Rubus idaeus

Scientific Name

***Rubus idaeus* L.**

Synonyms

Batidea idaea (L.) Nieuwl., *Rubus idaeus* subsp. *vulgatus* Arrh.

Family

Rosaceae

Common/English Names

European Raspberry, European Red Raspberry, Nectar Raspberry, Raspberry, Raspberry Bush, Red Raspberry.

Vernacular Names

Aragonese: Chordón;
Arabic: Tût El 'Ullayq;
Brasil: Framboesa (Portuguese);
Bulgarian: Malína;
Catalan: Gerd;
Chinese: Fu Pen Zi, Shan Mei;
Czech: Malina, Maliník Obecný, Ostružiník Maliník;
Danish: Almindelig Hindbær, Hindbær, Hindbærbusk;
Dutch: Framboos, Frambozenstruik;
Eastonian: Harilik Vaarikas;
Esperanto: Frambo;
Finnish: Vaapukka, Vadelma, Vattu;
French: Framboise (Fruit), Framboisier (Plant), Ronce De L'ida;
German: Himbeere, Himbeerstrauch (Plant);
Greek: Smeura; Zmeouriá (Plant), Zméouro, Vatomura Vatomouriá (Plant), Vatómouro;
Haitian: Franbwaz;
Hebrew: Petel Adom;
Hungarian: Málna;
India: Rasabharii (Hindu), Gauriphal (Sanskrit);
Italian: Amponello, Lampone, Lampone Rosso, Malina, Rovo Ideo;
Japanese: Ki Ichigo, Razuberii, Reddo Razuberii, Yezo Ichigo;
Korean: Na Mu Ddal Gi;
Lithuanian: Paprastoji Avietė;
Mexico: Frutilla De La India (Spanish);
Norwegian: Bringebær;
Portuguese: Framboesa Comum (Fruit), Framboeseiro Comum (Plant);
Romanian: Zmeur (Fruit), Zmeură (Plant);
Russian: Malina Obyknovennaia;
Samogitian: Paprastuoji Avėitė;
Serbian: Malína;
Slovašcina: Malinjak;
Spanish: Chordón, Frambuesa (Fruit), Frambueso (Plant);

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Swedish: Hallon (Fruit), Hallonbuske (Plant), Hallonsnår (Plant);
Taiwan: Fu Pen Zi;
Turkish: Ağaç Çileği, Ahududu;
Ukrainian: Malína;
Upper Sorbian: Čerwjeny Malenowc;
Vietnamese: Quả Mâm Xôi (Fruit), Cây Mâm Xôi (Canes);
Walloon: Amponî;

Origin/Distribution

Red raspberry is native to Europe and northern Asia, Russia (eastward to Eastern Siberia) and Central Asia (Tienschan).

Agroecology

Red raspberry is a temperate species with optimal growth in the moderate temperature range of 16–25°C and it is frost tolerant down to −40°C. It occurs in sparse forests, forest margins, thickets, valleys, slopes, meadows, roadsides, stream-sides, waste places from 500 to 2,500 m elevation in its native range. Raspberry prefers well drained, fertile loamy, subacid-neutral soil in humid sites that are protected from strong winds.

Edible Plant Parts and Uses

Red raspberries are grown for the fresh fruit market and for commercial processing into individually quick frozen (IQF) fruit, purée, juice, canned fruits, jams, marmalade, jellies, liqueur (wine and brandy), vinegar or as dried fruit used in a variety of grocery products. Fruits are relished fresh or with ice-cream. Dried leaves are used for tea.

Botany

A shrub, 1–2 m high with reddish-brown, terete, sparsely tomentose and prickled branchlets. Leaves are imparipinnate, petiolate (3–6 cm) with 5–7 leaflets and pubescent, linear stipules.

Plate 1 Leaves of red raspberry plant

Plate 2 Red raspberry fruits and leaves (*upper surface*)

Leaflets narrowly ovate or elliptic, 3–8 cm by 1.5–4.5 cm, tomentose abaxially and glabrous adaxially, base rounded to subcordate, apex acuminate, margin coarsely serrated (Plates 1, 2 and 3). Inflorescences terminal and racemose with several flowers in axillary clusters Flowers 1–1.5 cm across. Calyx with 5 erect, ovate-lanceolate sepals. Petals five, white, spatulate, puberulous or glabrous, base broadly clawed. Stamens many, shorter than petals with filaments broadened and flattened. Pistils shorter than stamens; ovary and base of style densely gray tomentose. Fruit red, subglobose, 1.5–2.5 cm across made up of an aggregate of numerous drupelets around a central core (Plates 2, 3 and 4), the drupelets separate from the core when picked, leaving a hollow fruit, pyrenes prominently pitted (Plate 4).

Plate 3 Red raspberry fruit and leaves (*lower surface*)

Plate 4 Harvested red raspberries

Nutritive/Medicinal Properties

The nutrient composition of raw red raspberries per 100 g edible portion was reported as (Saxholt et al. 2008): energy 228 kJ, total protein 1.4 g, total fat 1.4 g, saturated fatty acids 0.1 g, C 16:0 fatty acids 0.089 g, C 18:0 0.015 g; monounsaturated fatty acids 0.1 g, C 18:1 n-9 0.103 g; polyunsaturated fatty acids 0.9 g, C 18:2 n-6, 0.473 g, C18:3 n-3 0.0401 g; total omega 3 fatty acids 0.401 g, total omega 6 fatty acids 0.473 g, total carbohydrate 11.3 g, available carbohydrate 6.9 g, fructose 1.22 g, glucose 0.75 g, saccharose 0.08 g, total sugars 2.05 g, dietary fibre 4.4 g, moisture 85.9 g, vitamin A 3.50 RE, β-carotene equivalent 42 μg, vitamin E α-tocopherol 1.4 mg, thiamine 0.03 mg, riboflavin 0.05 mg, niacin 0.05 mg, vitamin B6 0.09 mg, pantothenic acid 0.24 mg, biotin 1.9 μg, folate 44 μg, vitamin C 24 mg, ash 0.5 g, Na 2 mg, K 228 mg, Ca 19.7 mg, Mg 17 mg, P 38 mg, Fe 0.55 mg, Cu 0.105 mg, Zn 0.34 mg, Iodine 0.4ug, Mn 1.2 mg, Cr 0.8 ug, Se 0.189 ug, Ni 17.9 μg and tryptophan 15 mg.

