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Frontiers of Fruit in California: New and Rediscovered Fruit Types with Potential for Commercial Cultivation

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Abstract

Many California farmers and breeders are actively searching for new or rediscovered fruit types with promising characteristics such as exceptional flavor, unusual color or texture, perceived health properties, or value to ethnic communities. Some of the most potentially valuable species and cultivar groups currently being grown or under trial in California, include greengage and mirabelle plums (*Prunus domestica*); tejocotes (*Crataegus mexicana*); fresh-quality quinces (*Cydonia oblonga*); goji (*Lycium barbarum*); and pollination variant, non-astringent persimmons (*Diospyros kaki*). These fruit types vary considerably in the reasons why they may be of commercial interest; origin and history of cultivation, particularly in California; germplasm resources and availability; environmental, horticultural and postharvest requirements and challenges; and marketing issues. Many of the fruit types are also potentially of interest for cultivation in states other than California.

California is by far the largest producer of fruits among the states of the United States, and has an extraordinarily wide diversity of growing areas and fruit crops. Since Franciscan friars brought fruit trees and seeds with them when they settled missions in the late 18th Century, California fruit growers have introduced dozens of exotic species and fruit types and experimented with their cultivation in different growing areas; but in recent decades interest in new fruit types has been particularly intense, for several reasons (12).

The basic impetus is that as supermarket chains have merged, profit margins generally have narrowed for farmers, who have sought to plant specialty items in order to remain profitable. As part of a wider interest in foods that are distinctive or are perceived to be prestigious, many consumers have sought new or rediscovered fruit types with exceptional flavors, unusual colors or textures. An influx of immigrants, particularly from Latin America and Asia, has led California farmers to plant previously rare or exotic fruits to appeal to these newly arrived consumers (e.g., tejocotes, sweet limes, guavas). Research and claims about the health benefits of certain fruits (e.g., pomegranates, blueberries) have led to their increased cultivation.

As a journalist writing about fruit for the past 20 years, and more recently as a researcher at the University of California, Riverside, and as the sponsor of a stonefruit test orchard, I have observed many such attempts to introduce, test and commercialize new fruit types. I believe that a survey of the most promising of these may be useful for pomologists, farm advisors, and specialty fruit growers. (I deliberately use the term "fruit type" rather than "species" or "cultivars," because in many though not all cases, this category most closely describes what is under study - a group of cultivars or selections with similar fruit qualities.) I have excluded those fruit types that are of interest primarily to home gardeners and scientific collections, and focused on those that have been planted commercially, if only on a small scale, or that show some realistic promise for this purpose. Undoubtedly some, perhaps the majority, will fail to gain traction as commercial crops. The focus is limited to fruit types that have been planted in California, but some of them are also potentially of interest for cultivation in other states.

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Greengage plums (*Prunus domestica*)

"For the qualities that gratify or assist in gratifying the sense of taste – richness of flavor, consistency and texture of flesh, abundance of juice and pleasant aroma – the Reine Claude is unsurpassed," wrote U. P. Hedrick in *The Plums of New York* (1911), and greengages still are widely considered the most delicious and intensely flavored European plums (3, 10). The term "greengage" refers to a group of hexaploid plums, which have been classified as both *Prunus domestica* and as *P. domestica* x *P. insititia*, originally native to the Subcaucasus (11). This type of the class was brought to Italy, and thence to France during the reign of King Francis I (1515-1547), where it was named "reine-claude" in honor of his queen, Claude. Brought to England by the early 17th Century, the original variety ('Reine-Claude Dorée', or 'Reine-Claude Verte') was named before 1724 for Sir William Gage of Suffolk, whose gardener imported a tree from Paris but lost the label. In England, the prototype is often called 'Green Gage', or 'Old Greengage', and its progeny are known as gages, as in 'Oullins' gage or 'Althan's' gage.

Greengages are widely grown in several European countries, including France, Italy, Spain and England (Fig.1). The center of commercial cultivation is southwestern France, where 4,700 acres of greengages and related varieties are grown. Good-quality fresh greengages are imported on a small scale from New Zealand to the United States in late February and early March. Greengages were cultivated commercially in California in the late 19th and early 20th Centuries, largely for canning, and primarily in intermediate coastal districts, such as Healdsburg and the Santa Clara Valley, where prunes were grown (14).



Fig. 1. 'Old greengage' grown by Andy Mariani in Morgan Hill, California. © David Karp.

