Prunus domestica

Scientific Name

Prunus domestica L.

Synonyms

Prunus communis Hudson, *Prunus domestica* Rouy & Camus, *Prunus domestica* subsp. *oeconomica* (Borkhausen) C. K. Schneider, *Prunus domestica* var. *damascena* Linnaeus, *Prunus sativa* L. subsp. *domestica* Rouy & Camus, *Prunus* sativa Rouy & Camus subsp. *domestica* (Linnaeus) Rouy & E. G. Camus.

Family

Rosaceae

Common/English Names

Common Plum, European Plum, Gage, Garden Plum, Plum, Prune, Prune Plum.

Vernacular Names

Afrikaans: Pruim;
Arabic: Barqûq, Iggâss;
Armenian: Salor;
Basque: Aran;
Brazil: Ameixa-Comum, Ameixa-Européia, Ameixa-Preta, Ameixa-Roxa, Ameixa-Vermela;
Bosnian: Šljiva;
Catalan: Pruna;
Chinese: Ou Zhou Li, Li Zi, Mei Zi;
Croatian: Šljiva;
Czech: Sliva;
Danish: Blomme;
Dutch: Pruim, Pruimenboom;
Eastonian: Aedploomipuu, Harilik Ploomipuu, Ploom, Ploomipuu;
Esperanto: Pruno;
Finnish: Luumu, Luumupuu;
French: Prunier, Prunier Commun, Prunier Domestique, Prunier Cultivé;
German: Bauernpflaume, Echte Pflaume, Hauspflaume, Kultur-Pflaume, Pflaume, Pflaumenbaum, Zwetsche, Zwetschge, Zwispeln;
Greek: Damáskino;
Hebrew: Shazif;
Hungarian: Kerti Szilva, Szilva;
Icelandic: Plóma;
Italian: Prugna, Pruno, Prugno, Susina, Susino;
India: Alu Bukhara (Hindu), Arukam (Malayalam), Heikha (Manipuri), Alpagodapandu (Telugu), Aalu Bukhara (Urdu);
Indonesia: Plum;
Japanese: Seiyou Sumomo, Seiyou Sumomo, Puramu, Yooroppa Sumomo;
Latvian: Plūme;
Malaysia: Plum;
Nepalese: Aalu Bakharaa, Alu Bakhara;
Persian: Aalu;

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Polish: Shliwa Domowa, Šliwa Domowa, Śliwka;
Portuguese: Abrunheiro, Abrunheiro-Manso, Abrunho, Agruñeiro, Ameixa, Ameixeira, Ameixoeira;
Roman: Šljiva;
Russian: Sliva Domašnaja;
Scots: Ploum;
Serbian: Šljiva;
Slovakian: Bystrické Slivky, Slivka, Slivky;
Slovenian: Češplja, Cheshplja, Sliva;
Spanish: Ciruela, Ciruelo, Pruna, Prunero, Pruno;
Swedish: Plommon;
Thai:
Turkish: Erik;
Vietnamese: (Quả) Mận, (Trái) Mận;
West Frisian: Prom;
Zulu: Umplaamuzi.

Origin/Distribution

Prunus domestica is believed to have originated in the area of the Caucusus and Asia Minor. First findings of primitive cultivars were reported to occur in Central Europe about 500 BC, probably known already by the Celtic and Teutonic tribes. Subsequently the fruit was distributed to countries in central Europe by the Romans. It is probable that high quality cultivars originated from southeast Europe after the Middle Ages, and distributed throughout Europe by the seventeenth century. Plum is now cultivated globally in temperate to warm-temperate regions, predominantly in Central, S and SE Europe, further on in N Africa, W Asia, India and North America, Australia, New Zealand, South Africa and in south America.

Prunus domestica, the domestic European plum, is a hexaploid species. Its origin is still doubtful. It is thought to have originated from natural amphiploid crosses of two wild species, the sloe plum, *Prunus spinosa* (4n)*,* and the cherry plum, *Prunus cerasifera* (2n). Another hypothesis is that the species arose from selections of hexaploid accessions from the gene-pool of *P. cerasifera.*

Agroecology

Plums are robust, vigorous trees that thrive in areas with cold winters, short springs and a long warm summer for optimum productivity. Plum like other *Prunu*s species has a winter chill requirement or vernalization to break dormancy. "Chill hours" or "chill units" refers to the hours of temperature below 7.2°C and above 0°C that occur while the tree is dormant. The trees require a certain number of chill hours for buds to break in a timely manner and start the growing season that follows the winter cold period. Depending on the cultivars and localities the chill hour requirements ranges from 250 to 500 chill hours. Frosts do not generally harm a plum tree during the winter period but frosts over flowering during spring can devastate a crop. Both the flowers and young fruit are susceptible to this frost and can all be killed if temperatures dip below 0°C. Traditional frost control measures such as smoke pots have been surpassed by over-head sprinkler frost fighting, propylene tarp or other cover material and now in some cases wind machines. Electric heat sources such as light bulbs can also be used.

Plums prefer a sunny well-drained, fertile soil. A well-drained, sandy loam is ideal and establishment on hilltops or slopes with good air circulation for spring frost protection is most preferable. Planting on gentle slope can cause the frosts to be less severe during the sensitive flowering period in the spring. They are slightly more tolerant of damp conditions than apricots but abhor water-logged conditions. Clay loams are tolerated as long as drainage is good. Sandy soils are also suitable especially if they are grafted on nematode resistant rootstock.

Rainfall by itself does not tend to harm plum trees but it does raise humidity and increase the incidences of fungal and bacterial diseases such as spot and blast during flushing, flowering and fruit development. During periods of dry weather plums will benefit from irrigation, especially before harvest as it allows the fruit to fill up.

Plate 1 Plum flowers in fascicles

The recommended growing degree day (GDD) value for plums is similar to that for peaches, nectarines and apricots and is at least 800 GDD at a base of 10°C, although a few cultivars are able to successfully fruit in regions with only 600 GDDs. GDD is calculated by taking the average of the daily high and low temperature each day compared to a baseline winter low (usually 10°C). As an equation; GDD = ((High + Low)/2)-Baseline. GDDs are typically measured from the winter low.