Flavonoids (kaempferol, quercetin, myricetin) and phenolic acids (p-coumaric, caffeic, ferulic, p-hydroxybenzoic, gallic and ellagic acids) were detected in the fruits of 19 berries (Hákkinen et al. 1999). Ellagic acid was the main phenolic compound in the berries of the genus *Rubus* (red raspberry, Arctic bramble and cloudberry) and genus *Fragaria* (strawberry). The data suggested berries to have potential as good dietary sources of quercetin or ellagic acid. Eleven anthocyanins, including cyanidin-3-sophoroside, cyanidin-3-(2(G)-glucosylrutinoside), cyanidin-3-glucoside, cyanidin-3-rutinoside, pelargonidin-3-sophoroside, pelargonidin-3-(2(G)-glucosylrutinoside), and pelargonidin-3-glucoside were identified in red raspberries (*R. idaeus*) (Mullen et al. 2002). Significant quantities of an ellagitannin, sanguiin H-6, were detected along with lower amounts of a second ellagitannin, lambertianin C, were detected. Other phenolic compounds that were detected included trace amounts of ellagic acid and its sugar conjugates along with one kaempferol- and four quercetin-based flavonol conjugates. The content of phenolic compounds varied widely and significantly between red raspberry (*Rubus idaeus*) cultivars (Anttonen and Karjalainen 2005). The quercetin content ranged from 0.32 (yellow cultivar) to 1.55 mg/100 g fresh weight (FW) (cv. Balder). The ellagic acid content varied from 38 (cv. Gatineau and cv. Nova) to 118 mg/100 g FW (cv. Ville). The total anthocyanin content varied from close to 0 (yellow cultivars) to 51 mg/100 g FW (cv. Gatineau). The content of total phenolics varied from 192 (cv. Gatineau) to 359 mg/100 g FW (cv. Ville). Among berry fruits, raspberries (*Rubus idaeus*) contained most xylitol, a non-sugar, a sugar alcohol, low calorie sweetener, about 400 μg/g (Makinen and Soderling 1980).

Eight anthocyanins were detected in raspberries, with cyanidin-3-O-sophoroside (375 nmol/g) the major anthocyanin followed by cyanidin-3-O-(2″-O-glucosyl) rutinoside, cyanidin-3-Osambubioside, and cyanidin-3-O-glucoside (all three totalled 307 nmol/g). Other phenolics included pelargonidin-3-O-sophoroside (44 nmol/g), cyanidin-3-O-rutinoside (85 nmol/g), pelargonidin-3-O-glucoside and pelargonidin-3-O-(″-O-glucosyl) rutinoside (both totalled 74 nmol/g) (Borges et al. 2010). The extract also contained the ellagitannins lambertianin C (322 nmol/g) and sanguin H-6 (1,030 nmol/g) along with trace amounts of ellagic acid derivatives and quercetin conjugates namely ellagic acid (11 nmol/g), ellagic acid-O-pentoside (10 nmol/g), ellagic acid-4-O-acetylxyloside (5.1 nmol/g) and quercetin-O-galactosylrhamnoside (7.5 nmol/g), quercetin-3-O-(2″-O-glucosyl) rutinoside (6.7 nmol/g), quercetin-3-O-galactoside (25 nmol/g) and quercetin-3-O-glucoside (28 nmol/g).

Studies found minimal changes in the volatile aroma composition of raspberry produced by the freezing process and frozen storage at −20°C for a 1 year (de Ancos et al. 2000b). Only a significant increase in extraction capacity was obtained for α-ionone (27%) and for caryophyllene (67%) in cv Heritage at 12 months of storage. The stability of anthocyanins to freezing and frozen storage depended on the seasonal period of harvest. Heritage and Autumn Bliss (early cultivars) were less affected by processing and long-term frozen storage (1 year), and the total pigment extracted showed the tendency to increase 17% and 5%, respectively. Rubi and Zeva (late cultivars) suffered a decreased trend on the total anthocyanin content of 4% for Rubi and 17.5% for Zeva. Cyanidin 3-glucoside was degraded most during processing and the storage period.

Cyanidin-3-sophoroside, cyanidin-3-(2(G)-glucosylrutinoside), cyanidin-3-sambubioside, cyanidin-3-rutinoside, cyanidin-3-xylosylrutinoside, cyanidin-3-(2(G)-glucosylrutinoside), and cyanidin-3-rutinoside were the main anthocyanin components in red raspberry (*Rubus idaeus* L. var. Heritage) extracts (Chen et al. 2007). In addition, in comparison with the conventional solvent extraction, ultrasound-assisted process was found to be more efficient and rapid to extract anthocyanins from red raspberry. Eight anthocyanin cyanidin and pelargonidin glycosides: -3-sophoroside, -3-glucoside, -3-rutinoside and -3-glucosylrutinoside were quantified across two seasons and two environments in progeny from a cross between two *Rubus* subspecies, *Rubus idaeus* (cv. Glen Moy) x *Rubus strigosus* (cv. Latham) (Kassim et al. 2009). Significant seasonal variation was detected across pigments less for different growing environments within seasons.

