Ribes nigrum

Scientific Name

***Ribes nigrum* L.**

Synonyms

Botrycarpum nigrum (L.) A. Rich., *Grossularia nigra* (L.) Rupr., *Ribes cyathiforme* Pojark, *Ribes nigrum* forma *chlorocarpum* (Späth) *Rehder, Ribes nigrum* var. *chlorocarpum*, *Ribes nigrum* var. *europaeum* Jancz, *Ribes nigrum* var. *pauciflorum* (Turcz. ex Ledeb.) Jancz, *Ribes nigrum* var. *sibiricum* W.Wolf, *Ribes olidum* Moench nom. illeg., *Ribes pauciflorum* Turcz. ex Ledeb.

Family

Grossulariaceae

Common/English Names

Blackcurrant, European Blackcurrant, Garden Blackcurrant

Vernacular Names

Arabic: Kishmish Aswad;
Brazil: Groselha (Portuguese);
Chinese: Hei Cha Bao Zi;
Czech: Rybíz Černý;
Danish: Solbær, Vild Solbær;
Dutch: Zwarte Aalbes, Zwarte Bes, Zwarte Trosbes;
Eastonian: Must Sõstar;
Finnish: Mustaherukka, Mustaviinimarja;
French: Cassis, Cassissier, Gadellier Noir, Groseillier À Fruits Noirs, Groseillier Noir;
German: Ahlbeere, Cassis, Schwarze Johannisbeere, Schwarze Johannisbeeren;
Greek: Fragostafyla Mavra;
Hungarian: Fekete Ribiszke;
Icelandic: Sólber, Sólberjarunni, Svört Hlaupber;
Irish: Cuirín Dubh;
Italian: Ribes Nero, Ribes Nigrum;
Japanese: Kashisu, Kuro Fusa Suguri, Kurorasasuguri;
Korean: Komunkkachibapnamu, Komunsongimulaengdunamu;
Lithuanian: Juodųjų Serbentų;
Morocco: Nnbaq Aswad (Arabic);
Norwegian: Solbær;
Pakistan: Karan;
Polish: Porzeczka Czarna;
Portuguese: Groselha Negra , Groselheira Negra, Groselheira-Preta;
Russian: Smorodina Černaja;
Serbian: Crna Ribizla;
Slovašcina: Črni Ribez, Črno Grozdičje, Grozdičje Črno;
Slovencina: Ríbezľa Čierna;
Spanish: Casis, Grosella Negra, Grosellero Negro;
Swedish: Svarta Vinbär, Solbär, Svart Vinbär, Tistron;

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Origin/Distribution

Ribes nigrum is indigenous to central and northern Europe, Caucasus, Central Siberia and Himalaya.

Agroecology

Black current is a temperate species, winter hardy with optimal temperature for the growth of 18–20°C and optimal temperature for photosynthesis 15–25°C. Temperatures above 35°C are detrimental and cause leaf fall. The crop requires a period of winter chill to terminate dormancy and stimulate bud break the following spring. The optimum temperature for meeting the chill requirement is between 0°C and 10°C, with general agreement that 5 ± 1°C is satisfactory (Shirazi 2003). Studies in Tasmania showed that 2°C was more effective than the winter chill model of 7.2°C adopted by the Tasmanian Blackcurrant industry (Westmore 2004).

Blackcurrant prefers moisture-retentive, well-drained, fertile loams or deep sandy loamy soils. It prefers damp fertile soils with subsoil water not nearer than 1–1.5 m from surface. It is the least drought-resistant species among currants. Blackcurrant abhors heavy clay, chalky soils and thin dry soils. It is intolerant of acid soils and prefers soils in pH range of 6.7–7.

Edible Plant Parts and Uses

Blackcurrants can be eaten fresh, on its own, or with ice cream or in mixed fruit salad. They are more often processed into jam, fruit jelly, compote, syrup juice, preserves, wines and liqueurs and other beverages. In UK pubs blackcurrant cordial is often mixed with cider in a drink called "Cider and Black" or "snakebite". A dash of blackcurrant juice is used in Guinness stout to augment the taste. Blackcurrant syrup when added to white wine is called *Kir* or *Kir Royale* when mixed with champagne. In Belgium and the Netherlands, macerated blackcurrants are also the primary ingredient in the apéritif *crème de cassis.* A universally available popular drink, "Ribena", is a juice drink made from blackcurrants.

Blackcurrants are also cooked and used in pies, sauces, meat dishes, desserts and confectionery and as relish for dishes. Blackcurrant is a standard ingredient of "*Rødgrød*", a popular kissel-like dessert in North German and Danish cuisines. In UK and Europe blackcurrant is used to flavour some confectionery. Dried blackcurrant is used as a main ingredient of *pemmican* which is a mixture of dried meat and fat (tallow). Japan imports considerable volume of New Zealand blackcurrants for uses as dietary supplements, snacks, functional food products and as quick-frozen (IQF) produce for culinary food products such as jams, jellies or preserves. An essential "*Níribine*" oil can be distilled from the buds for use in the food and alcohol industry.

Studies showed that blackcurrant jam with low sugar content and without additives and manufactured at 92°C and stored at 8°C still have good sources of vitamins and antioxidant after a year (Viberg et al. 1997). After 13 months of storage, at 8°C, 60% of the amount of ascorbic acid and 29% of the quantity of anthocyanins were retained. In the jam stored at higher temperatures less of both were retained. The β-carotene in the jam was found to be stable throughout the whole shelf-life study. Another study showed that black currant could be used as fermentation substrates for producing alcoholic beverages obtained by distillation of the fruits previously fermented with *Sacchromyces cerevisiae* (Alonso González et al. 2010). The amount of volatile compounds in the black currant distillate (121.1 g/hL absolute alcohol) was lower than the minimum limit (200 g/hL absolute alcohol) fixed by the European Council (Regulation 110/2008) for fruit spirits and did not pose health hazards.