Asian plums (*P. salicina*) and their hybrids, which were larger, more highly colored, higher yielding, and more durable, almost entirely supplanted greengages in cultivation in California by the mid-20th Century. The challenges for growers are many. The trees take five or more years to come into bearing, longer than most plum varieties. Most cultivars are self-infertile and are often relatively shy and alternate bearers. The fruits are small, 30-35 g (1), and greenish, a color unfamiliar or unappealing as a fruit to many Americans. Fully ripe fruits, which have the best flavor, are too soft to ship long distances. When it rains the fruits crack and rot, a major problem in Eastern and Midwestern orchards, but less so in California coastal valleys, where the harvest falls in late July and August, which are usually rain-free. The high quality and value of this fruit may make it worthwhile to grow under high tunnels in areas with rainy summers.

After almost entirely disappearing from commercial cultivation in the United States, greengages have been planted on a modest scale in the past decade, on perhaps 10 hectares in total, mostly in California, Oregon, Michigan and New York. Ripe fruit from Morgan Hill, Calif. averages in the high 20s in soluble solids concentration (19), with an intense, distinctive flavor that most buyers find very attractive, and demand for the limited quantities of available fruit has been strong. Dried greengages are of good quality, but not nearly on the level of the fresh fruit. However, there is rich potential for culinary and processing uses of greengages, as for making preserves, tarts and ice cream. It is not clear that a robust trade in greengages through standard commercial channels, involving shipments over long distances and sales at supermarkets, will ever prove viable

in the United States; but it seems clear that sales through local channels, such as farmers' markets, farm stands, and high-end local restaurants, groceries and processors, could be profitable.

Considerable confusion exists concerning the names and identities of the various selections marketed as greengages in the United States. As far back as 1817, in the first major pomological work published in the United States, William Coxe wrote that there were "several varieties" of greengages (5). In France many numbered selections of the leading cultivars exist and have been assessed in controlled studies and through long grower experience (1). In the United States, no such reliable germplasm resources exist, and the varieties available at nurseries are a hodgepodge; a decade ago, a major nursery in the San Joaquin Valley was selling trees of green-skinned Asian plums, which have sometimes been called "Japanese greengages," as the authentic European plum. For another example, the selection known as 'Bavay's' gage in California ripens about the same time as the 'Old Greengage', whereas in Southwestern France it ripens three weeks later. It would be crucial to the prospects for greengage cultivation in the United States to: 1) import elite clones of the leading cultivars from France and possibly other European and West Asian countries; 2) using molecular markers, compare the genotypes now being sold in the United States with securely identified material from Europe; 3) test elite imported and domestic genotypes in the most promising growing areas to evaluate production, fruit size, fruit quality, precocity, self-fertility, pollination, suitable roostocks, and other important characteristics.

In Southwestern France, 'Stanley', 'Prune D'Ente', 'Monsieur', 'Oullins', and 'Royale' are the cultivars most often used to pollinate the 'Old Greengage' (2), but the last three of these are of limited availability in the United States, and it is not clear to what extent the flowering periods of any of these cultivars overlap with 'Old Greengage' under local American conditions. In addition, the chilling requirements of greengage cultivars are poorly understood; in Morgan Hill, Calif., south of San Jose, which averages 750 or 800 hours of chilling, bloom is generally adequately vigorous, but in some years with lower chill, bloom can be quite protracted (20).

Mirabelle plums (*Prunus domestica*)

Of uncertain origin, but probably from Asia Minor or Western Asia, mirabelle plums are small, round, yellow European plums variously classified as *Prunus domestica*, *P. insititia*, or *P. domestica* subsp. *insititia* (10). They are primarily grown in Europe, and particularly in Lorraine, in northeastern France, where some 2,000 hectares are cultivated, accounting for 70% of plantings worldwide (23). The harvest takes place in August in this region and in the coastal valleys surrounding the San Francisco Bay area. The flavor is sweet, but not especially rich; the fruit is quite pleasant eaten fresh, and some is sold for this purpose, but the primary uses are culinary and for processing, for making preserves, compotes, tarts, and brandies.

Although described in William Prince's *Pomological Manual* as early as 1832 (26), mirabelles have never caught on in cultivation in the United States, for reasons that remain unclear (10). They are at least partly self-fertile, and they grow well and produce vigorously in suitable parts of California, Oregon and New York. In the past decade or so, specialty growers have planted them on a small scale in these states, on a total of perhaps 8 hectares. It is not likely that growing mirabelles on a large scale for processing would be profitable in this country, where the fruit is little known, but a gradual increase in cultivation could most likely be sustained. The small size of the fruit makes it more expensive to harvest and pack, but this also makes it suitable for packing in clamshells, and convenient for snacking out of hand.