Edible Plant Parts and Uses

Ripe, plum fruit is sweet and juicy and it can be eaten fresh or made into jams, preserves, pastry, plum dumplings, and other foods. Plum juice can be fermented into plum wine; when distilled, this produces a brandy known in Serbia as *Slivovitz*, in Romania *as Tzuica*, in Hungary as *Palink*a and *rakia* or *rakija* in Albania, Bosnia, Croatia and Serbia. Acid plums are used for cooking. Dried plums are also known as prunes. Prunes are also sweet and juicy and are also rich antioxidant polyphenols. Prune juice is also a popular drink and is beneficial to health. Various flavours of dried plum are available at Chinese grocers and specialty stores worldwide such as salty plums, spicy, liquorice and ginseng flavoured dried plums. Such Asian store also sell pickled plums. Prune kernel oil is made from the fleshy seed kernel inside the pit. Plum flowers are also edible. They are used as garnish for salads and ice-cream or brewed into a tea plum-jam and dried prunes.

Botany

A small, branched, deciduous tree, 4–15 m high with reddish-brown, glabrous branches, unarmed or armed with few spines and reddish-brown to greyish-green, pubescent branchlets. Winter buds are reddish-brown and glabrous. Stipules linear and glandular and petioles densely pubescent, 1–2 cm long. Leaves are alternate, deep green, elliptic to obovate, 4–10 × 2.5–5 cm, pubescent below, glabrous above, margins serrulate, apex acute to obtuse, base cuneate with a pair of nectaries, and with 5–7 pairs of lateral veins (Plates 3, 5, and 9). Flowers are solitary or in fascicles of 3 at the tip of branchlets, pedicellate (10–12 mm), 10–15 mm across (Plates 1 and 2). Hypanthium is pubescent; sepals 5, ovate with acute apex, imbricate; petals 5, white or greenish-white, obovate, apex rounded to obtuse, imbricate, on rim of hypanthium; stamens 20–30, in 2 whorls; filaments unequal; carpel 1; ovary superior, 1-loculed, glabrous or sometimes villous; style terminal, elongated. Drupe red, purple, purple-black, green, yellow or golden yellow, usually

Plate 2 Close-up of plum flowers

Plate 3 Developing common garden plum fruits and leaves

Plate 4 Ripening common garden plums with wax bloom

globose to oblong, rarely subglobose, 3–6 cm in diameter often glaucous with a whitish bloom (Plates 3, 4, 5, 6, 7, 8, and 9); mesocarp fleshy, not splitting when ripe, endocarp broadly ellipsoid, laterally compressed, pitted.

Nutritive/Medicinal Properties

Food value of raw, plum fruit (refuse 6% pit) per 100 g edible portion was reported as follows (USDA 2011): water 87.23 g, energy 46 kcal (192 kJ), protein 0.70 g, total lipid (fat) 0.28 g, ash 0.37 g, carbohydrate 11.42 g; fibre (total dietary) 1.4 g, total sugars 9.92 g, sucrose 1.57 g, glucose 5.07 g, fructose 3.07 g, maltose 0.08 g, galactose 0.14 g; calcium 6 mg, iron 0.17 mg, magnesium 7 mg, phosphorus 16 mg, potassium 157 mg, sodium 0 mg, zinc 0.10 mg, copper 0.057 mg, manganese 0.052 mg, fluoride 2 μg, vitamin C (total ascorbic acid) 9.5 mg, thiamine 0.028 mg, riboflavin 0.026 mg, niacin 0.417 mg, pantothenic acid 0.135 mg, vitamin B-6 0.029 mg, folate (total) 5 μg, total choline 1.9 mg, vitamin A 345 IU (17 μg RAE), vitamin E (α-tocopherol) 0.26 mg, γ-tocopherol 0.08 mg, vitamin K (phylloquinone) 6.4 μg, total saturated fatty acids 0.017 g, 16:0 (palmitic acid) 0.014 g, 18:0 (stearic

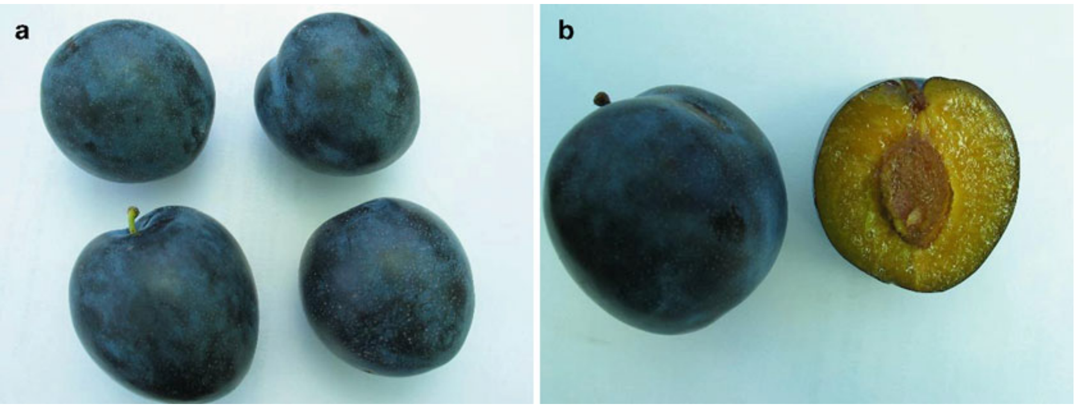

Plate 5 (**a**) Whole black plum (**b**) Halved black plum with sweet-yellow flesh