Leaves have been reported to be used in soups. In Russia, blackcurrant leaves are used to flavour tea or preserves. Sweetened vodka is often infused with blackcurrant leaves or berries, to give a deep yellowish-green beverage with a sharp flavour and astringent taste. Dried leaves are used in herbal teas or tea blends. The leaves are utilized for preservation of mushrooms and vegetables.

Botany

A small, erect shrub growing to 1–2 m tall with glabrous branchlets which are pubescent when young. Leaves are alternate, petiolate (petiole 1–4 cm long), suborbicular, palmately lobed with five lobes, 3–5 cm long and broad, and with a serrated margin, base cordate, abaxial surface pubescent and glandular, adaxial surface puberulent when young, glabrescent (Plates 1 and 3). Flowers in 4–12-flowered racemes with pubescent rachis and pedicels and pubescent, lanceolate or ovate bracts (Plate 2). Flower bisexual, 5–7 mm across. Calyx yellowish green to pinkish, pubescent and yellow glandular; tube subcampanulate, 1.5–2.5 mm with lobes spreading or reflexed, ligulate, lobes. Petals ovate to ovate-elliptic, 2–3 mm, white to reddish, nectary disc prominent, green or purplish, circular, covering ovary; stamens slightly longer than petals; filaments linear with white sagittate anthers. Fruit, globose, 0.8–1 (–1.4) cm, sparsely glandular, green (Plates 3 and 4) turning to glossy, black, but sometimes brown or green, with persistent calyx and containing several to numerous seeds.

Nutritive/Medicinal Properties

Nutrient composition of raw ripe *Ribes nigrum* fruits per 100 g edible portion was reported as: water 81.96 g, energy 63 kcal (264 kJ), protein 1.40 g, total lipid 0.41 g, ash 0.86 g, carbohydrate 15.38 g, Ca 55 mg, Fe 1.54 mg, Mg 24 mg, P 59 mg, K 322 mg, Na 2 mg, Zn 0.27 mg, Cu 0.086 mg, Mn 0.256 mg, Vitamin C 181 mg, thiamine 0.05 mg, riboflavin 0.05 mg, niacin 0.3 mg, panthothenic acid 0.398 mg, vitamin B-6 0.066 mg, vitamin A 230 IU, vitamin E (α-tocopherol) 1 mg, total saturated fatty acids 0.034 g, 16:0 (palmitic) 0.02 g, 18:0 (stearic) 0.056 g, total monounsaturated fatty acids 0.058 g, 16:1 undifferentiated (palmitoleic) 0.001 g, 18:1 undifferentiated (oleic) 0.056 g, total polyunsaturated fatty acids 0.179 g, 18:2 undifferentiated (linoleic) 0.107 g, and 18:3 undifferentiated (linolenic) 0.072 g (USDA 2011).

Plate 1 Blackcurrant leaves

Plate 2 Blackcurrant flowers and buds

The total lipid content by weight of fruit seeds of the *Ribes* family was found to range from 18.3% in goose-berries (*Ribes uva crispa*) to 30.5% in black currants (*Ribes nigrum*) (Traitler

Plate 3 Unripe blackcurrant fruits

Plate 4 Close-up of unripe blackcurrant fruits

et al. 1984). Black currant seed oil was found to contain up to 19% by weight of γ-linolenic acid (γ-LA, C18:3, n-6). Black currant species thus represents one of the richest natural sources in γ-LA yet described. These oils had been reported to be promising for critically ill patients unable to convert linoleic acid into subsequent essential fatty acid fractions. Study of the fatty acid profile of 29 black currant genotypes found that α-linolenic, stearidonic, and γ-linolenic acid (GLA) contents, varied between 11.1% and 18.7%, between 2.5% and 4.5%, and between 11.6% and 17.4%, respectively (Del Castillo et al. 2004). Although GLA content was not strongly correlated with juice parameters, some genotypes had both high GLA contents and desirable juice characteristics.

Goffman and Galletti (2001) found that the highest total tocopherol content was found in *R. nigrum* (mean, 1,716 mg/kg oil), followed by *R. rubrum* (mean, 1,442 mg/kg oil). *R. grossularia* showed the lowest tocopherol content (mean, 786 mg/kg oil). The three species also differed markedly in tocopherol composition. *R. rubrum* had the highest content of δ-tocopherol (mean, 20.2%); *R. grossularia* had the highest level of γ-tocopherol (mean, 70.0%), and *R. nigrum* the highest percentage of α-tocopherol (mean, 34.8%), the most biologically active among the four tocopherols. As for γ-linolenic acid, the highest concentration was found in *R. nigrum*, up to 15.8% while *R. grossularia* and *R. rubrum* showed mean γ-linolenic acid levels of 8% and 6.2%, respectively. The present study indicated that seeds of *Ribes* species, especially *R. nigrum*, could be used as sources of gamma-linolenic acid and natural vitamin E. γ-linolenic acid is an essential fatty acid for humans with δ-6-desaturase deficiency; it is a precursor of prostaglandins, prostacyclins, and tromboxanes; and has anti-inflammatory and antitumoral effects. Tocopherols are natural antioxidants with biological activity, heart/vascular, and cancer protective properties.

Oil contents of Canadian black currant seeds varied from 27% to 33% (Bakowska-Barczak et al. 2009). The γ-linolenic acid content varied significantly among the cultivars (from 11% for Ben Conan to 17% for Ben Tirran). Among the 44 triacylglycerol identified, LLαLn, αLnLγLn, and PLγLn (where L = linoleoyl, αLn = α-linolenoyl, γLn = γ-linolenoyl, and P = palmitoyl) were the predominant ones. Black currant seed oil was also a good source of tocopherols (mean 1,143 mg/100 g of oil) and phytosterols (6,453 mg/100 g of oil on average). Quercetin-3-glucoside and p-coumaric acid were the main phenolic components in the seed residues. The high concentration of flavonols and phenolic acids was correlated with a high antioxidant activity of seed residue (average ABTS value of 1.5 mM/100 g and DPPH value of 1.2 mM/100 g). The data indicated Canadian black currant seed oil to be a good source of essential fatty acids, tocopherols, and phytosterols.