More than a dozen cultivars of mirabelle have been identified, of which by far the most important in Lorraine is 'De Nancy'. As for

greengages, various numbered selections are available in France (7), and it would be advantageous for American growers if one or more of the best of these were imported. The other leading cultivar, 'De Metz,' is smaller, slightly more oval in shape, slightly higher in acidity, and arguably a bit more intense in flavor; traditionally it is chiefly used for culinary purposes and distillation (3). Trees are available from a limited number of nurseries in the Unites States, but germplasm resources are reasonably adequate.

Tejocote *(Crataegus mexicana)*

Mexican hawthorn (*Crataegus mexicana*; syn. *C. pubescens*), commonly called *tejocote* in Spanish, is native to the highlands of Mexico, where it is cultivated on some 700 hectares, predominantly in Puebla state (Fig.2). It plays a crucial role in traditional Christmas celebrations as an ingredient in *ponche*, the hot fruit punch emblematic of the holidays. It is also used to adorn "Day of the Dead" altars; in Christmas piñatas; for making jams, jellies and fruit cheese; for candying; and it is peeled and preserved in heavy syrup (20).

Although tejocote was introduced to California by the late 19th Century, it was not cultivated in the United States until recently, and smuggled and backyard fruit sold for very high prices, typically $8 to $10 a pound retail. Tejocote smuggled from Mexico was the fruit most seized by the U.S. Department of Agriculture's Smuggling, Interdiction and Trade Compliance branch from 2002 to 2006, according to a publication of the Department's Economic Research Service (6). Such smuggled fruit presented a serious risk of introducing exotic pests and diseases to the United States.



Fig. 2. Tejocote on the tree at Serrato Farms, Pauma Valley, California. 5 November, 2009. © David Karp.

Jaime Serrato, a grove manager and exotic fruit grower in San Diego County, Calif., saw an opportunity and established a commercial planting on 15 hectares, starting in about 2000 with cuttings from a backyard tree. He planted a large-fruited, thornless cultivar, which appears to be 'Pecoso de Huejotzingo' ("Freckled of Huejotzingo"), the most common cultivar in Puebla. His orchard has flourished and borne heavy crops, which he has sold through distributors to Latino chain stores at high prices, $3 to $4 a pound (or $1.5 to $2 a kg). Other growers have noted his success and have planted tejocote orchards of their own, on about 6 to 8 hectares in total. Importantly for United States farmers, tejocote smuggling has declined in recent years, since demand for the fruit is being satisfied through legal channels (15).

There are many challenges for aspiring growers. Tejocote trees are susceptible to fire blight, and the fruits to sunburn. Tejocote fruits ripen from October to December in Southern California, but the main demand is during the extended Christmas season, from the Day of Guadalupe to Epiphany, so growers have to store the fruit for as long as three months, during which they are subject to decay. So far, elite Mexican cultivars have not been widely available to United States nurseries and consequently growers have, in some cases, planted less desirable thorny trees bearing smaller fruits. In addition, Mexico has applied to the USDA to export tejocote to the United States, and USDA APHIS is conducting a pest risk assessment (15, 22). If importation of the fruit is allowed, this would probably lower the price the fruit commands in the United States.

Quince edible fresh *(Cydonia oblonga)*

A somewhat less esoteric pome fruit, quince *(Cydonia oblonga*), is cultivated on about 120 hectares in California, mostly in the San Joaquin Valley. In the United States it is used almost exclusively as a culinary fruit, for preserves, compotes, condiments and stews. As a fresh fruit it is typically so hard, sour and astringent that in Turkey, the world's largest producer, "to eat the quince" is slang meaning "to get into serious trouble" (16).

Since the days of the Roman naturalist Pliny the Elder, anecdotal reports have described dessert varieties of quince that are delicious to eat fresh. In Western Turkey, near to the presumed center of origin for quince, dessert as well as culinary varieties of quince were described in 1972 (29), but these have not been grown in the Unites States. The leading cultivar grown in California, 'Pineapple', does become more tender a month after the end of its season in the San Joaquin Valley, in November, but even then the flesh is still somewhat too woody to be enjoyed fresh.