Anthocyanin contents in 11 red raspberry varieties ranged from 76.22 to 277.06 mg per 100 g of dry weight (dw) and the content of the ellagitannin varied from 135.04 to 547.48 mg per 100 g of dw (Sparzak et al. 2010). The predominant anthocyanin in varieties Heritage and Willamette were cyanidin-3-O-sophoroside and cyanidin-3-O-glucoside, while in the other varieties the predominant compounds were cyanidin-3-O-rutinoside and cyanidin-3-O-(2G-O-glucosylru tinoside). Raspberry ketone (4-(4-hydroxyphenyl) butan-2-one; RK) was found to be a major aromatic compound of red raspberry (*Rubus idaeus*) (Morimoto et al. 2005).

The yield of lipid ratio was between 0.40% (cv ERZ9) and 0.63% (cv Heritage) indicating cultivated raspberry had higher lipid ratio than all wild materials (Celik and Ercisli 2009). The 11 red raspberry genotypes and one cultivar studied contained 10 major compounds, and statistically important differences was observed among genotypes on C16:0 (palmitic acid), C18:1 (oleic), C18:2 (linoleic) and C18:3 (linolenic). Linoleic acid (42.18–52.61%) and linolenic acid (17.83–24.10%) was the main fatty acids for all genotypes studied.

Cold-pressed marionberry, boysenberry, red raspberry, and blueberry seed oils were evaluated for their fatty acid composition, carotenoid content, tocopherol profile, total phenolic content (TPC), oxidative stability index (OSI), peroxide value, and antioxidant properties. Cold-pressed marionberry, boysenberry, red raspberry, and blueberry seed oils were found to contain significant levels of α-linolenic acid ranging from 19.6 to 32.4 g per 100 g of oil, along with a low ratio of n-6/n-3 fatty acids (1.64–3.99) (Parry et al. 2005). The total carotenoid content ranged from 12.5 to 30.0 μmol per kg oil. Zeaxanthin was the major carotenoid compound in all tested berry seed oils, along with β-carotene, lutein, and cryptoxanthin. Total tocopherol was 260.6–2276.9 µmol/kg oil, including α-tocopherol, γ-tocopherol and δ-tocopherol. OSI values were 20.07, 20.30, and 44.76 h for the marionberry, red raspberry, and boysenberry seed oils, respectively. The highest total phenol content of 2.0 mg gallic acid equivalents per gram of oil was observed in the red raspberry seed oil, while the strongest oxygen radical absorbance capacity was in boysenberry seed oil extract (77.9 µmol trolox equivalents per g oil). All tested berry seed oils directly reacted with and quenched DPPH radicals in a dose- and time-dependent manner. The data suggested that the cold-pressed berry seed oils may serve as potential dietary sources of tocopherols, carotenoids, and natural antioxidants. Seeds from red raspberry, black raspberry, boysenberry, Marion blackberry, and evergreen blackberry were found to have 6–7% protein and 11–18% oil (Bushman et al. 2004). The oils contained 53–63% linoleic acid, 15–31% linolenic acid, and 3–8% saturated fatty acids. The two smaller seeded raspberry species had higher percentages of oil, the lowest amounts of saturated fatty acid, and the highest amounts of linolenic acid. Antioxidant capacities were detected both for whole seeds and for cold-pressed oils but did not correlate to total phenolics or tocopherols. Ellagitannins and free ellagic acid were the main phenolics detected in all five caneberry species and were approximately threefold more abundant in the blackberries and the boysenberry than in the raspberries.

Oil yield from *Rubus idaeus* seed was 10.7% and its saponification number was 191; diene value 0.837; p-anisidine value 14.3; peroxide value 8.25 meq/kg; carotenoid content 23 mg/100 g; and viscosity of 26 mPa-s at 25°C (Oomah et al. 2000). Raspberry seed oil showed absorbance in the UV-B and UV-C ranges with potential for use as a broad spectrum UV protectant. The seed oil was rich in tocopherols with the following composition (mg/100 g): α-tocopherol 71, γ-tocopherol 272, δ-tocopherol 17.4, and total vitamin E equivalent of 97 mg. The oil had good oxidation resistance and storage stability. Lipid fractionation of crude raspberry seed oil yielded 93.7% neutral lipids, 3.5% phospholipids, and 2.7% free fatty acids. The main fatty acids of crude oil were C18:2 n-6 (54.5%), C18:3 n-3 (29.1%), C18:1 n-9 (12.0%), and C16:0 (2.7%).

Fruits of red raspberry were found to be rich in elagic acid (Daniel et al. 1989; Zafrilla et al. 2001; Juranic et al. 2005; Salinas-Moreno et al. 2009). The concentration of elagic acid in various fruits was reported as follows: strawberries (630 µg), raspberries (1,500 µg), blackberries (1,500 µg), walnuts (590 µg), pecans (330 µg), and cranberries (120 µg ellagic acid/g dry wt) (Daniel et al. 1989). In strawberries, 95.7% of the ellagic acid was found in the pulp while 4.3% was contained in the seeds. The seeds of raspberries contained 87.8% of the ellagic acid, and 12.2% was present in the pulp. The juice of both fruits contained negligible amounts of ellagic acid. The fruits of "Autumn Bliss" variety red raspberry fruits (*Rubus idaeus*) with deep red colour (degree 3 ripening) was found to have the highest free ellagic acid content, with a value of 5.38 mg/kg of fresh fruit, the anthocyanin profile was more complex as fruits advanced in maturity (Salinas-Moreno et al. 2009). In the immature fruits only four anthocyanins were observed, while in the completely mature fruits there were eight. In the completely mature fruits the anthocyanins with the highest relative percentages were: cyanidin 3-soforoside (46.2%) and cyianidin 3-(2-glucosyl rutinoside) (25.9%). The maximum levels of free ellagic acid and the highest number of anthocyanins were present in the completely mature raspberry fruits. From red raspberries, ellagic acid, its 4-arabinoside, its 4′ (4″-acetyl) arabinoside, and its 4′ (4″-acetyl) xyloside, as well as quercetin and kaempferol 3-glucosides, were identified (Zafrilla et al. 2001). All of the isolated compounds showed antioxidant activity. The flavonol content decreased slightly with processing and more markedly during storage of raspberry jams. The ellagic acid derivatives, with the exception of ellagic acid itself, remained quite stable with processing and during 6 months of jam storage. The content of free ellagic acid increased threefold during the storage period. The initial content (10 mg/kg of fresh weight of raspberries) increased twofold with processing, and it continued increasing up to

35 mg/kg after 1 month of storage of the jam. The increase observed in ellagic acid could be explained by a release of ellagic acid from ellagitannins with the thermal treatment.