Besides genotype, latitude and weather conditions were found to impact on sugars, fruit acids, and ascorbic acid levels in black currant juice (Zheng et al. 2009). In comparison to black currants grown in northern Finland (latitude 66° 34′N), the berries grown in southern Finland (latitude 60° 23′N) had higher contents of fructose, glucose, sucrose, and citric acid (by 8.8%, 6.1%, 10.0%, and 11.7%, respectively) and lower contents of malic acid, quinic acid, and vitamin C (by 31.1%, 23.9%, and 12.6%). Fructose, glucose, and citric acid in cultivar Melalahti were not influenced by the weather, whereas their concentrations in Mortti and Ola correlated positively with the average temperature in February and July and negatively with the percentage of the days with a relative humidity of 10–30% from the start of the growth season until the day of harvest. Similarly latitude and weather conditions were found to impact on the regioisomer compositions of triacylglycerols like α-linolenoyldilinoleoylglycerol and γ-linolenoyldilinoleoylglycerol in currant seed oils (Leskinen et al. 2009). In *R. rubrum* the proportion of the symmetric regioisomer LAlaL among Ala/L/L (18:3(n-3)/18:2(n-6)/18:2(n-6)) was higher (14.1%) than in *R. nigrum* (12.1%). Generally in currants, the portion of LAlaL was lower in northern Finland (12.1%) than in southern Finland (13.5%), where temperature and radiation sums were higher.

Other Phytochemicals

The major flavonol glycosides isolated from ripe blackcurrants (*Ribes nigrum* cv. Silvergieters Schwarze) were myricetin 3-β-D-glucopyranoside, rutin, and isoquercitrin (Koeppen and Herrmann 1977). The presence of the 3-rutinosides and 3-glucosides of cyanidin and delphinidin was also confirmed. No free flavonoid aglycones was detected in the fresh berries. The major constituent fluorescing blue under ultraviolet light was isolated and characterized as 1-O-caffeyl-β-D-glucopyranose. Also isolated were 1-O-ferulyl- and 1-O-p-coumaryl-β-D-glucopyranose and hydroxycinnamyl-D-glucoses. Matsumoto et al. (2001) isolated from black currant fruits four anthocyanin components: delphinidin 3-O-β-rutinoside, cyanidin 3-O-β-rutinoside, delphinidin 3-O-β-glucoside, and cyanidin 3-O-β-glucoside. Fifteen anthocyanin structures were reported from an extract of black currant berries (*Ribes nigrum*) (Slimestad and Solheim 2002). These were the 3-O-glucosides and the 3-O-rutinosides of pelargonidin, cyanidin, peonidin, delphinidin, petunidin, and malvidin, cyanidin 3-O-arabinoside, and the 3-O-(6″-p-coumaroylglucoside)s of cyanidin and delphinidin. The four main pigments (the 3-O-glucosides and the 3-O-rutinosides of delphinidin and cyanidin) comprised >97% of the total anthocyanin content. The amounts of anthocyanin rutinosides were found to be higher than the amount of the corresponding glucosides for all detected pigments having the same aglycon moiety.

Eleven delphinidin-, cyanidin-, malvidin-, petunidin-, and peonidin-based anthocyanins were detected, with the main components being delphinidin-3-O-glucoside (839 nmol/g of fresh weight), delphinidin-3-O-rutinoside (2,233 nmol/g), and cyanidin-3-O-rutinose (1,693 nmol/g) (Borges et al. 2010). The other anthocyanins were cyanidin-3-O-glucoside (327 nmol/g), delphinidin-3-O-(600-p-coumaroyl)glucoside (77 nmol/g), delphinidin-3-O-galactoside (52 nmol/g), petunidin-3-O-rutinoside peonidin-3-O-galactoside (103 nmol/g), malvidin-3-O-galactoside peonidin-3-O-glucoside (71 nmol/g), peonidin-3-O-rutinoside peonidin-3-O-rutinoside (126 nmol/g). In addition to anthocyanins, the black currants contained vitamin C (2,328 nmol/g) and smaller quantities of a caffeic acid-O-glucoside (76 nmol/g). Several flavonols myricetin-3-O-rutinoside (135 nmol/g), myricetin-O-glucuronide

(138 nmol/g), and myricetin-3-O-(600-malonyl) glucoside (29 nmol/g) were also detected. Several kaempferol and quercetin conjugates were also found such as kaempferol-3-O-rutinoside (12 nmol/g), kaempferol-3-O-galactoside (23 nmol/g), quercetin-3-O-rutinoside (77 nmol/g), quercetin-3-O-glucoside (83 nmol/g), and quercetin-3-O-(600-malonyl)glucoside (17 nmol/g).

Of the berries of *Ribes nigrum* (black and green currants) and *Ribes x pallidum* (red and white currants), the highest contents of anthocyanins (3,011 mg/kg fresh weight, expressed as the aglycon) and flavonol glycosides (100 mg/kg) were found in black currant (Maatta et al. 2001). The lack of anthocyanins in the colourless (green, white) berries was associated with elevated levels of phenolic acids, especially p-coumaric acid (80 mg/kg in green currant versus 45 mg/kg in black currant) and 4-hydroxybenzoic acid (18 mg/kg in white currant versus 3 mg/kg in red currant). The study demonstrated that the amounts of extractable (22–41 mg/kg) and non-extractable proanthocyanidins (32–108 mg/kg) were comparable to those of other phenolics, with the exception of anthocyanins in black currant. The results suggested that anthocyanins dominated in black and red currants, whereas proanthocyanidins and phenolic acids were the predominant phenolic compounds in green and white currants. Rubinskiene et al. (2005) reported that the highest contents of pigments were found in overripe *Ribes nigrum* berries. Delphinidin-3-rutinoside was the major component in the reddish coloured berries (onset of ripening), and cyanidin-3-rutinoside was the dominant pigment in the black ones (ripe berries). Cyanidin-3-rutinoside was found to be the most thermally stable anthocyanin.