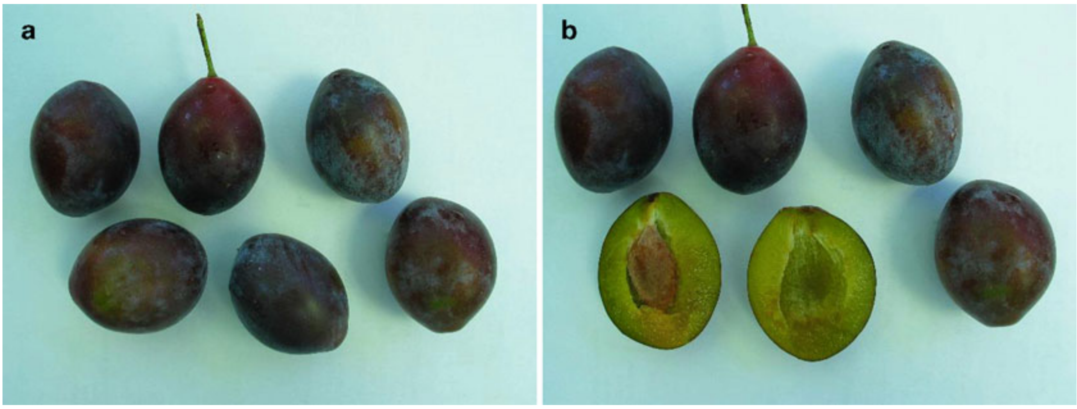

Plate 6 (**a**) Whole Stanley prune plum and (**b**) Halved Stanley Prune plum with sweet greenish-yellow flesh

Plate 7 Golden plum with sweet orangey-yellow flesh

Plate 8 Teagan blue plum with sweet, golden-yellow flesh

Plate 9 Green gage plum

acid) 0.003 g; total monounsaturated fatty acids 0.134 g, 16:1 undifferentiated (palmitoleic acid) 0.002 g, 18:1 undifferentiated (oleic acid) 0.132 g; total polyunsaturated fatty acids 0.044 g, 18:2 undifferentiated (linoleic acid) 0.044 g, phytosterols 7 mg, β-carotene 190 μg, β-cryptoxanthin 35 μg, lutein+zeaxanthin 73 μg; tryptophan 0.009 g, threonine 0.010 g, isoleucine 0.014 g, leucine 0.015 g, lysine 0.016 g, methionine 0.008 g, cystine 0.002 g, phenylalanine 0.014 g, tyrosine 0.008 g, valine 0.016 g, arginine 0.009 g, histidine 0.009 g, alanine 0.028 g, aspartic acid 0.352 g, glutamic acid 0.035 g, glycine 0.009 g, proline 0.027 g and serine 0.023 g.

In plums, the anthocyanin content increased with the red colour intensity (Vizzotto et al. 2006). Red/purple-flesh plums generally had higher phenolic content (400–500 mg chlorogenic acid/100 g fw) than the other plums. Carotenoid content in plums was similar for all varieties. AOA (antioxidant activity) tended to be higher in red/purple-flesh varieties as compared to light colored flesh plums. The best correlations were between the AOA and the total phenolics content of the fruit. The phenolic compounds hydroxycinnamates, procyanidins, flavonols, and anthocyanins were detected and quantified in red plum cultivars (Tomás-Barberán et al. 2001). As a general rule, the peel tissues contained higher amounts of phenolics, and anthocyanins and flavonols were almost exclusively located in this tissue. There was no clear trend in phenolic content with ripening of the different cultivars. The plum cultivars Black Beaut and Angeleno were especially rich in phenolics.

From the heartwood of *Prunus domestica* the following components have been isolated: (i) a new dihydroflavonol, 5,7-dihydroxy-4′-methoxy dihydroflavonol (dihydrokaempferide), (ii) a new flavonol prudomestin whose constitution is established as 5,7-dihydroxy-8,4′-dimethoxyflavonol, (iii) kaempferol (Nagarajan and Seshadri 1964). Besides these, a second dihydroflavonol and a leucoanthocyanidin were also isolated.

Prunes are good source of energy in the form of simple sugars, but do not mediate a rapid rise in blood sugar concentration, possibly because of high fibre, fructose, and sorbitol content (Stacewicz-Sapuntzakis et al. 2001). Prunes were found to contain large amounts of phenolic compounds (184 mg/100 g), mainly as neochlorogenic and chlorogenic acids, which may aid in the laxative action and delay glucose absorption. Phenolic compounds in prunes had been found to inhibit human LDL oxidation in-vitro, and thus might serve as preventive agents against chronic diseases, such as heart disease and cancer. Additionally, high potassium content of prunes (745 mg/100 g) might be beneficial for cardiovascular health.

Plums and prunes are rich in phenolic compounds and potent antioxidant property which endowed it with many pharmacological functions that include anticancer, laxative, anti-osteoporosis, antidiabetic, antihypercholesterolemic, anxiolytic, antimicrobial and mitigating cognitive deficit mitigating activities.

Antioxidant Activity

Fruit and vegetables rich in anthocyanins (e.g. strawberry, raspberry and red plum) demonstrated the highest antioxidant activities, followed by those rich in flavanones (e.g. orange and grapefruit) and flavonols (e.g. onion, leek, spinach and green cabbage), while the hydroxycinnamate-rich fruit (e.g. apple, tomato, pear and peach) consistently elicited the lower antioxidant activities (Proteggente et al. 2002). The TEAC (Trolox Equivalent Antioxidant Capacity), the FRAP (Ferric Reducing Ability of Plasma) and ORAC (Oxygen Radical Absorbance Capacity) values for each extract were relatively similar and well-correlated with the total phenolic and vitamin C contents. The TEAC antioxidant activities in terms of 100 g FW uncooked portion size were in the order: strawberry>>raspberry=red plum>>red cabbage >>>grapefruit=orange>spinach>broccoli>green grape approximately/= onion>green cabbage>pea>apple>cauliflower tomato approximately/= peach=leek>banana approximately/= lettuce.

The anthocyanin content of plums ranged from 44.1 to 231.29 mg cyanidin 3-glucoside/100 g fresh tissue (Cevallos-Casals et al. 2002). The total phenolic content ranged from 298 to 563 mg chlorogenic acid/100 g fresh tissue. The antioxidant activity ranged from 1,254 to 3,244 μg Trolox equivalent /g fresh tissue for the plums. Correlation analysis indicated that the anthocyanin content and phenolic content was well correlated with the anti-oxidant activity. Plum extracts showed good antimicrobial activity and some potential as a colourant.

