.

Starting in 1974, there were extensive surveys of wild *Actinidia* germplasm resources. There are many millions of plants of both *A. chinensis* var. *chinensis* and *A. chinensis* var. *deliciosa* throughout China. In 1974, the Guangxi Forest Institute started surveying the *Actinidia* resources in the mountainous areas of Guangxi Province. In 1975, the Zhengzhou Fruit Institute, Chinese Academy of Agricultural Sciences, collaborated with the Xixia Forest Institute in an extensive survey of *Actinidia* resources in Xixia County, Henan. This survey was extended to other parts of Henan in co-operation with other research institutes during 1976–78. Likewise, in 1978, the Central China Agricultural College at Yichang, Hubei, started surveying the *Actinidia* resources in the mountainous areas of Hubei Province. Eventually, more than 1400 large-fruited plants of *A. chinensis* var. *chinensis* and *A. chinensis* var. *deliciosa* were selected directly from the wild for further study and cultivar development. It is a striking example of fruit crop improvement being based on multiple selections from wild populations of germplasm from widely separated parts of the natural distribution (Huang *et al*., 2003). The selections varied greatly in many commercial traits (Huang, 2016), including fruit size, vitamin C content, soluble solids content and suitability for storage. Some selections were cold-hardy, drought-tolerant or could adapt readily to the different environments in many parts of China.

1.4.3 Selections of *Actinidia chinensis* var. *deliciosa* in China

A dozen cultivars of *A. chinensis* var. *deliciosa* were initially selected from wild germplasm, including 'Qinmei', 'Guichang' and 'Miliang No. 1'. These, as well as 'Hayward', were important in the initial stages of commercial kiwifruit production in China (Huang and Ferguson, 2001, 2007; Huang, 2016; Huang and Zhong, 2018) and many are still important (see Chapter 4). Some subsequent selections were one generation removed from the wild. In 2020, cultivars of *A. chinensis* var. *deliciosa* comprised about half of Chinese kiwifruit plantings (Zhong *et al*., 2022; Chapter 4). All these cultivars have green-fleshed fruit.

1.4.4 Selections of *Actinidia chinensis* var. *chinensis* in China

Surveys of wild *Actinidia* resources in China quickly revealed the potential of *A. chinensis* var. *chinensis* genotypes. As early as 1985–90, several cultivars selected from wild populations were released. Nearly all these had yellow-fleshed fruit. Since then, many more cultivars of *A. chinensis* var. *chinensis* have been authorized or registered in China than have cultivars of *A. chinensis* var. *deliciosa*.

In 2002, only about 20% of the total Chinese area planted in kiwifruit was of cultivars of *A. chinensis* var. *chinensis* (Huang *et al*., 2003). By 2020, this had risen to almost 50%, one-third of which was in yellow-fleshed cultivars and two-thirds in red-fleshed cultivars (Zhong *et al*., 2022). The domestication of *A. chinensis* var. *chinensis* resulted in China being the first country to have extensive plantings of green-, yellow- and red-fleshed kiwifruit. 'Jinyan' (described in Chapter 4) remains exceptional in that it is the first kiwifruit cultivar resulting from interspecific hybridization to be planted on a commercial scale.

Red-fleshed kiwifruit are uniquely important in China. 'Hongyang', the first red-fleshed cultivar, was selected in Sichuan from seedlings raised from seed collected from wild *A. chinensis* var. *chinensis* populations in Henan (Wu and Li, 1993; Wang *et al*., 2003). By 2020, it was the most widely planted kiwifruit cultivar in China (66,700 ha), nearly a quarter of the total area of kiwifruit. Its fruit has proved very popular, receiving about three times the wholesale price of 'Hayward' fruit. Its popularity is probably largely due to its perceived sweetness.

1.4.5. Expansion of the Chinese kiwifruit industry

In 1980, there was only about 1 ha of cultivated kiwifruit in China. That year, France had about

600 ha, California and Italy each had an estimated 1000 ha and New Zealand had 3500 ha (Warrington, 1990). Subsequently, the areas planted in kiwifruit in Italy and New Zealand increased rapidly but were soon dwarfed by those in China (Fig. 1.15): 4000 ha in 1990, 45,000 ha in 1998, 57,400 ha in 2002, 70,000 ha in 2011, 286,500 ha in 2020 (Huang and Ferguson, 2001; Huang *et al.*, 2003; Zhong *et al.*, 2022).