Scalzo et al. (2008) found that *Ribes* genotypes had greater total anthocyanin contents than *Vaccinium* which was, in turn, higher than *Rubus*. However, all genera afforded rich sources of anthocyanins and individual crop types within genera varied substantially. Five percent (i.e., 223) of samples comprising mostly blackcurrants, some black raspberries and three ornamental blueberries had total anthocyanin contents >5,000 μg/g. *Ribes nigrum* samples were predominated by cyanidin and delphinidin rutinosides which, comprised almost 80% of the total anthocyanin contents. Non-structural carbohydrates of blackcurrant fruits from 17 UK-grown black currant cultivars were found to range from 85.09 to 179.92 mg/g fresh weight basis, while organic acids contents ranged from 36.56 to 73.35 mg/g FW. Relative concentrations of cyanidin 3-glucoside, cyanidin 3-rutinoside, delphinidin 3-glucoside and delphinidin 3-rutinoside were 3.1–7.9%, 35.4–47.0%, 7.6–12.5% and 36.9–50.9%, respectively (Bordonaba and Terry 2008).

Raw cutin (i.e., extractive-free isolated cuticular membrane) fraction from Finnish berries including *Ribes nigrum* was found to contain <50% polyester polymer cutin (Kallio et al. 2006). The major cutin monomers were C(16) and C(18) omega-hydroxy acids with mid-chain functionalities, mainly epoxy and hydroxyl groups. Generally, the dominant compounds were 9,10-epoxy-18-hydroxyoctadecanoic acid, 10,16-dihydroxyhexadecanoic acid, 9,10,18-trihydroxyoctadecanoic acid, 9,10-epoxy-18-hydroxyoctadec-12-enoic acid, and 18-hydroxyoctadec-9-enoic acid. The black currant cutin differed from that of the other berries with a significant component of hydroxyoxohexadecanoic acid (about 12% of total monomers).

Two novel nitrile-containing compounds, nigrumin-5-p-coumarate and nigrumin-5-ferulate, together with six known flavonoids, were isolated from black currant (*Ribes nigrum*) seeds (Lu et al. 2002). The chemical structures of nigrumin-5-p-coumarate and 5-ferulate were elucidated as 2-trans-p-coumaroyloxymethyl-4-β-D-glucopyranosyloxy-2(E)-butenenitrile and 2-trans-feruloyloxymethyl-4-β-D-glucopyranosyloxy-2(E)-butenenitrile, respectively. The non-conjugated octadecatetraenoic acid found in the seed oil of *Ribes nigrum* was found to be identical to the C18-polyunsaturated fatty acid previously isolated in a number of fish oils and seed oils (Moine et al. 1992). Comparison with authentic material prepared by chemical synthesis provided further confirmation of the (all-cis)-6,9,12,15-octadecatetraenoic acid structure.

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). In the genus *Ribes*, quercetin was the main compound in gooseberry, red currant and black currant. The data suggested berries to have potential as good dietary sources of quercetin or ellagic acid. The major phenolic compound in red currant was found to be chlorogenic acid (da Silva Pinto et al. 2010). Of red and black currants, and red and green gooseberries, red currants had the highest α-glucosidase, α-amylase and angiotensin I-converting enzyme (ACE) inhibitory activities. A complex profile of anthocyanins, flavonols, flavan-3-ols and hydroxycinnamic acid derivatives were assayed in acetone-acetic acid (99:1, v/v) extracts of blue berries, red and black currants (Gavrilova et al. 2011). Anthocyanins comprised the highest content of total phenolic compounds in currants (>85%) and lower and variety dependent in blueberries (35–74%). Hydroxycinnamic acid derivatives comprised 23–56% of total phenolics in blueberries and 1–6% in currants. From flavan-3-ols, epigallocatechin was detected in currants.

Fifty-three volatile compounds were identified from blackcurrants and quantified through calibration curves (Harb et al. 2008). Terpene compounds included terpene alcohols: terpineal-4-ol, eucalyptol, β-linalool, nerol; terpene esters: nerol acetate, linalool acetate, citronellyl butyrate, α-terpineol acetate; monoterpenes: 3-carene, α-pinene, β-pinene, β-myrcene, D-limonene, 4-carene, β-phellandrene; and sesquiterpenes: β-caryophlene, α-farnesene, (z)-β-farnesene. Nonterpene volatiles included non-terpene alcohols: tetradecane, 10-undecen-1-ol, 1-octanol, 1-hexanol, 1-heptanol, eugenol; aldehydes: hexanal, 2-nonenal (E), nonanal, benzaldehyde; and branched or straight-chain esters: methyl decanoate, hexyl acetate, methyl benzoate and hexyl hexanoate, ethyl butanoate, heptyl butanoate, hexyl 2-methylbutanoate, ethyl benzoate, ethyl acetate, butyl 2-methylbutanoate and ethyl 2-methylbutanoate, ethyl octanoate, ethyl 2-butenoate, hexyl formiate, ethyl hexanoate, heptyl acetate, methyl octanoate, octyl acetate, octyl formiate and β-phenyethyl acetate. Fruit that were stored in air, for either 3 or 6 weeks, did not differ significantly from freshly harvested fruit with respect to total terpene volatiles. However, decreasing O2 levels and increasing CO2 levels retarded the capacity of 3-week stored fruit to synthesize terpenes, although prolonged storage under these conditions led to a partial recovery. Terpene alcohols reached a peak in 6-week air-stored fruit, and storing berries under a high CO_2 level (18 kPa) and/or decreasing O_2 level (2 kPa) resulted, in most cases, in lower biosynthesis of these alcohols compared to 6-week air-stored fruit. Non-terpene compounds, mainly esters and alcohols, were also increased in air-stored fruit. Non-terpene esters differed greatly in storage, in particular the ester ethyl butanoate. Air-stored fruit at both sampling dates synthesized significantly higher amounts of esters than freshly harvested fruit but a significant decline was observed for branched butyl substances (2-methylbutanoate) after 6 weeks storage. Forty-nine aromatic compounds were quantified in black currant juice, and the thermal treatment resulted in concentration increases of most terpenes, aldehydes, furans, and phenols, whereas the concentration of esters slightly decreased (Varming et al. 2004). Higher temperatures and longer exposure times had larger effects on the aroma compounds. It was found that a 90°C thermal treatment of black currant juice, the temperature range used for conventional evaporation of black currant juice, had an effect on the aroma and sensory properties.