The total phenolic contents of various plum cultivars widely varied from 125.0 to 372.6 mg/100 g expressed as gallic acid equivalents (Kim et al. 2003). The level of total flavonoids in fresh plums ranged between 64.8 and 257.5 mg/100 g expressed as catechin equivalents. Antioxidant capacity, expressed as vitamin C equivalent antioxidant capacity (VCEAC), ranged from 204.9 to 567.0 mg/100 g with an average of 290.9 mg/100 g of fresh weight. Cv. Beltsville Elite B70197 showed the highest amounts of total phenolics and total flavonoids and the highest VCEAC. A positive relationship (correlation coefficient $R^2=0.977$) was presented between total phenolics and VCEAC, suggesting polyphenolics would play an important role in free radical scavenging. The level of IC_{50} value of superoxide radical anion scavenging activity of the plum cultivars ranged from 13.4 to 45.7 mg of VCEAC/100 g. Neochlorogenic acid was the predominant polyphenolic among fresh plums tested. Flavonols found in plum were commonly quercetin derivatives. Rutin was the most predominant flavonol in plums. Various anthocyanins containing cyanidin aglycon and peonidin aglycon were commonly found in all plums except for cv. Mirabellier and NY 101. Further the scientists reported that the superoxide radical scavenging activity (SRSA) levels of the polyphenols were closely related to their chemical structures; cyanidin showed the lowest IC_{50} among the polyphenols examined, and aglycones are more effective than their glycosides (Chun et al. 2003a). BY 69–339 cultivar exhibited the lowest IC_{50} among the 11 plum cultivars, which means the highest antioxidant activity in scavenging superoxide radicals, followed by French Damson, Cacaks Best, Beltsville Elite B70197, Empress, Castleton, Stanley, NY 6, NY 101, Mirabellier, and NY 9. IC_{50} values showed a higher correlation with total flavonoids ($R^2=0.8699$) than total phenolics ($R^2=0.8355$), which indicated that flavonoids might contribute to the total SRSA more directly than other polyphenols. Anthocyanins in plums appeared to be the major contributors to the total SRSA, except for two yellow cultivars having no anthocyanins. Chlorogenic acid was the predominant phenolic acid, and it also exhibited SRSA significantly in the range of 1.0–94.9%. Quercetins were the major flavonols in plums. However, they showed relatively low contribution to the total SRSA. The scientists also found a good linear relationship between the amount of total phenolics and total antioxidant capacity ($R^2=0.9887$) (Chun et al. 2003b). The amount of total flavonoids and total antioxidant capacity also showed a good correlation ($R^2=0.9653$). Although the summation of individual antioxidant capacity was lower than the total antioxidant capacity of plum samples, there was a positive correlation ($R^2=0.9299$) of total antioxidant capacity of plum samples with the sum of the vitamin C equivalent antioxidant capacity (VCEAC) s calculated from individual phenolics. Chlorogenic acids and glycosides of cyanidin, peonidin, and quercetin were major phenolics among 11 plum cultivars. The antioxidant capacity of chlorogenic acids and anthocyanins showed higher correlation (R^2) of 0.7751 and 0.6616 to total VCEAC, respectively, than that of quercetin glycosides ($R^2=0.0279$). Chlorogenic acids were a major source of antioxidant activity in plums, and the consumption of one serving (100 g) of plums can provide antioxidants equivalent to 144.4–889.6 mg of vitamin C.

In recent studies, the 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and cellular tests revealed that the total antioxidant capacities, expressed as vitamin C equivalents, ranged from 691.2 to 2,164.64 mg and from 613.98 to 2,137.59 mg per 100 g of fresh weight, respectively, suggesting plums to be rich in natural antioxidants and appreciably protect granulocytes from oxidative stress (Bouayed et al. 2009). The results showed a linear correlation between either total phenolic or flavonoid contents and total antioxidant capacity, revealing that these compounds contributed significantly to the antioxidant activity of plums. The results also suggested that individual polyphenolics contributed directly to the total protective effect of plums.

Neochlorogenic acid was found to be the most important phenolic acid in all the Norwegian plum cultivars studies (Slimestad et al. 2009). Together with other phenolic acids, this compound varied significantly in amount among the cultivars. Cyanidin 3-rutinoside was found to account for >60% of the total anthocyanin content. Minor amounts of flavonols (rutin and quercetin 3-glucoside) were detected in all cultivars. Total antioxidant capacity varied from 814 to 290 μmol of Trolox 100/g of fresh weight.

Thiolysis of the phenolic compounds showed that the flesh and skin contained a large proportion of flavan-3-ols, which account, respectively, for 92% and 85% in ‘Golden Japan’ (GJ), 61% and 44% in ‘Green Gage’ (GG-V), 62% and 48% in ‘Green Gage’ (GG-C), 54% and 27% in ‘Mirabelle’ (M) and 45% and 37% in ‘Green Gage’ (GG-F) (Nunes et al. 2008). Terminal units of procyanidins observed in plums were mainly (+)-catechin (54–77% of all terminal units in flesh and 57–81% in skin). The GJ plums showed a phenolic composition different from all of the others, with a lower content of chlorogenic acid isomers and the presence of A-type procyanidins as dimers and terminal residues of polymerized forms. The average degree of polymerization (DPn) of plum procyanidins was higher in the flesh (5–9 units) than in the skin (4–6 units). Procyanidin B7 was observed in the flesh of all ‘Green Gage’ plums and in the skin of the Portuguese ones “Rainha Claudia Verde”.

Studies show that prunes and prune juice may provide a source of dietary antioxidants (Donovan et al. 1998).The mean concentrations of phenolics were 1,840 mg/kg, 1,397 mg/kg, and 441 mg/L in pitted prunes, extra large prunes with pits, and prune juice, respectively Hydroxycinnamates, especially neochlorogenic acid, and chlorogenic acid predominated, and these compounds, as well as the prune and prune juice extracts, inhibited the oxidation of low-density lipoprotein (LDL). The pitted prune extract inhibited LDL oxidation by 24, 82, and 98% at 5, 10, and 20 μM gallic acid equivalents (GAE). The prune juice extract inhibited LDL oxidation by 3, 62, and 97% at 5, 10, and 20 μM GAE.