It is now evident that at least one fresh-quality genotype does exist in the United States, and is present in the National Clonal Germplasm Repository in Corvallis, Ore., where it was originally called 'Karp's Sweet' (the author was involved in its donation) (30) (Fig. 3). It is now more properly named 'Majes Valley', since cuttings of this cultivar were introduced from this valley in southern Peru, near Ariquipa, to Simi Valley, Calif., c. 1990. In its homeland, where it is a common backyard tree, it is known as "*membrillo manzano*" ("apple quince"), both because of its shape and because it is tender enough to be eaten fresh, like an apple.



Fig. 3. Peruvian apple quince ("membrillo manzano," aka 'Karp's Sweet' quince) grown by Edgar Valdivia at his garden in Simi Valley, California, is more tender, juicy and sweet than standard varieities, and is eminently edible as a dessert fruit. 30 August, 2001. © David Karp.

Small to medium in size for a quince, it is round, with pronounced ribbing, light pubescence, and a typical quince aroma. Compared to other quince, its flesh texture is fine, juicy, and tender, so that it can easily be cut by a knife, or sheared by teeth. The flesh does not brown when cut, and it is non-astringent, with a good balance of sweetness and acidity, so that it can be eaten fresh with pleasure. The harvest season falls in late August and September in Simi Valley, in inland Ventura County (16).

Quince has enjoyed a modest revival in public attention in recent years, as part of a renewed appreciation for traditional fruits, but sales of such exclusively culinary fruits are likely to remain limited. A fresh-market quince would appeal because of its novelty, and it would allow non-cooks to experience the distinctive, intense flavor of this fruit. Many Hispanic-Americans have a taste for quince, and try to eat fresh the commercial varieties grown here; they would very much appreciate and provide ready demand for a variety that is truly edible when fresh.

So far the 'Majes Valley' quince has mostly been grown in backyards by rare fruit enthusiasts, but several farmers' market growers have planted about half a hectare of trees in total. Challenges include susceptibility to sunburn, codling moth, and fire blight. It is unclear how well suited the fruit would be to standard cooking techniques. The variety requires warm summer temperatures to mellow in flavor and soften in texture; in the cooler climate of Corvallis, it might better be called 'Karp's Sour' rather than 'Karp's Sweet', quipped the quince curator, Joseph Postman (24).

However, the National Clonal Germplasm

Repository has 82 accession of *Cydonia oblonga*, many of which have only recently been imported, primarily from Western and Central Asia (25), and some of which are reputed to be sweet enough for fresh eating (31). If the experience of 'Majes Valley' holds true, it is likely that this potentially valuable characteristic will only manifest itself in a warmer climate; a trial planting of these recently imported cultivars in the San Joaquin Valley, where the domestic quince industry is based, might very well turn up other promising candidates for commercialization.

Goji *(Lycium barbarum)*

One of several species of *Lycium* native to China, *L. barbarum* is called *gou-qi* in Mandarin, which has been translated as wolfberry, and anglicized as goji. Commercial cultivation was promoted starting in 1987 by government-backed company projects (12), and greatly expanded in recent years, as scientists discovered that the fruit is rich in nutrients and antioxidants, and marketers started claiming that it combats aging, boosts the immune system, prevents cancer and improves vision. The largest and most renowned production district for medicinal goji, with 70,000 hectares, is Ningxia Hui, a small autonomous region in north-central China, south of Inner Mongolia. The very small, orange-red berries, which have a mild, sweet, somewhat tomato-like flavor, with vegetal, rose and red pepper notes, are generally dried or juiced. Because the fresh berries are quite perishable, only modest quantities are sold fresh locally (8, 17) (Fig. 4).

To take advantage of a wide and growing interest in exotic "superfruits" perceived to have special health benefits (e.g., mangosteen, acai, and seabuckthorn), in the past decade United States marketers have promoted dried goji and goji juice, which have become trendy and sell at relatively high prices. The success of these products has carried over into attempts by nurseries to promote the sales and cultivation of goji bushes. Most have planted bushes derived from seedlings, but these are much less productive than the best Chinese cultivars, which need to be grown from cuttings to come true, and have only recently become available. The owners of One Green Nursery in Oregon traveled to Ningxia in 2005 and returned with the leading cultivar, 'Ning-qi No. 1', which they are selling as 'Crimson Star' (17).



Fig. 4. Goji berries grown by Charles Garrigus in Selma, and sold by Harry Nicholas at the Beverly Hills farmers market, 25 July, 2010. © David Karp.