A striking feature of the evolution of the Chinese kiwifruit industry since 1980 is the frequent changes in the cultivars grown. There has been a much greater use of cultivars of *A. chinensis* var. *chinensis*, particularly of the red-fleshed cultivars 'Hongyang' and 'Donghong', probably in response to the market prices realized. Perceived fruit quality and market returns have probably also influenced plantings of *A. chinensis* var. *deliciosa* cultivars.

Another notable difference is that kiwifruit production in China is almost entirely for local consumption, with exports being insignificant. In New Zealand and Chile, and, to a lesser extent, other countries, kiwifruit are produced for export.

1.5 *Actinidia chinensis* var. *chinensis* in Countries Other than China

1.5.1 Yellow-fleshed kiwifruit

Until 2000, consumers throughout most of the world had little choice in the kiwifruit they could buy. The only real choice was the country of origin, as different countries in both hemispheres were, by then, producing and marketing 'Hayward' kiwifruit. To consumers, 'Hayward' *was* the kiwifruit. Only in China were fruit of different kiwifruit cultivars readily available, but these were not offered outside China and were not generally known.

Fig. 1.15. Successful kiwifruit cultivation near Chengdu, Sichuan, China. (Photo: C.H. Cheng, Kiwifruit Breeding Centre, New Zealand)

Zespri GOLD™ Kiwifruit were the first yellow-fleshed kiwifruit on the international market, available from 2000. They were fruit of a new *A. chinensis* var. *chinensis* cultivar, 'Hort16A', bred by HortResearch in New Zealand (Muggleston *et al*., 1998). Limited quantities of seed and budwood of *A. chinensis* var. *chinensis* that had been introduced from China to New Zealand were the starting material for a large breeding programme. 'Hort16A' kiwifruit were novel, differing from 'Hayward' fruit in that they were ovoid with a protruding distal end (beak), the fruit skin was covered by soft fine hairs, rather like the fuzz on a peach, the internal flesh was a beautiful clear yellow (if the fruit were harvested at the right maturity), and the flavour was very different, being sweeter, more aromatic and less tart. 'Hort16A' was also novel in that it was the first commercially successful kiwifruit cultivar to come from a planned breeding programme. It was a protected cultivar, which meant that it could be legally grown only by growers licensed by Zespri, the New Zealand owner. Initially, 'Hort16A' was grown only in New Zealand, but plantings were established under licence in northern hemisphere countries such as France, Italy, South Korea and Japan, to enable year-round marketing of the fruit. This is increasingly the trend with other protected kiwifruit cultivars.

Selection of a new cultivar is only the first step (Martin and Luxton, 2005). Suitable vine management techniques had to be developed, including the selection of suitable pollenizer cultivars since 'Hort16A' flowers some weeks earlier than 'Hayward'. Harvest maturity indices needed to take into account the fruit flesh changing from green to yellow only late in the season. Procedures were also required for the handling and storage of the fruit since they were very different from those of 'Hayward'.

'Hort16A' proved very successful, and the fruit fetched very high prices; it was very profitable for growers. By 2010 it accounted for a third of the New Zealand kiwifruit industry's total sales. Unfortunately, it was also very susceptible to bacterial canker of kiwifruit, caused by *Pseudomonas syringae* pv. *actinidiae* (Psa). Within a couple of years of this disease arriving in New Zealand, 'Hort16A' could no longer be grown commercially. Fortunately, the New Zealand kiwifruit breeding programme had produced a seedling selected on fruit weight, shape and taste (Ferguson, 2020b). This cultivar, 'Zesy002', turned out to be much less susceptible to Psa. It was chosen as a replacement for 'Hort16A', and its fruit marketed as Zespri SunGold™ Kiwifruit. New Zealand is currently the only kiwifruit-producing country in which yellow-fleshed kiwifruit are more important than green-fleshed kiwifruit. In 2022, almost two-thirds, by volume, of the kiwifruit exported from New Zealand were yellow-fleshed and as they fetched much higher prices, they were much more profitable for growers than 'Hayward'. Kiwifruit is now the most valuable of New Zealand's horticultural exports.

Yellow-fleshed *A. chinensis* var. *chinensis* cultivars are also important in Italy (Costa and Testolin, 2022); in 2020, yellow-fleshed cultivars made up about 15% of kiwifruit plantings but 25% of total kiwifruit production. The most widely cultivated is 'Zesy002', grown under licence for Zespri. The second most widely planted yellow-fleshed cultivar is a Chinese cultivar, 'Jintao' (fruit marketed by Jingold S.p.A.). There are also plantings of one other Chinese cultivar, 'Jinyan', and two that are the result of Italian kiwifruit breeding programmes, 'Soreli' and 'AC 1536' (fruit marketed by Consorzio Dorì Europe S.r.l). Limited areas of these yellow-fleshed kiwifruit cultivars have been established in other countries such as Chile and South Africa.

