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A review of the nutrient composition of selected Rubus berries

Abstract

Purpose - The purpose of this paper is a nutritional review of the scientific literature of four Rubus varieties: raspberry, blackberry, boysenberry and loganberry. The study aimed to review the scientific literature related to Rubus and the bioactives and key nutrients. **Design/methodology/approach** - Nutrient data were obtained from Australia and New Zealand, where Australian data were absent; to provide an overview of the existing and available nutrient composition data, a review of the scientific literature using defined search terms in the Web of Science and Scopus databases for the years 2001-2011 was conducted. The primary components of Rubus are the water-soluble vitamins. **Findings** - A review of Australian and New Zealand nutrient composition databases revealed that Rubus can range from 184 to 293 kJ energy, 0.3 to 0.7 per cent total fat content, 1.1 to 1.5 per cent protein, 4.9 to 7.5 per cent carbohydrate and 34 to 63 mg/100 g folate and 9 to 38 mg/100 g vitamin C. Many publications have addressed the nutrient content of the berries individually with 24 identified in this project relating to raspberries, 15 for blackberries, 3 for boysenberries and 2 for loganberries. **Research limitations/implications** - Research relating to bioactive compounds in Rubus berries appears to be targeted towards those more commonly consumed and readily available in Australia. **Practical implications** - The most commonly identified bioactives were the phenolic compounds with ellagic acid, the specific bionutrient of interest. This suggests the need for a targeted approach to build a consistent set of values for bioactive compounds in Rubus berries. **Originality/value** - Given the growing interest in phytochemical compounds and their inclusion in Australian Dietary Guidelines, collation of analytical data for specific food categories is vital.

Disciplines

Medicine and Health Sciences | Social and Behavioral Sciences

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A review of the nutrient composition of selected *Rubus* berries

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Purpose: This study includes a nutritional review of the scientific literature of four *Rubus* varieties (raspberry, blackberry, boysenberry, loganberry). The study aimed to review the scientific literature related to *Rubus* and the bioactives and key nutrients.

Design/methodology/approach: Nutrient data was obtained from New Zealand, where Australian data was absent; to provide an overview of the existing and available nutrient composition data and a review of the scientific literature using defined search terms in the Web of Science and Scopus databases for the years 2001-2011 was conducted. The primary components of *Rubus* are the water soluble vitamins.

Findings: A review of Australian and New Zealand nutrient composition databases revealed that *Rubus* can range from 184-293 kJ energy, 0.3-0.7 % total fat content, 1.1-1.5 % protein, 4.9-7.5 % carbohydrate and also contain 34-63 mg/100 g folate and 9-38 mg/100 g vitamin C. Many publications have addressed the nutrient content of the berries individually with 24 identified in this project relating to raspberries, 15 for blackberries, 3 for boysenberries and 2 for loganberries.

Research limitations/implications: Research relating to bioactive compounds in *Rubus* berries appears to be targeted towards those more commonly consumed and readily available in Australia.

Originality/value: The most commonly identified bioactives were the phenolic compounds with ellagic acid the specific bionutrient of interest. This suggests the need for a targeted approach to build a consistent set of values for bioactive compounds in *Rubus* berries

Introduction:

Berries in general have long been identified as having components that provide health benefits. The genus *Rubus*, within the family *Rosaceae*, is one of the largest plant genus containing over 740 subspecies which are divided into approximately 12-15 subgenera.¹ The genus *Rubus* is native to six continents and can grow in several locations. The name *Rubus* refers to a bramble and the health benefits have been noted as far back as the time of Hippocrates (500-370 BCE) in relation to wound healing and childbirth.¹ Australian Aborigines were identified to use large quantities of raspberries for their laxative effect. In the present day the health benefits of *Rubus* extend to a number of conditions with specific nutrients and targeted bioactive compounds, of which anthocyanins were the most commonly identified.

Materials and methods:

Existing and available food composition databases for Australia were searched to obtain the nutrient data for raspberry, blackberry, boysenberry and loganberry. Where this data was absent, the New Zealand food composition database was used as an alternative. To compliment this, a review of the scientific literature using defined search terms was conducted to produce a summary of the research on key nutrient and bioactive components of *Rubus*, namely

- a. Raspberry
- b. Blackberry
- c. Boysenberry [hybrid of a, b]
- d. Loganberry [hybrid of a, b, c].