Prune were found to contain neochlorogenic acid, cryptochlorogenic acid and chlorogenic acid in the ratio 78.7:18.4:3.9, respectively (Nakatani et al. 2000). Each chlorogenic isomer showed antioxidative activities which were almost the same as evaluated by scavenging activity on superoxide anion radicals and inhibitory effect against oxidation of methyl linoleate. Furthermore, hydrolysis of EtOH extract residue led to higher levels of total phenolics and ORAC, and these results suggested the existence of conjugated antioxidant components in prunes.

The methanol eluate exhibited the strongest antioxidant activity among the separated fractions of prune extract evaluated by oxygen radical absorbance capacity (ORAC) (Kayano et al. 2002). Further purification of the MeOH eluate led to isolation of a novel compound, 4-amino-4-carboxychroman-2-one, together with four known compounds (p-coumaric acid, vanillic acid β-glucoside, protocatechuic acid, and caffeic acid), The ORAC values of these isolated compounds showed 0.15–1.43 units (μmol of Trolox equiv)/μmol, and the new compound showed a remarkable synergistic effect on caffeoylquinic acid isomers. The antioxidant activity of the MeOH eluate was highly dependent on the major prune components, caffeoylquinic acid isomers, with a contribution from the new synergist. Prunes showed high antioxidant activity on the basis of the oxygen radical absorbance capacity (ORAC), and their major antioxidant components were caffeoylquinic acid isomers (Kayano et al. 2003). A novel bipyrrole compound identified to be 2-(5-hydroxymethyl-2′,5′-dioxo-2′,3′,4′,5′-tetrahydro-1′H-1,3′-bipyrrole) carbaldehyde, and 7 phenolic compounds were isolated from prunes for the first time (Kayano et al. 2004a). The degree of contribution caffeoylquinic acid isomers to the ORAC was found to be 28.4%; the remaining ORAC is dependent on other antioxidant phenolic compounds. The contribution of caffeoylquinic acid (CQA) isomers to the antioxidant activity of prunes was revealed to be 28.4% on the basis of oxygen radical absorbance capacity (ORAC); hence, it was indicated that residual ORAC is dependent on unknown antioxidant components (Kayano et al. 2004b). Of the total 28 compounds isolated, four abscisic acid related compounds, a chromanon, and a bipyrrole were novel. Each CQA isomer in prunes showed high antioxidant activities when measured by the oil stability index (OSI) method, O^{2-} scavenging activity, and ORAC. Other isolated compounds such as hydroxycinnamic acids, benzoic acids, coumarins, lignans, and flavonoid also showed high ORAC values.

Four new abscisic acid related compounds (1–4), together with (+)-abscisic acid (5), (+)-β-D-glucopyranosyl abscisate (6), (6S,9R)-roseoside (7), and two lignan glucosides ((+)-pinoresinol mono-β-D-glucopyranoside (8) and 3-(β-D-glucopyranosyloxymethyl)-2- (4-hydroxy-3-methoxyphenyl)-5-(3-hydroxypropyl)-7-methoxy-(2R,3S)-dihydrobenzofuran (9)) were isolated from the antioxidative ethanol extract of prunes (*Prunus domestica*) (Kikuzaki et al. 2004). The structures of 1–4 were elucidated to be rel-5-(3S,8S-dihydroxy-1R,5S-dimethyl-7-oxa-6-oxobicyclo[3,2,1]oct-8-yl)-3-methyl-2Z,4E-pentadienoic acid (1), rel-5-(3S,8S-dihydroxy-1R,5S-dimethyl-7-oxa-6-oxobicyclo[3,2,1]oct-8-yl)-3-methyl-2Z,4E-pentadienoic acid 3′-O-β-d-glucopyranoside (2), rel-5-(1R,5S-dimethyl-3R,4R,8S-trihydroxy-7-oxa-6-oxobicyclo[3,2,1]oct-8-yl)-3-methyl-2Z,4E-pentadienoic acid (3), and rel-5-(1R,5S-dimethyl-3R,4R,8S-trihydroxy-7-oxabicyclo[3,2,1]- oct-8-yl)-3-methyl-2Z,4E-pentadienoic acid (4). The ORAC values of abscisic acid related compounds (1–7) were very low. Two lignans (8 and 9) were more effective antioxidants whose ORAC values were 1.09 and 2.33 μmol of Trolox equivalent/μmol, respectively. An antioxidative oligomeric proanthocyanidin from prunes composed of epicatechin and catechin units showed greater potency than chlorogenic acid another potent antioxidative component in prunes (Kimura et al. 2008).

Anxiolytic Activity

Chlorogenic acid, a polyphenol from *Prunus domestica* (Mirabelle), exhibited anxiolytic effects coupled with antioxidant activity (Bouayed et al. 2007). Chlorogenic acid (20 mg/kg) induced a decrease in anxiety-related behaviors suggesting an anxiolytic-like effect of this polyphenol. The anti-anxiety effect was blocked by flumazenil suggesting that anxiety was reduced by activation of the benzodiazepine receptor. In-vitro, chlorogenic acid protected granulocytes from oxidative stress.

Antiosteoporosis Activity

Osteoporosis is a common debilitating disorder that affects both female and male, albeit more so in women. Aside from existing drug therapies, certain lifestyle and nutritional factors are known to reduce the risk of osteoporosis. Dried prunes being an important source of boron, had been postulated to play a role in prevention of osteoporosis (Stacewicz-Sapuntzakis et al. 2001). A serving of prunes (100 g) would fulfill the daily requirement for boron (2–3 mg).