The total amount of phenolic compounds in *Rubus idaeus* leaves varied from 0.3 to 2.2 mg of gallic acid equivalents (GAE) in 1 g of dry leaves (Dvaranauskaite et al. 2008). Quercetin glucuronide, quercetin-3-glucoside and quercetin glucosylrhamnoside (rutin) were identified in the leaf. The concentration of ellagic acid in the leaves of *Rubus* species: raspberry (2 wild and 13 cultivars) and blackberry (3 wild and 3 cultivars) after acid hydrolysis ranged from 2.06% to 6.89% (Gudej and Tomczyk 2004). The flavonoid content varied between 0.27% and 1.06%; quercetin and kaempferol were predominant in all samples. The leaves of raspberries were characterized by greater amounts of tannins (varying between 2.62% and 6.87%) than the leaves of other species.

Antioxidant Activity

In raspberry fruit, the antioxidant activity of vitamin C was 681 nmol Trolox/g, sanguine H-6 2,905 nmol Trolox/g, lambertianin C 886 nmol Trolox/g (Borges et al. 2010). Aanthocyanins present at a total concentration of 885 nmol/g contributed 16.5% to the overall AOC (antioxidant capacity), whereas vitamin C (1,014 nmol/g) contributed 10.5%. In contrast to the black currant and blueberry extracts, the ellagitannins lambertianin C and sanguiin H-6 were the main contributors to the AOC, being responsible for >58% of the total.

The amount of total phenolics varied between 617 and 4,350 mg/kg in fresh berries (blackberries, red raspberries, blueberries, sweet cherries and strawberries), as gallic acid equivalents (GAE) (Heinonen et al. 1998). In the copper-catalyzed in-vitro human low-density lipoprotein oxidation assay at 10 μM gallic acid equivalents (GAE), berry extracts inhibited hexanal formation in the order: blackberries > red raspberries > sweet cherries > blueberries > strawberries. In the copper-catalyzed in-vitro lecithin liposome oxidation assay, the extracts inhibited hexanal formation in the order: sweet cherries > blueberries > red raspberries > blackberries > strawberries. Red raspberries were more efficient than blueberries in inhibiting hydroperoxide formation in lecithin liposomes. HPLC analyses showed high anthocyanin content in blackberries, hydroxycinnamic acid in blueberries and sweet cherries, flavonol in blueberries, and flavan-3-ol in red raspberries. The antioxidant activity for LDL was associated directly with anthocyanins and indirectly with flavonols, and for liposome it correlated with the hydroxycinnamate content. Berries thus may contribute a significant source of phenolic antioxidants with potential health effects.

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 antioxidant activities TEAC 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 approximately/= tomato approximately/= peach = leek > banana approximately/= lettuce. Blackberries (*Rubus* sp.) and strawberries (*Fragaria* × *ananassa*) had the highest ORAC values during the green stages, whereas red raspberries (*Rubus idaeus*) had the highest ORAC activity at the ripe stage (Wang and Lin 2000). All of five types of caneberries [evergreen blackberries (*Rubus laciniatus*), marionberries (*Rubus ursinus*), boysenberries (*Rubus ursinus x idaeus*), red raspberries (*Rubus idaeus*), and black raspberries (*Rubus occidentalis*)] were found to have high oxygen radical absorbance capacity (ORAC) activity ranging from 24 to 77.2 μmol of Trolox equiv/g of fresh berries (Wada and Ou 2002).

Anthocyanin content ranged from 0.65 to 5.89 mg/g, and phenolics ranged from 4.95 to 9.8 mg/g. Black raspberries had the highest ORAC, anthocyanin and phenolic contents. Only red raspberries had detectable amounts of procyanidin oligomers (monomer, dimers, and trimers). All berries had high levels of ellagic acid (47–90 mg/g), but boysenberries had the highest level prior to hydrolysis. The data indicated that these caneberries were high in antioxidant activity and were rich sources of anthocyanins and phenolics.

Among the berry fruits analysed, red raspberry (*Rubus idaeus*), black raspberry (*Rubus occidentalis*), and strawberry (*Fragaria x ananassa*), black raspberries and strawberries had the highest ORAC (oxygen radical absorbance capacity) values during the green stages, whereas red raspberries had the highest ORAC activity at the ripe stage (Wang and Lin 2000). Total anthocyanin content increased with maturity for all species of fruits. Compared with fruits, leaves were found to have higher ORAC values. In fruits, ORAC values ranged from 7.8 to 33.7 μmol of Trolox equivalents (TE)/g of fresh berries (35.0–162.1 μmol of TE/g of dry matter), whereas in leaves, ORAC values ranged from 69.7 to 182.2 μmol of TE/g of fresh leaves (205.0–728.8 μmol of TE/g of dry matter). As the leaves become older, the ORAC values and total phenolic contents decreased. The results showed a linear correlation between total phenolic content and ORAC activity for fruits and leaves. For ripe berries, a linear relationship existed between ORAC values and anthocyanin content. Of the ripe fruits tested, on the basis of wet weight of fruit, cv. Jewel black raspberry and blackberries were the richest source for antioxidants. On the basis of the dry weight of fruit, strawberries had the highest ORAC activity followed by black raspberries (cv. Jewel), blackberries, and red raspberries.