Using the search terms raspberr*, blackberr*, boysenberr*, loganberr* and rubus the Web of Science and Scopus databases (2001-2011) were searched to obtain English language publications, scientific journal articles and reviews relating to these berries.

The search retrieved 410 documents from Scopus and 137 from Web of Science. Of these 91 were duplicate references. The abstracts of the remaining 456 articles were read to determine suitability and full text articles obtained for those related to the work of this project. Articles specifically focussed on the composition of the berries, antioxidant capacity of the nutrients alone, bioavailability and metabolism of the nutrients were included, while botanical characteristics of the plants, inedible components of the plant and genetic variability of the plant were excluded from the review. Human cellular studies, mouse, rat and hamster animal studies and human participant studies related to health were also excluded though reviewed for compositional information.

All relevant information from each included study was summarised in a tabular format and grouped by the *Rubus* variety to which it related. Any review articles were used to provide a narrative summary.

Results:

Rubus are a low energy fruit comprised primarily of natural carbohydrate and dietary fibre, with the main sugar form being fructose. They contain minimal dietary protein and very minor quantities of dietary fatty acids. *Rubus* contain negligible amounts of cholesterol and long chain omega-3 fatty acids and are also low in natural sodium,²⁻³ though this is dependent on the region of growth. The micronutrient composition sees levels of vitamin C, potassium and folate levels that are able to provide substantial contributions to the recommended dietary intakes for Australian adults and children. Blackberries also contain higher amounts of beta-carotene and retinol equivalents than Raspberries, Loganberries and Boysenberries, though Blackberries and Raspberries both provide dietary sources of magnesium as well.²⁻³

The phenolic compounds are the most commonly studied phytonutrient of *Rubus* with the differing sub-types addressed in many studies as well. The phenolic composition changes dramatically throughout the growing and ripening stage of *Rubus* and the types of individual compounds studied also vary widely. Anthocyanins are the most common sub-type of phytonutrient studied. This class has been found to provide the red, blue or purple colouring of the berries depending on the overall pH of the fruit. For raspberries (table 2) the total anthocyanin content appears to vary from 2.43 mg/100 g⁴ to 1113.1 mg/100 g.⁵ Anthocyanins are a type of flavonoid compound and, therefore, when total flavanol content is presented without a further breakdown, these figures may include the anthocyanin content as well. Furthermore, the extraction technique used also has the potential to influence the figures presented with aqueous acetone resulting in greater yields of anthocyanins, ellagitannins and hydroxycinnamates when compared with methanol extraction techniques.⁶ Raspberries are particularly rich in cyanidin glycosides, are unique for their high ellagitannin content and are one of the main dietary sources of ellagitannins.⁷⁻⁸ Epidemiological evidence supports anthocyanins for health purposes.⁹ Of the individual types of phenolic compounds studied, the one available in the greatest abundance appears to be gallic acid. This phenolic acid has strong antioxidant properties and as a result is often used as a marker (gallic acid equivalents, GAE) when extracts are used for further studies.

Very few studies address other nutrients of *Rubus*. Those that were identified in this review include phytonutrients¹⁰ which have been identified to have an oestrogenic effect on the body in particular with post menopausal women. The phytonutrient sub-types mimic the actions of natural oestrogen in the body. These nutrients were studied for raspberries but the quantities identified were small. The values identified for the natural sugars found in raspberries were not dissimilar to those of the Australian food composition databases shown in table 1. The values identified for the

percentage fatty acids for raspberries were largely different to those found in the Australian database indicating the importance of using country specific nutrient data.

The natural sugar levels for blackberries (table 3) were seen to be higher for the Australian food composition data than those of the published studies found for this report.¹¹⁻¹² Similarly, the values for protein were also higher for the Australian data and the values for vitamin C were comparable for one of the two studies found.¹¹ The anthocyanins were similarly studied for blackberries though cyanidin 3-glucoside appeared to be the compound identified in the greatest abundance. Again, a powerful antioxidant, this anthocyanin is suggested to be higher in blackberries due to the dark colouring of the fruit. The total anthocyanin content appears to vary from 11.08 mg/100 g⁴ to 1660 mg/100 g¹³ showing a general trend toward increased anthocyanin content in blackberries compared to raspberries.