The glycerolipid composition of *R. nigrum* leaves was found to be largely characteristic of 16:3 plants but there was a minor contribution typical of 18:4 plants (Dobson 2000). The total fatty acid composition was unusual in that α-linolenic acid (alpha-18:3) occurred together with cis-7,10,13-hexadecatrienoic acid (16:3) and lower amounts of stearidonic acid (18:4) and γ-linolenic acid (γ-18:3). Monogalactosyldiacylglycerol contained the highest proportion of 16:3 with less in digalactosyldiacylglycerol. All lipids had γ-18:3 and 18:4 with the latter always higher than the former. The highest percentages of γ-18:3 and 18:4 were in phosphatidylcholine, but phosphatidylglycerol was particularly low in these acids. A flavonoid, kaempferol-3-0-(6″-0-

malonyl)-6-D-glucopyranoside was isolated from the leaves of black-currant (Pieri et al. 2002).

Amongst nine different berry extracts investigated for their free radical scavenging activity, black currant (*Ribes nigrum*) extract was recently found to be the second most effective (Bishayee et al. 2010). Black currant is known to have high contents of anthocyanins (250 mg/100 g fresh fruit). Black currant fruits have been used in Asian and European traditional medicine for the treatment of a variety of diseases. Compounds present in black currant juice were found to exert a number of health-promoting effects, including immunomodulatory, antioxidant, antimicrobial and antiinflammatory actions, inhibition of low-density lipoprotein, and reduction of cardiovascular diseases.

Antioxidant Activity

In black currant, the three main anthocyanins, delphinidin-3-O-glucoside (14.2%), delphinidin-3-O-rutinoside (32.8%), and cyanidin-3-O-rutinose (18.5%) along with vitamin C (17.5%), were the major contributors to the antioxidant capacity (AOC) of the extract (Borges et al. 2010) The flavonols myricetin-3-O-rutinoside and myricetin-3-O-glucuronide were each responsible for 1.9% of the total AOC, with the quercetin and kaempferol and quercetin conjugates (each <1%) providing minimal contribution.

All the crude extracts of the berries of several cultivars of *Ribes, Rubus*, and *Vaccinium* genera examined showed a significantly high activity towards chemically-generated superoxide radicals (Costantino et al. 1992). The activities were higher than those expected on the basis of the quantities of anthocyanins and polyphenols present in the samples. In addition, the extracts exhibited inhibitory activity towards xanthine oxidase. *Ribes nigrum* extracts showed the highest activity, being the richest in both anthocyanins and polyphenols. In contrast, *Ribes rubrum* extracts seemed to contain more active substances than the other crude extracts. 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 bilberries and black currants, anthocyanins contributed the most to the antioxidant effect by inhibiting the formation of both hexanal and protein carbonyls. Studies showed that black currant anthocyanins provided good antioxidant protection toward oxidation of tryptophan (Salminen and Heinonen 2008).

After treatment with ornithine decarboxylase inhibitor, a polyamine inhibitor (O-phosphoethanolamine, KF), and a phenol biosynthesis stimulator (carboxymethyl chitin glucan, CCHG), the antioxidant activities compared using LDL in-vitro oxidation assay were increased more markedly after treatment with KF in both black currant and chokeberry, though the regulators had the lower effect on the phenolic accumulation in black currant (Hudec et al. 2009). There was a strong correlation between the total phenolics in the both crops and anthocyanins, hydroxybenzoic acids, and hydroxycinnamic acids contents, respectively. Both regulators significantly changed the ratio of conjugated (rutin) to free (quercetin) flavonol mainly in black chokeberry.

Treatment of black currant pomace with commercial pectinolytic enzyme preparations, Macer8 FJ, Macer8 R, Novozym 89 protease and Pectinex BE significantly enhanced the contents of phenols extracted from the pomace (Landbo and Meyer 2001). A decrease in pomace particle sizes from 500–1,000 μm to <125 μm elevated the phenol yields 1.6–5 fold. Black currant pomace without seeds gave significantly higher yields of phenols than pomace with seeds and seedless wine pomace. Four selected black currant pomace extracts all exerted a pronounced antioxidant activity against human LDL oxidation in vitro when tested at equimolar phenol concentrations of 7.5–10 μM.

Four black currant anthocyanins, cyanidin 3-O-β-glucoside, cyanidin 3-O-β-rutinoside, delphinidin 3-O-β-glucoside, and delphinidin 3-O-β-rutinoside were quantitatively determined in black current juices (Nielsen et al. 2003). The antioxidant capacity of all 13 black currant juices was determined by TEAC and FRAP. Less than 70% of the antioxidant capacity of the juices could be due to vitamin C or the anthocyanin indicating that other very potent antioxidants were present in commercial black currant juices. In another study, phenol content in the black currant press residue (BPR) extracts was found to be 8–9 times higher than in the black currant pomace extracts (Kapasakalidis et al. 2006). Acid hydrolysis liberated a much higher concentration of phenols from the pomace than from the black currant press residue. The main anthocyanins constituted the main class of phenols and the following anthocyanins were indentified delphinidin-3-O-glucoside, delphinidin-3-O-rutinoside, cyanidin-3-O-glucoside, and cyanidin-3-O-rutinoside. Anthocyanins were present in considerably lower amounts in the pomace than in the BPR. Using the ABTS(*)(+) assay, BPR extracts prepared by solvent extraction exhibited significantly higher (7–10 times) radical scavenging activity than the pomace extracts, and BPR anthocyanins contributed significantly (74% and 77%) to the observed high radical scavenging capacity of the corresponding extracts.