Raspberry cultivar 'Heritage' had the highest total phenolic content (512.70/100 g fruit) followed by 'Kiwigold' (451.06 mg/100 g fruit), 'Goldie' (427.51 mg/100 g fruit) and 'Anne' (359.19 mg/100 g fruit) (Liu et al. 2002; Weber et al. 2002). Similarly, 'Heritage' contained the highest total flavonoids (103.41 mg/100 g fruit) followed by 'Kiwigold' (87.33 mg/100 g fruit), 'Goldie' (84.16 mg/100 g fruit) and 'Anne' (63.53 mg/100 g fruit). 'Heritage' had the highest a/b colorimeter ratio and the darkest colored juice with the highest phenolic/flavonoid content, and 'Anne' had the lowest phytochemical content, the palest color, and lowest a/b ratio. 'Heritage' had the highest total antioxidant activity, followed by 'Kiwigold' and 'Goldie'. 'Anne' had the lowest antioxidant activity of the cultivars tested. The antioxidant activity of each of the cultivars was directly related to the total amount of phenolics and flavonoids. In another study, the highest phenolic compounds were found in wild Yayla raspberry ecotype (26.66 gallic acid equivalents GAE /mg extract). Whilst, the highest flavonoids were determined in wild Yedigöl ecotype (6.09 quercetin equivalents QE/mg extract) (Gülçin et al. 2011). The compounds found in lyophilized aqueous extracts of domesticated and wild ecotypes of raspberry fruits caffeic acid, ferulic acid, syringic acid, ellagic acid, quercetin, α-tocopherol, pyrogallol, p-hydroxybenzoic acid, vanillin, p-coumaric acid, gallic acid, and ascorbic acid. Antioxidant assays using different in vitro assays including $DPPH^{\bullet}$, $ABTS^{\bullet+}$, $DMPD^{\bullet+}$, and O^{-2} radical scavenging activities, H_2O_2 scavenging activity, ferric (Fe^{3+}) and cupric ions (Cu^{2+}) reducing abilities, ferrous ions (Fe^{2+}) chelating activity, showed that p-coumaric acid was the main phenolic acid responsible for the antioxidant and radical scavenging activity of lyophilized aqueous extracts of domesticated and wild ecotypes of raspberry fruits.

Studies by de Ancos et al. (2000a) found that cultivars, freezing time and storage impacted on the ellagic acid, total phenolic, and vitamin C contents of raspberry. Ellagic acid [207–244 mg/kg fresh weight (FW)], total phenolic (137–1,776 mg/kg FW), and vitamin C (221–312 mg/kg FW) contents in raw material were higher in the late cultivars Zeva and Rubi than in the early cultivars Autumn Bliss and Heritage. At the end of long-term −20°C storage (12 months), no significant change of total phenolic content extracted was observed, but significant decreases of 14–21% in ellagic acid and of 33–55% in vitamin C were quantified. Free radical scavenging capacity measured as antiradical efficiency (AE) was found to depend on the seasonal period of harvest. Late cultivars, Rubi (6.1×10^{-4}) and Zeva (10.17×10^{-4}), showed higher AE than early cultivars, Heritage (4.02×10^{-4}) and Autumn Bliss (4.36×10^{-4}). The freezing process produced a decrease of AE values in the four cultivars ranging between 4% and 26%.

The ellagitannin, sanguiin H-6 was a major contributor to the antioxidant capacity of raspberries together with vitamin C and the anthocyanins (Mullen et al. 2002). Berries such as raspberry (*Rubus idaeus*), bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-idaea*), and black currant (*Ribes nigrum*) were found to be rich in monomeric and polymeric phenolic compounds providing protection toward both lipid and protein oxidation as assessed by a lactalbumin-liposome system (Viljanen et al. 2004). In raspberries, ellagitannins were responsible for the antioxidant activity. While the antioxidant effect of berry proanthocyanidins and anthocyanins was dose-dependent, ellagitannins appeared to be equally active at all concentrations. Ferric reducing antioxidant power (FRAP) values of raspberry (*Rubus idaeus*), blackberry (*Rubus fructicosus*), raspberry × blackberry hybrids, red currant (*Ribes sativum*), gooseberry (*Ribes glossularia*) and Cornelian cherry (*Cormus mas*) cultivars ranged from 41 to 149 μmol ascorbic acid/g dry weight and protection of deoxyribose ranged from 16.1% up to 98.9% (Pantelidis et al. 2007). Anthocyanin content ranged from 1.3 mg in yellow-coloured fruit, up to 223 mg cyanidin-3-glucoside equivalents 100/g fresh weight in Cornelian cherry, whereas phenol content ranged from 657 up to 2,611 mg gallic acid equivalents/100gdry weight. Ascorbic acid content ranged from 14 up to 103 mg/100 g fresh weight.

The total amount of phenolic compounds in *R. idaeus* fruits varied from 5.6 to 13.7 mg of gallic acid equivalents per 1 g of plant extract (Dvaranauskaite et al. 2006). All tested raspberry fruit extracts were antioxidatively active; their radical scavenging capacity at the applied concentrations varied from 52.9% to 92.6% in DPPH·reaction system and from 52.5% to 97.8% in ABTS·+ system. The dominant antioxidants in red raspberry fruit could be classified as anthocyanins, ellagitannins, and proanthocyanidin-like tannins (Beekwilder et al. 2005). During fruit ripening, some anthocyanins were freshly produced, while others, like cyanidin-3-glucoside, were already present early in fruit development. The level of tannins, both ellagitannins and proanthocyanidin-like tannins, was reduced strongly during fruit ripening. Among the 14 cultivars, major differences (>20-fold) were observed in the levels of pelagonidin type anthocyanins and some proanthocyanidin type tannins. The content of ellagitannins varied approximately threefold. The antioxidant capacity among wild and cultivated red raspberry samples averaged 14.6 and 14.1 μmol TE/g FW using FRAP and TEAC methods, respectively (Çekiç and Özgen 2010). Significant variability was found for antioxidant capacity, total phenolics, total monomeric anthocyanins, organic acids and sugars of wild raspberries.