Among nutritional factors, recent studies suggested that dried plum, or prunes (*Prunus domestica*) was the most effective fruit in both preventing and reversing bone loss (Hooshmand and Arjmandi 2009). Animal studies and a 3-month clinical trial had shown that dried plum had positive effects on bone indices. The animal data indicated that dried plum not only protected against but more importantly reversed bone loss in two separate models of osteopenia. Initial animal study indicated that dried plum prevented the ovariectomy-induced reduction in bone mineral density (BMD) of the femur and lumbar vertebra (Arjmandi et al. 2002). In another study (Deyhim et al. 2005), found that dried plum as low as 5% (w/w) restored femoral and tibial BMD to the level of intact rats. Dried plum reversed the loss of trabecular architectural properties such as trabecular number and connectivity density, and trabecular separation in ovarietomized rats. Varying doses of dried plum were also able to significantly improve trabecular microarchitectural properties in comparison with ovariectomized controls. Analysis of BMD and trabecular bone structure by microcomputed tomography (microCT) revealed that dried plum enhanced bone recovery during reambulation following skeletal unloading and had comparable effects to parathyroid hormone. In addition to the animal studies, the 3-month clinical trial indicated that the consumption of dried plum daily by postmenopausal women significantly increased serum markers of bone formation, total alkaline phosphatase, bone-specific alkaline phosphatase and insulin-like growth factor-I by 12%, 6%, and 17%, respectively (Arjmandi et al. 2002). Higher levels of both serum IGF-I and BSAP were associated with greater rates of bone formation. Additional studies showed that dried plum prevented osteopenia in androgen deficient male rats, and these beneficial effects may be attributed in part to a decrease in osteoclastogenesis via down-regulation of receptor activator of NFκ-B ligand (RANKL) and osteoprotegerin and stimulation of bone formation mediated by serum insulin-like growth factor (IGF)-I (Franklin et al. 2006).

In a study involving 236 women with 1–10 years postmenopausal and not on hormone replacement therapy or any other prescribed medication, dried plum daily ingestion significantly increased bone mineral density of ulna and spine in comparison with dried apple when assessed at 12 months (Hooshmand et al. 2011). In comparison with corresponding baseline values, only dried plum significantly decreased serum levels of bone turnover markers including bone-specific alkaline phosphatase and tartrate-resistant acid phosphatase-5b. The findings of the study confirmed the ability of dried plum in improving bone mineral density in postmenopausal women in part due to suppressing the rate of bone turnover.

Anticancer Activity

Ethanol fraction from concentrated prune juice (PE) dose-dependently reduced the viable cell number of Caco-2, KATO III, but does not reduce the viable cell number of human normal colon fibroblast cells (CCD-18Co) used as a normal cell model (Takashi et al. 2006). PE treatment for 24 hours led to apoptotic changes in Caco-2 such as cell shrinkage and blebbed surfaces due to the convolutions of nuclear and plasma membranes and chromatin condensation, but this was not observed in CCD-18Co. PE induced nucleosomal DNA fragmentation typical of apoptosis in Caco-2 after 24 hours of treatment. These results show that PE induced apoptosis in Caco-2.

Laxative Effect

Because of their sweet flavor and well-known mild laxative effect, prunes are considered to be an epitome of functional foods. Dried prunes contain approximately 6.1 g of dietary fiber per 100 g, while prune juice is devoid of fiber due to filtration before bottling (Stacewicz-Sapuntzakis et al. 2001). The laxative action of both prune and prune juice could be explained by their high sorbitol content (14.7 and 6.1 g/100 g, respectively).

Antihypercholesterolemic Activity

Consumption of prunes as a source of dietary fiber in men with mild hypercholesterolemia was found to have beneficial effect (Tinker et al. 1991). Plasma low-density-lipoprotein cholesterol was significantly lower after the prune period (3.9 mmol/L) than after the grape-juice-control period (4.1 mmol/L). Faecal bile acid concentration of lithocholic acid was significantly lower after the prune period (0.95 mg bile acid/g dry weight stool) than after the grape-juice-control period (1.20 mg bile acid/g dry weight stool). Both fecal wet and dry weights were approximately 20% higher after the prune period than after the grape-juice-control period. Total bile acids (mg/72 h) did not significantly differ between experimental periods.

Antihypertensive Activity

In an 8-week placebo controlled clinical trial involving 259 pre-hypertensive volunteers, single dose of prune comprising prune juice and dried prune (*P. domestica*) daily caused a significant reduction in blood pressure (BP) (Ahmed et al. 2010a). With the double dose of prunes, only systolic BP was reduced significantly. Control group had significantly increased serum HDL whereas prune groups had significantly reduced serum cholesterol and LDL.

Hepatoprotective Activity

In an 8 week clinical trial involving 166 healthy volunteers, ingestion of prune juice and prune fruit (single or double dose) was found to have a beneficial effect in hepatic disease (Ahmed et al. 2010b) There was significant reduction of serum alanine transaminase and serum alkaline phosphatase by the lower dose of prunes. There was no change in serum aspartate transaminase and bilirubin.

Cognitive Activity

Studies showed that supplementation with *Prunus domestica* mitigated age-related deficits in cognitive function in rats (Shukitt-Hale et al. 2009). Rats that drank plum juice from 19 to 21 months of age had improved working memory in the Morris water maze, whereas rats fed dried plum powder were not different from the control group, possibly due to the smaller quantity of phenolics consumed in the powder group compared with the juice group.

Antimicrobial Activity

Prunusins A (1) and B (2), the new C-alkylated flavonoids, isolated from the seed kernels of *Prunus domestica* showed significant antifungal activity against pathogenic fungus *Trichophyton simmi* (Mahmood et al. 2010). 3, 5, 7, 4′-Tetrahydroxyflavone (3) and 3, 5, 7-trihydroxy-8, 4′-dimethoxyflavone (4) were also isolated.

Oil fractions, obtained from n-hexane extract *of Prunus domestica* shoots contained hentricontane (35.7%), ethyl hexadecanoate (21.7%) and linoleic acid (16.16%) (Mahmood et al. 2009). Bioassay screening of oil showed moderate antibacterial activity against *Salmonella* group (Gram +ve and −ve), moderate antifungal activity against *Microsporum canis* and good antioxidant activity by DPPH radical scavenging method.