Black currant berries contained very high levels of natural phenolic compounds; the leaves and buds were also found to be a good source of natural antioxidants (Tabart et al. 2011). They contained high amount of phenolic acids, flavonoids and carotenoids. An acetone mixture extract gave good yield of several classes of phenolic compounds that included flavonols, flavan-3-ols and anthocyanins.

Stability and Bioavailability of Anthocyanins

Studies found that anthocyanins present in commercial black currant juice remained stable during in-vitro digestion in gastric fluid regardless of the addition or not of pepsin into the medium (Uzunović and Vranić 2008). The anthocyanins remained stable during in-vitro digestion in simulated intestinal fluid without pancreatin. With pancreatin in the intestinal fluid there was a reduction in stability, and this also contributed to slight reduction of total anthocyanins content (−1.83%) in commercial black currant juice. Steinert et al. (2008) studied the bioavailability of blackcurrant anthocyanins using Caco-2 monolayers as an in-vitro model of the absorptive intestinal epithelium. They found that cell metabolism and translocation across the basolateral membrane may be the key determinants of anthocyanin absorption and bioavailability. Apical transport might occur to a much larger extent than the further translocation across the basolateral membrane.

Antiinflammatory Activity

Total flavonoids extracted from *Ribes nigrum* leaves and their two major components, rutin and isoquercitrin did not exhibit spasmodic nor relaxing activity on rat stomach strip (Chanh et al. 1986). They were not capable of inducing any biosynthesis and release of prostaglandin-like substances and did not act on prostaglandin E2 receptor receptors. They inhibited both biosynthesis and release of prostaglandin-like substances. Total flavonoids were more active than rutin and isoquercitrin: ID30 was 1.03 mg/ml for total flavonoids compared to 3.75 and 2.31 mg/ml for rutin and isoquercitrin respectively. A hydroalcoholic extract of black currant leaves exhibited antiinflammatory activity when tested on carrageenan-induced rat paw oedema (Declume 1989) The black currant extract and lyophilisate revealed significant antiinflammatory activity comparable to that seen with the reference substances, indomethacin and niflumic acid, but without their ulcerogenic potential, even at high doses during chronic treatment.

Pretreatment of rats with proanthocyanidins (PACs), isolated from blackcurrant (10, 30, 60 and 100 mg/kg, i.p.) reduced paw oedema induced by carrageenin in a dose and time-dependent manner (Garbacki et al. 2004; 2005). PACs also inhibited dose-dependently carrageenin-induced pleurisy in rats. They decreased lung injury, pleural exudate formation, polymorphonuclear cell infiltration, pleural exudate levels of TNF-alpha, IL-1beta and CINC-1 but did not affect IL-6 and IL-10 levels. PACs inhibited in vivo nitric oxide release; they lowered exudate levels of nitrite/nitrate (NOx). In indomethacin treated rats, the volume of pleural exudate was low; leukocytes and TNF-alpha, IL-1beta, IL-6 and IL-10 contents were reduced but not NOx. The data suggested that the antiinflammatory properties of PACs were achieved through a different pattern from those of indomethacin, mainly in an interference with the migration of the leukocytes. The antiinflammatory activity of proanthocyanidins was found to be related to an inhibition of leukocyte infiltration partially caused by a down-regulation of endothelial adhesion molecules, ICAM-1 and VCAM-1 and these compounds were capable of modulating TNF-alpha-induced vascular endothelial growth factor (VEGF) transcription.

Antiviral Activity

The major constituents of the fraction D separated from *R. nigrum* "Kurokarin" fruit extract were determined as anthocyanins (Knox et al. 2001). Further fractionation of fraction D yielded fractions A′ to G′. The fraction E′ consisted of 3-O-α-L-rhamnopyranosyl-β-D-glucopyranosyl-cyanidin and 3-O-β-D-glucopyranosyl-cyanidin, and the fraction F′ consisted of 3-O-α-L-rhamnopyranosyl-β-D-glucopyranosyl-delphinidin and 3-O-β-D-glucopyranosyl-delphinidin. The fractions D′ to G′ showed potent antiviral activity against influenza viruses A and B. The additive antiviral effect of a combination of the fractions E′ and F′ was assessed. Anthocyanins in the fraction F′ did not directly inactivate influenza viruses A and B, but they inhibited virus adsorption to cells and also virus release from infected cells. In further studies, Knox et al. (2003) showed that the concentration of Kurokarin extract required to inhibit the plaque formation of both influenza virus types IVA and IVB by 50% (IC_{50}) was 3.2 μg/ml. Both IVA and IVB were directly inactivated up to 99% by 10 μg/ml of the extract at pH 2.8, and 95–98% at pH 7.2. The growth of IVA in cells treated with 10 and 100 μg/ml of the extract for 6 hours after infection was completely suppressed. Virus titres in culture fluids of the cells treated with 100 μg/ml of Kurokarin extract for 1 hour at 8–9 hours post infection, were completely suppressed, indicating that the extract inhibited the virus release from the infected cells. Suzutani et al. (2003) reported that found *R. nigrum* (Kurokarin) fruit extract inhibited completely herpes simplex virus type 1 attachment on the cell membrane at a 100-fold dilution, as well as the plaque formation of herpes simplex virus types 1 and 2, and varicella-zoster virus by 50% at a 400-fold dilution or lower concentrations. This latter activity of inhibition of virus replication in cells was attributed to the inhibition of protein synthesis in infected cells from the early stage of infection.