Thirty-seven compounds comprising flavanol monomers and oligomers, as well as varieties of ellagitannin components were identified in *R. idaeus* seed methanol extracts (Godevac et al. 2009). Treatment of human lymphocytes with the seed extracts induced a significant decrease in the frequency of micronuclei by 80%. The results demonstrated that the constituents of the seed extracts may be important in the prevention of oxidative lymphocyte damage by reactive oxygen species and may also reduce the level of DNA damage. Further the findings support the potential benefits of polyphenolic compounds from raspberry seeds as efficient antioxidants.

All raspberry (*Rubus idaeus*) leaf ethanol extracts were found to be bioactive, with radical scavenging capacity at the used concentrations from 20.5% to 82.5% in DPPH* reaction system and from 8.0% to 42.7% in ABTS^{+} reaction (Venskutonis et al. 2007). The total amount of phenolic compounds in the leaves varied from 4.8 to 12.0 mg of gallic acid equivalents (GAE) in 1 g of plant extract. Quercetin glucuronide, quercetin-3-O-glucoside and rutin were identified in the extracts

Anticancer Activity

The anticancer potential of berries fruits such as blackberries, black raspberries, blueberries, cranberries, red raspberries, and strawberries had been associated partially, to a multitude of bioactive phytochemicals such as polyphenols (flavonoids, proanthocyanidins, ellagitannins, gallotannins, phenolic acids), stilbenoids, lignans, and triterpenoids (Seeram 2008). Studies showed that the anticancer effects of berry bioactives were partially mediated through their abilities to counteract, reduce, and also repair damage resulting from oxidative stress and inflammation. In addition, berry bioactives also regulated carcinogen and xenobiotic metabolizing enzymes, various transcription and growth factors, inflammatory cytokines, and subcellular signaling pathways of cancer cell proliferation, apoptosis, and tumour angiogenesis. Berry phytochemicals may also potentially sensitize tumour cells to chemotherapeutic agents by inhibiting pathways that lead to treatment resistance, and berry fruit consumption may provide protection from therapy-associated toxicities.

The major classes of phenolics found in blackberry, black raspberry, blueberry, cranberry, red raspberry and strawberry were anthocyanins, flavonols, flavanols, ellagitannins, gallotannins, proanthocyanidins, and phenolic acids (Seeram et al. 2006). With increasing concentration of berry extract from 25 to 200 µg/ml, increasing inhibition of cell proliferation in the human oral (KB, CAL-27), breast (MCF-7), colon (HT-29, HCT116), and prostate (LNCaP) tumour cell lines were observed, with different degrees of potency between cell lines.

A tiliroside, kaempferol-3-O-β-D-(6″-E-p-coumaroyl)-glucopyranoside was isolated from the methanolic extract *Rubus idaeus* plant (Nowak 2003). The compound exhibited cytotoxic activity for human leukaemic cell lines and anti-complement activity. Raspberry fruit extracts significantly inhibited in a dose-dependent manner the proliferation of HepG2 human liver cancer cells (Liu et al. 2002; Weber et al. 2002). The antiproliferative activity of the extract equivalent to 50 mg for cv 'Anne', 'Goldie', 'Heritage', and 'Kiwigold' fruit inhibited the proliferation of those cells by 70.33%, 89.43%, 87.96% and 87.55%, respectively. No significant relationship was found between antiproliferative activity and the total amount of phenolics/flavonoids. Studies showed that water extracts of seeds or pulp of five different raspberry cultivars: K81-6, Latham, Meeker, Tulameen and Willamette rich in ellagic acid possessed the potential for antiproliferative action against malignant human colon carcinoma LS174 cells in-vitro (Juranic et al. 2005). The antiproliferative action of seeds extract was correlated with its content of ellagic acid. The cytotoxic activity of seeds extracts was not pronounced on normal human PBMC.

Studies showed that dietary ellagic acid significantly inhibited the metabolism of [3H] benzo[a]pyrene (BP) by cultured primary keratinocytes prepared from BALB/C mouse epidermis (Mukhtar et al. 1984). Varying concentrations of ellagic acid added to the keratinocyte cultures resulted in a dose-dependent inhibition of the cytochrome P-450-dependent monooxygenases aryl hydrocarbon hydroxylase (AHH) and 7-ethoxycoumarin-O-deethylase (ECD). The results indicated that cultured primary mouse keratinocytes offered a useful model system for studying factors affecting the metabolic activation and detoxification of polycyclic aromatic hydrocarbon carcinogens in the epidermis, and that polyphenolic compounds such as ellagic acid may prove useful in modulating the risk of cutaneous cancer arising from exposure to these environmental chemicals.

Mandal and Stoner (1990) reported that ellagic acid inhibited N-nitrosobenzylmethylamine (NBMA) tumorigenesis in the rat esophagus. Administration of ellagic acid in a semi-purified diet at concentrations of 0.4 and 4 g/kg significantly reduced the average number of NBMA-induced esophageal tumours after 20 and 27 weeks of the bioassay. Ellagic acid exhibited inhibitory effects toward preneoplastic lesions as well as neoplastic lesions. Dietary ellagic acid (EA), had been shown to reduce the incidence of *N*-2-fluorenyl acetamide-induced hepatocarcinogenesis in rats and *N*-nitrosomethylbenzylamine (NMBA)-induced rat esophageal tumours (Ahn et al. 1996). Further studies demonstrated that EA caused a fall in total hepatic P450 with a significant effect on hepatic P450 2E1, enhanced some hepatic phase II enzyme activities (GST, NAD(P)H: QR and UDPGT) and decreased hepatic mEH expression. It also inhibited the catalytic activity of some P450 isozymes in-vitro.