Antidiabetic Activity

Purunusides A-C, new homoisoflavone glucosides together with the known compounds β-sitosterol and 6,7-methylenedioxy-8-methoxy coumarin were isolated from n-butanol and ethyl acetate soluble fractions of *Prunus domestica* (Kosar et al. 2009). The purunusides A-C showed potent inhibitory activity against the enzyme α-glucosidase. α-glucosidase inhibitors and acted as antidibaetic drugs, preventing digestion of carbohydrates in the digestive tract, thereby lowering the after-meal glucose levels.

Respiratory Toxin

Plum (*Prunus domestica*) seeds contain the cyanogenic diglucoside (R)-amygdalin and lesser amounts of the corresponding monoglucoside (R)-prunasin, which releases the respiratory toxin, hydrogen cyanide upon tissue disruption (Poulton and Li 1994).

Traditional Medicinal Uses

Dried plum fruit or prunes are used as laxative and also as stomachic. The seed contains amygdalin and prusin which break down in water to form hydrocyanic acid and prussic acid. Amydalin has been illegally used for treating cancer but has now been proven to be not effective for cancer (see *Prunus persica*). The bark is occasionally used as a febrifuge.

Other Uses

Green, dark grey and yellow dyes can be obtained from the leaves, fruit and bark respectively. The gum from the stem can be used as adhesive. Ground seeds are used in cosmetics in the production of face masks for dry skin. The wood can be used for making musical instruments.

Comments

Prunus domestica has a long history of cultivation. Three subspecies have been recognised, each with a host of horticultural varieties:

P. domestica ssp. *domestica* the common plums;

P. domestica ssp. *institia*, the damson, bullace or mirabelle

P. domestica ssp. *italica,* the greengage.

Selected References

Ahmed T, Sadia H, Batool S, Janjua A, Shuja F (2010a) Use of prunes as a control of hypertension. J Ayub Med Coll Abbottabad 22(1):28–31

Ahmed T, Sadia H, Khalid A, Batool S, Janjua A (2010b) Report: prunes and liver function: a clinical trial. Pak J Pharm Sci 23(4):463–466

Arjmandi BH, Khalil DA, Lucas EA, Georgis A, Stoecker BJ, Hardin C, Payton ME, Wild RA (2002) Dried plums improve indices of bone formation in postmenopausal women. J Womens Health Gend Based Med 11(1):61–68

Bouayed J, Rammal H, Dicko A, Younos C, Soulimani R (2007) Chlorogenic acid, a polyphenol from *Prunus domestica* (Mirabelle), with coupled anxiolytic and antioxidant effects. J Neurol Sci 262(1–2):77–84

Bouayed J, Rammal H, Dicko A, Younos C, Soulimani R (2009) The antioxidant effect of plums and polyphenolic compounds against H(2)O(2)-induced oxidative stress in mouse blood granulocytes. J Med Food 12(4):861–868

Bown D (1995) Encyclopaedia of herbs and their uses. Dorling Kindersley, London, 424pp

Byrne D, Vizzotto M, Cisneros-Zevallos L, Ramming DW, Okie WR (2004) Antioxidant content of peach and plum genotypes. HortScience 39(4):798

Cevallos-Casals BA, Byrne DH, Cisneros-Zevallos L, Okie WR (2002) Total phenolic and anthocyanin content in red-fleshed peaches and plums. Acta Hort (ISHS) 592:589–592

Chun OK, Kim DO, Lee CY (2003a) Superoxide radical scavenging activity of the major polyphenols in fresh plums. J Agric Food Chem 51(27):8067–8072

Chun OK, Kim DO, Moon HY, Kang HG, Lee CY (2003b) Contribution of individual polyphenolics to total antioxidant capacity of plums. J Agric Food Chem 51(25):7240–7245

Deyhim F, Stoecker BJ, Brusewitz GH, Devareddy L, Arjmandi BH (2005) Dried plum reverses bone loss in an osteopenic rat model of osteoporosis. Menopause 12(6):755–762

Donovan JL, Meyer AS, Waterhouse AL (1998) Phenolic composition and antioxidant activity of prunes and prune juice (*Prunus domestica)*. J Agric Food Chem 46(4):1247–1252

Facciola S (1990) Cornucopia. A source book of edible plants. Kampong Publication, Vista, 677pp

Franklin M, Bu SY, Lerner MR, Lancaster EA, Bellmer D, Marlow D, Lightfoot SA, Arjmandi BH, Brackett DJ, Lucas EA, Smith BJ (2006) Dried plum prevents bone loss in a male osteoporosis model via IGF-I and the RANK pathway. Bone 39(6):1331–1342

Gil MI, Tomás-Barberán FA, Hess-Pierce B, Kader AA (2002) Antioxidant capacities, phenolic compounds, carotenoids, and vitamin C contents of nectarine, peach, and plum cultivars from California. J Agric Food Chem 50(17):4976–4982

Grieve M (1971) A modern herbal, 2 vols. Penguin/Dover publications, New York, 919pp

Gu C, Bartholomew B (2003) *Prunus* Linnaeus. In: Wu ZY, Raven PH, Hong DY (eds) Flora of China, vol 9 (*Pittosporaceae* through *Connaraceae*). Science Press/Missouri Botanical Garden Press, Beijing/St. Louis

Hedrick UP (1972) Sturtevant's edible plants of the world. Dover Publications, New York, 686pp

Hooshmand S, Arjmandi BH (2009) Viewpoint: dried plum, an emerging functional food that may effectively improve bone health. Ageing Res Rev 8(2):122–127

Hooshmand S, Chai SC, Saadat RL, Payton ME, Brummel-Smith K, Arjmandi BH (2011) Comparative effects of dried plum and dried apple on bone in postmenopausal women. Br J Nutr 106(6):923–930

Kayano S, Kikuzaki H, Ikami T, Suzuki T, Mitani T, Nakatani N (2004a) A new bipyrrole and some phenolic constituents in prunes (*Prunus domestica* L.) and their oxygen radical absorbance capacity (ORAC). Biosci Biotechnol Biochem 68(4):942–944