Anticancer Activity

Black currant fruit juice was found to contain a polysaccharide-rich substance, which was named cassis polysaccharide (CAPS), with macrophage-stimulating activity (Takata et al. 2005). Its interleukin (IL)-1beta-inducing activity was extraordinarily high, compared with other fruit juice preparations. CAPS was found to consist of rhamnose, mannose, arabinose, galactose, xylose, and glucose in a molar ratio of 11.3:0.9:54.1:29.8:2.0:1.9. CAPS was partitioned into a soluble component (CAPS-l.m.) and a precipitable component (CAPS-h.m.) with mean molecular weights of 80,000 and 600,000 respectively. CAPS-l.m. rather than CAPS-h.m. appeared to play an important role in macrophage activation in-vitro. Oral administration of black currant juice and CAPS to Ehrlich carcinoma-bearing mice inhibited the growth of the solid tumour by 45% and 51% respectively. CAPS administration had a stimulatory effect on the release of IL-2, IL-10, interferon-gamma, and IL-4 from splenocytes in comparison with phosphate buffered saline treatment in tumour-bearing mice. The IL-4 concentration was, however, still lower than that exhibited by a group of normal mice. Cassis polysaccharide exhibited cytotoxicity directly against Ehrlich ascites cells with an estimated IC_{50} of 760 µg/ml.

The aqueous extract of black currant fruit skin yielded an anthocyanin-rich fraction with cyanidin-3-O-rutinoside as one of the major anthocyanins (Bishayee et al. 2010). This fraction exhibited a potent cytotoxic effect on HepG2 liver cancer cells. This effect was more marked than that of delphinidin and cyanidin, two major aglycones of anthocyanins present in black currant. This action was possibly attributable additive as well as synergistic effects in the anthocyanin-rich fraction of black currant skin. Bishayee et al. (2011) reported that the anthocyanin-rich black currant skin extract (BCSE) dose-dependently decreased the incidence, total number, multiplicity, size and volume of preneoplastic hepatic nodules in model of rat liver hepatocarcinogenesis induced by of diethylnitrosamine (DENA) followed by promotion with phenobarbital. The antihepatocarcinogenic effect of BCSE was confirmed by histopathological examination of liver sections. Immunohistochemical analysis of proliferating cell nuclear antigen and DNA fragmentation revealed BCSE-mediated inhibition of abnormal cell proliferation and induction of apoptosis in DENA-induced rat liver tumorigenesis respectively. Mechanistic studies revealed that BCSE-mediated proapototic signal during experimental hepatocarcinogenesis may be evoked via the up-regulation of Bax and down-modulation of Bcl-2 expression at the translational level. The author maintained that the results together with a safety profile of BCSE supported the development of black currant bioactive constituents as chemopreventive agents for human liver cancer.

Skin Cell Stimulation Activity

An arabinogalactan protein (F2) isolated from *Ribes nigrum* was found to stimulate significantly cellular dehydrogenase activities (MTT and WST-1 tests) of human skin cells (fibroblasts, keratinocytes) as well as the proliferation rate of keratinocytes at 10 and 100 µg/ml (Zippel et al. 2009). F2 did not affect the differentiation status of keratinocytes and did not exert any cytotoxic potential using the lactate dehydrogenase test. The fluorescein isothiocyanate-labeled polysaccharide was incorporated in a time-dependent manner into human fibroblasts via endosomal transport. This internalization of the polysaccharide was inhibited by Cytochalasin B.

Antimicrobial Activity

Ribes nigrum bud essential oils exhibited strong antibacterial activity against *Acinetobacter baumanii, Escherichia coli, Pseudomonas aeruginosa* and *Staphylococcus aureus*, as evidenced by the very low MIC values observed for the respective strains (Oprea et al. 2008). Lengsfeld et al. (2004) found that acidic, high molecular weight 1,3-linked galactans with side chains possessing 1,4-galacturonic acid, galactose and arabinose residues were responsible for the anti-adhesive qualities of black currant seed extracts. These polymers were able to block *Helicobacter pylori* surface receptors, thus inhibiting their interaction with specific binding factors located on human gastric epithelia. The juice, water and methanol extracts of the polyphenol–rich pomace of *Ribes nigrum* exhibited efficient antibacterial activity against both Gram positive *Bacillus subtilis* and *B. cereus,* and Gram negative bacteria *Escherichia coli* and *Serratia marcescens* except for the water pomace extract which was very much less inhibitory to *B. cereus* and the methanol pomace extract to *Serratia marcescens* (Krisch et al. 2008). The juice, water and methanol extracts of the polyphenol–rich pomace of *Ribes nigrum* exhibited anti-fungal activity against 8 *Candida* spp., namely *Candida glabrata, C. guilliermondii, C. inconspicua, C. lipolytica, C. norwegica, C. parapsilosis, C. tropicalis* and *C. zeylanoides* (Krisch et al. 2002). The MIC (minimum inhibitory concentration) values of the juice and pomace extracts ranged from 1.83 to 10.38 mg/ml of dry matter. The total phenolic content of the juice, methanol and water extracts of the pomace was 68.03, 145.60 and 178.39 µg gallic acid equivalent/mg dry weight.

Angioprotective Activity

Extract from *Ribes nigrum* inhibited 50% of the activity of porcine pancreas elastase at concentrations of 0.56 mg/ml against a synthetic substrate (Jonadet et al. 1986). Inhibition was less effective on activity of trypsin and alpha-chymotrypsin. Marked in-vivo angioprotective properties were shown by the compounds studied. The results suggested a possible role by these inhibitors in the protection of conjunctive and elastic tissues adversely affected by proteolytic enzymes.

Antiatherogenic Activity

Currant oil from *Ribes nigrum* is one of the few plant oils containing PUFAn-3 (15.3 mol%) in addition to PUFAn-6 (60.5 mol%) (Vecera et al. 2003). Plant-based n-3 polyunsaturated fatty acids (PUFA) possess a prospective antiatherogenic potential. Studies in rats found that after 3 weeks of feeding, the currant oil caused a significant decrease in blood glutathione (GSH) and an increase in Cu(2+) induced oxidizability of serum lipids, but did not affect liver GSH and t-butyl hydroperoxide-induced lipoperoxidation of liver microsomes. Although currant oil did not cause accumulation of liver triacylglycerols as lard fat, the lipoprotein profile (VLDL, LDL, HDL) was not significantly improved after currant oil feeding. The consumption of PUFAn-3 was reflected in LDL as an increase in eicosapentaenoic and docosahexaenoic acid. The results suggested that currant oil affected positively the lipid metabolism in the liver, and did not cause the development of a fatty liver. However, adverse effects of currant oil on the antioxidant status in the blood still remained of concern.