Thus, the chemoprotective effect of EA against various chemically induced cancers may involve decreases in the rates of metabolism of these carcinogens by phase I enzymes, in addition to effects on the expression of phase II enzymes, thereby enhancing the ability of the target tissues to detoxify the reactive intermediates.

Results of studies by Narayanan and Re (2001) suggested that growth inhibition of colon cancer cells (SW 480) by dietary ellagic acid was mediated by signaling pathways that mediated DNA damage, triggered p53, which in turn activated p21 and at the same time altered the growth factor expression, resulting in the down regulation of mitogenic insulin like growth factor IGF-II and caused apoptotic cell deaths. The study of Falsaperla et al. (2005) suggested that the use of ellagic acid as support therapy reduced chemotherapy induced toxicity, in particular neutropenia, in hormone refractory prostate cancer (HRPC) patients. Ellagitannins were reported to be hydrolyzed to ellagic acid under physiological conditions in-vivo and then ellagic acid in turn was gradually metabolized by the intestinal microbiota to produce different types of urolithins (Landete 2011). Urolithinshad been reported to be not potent antioxidants as ellagitannins. In contrast urolithins could display estrogenic and/or anti-estrogenic activity and tissue disposition studies revealed urolithins to be rich in prostate, intestinal, and colon tissues in mouse, which could explain why urolithins inhibit prostate and colon cancer cell growth.

In HeLa cells co-transfected with an estrogen response element (ERE)-driven luciferase (Luc) reporter gene and an ERα- or ERβ-expression vector, ellagic acid at low concentrations (10^{-7} to 10^{-9} M) displayed a small but significant estrogenic activity via ERα, whereas it was a complete estrogen antagonist via ERβ (Papoutsi et al. 2005). Further evaluation revealed that ellagic acid was a potent antiestrogen in MCF-7 breast cancer-derived cells. Moreover, ellagic acid induced nodule mineralization in an osteoblastic cell line (KS483), an effect that was abolished by the estrogen antagonist. These findings suggested that ellagic acid may be a natural selective estrogen receptor modulator (SERM).

Antinflammatory Activity

Anthocyanins from raspberries *Rubus idaeus* and sweet cherries *Prunus avium* demonstrated 45% and 47% cyclooxygenase-I and cyclooxygenase-II inhibitory activities, respectively, when assayed at 125 μg/mL (Seeram et al. 2001). The cyclooxygenase inhibitory activities of anthocyanins from these fruits were comparable to those of ibuprofen and naproxen (antiinflammatory agents) at 10 μM concentrations. Anthocyanins cyanidin-3-glucosylrutinoside and cyanidin-3-rutinoside were present in both cherries and raspberry. The yield of the two pure anthocyanins in 100 g raspberries was 13.5 mg, respectively.

Antiurolithiasis Activity

Administration of a herbal decoction of *R. idaeus* to nephrolithic mice for 12 days caused a significant reduction in urinary oxalate, calcium and phosphorus values compared to untreated mice, while creatinine excretion increased (Ghalayini et al. 2011). Serum oxalate, calcium and creatinine were significantly reduced, while phosphorus was not significantly altered. Kidney content of calcium was higher in the untreated group. Mice in treated groups at 12 days had significantly more superoxide dismutase, catalase, glutathione reductase (GSH) and G6PD activities than the untreated group. Hyperoxaluria-induced generation of malondialdehyde (MDA) and protein carbonyls was significantly prevented in the treated groups. A significantly high content of vitamin E was found in the herbal treated groups. The histology showed more calcium oxalate deposition in the kidneys of untreated animals.

Anticariogenic Activity

Raspberry contain xylitol (Makinen and Soderling 1980), an anticariogenic polyol, non-sugar sweetener that has been approved for use in foods, chew gum, toothpaste and other items in many countries (Maguire and Rugg-Gunn 2003). Xylitol was reported to exhibit dental health benefits which were superior to other polyols in all areas where polyols had been shown to have an effect. Xylitol's specific effects on oral flora and especially on certain strains of mutans Streptococci augmented its caries-preventive profile and gave it a unique role in preventive strategies for dental health. The inhibition of mother/child transmission of cariogenic oral flora by xylitol leading to reduced caries development in young children was found to be caries-preventive.

Diuretic Activity

Studies showed that the methanol extract of raspberry (*R. idaeus*) fruits exerted diuretic effect on rats (Zhang et al. 2011). Compared to the control group, significant increase in urine volume was observed from rats treated with wild raspberry methanol extract. There was no increase in potassium excretion following administration of the methanol extract suggesting that this extract had potassium-sparing properties. The results partially elucidated the use of raspberry as a cure for renal diseases in Chinese traditional medical practice.

Antiobesity Activity

Raspberry ketone (4-(4-hydroxyphenyl) butan-2-one; RK) prevented the high-fat-diet-induced increases in body weight and the weights of the liver and visceral adipose tissues (epididymal, retroperitoneal, and mesenteric) (Morimoto et al. 2005). RK also decreased these weights and hepatic triacylglycerol content after they had been increased by a high-fat diet. RK significantly increased norepinephrine-induced lipolysis associated with the translocation of hormone-sensitive lipase from the cytosol to lipid droplets in rat epididymal fat cells. The findings suggested that raspberry ketone prevented and improved obesity and fatty liver by altering the lipid metabolism, or more specifically, in increasing norepinephrine-induced lipolysis in white adipocytes.