Kayano S, Kikuzaki H, Yamada NF, Aoiki A, Kasamatsu K, Yamasaki Y, Ikami T, Suzuki T, Mitani T, Nakatani N (2004b) Antioxidant properties of prunes (*Prunus domestica* L.) and their constituents. Biofactors 21(1–4):309–313

Kayano S, Kikuzaki H, Yamada NF, Mitani T, Nakatani N (2002) Antioxidant activity of prune (*Prunus domestica* L.) constituents and a new synergist. J Agric Food Chem 50:3708–3712

Kayano S, Yamada NF, Suzuki T, Ikami T, Shioaki K, Kikuzaki H, Mitani T, Nakatani N (2003) Quantitative evaluation of antioxidant components in prunes (*Prunus domestica* L.). J Agric Food Chem 51(5):1480–1485

Kikuzaki H, Kayano S, Fukutsuka N, Aoki A, Kasamatsu K, Yamasaki Y, Mitani T, Nakatani N (2004) Abscisic acid related compounds and lignans in prunes (*Prunus domestica* L.) and their oxygen radical absorbance capacity (ORAC). J Agric Food Chem 52(2):344–349

Kim DO, Chun OK, Kim YJ, Moon HY, Lee CY (2003) Quantification of polyphenolics and their antioxidant capacity in fresh plums. J Agric Food Chem 51(22):6509–6515

Kimura Y, Ito H, Kawaji M, Ikami T, Hatano T (2008) Characterization and antioxidative properties of oligomeric proanthocyanidin from prunes, dried fruit of *Prunus domestica* L. Biosci Biotechnol Biochem 72(6):1615–1618

Kosar S, Fatima I, Mahmood A, Ahmed R, Malik A, Talib S, Chouhdary MI (2009) Purunusides A-C, alpha-glucosidase inhibitory homoisoflavone glucosides from *Prunus domestica*. Arch Pharm Res 32(12):1705–1710

Mahmood A, Ahmed R, Kosar S (2009) Phytochemical screening and biological activities of the oil components of *Prunus domestica* Linn. J Saudi Chem Soc 13(3):273–277

Mahmood A, Fatima I, Kosar S, Ahmed R, Malik A (2010) Structural determination of prunusins A and B, new C-alkylated flavonoids from *Prunus domestica*, by 1D and 2D NMR spectroscopy. Magn Reson Chem 48(2):151–154

McLaren GF, Glucina PG (1995) Prunes: prospects for a new fruit crop in New Zealand. Hortnet. http://www.hortnet.co.nz/publications/science/prune.htm

Nagarajan GR, Seshadri TR (1964) Flavonoid components of the heartwood of *Prunus domestica* Linn. Phytochemistry 3(4):477–484

Nakatani N, Kayano S, Kikuzaki H, Sumino K, Katagiri K, Mitani T (2000) Identification, quantitative determination, and antioxidative activities of chlorogenic acid isomers in prune (*Prunus domestica* L.). J Agric Food Chem 48:5512–5516

Nunes C, Guyot S, Marnet N, Barros AS, Saraiva JA, Renard CM, Coimbra MA (2008) Characterization of plum procyanidins by thiolytic depolymerization. J Agric Food Chem 56(13):5188–5196

Porcher MH et al (1995–2020) Searchable World Wide Web Multilingual Multiscript Plant Name Database. Published by The University of Melbourne, Australia. http://www.plantnames.unimelb.edu.au/Sorting/Frontpage.html

Poulton JE, Li CP (1994) Tissue level compartmentation of (R)-amygdalin and amygdalin hydrolase prevents large-scale cyanogenesis in undamaged *Prunus* seeds. Plant Physiol 104(1):29–35

Proteggente AR, Pannala AS, Paganga G, Van Buren L, Wagner E, Wiseman S, Van De Put F, Dacombe C, Rice-Evans CA (2002) The antioxidant activity of regularly consumed fruit and vegetables reflects their phenolic and vitamin C composition. Free Radic Res 36(2):217–233

Shukitt-Hale B, Kalt W, Carey AN, Vinqvist-Tymchuk M, McDonald J, Joseph JA (2009) Plum juice, but not dried plum powder, is effective in mitigating cognitive deficits in aged rats. Nutrition 25(5):567–573

Slimestad R, Vangdal E, Brede C (2009) Analysis of phenolic compounds in six Norwegian plum cultivars (*Prunus domestica* L.). J Agric Food Chem 57(23):11370–11375

Stacewicz-Sapuntzakis M, Bowen PE, Hussain EA, Damayanti-Wood BI, Farnsworth NR (2001) Chemical composition and potential health effects of prunes: a functional food? Crit Rev Food Sci Nutr 41(4):251–286

Takashi F, Takao I, Xu JW, Katsumi I (2006) Prune extract (*Prunus domestica* L.) suppresses the proliferation and induces the apoptosis of human colon carcinoma Caco-2. J Nutr Sci Vitaminol 52(5):389–391

Tinker LF, Schneeman BO, Davis PA, Gallaher DD, Waggoner CR (1991) Consumption of prunes as a source of dietary fiber in men with mild hypercholesterolemia. Am J Clin Nutr 53(5):1259–1265

Tomás-Barberán FA, Gil MI, Cremin P, Waterhouse AL, Hess-Pierce B, Kader AA (2001) HPLC-DAD-ESIMS analysis of phenolic compounds in nectarines, peaches, and plums. J Agric Food Chem 49(10):4748–4760

U.S. Department of Agriculture, Agricultural Research Service (2011) USDA National Nutrient Database for Standard Reference, Release 24. Nutrient Data Laboratory Home Page. http://www.ars.usda.gov/ba/bhnrc/ndl

Vizzotto M, Cisneros-Zevallos L, Byrne DH, Ramming DW, Okie WR (2006) Total phenolic, carotenoid, and anthocyanin content and antioxidant activity of peach and plum genotypes. Acta Hort 713:453–456