In the past five years there have been at least a dozen attempts to grow goji commercially in the United States and Canada (several of them in California), on a total of at least 10 hectares. There has been a steep learning curve, however, and many growers have already stopped raising goji. The brightly colored berries are highly attractive to birds, and growers have quickly found that they need to protect their plantings with netting. In warm and humid areas, the plants have died or failed to thrive.

It remains unclear which areas of the United States or Canada might be best suited to goji cultivation. Cultivars originating in Ningxia would most likely be best adapted to areas with a similarly hot, dry summer, cold winters, strong solar radiation, and a high diurnal range in temperature. It seems likely that parts of the intermountain West, such as Idaho, Nevada and Utah, might be suitable, at sites that have access to water for irrigation (27). Some growers have deliberately planted seedlings, hoping to find selections adapted to their area.

Breeders in China have collected goji material from many areas of the country, so it might eventually be possible to grow goji in warmer and more humid climates.

Goji appeals to health-conscious buyers, who might well prefer domestically grown products to those imported from China, where pesticide usage and sanitation are less strictly regulated. The problem for domestic growers aiming at the processed market, however, is that the tiny fruits must be hand harvested continually throughout the season, so labor costs are prohibitive. If new cultivars could be bred in which the fruits mature at the same time and abscise readily when shaken, mechanized harvest might be possible, but breeders in China have just started looking into this possibility (9).

USDA restrictions do not allow the importation of fresh goji. One grower in Selma, Calif., near Fresno, tried selling the fruit to supermarkets, but his experience was unsuccessful (18). Even when the berries are cooled directly after harvest, their postharvest life is just a few days, at least for the genotypes currently available here, making it difficult for them to arrive at distant markets in salable condition. The best prospects for fresh sale may be at local farmers' markets, farm stands and specialty groceries.

PNVA persimmon *(Diopyros kaki)*

Persimmons are grown on approximately 2,500 acres in California, primarily in the Central Valley and San Diego County (4). The great majority are pollination-constant, meaning that their flesh remains the same color whether they have seeds or not. Of these, most are 'Fuyu', 'Jiro' and related cultivars, which are non-astringent and eaten firm, or 'Hachiya', which is astringent until it softens. There is, however, a third class, the pollination variant, non-astringent (PVNA) type, which is astringent when unpollinated, but in which seeded fruits develop non-astringent, pigmented flesh, as alcohol exuding from the seeds causes the astringent tannins in the flesh to clump together and turn brown. Introduced by Japanese immigrants to California in the late 19th and early 20th Centuries, PVNA cultivars have been largely neglected until the past decade, but have since been slowly gaining favor among foodies, backyard and specialty growers, and nurseries, because of their unique appearance and rich, distinctive flavor (13) (Fig. 5).



Fig. 5. Maru persimmons at Otow Orchards, Granite Bay, California, 29 November, 2001. © David Karp.

The Japanese term for dark-fleshed cultivars is "goma," literally "sesame seed", though it usually means black sesame seed, which is easy to visualize in the speckling of the flesh. About half a dozen cultivars are available in California, including 'Tsurunoko', often marketed as 'Chocolate', which is small to medium and cylindrical, with orange-red skin, and dark brown flesh; 'Zengi Maru', which is small to medium and roundish, with dark cinnamon flesh, and a particularly rich, sweet flavor; and 'Hyakume', medium to large, slightly oblong, with buff-yellow to orange skin, and cinnamon flesh. PVNA cultivars generally are best eaten at an intermediate stage of ripeness at which the flesh has just started to soften, so that it is buttery and juicy, without being gelatinous like a ripe 'Hachiya'. If unpollinated, they can be artificially ripened using alcohol fumes, or one can wait for the fruit to soften (13).

The key to success in growing PVNA persimmons is proper pollination, since if only one or two seeds form, the seeded portion of

the fruit will be brown and delicious, while the unseeded part will be inedibly puckery. For instance, 'Tsurunoko' serves as a pollenizer for 'California Maru', 'Hyakume', and 'Zenji Maru' (27). For commercial sales, however, unpredictability is the kiss of death, so PVNA cultivars have so far been planted on less than 10 hectares in California by specialty growers, who find that the fruit brings a premium over common cultivars.

To help foster the cultivation of this unique class of persimmons, it would be helpful to determine the identities of the cultivars sold at nurseries, using molecular markers; to systematically study their pollination and postharvest requirements; and to acquire some of the more recently developed PVNA cultivars from Asia.

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