Relaxant/Spasmolytic Activity

As a pregnancy tonic, an infusion of dried raspberry leaves have been used by pregnant women in England, China, Europe, and North America to allay the pains of labour (Whitehouse 1941; Lieberman 1995; McFarlin et al. 1999). In a national survey of herbal preparation use by nurse-midwives for labour stimulation conducted by the American College of Nurse-Midwives 90 certified nurse-midwives who used herbal preparations to stimulate labour, reported that 64% used blue cohosh, 45% used black cohosh, 63% used red raspberry leaf, 93% used castor oil, and 60% used evening primrose oil. Burn and Withell (1941) first demonstrated that the raspberry leaf infusion caused a relaxation of the uterus in the non-pregnant cat and a fall in blood pressure. In subsequent experiments the extract produced a contraction of the isolated uteri of both the cat and the guinea-pig. The active principle was identified as the alkaloid, fragarine (Whitehouse 1941). Studies in human puerperal uterus confirmed that fragarine inhibited uterine contraction. Contractions were diminished in force and frequency, secondary contractions were eliminated, and such contractions as occurred were evenly spaced. Whitehouse added that in the absence of more elegant preparation, crude raspberry-leaf tea was being used in one of the Worcestershire maternity hospitals, and the nursing staff report favourably upon its effect in "making things easier".

Beckett et al. (1954) reported that raspberry leaf extracts contained a number of active constituents including a smooth muscle stimulant, an anticholinesterase, and a "spasmolytic". Bamford et al. (1970) demonstrated that dried raspberry leaf extract inhibited uteri of pregnant rat but had no effect on non-pregnant rats. Patel et al. (1995) found that raspberry leaf extract caused a relaxation of intestinal smooth muscles in-vitro. The methanol extract of raspberry leaves exhibited the largest in-vitro relaxant activity on transmurally stimulated guinea-pig ileum (Rojas-Vera et al. 2001). The fractions eluted with chloroform lacked relaxant activity. Samples eluted with chloroform: methanol (95:5) had moderate relaxant activity, while a more polar solvent mixture (chloroform: methanol 50:50) provided strong dose dependent responses. Vasorelaxation activity was restricted to raspberry fruit fractions containing the ellagitannins, lambertianin C and sanguiin H-6 (Mullen et al. 2002). Zheng et al. (2010), found that in pregnant rats red raspberry leaf tea had variable effects on pre-existing oxytocin-induced contractions, sometimes augmenting oxytocin's effect and sometimes causing augmentation followed by inhibition. Their results did not support the hypothesis that red raspberry leaf augmented labour by a direct effect on uterine contractility. Johnson et al. (2009) found that raspberry leaf use during pregnancy was associated with increased gestation length and accelerated reproductive development in the F1 offspring of Wistar rats, raising concerns on the long-term consequences for the health of the offspring and the safety of this herbal preparation for use during pregnancy.

A retrospective observational design study of 108 mothers suggested that women who ingested raspberry leaf might be less likely to receive an artificial rupture of their membranes, or require a caesarean section, forceps or vacuum birth than the women in the control group (Parsons et al. 1999). The findings suggested also that the raspberry leaf herb consumed by women during their pregnancy for the purpose of shortening labour had no identified side effects for the women or their babies. In a double-blind, randomized, placebo-controlled trial, Simpson et al. (2001) found that raspberry leaf, consumed in tablet form, caused no adverse effects for mother or baby, but contrary to popular belief, did not shorten the first stage of labour. The only clinically significant findings were a shortening of the second stage of labour (mean difference = 9.59 min) and a lower rate of forceps deliveries between the treatment group and the control group (19.3% vs. 30.4%). No significant relationship was found between tablet consumption and birth outcomes.

After reviewing 12 original publications on the efficacy – safety of the use of raspberry leaves in pregnancy, Holst et al. (2009) concluded that evidence was not convincingly documented and recommendations made of its use was still questionable and proposed suggestions for future studies.

Mutagenic/Antimutagenic Activity

Raspberry (*Rubus idaeus*) extract and ellagitannin and anthocyanin fractions did not show any mutagenic effects in the miniaturized Ames test and were not cytotoxic to Caco-2 cells at the tested concentrations (Kreander et al. 2006). However, the anti-mutagenic properties were changed (i.e. decreased mutagenicity of 2-nitrofluorene in strain TA98, and slightly increased mutagenicity of 2-aminoanthracene in strain TA100) with metabolic activation.

Drug Interaction Activity

Raspberry extract and fractions were found to affect the permeability of some drugs depending on the components (Kreander et al. 2006). The apical-to-basolateral permeability across Caco-2 monolayers of highly permeable verapamil was mostly affected (decreased) during co-administration of the raspberry extract or the ellagitannin fraction. Ketoprofen permeability was decreased by the ellagitannin fraction. Consumption of food rich in phytochemicals, as demonstrated here with chemically characterized raspberry extract and fractions, with well-absorbing drugs would seem to affect the permeability of some of these drugs depending on the components.

Traditional Medicinal Uses

The fruit is antiscorbutic and diuretic, fresh raspberry juice with a little honey, makes an excellent refrigerant beverage for fever. A decongestant face-mask made from the fruit is used cosmetically to alleviate reddened skin. Tea made from the leaves of red raspberry has been used for centuries as a folk medicine to treat wounds, diarrhoea, colic pain and as a uterine. An infusion of dried raspberry leaves has been used as a pregnancy tonic by women to ease labour pains and relieve dsysmenorrhea. Leaf and root extracts are regarded to be anti-inflammatory, astringent, decongestant, ophthalmic, oxytocic and stimulant. Leaf and root extracts are used as a gargle to treat tonsillitis and mouth inflammations, as a poultice and wash to treat sores, conjunctivitis, minor wounds, burns, scalds and varicose ulcers.

Other Uses

The plant (especially the leaves) is rich in tannin. A purple to dull blue dye is obtained from the fruit. A fibre obtained from the stems is used in making a kind of brown-coloured paper.

Comments

Red raspberry is commonly propagated from suckers, root cuttings, tip layering and divisions of the stocks.

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