Antiosteoarthritic Activity

Studies by Garbacki et al. (2002) suggested that the prodelphinidins fractions, the major compounds isolated from *R. nigrum* leaves may be useful as an additive agent in the prevention of osteoarthritis. Gallocatechin trimer (GC-GC-GC) displayed the higher stimulation of proteoglycans and type II collagen production (1 μg/ml) and the synthesis of prostaglandin E(2) was significantly reduced by gallocatechin dimer (GC-GC), gallocatechin-epigallocatechin (GC-EGC) and GC-GC-GC at 10 and 100 μg/ml. The inhibition of prostaglandin E(2) synthesis was confirmed by the in-vitro test on purified COX enzymes, showing the selectivity of prodelphinidins on COX-2.

Immuno-Enhancing Activity

It had been shown that the age-associated elevation in prostaglandin E(2) production contributed to the decline in T cell-mediated immune function with age. Wu et al. (1999) conducted a randomized, double-blind, placebo-controlled (soybean oil) study to study the effect of 2 months supplementation with black current seed oil (BCSO) on the immune response of 40 healthy elderly subjects aged 65 years +. The BCSO group exhibited a significant increase in proliferative response of peripheral blood mononuclear (PBMC) cells to the T cell mitogen phytohemagglutinin that was not significantly different from that noted in the placebo group. BCSO did not affect concanavalin A-induced mitogenic response, interleukin 2 and -1beta production, and PBMC membrane fluidity. Prostaglandin E(2) production was significantly lowered in the BCSO-supplemented group, and this change was significantly different from that of the placebo group. The researchers concluded that black current seed oil had a moderate immune-enhancing action attributable to its ability to reduce prostaglandin E(2) production.

Protein Kinase Inhibition Activity

Wang et al. (1996) isolated and characterised condensed tannins based on procyanidin and/or prodelphinidin and having a cis or trans stereochemistry at positions 2 and, from various plant sources, including *R. nigrum*,. All the condensed tannin preparations were found to be potent inhibitors of rat liver cyclic AMP-dependent protein kinase catalytic subunit (cAK) with IC_{50} values ranging from 0.009 to 0.2 μM. The tannin preparations were also found to be excellent inhibitors of rat brain Ca^{2+}- and phospholipid-dependent protein kinase C (PKC) (IC_{50} values in the range 0.3–7 μM), wheat embryo Ca^{2+}-dependent protein kinase (CDPK) (IC_{50} values in the range 0.8–7 μM) and of calmodulin (CaM)-dependent myosin light chain kinase (MLCK) (IC50 values in the range 7–24 μM). One of the most effective preparations, that from the leaves of *Ribes nigrum*, exhibited IC_{50} values with respect to cAK, PKC, CDPK and MLCK of 0.009, 0.6, 2.0 and 16 μM, respectively. The sequence with regard to inhibition sensitivity by these condensed tannins was cAK > PKC > CDPK > MLCK. The *Ribes nigrum* preparation was found to be a competitive inhibitor of cAK with respect to both ATP and synthetic peptide substrate. These condensed tannin preparations were deemed to be the most potent plant-derived inhibitors of cAK yet found.

Atopic Activity

Linnamaa et al. (2010) conducted randomized, double-blind, placebo-controlled trial wherein 313 pregnant mothers were randomly assigned to receive blackcurrant seed oil (151) or olive oil as placebo (162) to ascertain the effect of dietary supplementation with the blackcurrant seed oil on the prevalence of atopy at 12 months of age. There was a significantly lower incidence of atopic dermatitis in the seed oil group than in the olive oil group at the age of 12 months (33.0% versus 47.3%). Similarly the severity (SCORAD index) was also lower in the seed oil group than in the olive oil group at 12 months of age. Dietary supplementation with blackcurrant seed oil was well tolerated and it transitionally lowered the incidence of atopic dermatitis. It could therefore be one potential tool in the prevention of atopic symptoms when used at an early stage of life.

Tocopherol Enhancing Activity

Dietary anthocyanins from blackcurrant did not affect feed intake, body weight, and organ weights in Sprague-Dawley rats (Frank et al. 2002). Dietary cyanidin-3-O-glucoside (C3G) elevated the concentrations of tocopherols in the liver and lungs. Cholesterol levels in plasma and liver were not affected by any of the regimens. C3G and blackcurrant concentrate lowered the relative amount of saturated fatty acids in the liver. The results indicated that dietary cyanidin-3-O-glucoside, and blackcurrant concentrate appeared to have little impact on cholesterol levels and the fatty acid pattern in the liver but appeared to be capable of sparing vitamin E in healthy, growing rats.

Traditional Medicinal Uses

Black currants are used as a remedy for colds and flu and the juice is used to stop diarrhoea and stabilise digestion. The raw juice is diuretic and diaphoretic and an excellent beverage for febrile diseases. Boiled, sugar-added juice is used to treat inflamed sore-throats. Lozenges are also prepared from it.

An infusion of the leaves is cleansing and diuretic. An infusion of leaves is used in the treatment of dropsy, rheumatic pain and whooping cough, and as a gargle for sore throats and mouth ulcers. It has also been used externally on slow-healing cuts and abscesses.

An infusion of the young roots is useful in the treatment of eruptive fevers. A bark decoction is useful for treating calculus, dropsy and haemorrhoidal tumours.

Other Uses

The leaves provide a yellow dye and the fruits a violet dye. The seed oil is used in skin and cosmetic preparations.

Comments

Blackcurrant are readily propagated from hardwood stem cuttings. The best time to take the cuttings is when the foliage has stopped growing or are being shed.

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