'Jintao' is now, after 'Zesy002', the most widely planted yellow-fleshed kiwifruit cultivar outside China. Many other countries, such as Japan and South Korea, which established kiwifruit industries based on 'Hayward', are also exploring the potential of yellow-fleshed kiwifruit.

1.5.2 Red-fleshed kiwifruit

There are limited plantings in Italy of several red-fleshed cultivars of Chinese origin including 'Hongyang' and 'Donghong'. In South Korea, the red-fleshed cultivar 'Redvita' has been registered (Kwack *et al*., 2017). In New Zealand, 'Zes008' (Zespri RubyRed™ Kiwifruit), the result of a breeding programme, is being commercialized with the beginning of exports. It is likely that cultivation of

red-fleshed kiwifruit will become more general because of keen consumer demand.

1.6 Cultivation of Other *Actinidia* Species

1.6.1 Kiwiberries and related species

The first *Actinidia* species to be cultivated outside their natural distributions were *A. arguta* (kiwiberries), *A. polygama* and *A. kolomikta* (Huang and Ferguson, 2007). Initially, they were valued mainly as ornamentals. Hobbyists in Europe and North America grew vines for fruit but the first commercial kiwiberry orchards seem to be those established in Oregon, USA (Finn, 1999). Since then, orchards have been established in many countries, mainly in China (see Chapter 7).

1.6.2 *Actinidia eriantha*

Superior *A. eriantha* genotypes have been selected and commercial orchards established in Zhejiang, China and South Korea. The cultivar 'Jinyan' is a hybrid between *A. eriantha* and *A. chinensis* var. *chinensis* (see Chapter 4).

1.7 Evolution of Kiwifruit as a Crop

The development of the green-fleshed kiwifruit (*A. chinensis* var. *deliciosa*) as a crop is a classic example of plant domestication from one sampling of wild germplasm. The industry that developed in New Zealand was based on what appears to have been a single introduction of seed from China at the beginning of the 20th century.

The development of the Chinese kiwifruit industry followed a very different pattern. Systematic evaluation of wild germplasm led to the selection and cultivation of superior genotypes of both *A. chinensis* var. *chinensis* and *A. chinensis* var. *deliciosa* with green, yellow or red fruit flesh. This is a rare example of crop development being based on multiple selections from wild germplasm.

Cultivation of yellow-fleshed kiwifruit, *A. chinensis* var. *chinensis*, started with the first commercial orchard in China around 1980. International trade in yellow-fleshed kiwifruit started in 2000 with the commercialization of 'Hort16A', bred in New Zealand. Subsequent loss of 'Hort16A' as a commercial cultivar from disease demonstrates the very real dangers of an industry being based on only a very small number of cultivars. 'Hort16A' was soon replaced by 'Zesy002' and now exports from New Zealand of yellow-fleshed kiwifruit are more important than those of green-fleshed kiwifruit. Yellow-fleshed kiwifruit are likewise becoming more important in other countries.

The first red-fleshed kiwifruit cultivar, 'Hongyang', was registered in 1997 and by 2020 was the most widely planted of all kiwifruit cultivars in China. 'Hongyang' and most of the red-fleshed kiwifruit cultivars grown in China are very closely related but together account for more than 40% of all Chinese kiwifruit plantings. Again, there is an obvious danger in such extensive plantings having so limited a genetic base. Red-fleshed kiwifruit are currently uniquely important in China, but production is starting in other countries.

'Jinyan', the first commercially important interspecific *Actinidia* cultivar (*A. eriantha* × *A. chinensis* var. *chinensis*) was authorized as a new kiwifruit cultivar by the Chinese National Forestry Cultivar Approval Committee in 2010.

We can reasonably expect, soon, sweeter, green-fleshed cultivars; red-fleshed cultivars with larger fruit that are more consistently red; hermaphrodite, self-setting cultivars; more cultivars coming from interspecific crosses. Perhaps green-fleshed kiwifruit will steadily become less important. Certainly, the dominance of 'Hayward' is being rapidly eroded. Thus, the evolution of the kiwifruit as a crop plant continues; indeed, it appears to be accelerating.

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