Loganberries were only analysed in two studies. The first addressed the mean anthocyanin content, finding it to be 1126 ug/g¹⁴ and the second the mean total phenolic content 429 mg/100 g.¹² Boysenberry analysis found the mean anthocyanin content of the fruit to be 1514 ug/g¹⁴ with proanthocyanins from the juice reaching 1.14 mg/100 g and 76.3 mg/100 g from the seeds.¹⁵ The mean phenolic content of boysenberry was higher than for loganberries, reaching 536 mg/100 g.¹² The total flavanol content was assessed at 1.94 mg/100 g from the juice and 12.8 mg/100 g from the seed with the total flavanols analysed reaching 3.26 mg/100 g for the juice and again higher at 25.9 mg/100 g for the seed.¹⁵ These limited studies support the findings from the food composition databases in which New Zealand data was used in the absence of Australian data and both datasets similarly contained many gaps in the nutritional data.

When considering the primary nutrient composition of the *Rubus* types, absorption of the anthocyanins may be influenced by other foods consumed at the same meal. Alcohol has been identified to have little or even a detrimental effect, while a high fat diet may actually improve absorption.¹⁶ It is suggested that anthocyanins absorbed from the stomach, are not circulated through the bile and long term exposure to the fruit in the longer term may be required for anthocyanins to be found in the bodily tissues.¹⁷ Anthocyanins have been found to cross the blood-brain barrier and accumulate in areas of the brain according to different phytochemical profiles.⁷ Determining dosages is difficult for any particular berry as the indication is that bioavailability is different between flavonoids and different forms of berry product, and also degradation of the nutrients are of concern.¹⁸

Many publications have addressed the nutrient content of the berries individually. The 44 publications reviewed in this study show a clear trend towards analysis of raspberries and blackberries with the two hybrid forms of *Rubus* minimally studied. Overall, the phenolic compounds with a particular focus on ellagic acid were reported most commonly though this is expected to be the result of the higher proportion of this nutrient in *Rubus* berries overall. In support of the literature, the nutrient composition for *Rubus* obtained from the existing Australian food composition databases also found no data available for Boysenberries. This data was obtained from New Zealand food composition databases though is likely to differ due to the changed climate, soil and growing conditions overall. The existing Australian data for Loganberry, the other hybrid berry of this study, is a combination of data from early 1980 and early 1990 and considered to be old data. This stresses the importance of obtaining more recent analytical data for inclusion in the food composition database. Such data will not only provide current day insight into the nutrient composition but it will also allow for theoretical studies to be conducted within which *Rubus* fruit may be modelled into a healthy diet in place of other fruit to see the impact this

may have on the nutrient outcomes. Similarly, analytical data for boysenberries will provide more accurate data for Australian use overall as this is presently not available.

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Tables and Figures:

Table 1: Nutrient composition of fresh *Rubus* (per 100 g) sourced from Australian (1999, 2010) and New Zealand (2008) food composition databases.

Nutrient	Raspberry ^a	Blackberry ^b	Boysenberry ³	Loganberry ^c
Energy, including dietary fibre, kJ	225	211	184	292.8
Energy, kcal	54	50	44	70
Moisture, g	84.6	84.2	85	84.5
Protein, g	1.2	1.4	1.1	1.5
Fat, g	0.3	0.3	0.7	0.3
Dietary fibre, g	6.1	6.1	3	8.1
Fructose, g	3.8	3.9		
Glucose, g	3.1	3.6		
Sucrose, g	0.1	ns		
Maltose, g	ns	ns		
Lactose, g	ns	ns		
Total sugars, g	7	7.5	7.1	4.9
Starch, g	0.3	ns	0.1	
Mannitol, g	0.1			
Sorbitol, g	ns			
Available carbohydrate, without sugar alcohols, g	7.3	7.5		
Available carbohydrate, with sugar alcohols, g	7.4	7.5	7.2	4.9
Lactic acid, g	ns	0.1		
Malic acid, g	0.1	0.2		
Acetic acid, g	ns	ns		
Citric acid, g	2.4	0.4		
Quinic acid, g	ns	ns		
Calcium, mg	28	30	24	27
Copper, mg	0.104	0.16		
Fluoride, µg	ns	ns		
Iron, mg	0.6	0.42	0.8	0.6
Magnesium, mg	22	30		21
Manganese, mg	0.565	0.55		
Phosphorus, mg	37	29	19	26
Potassium, mg	169	114	150	161
Selenium, µg	1.2	2	0.1	
Sodium, mg	1	ns	3	1

Sulphur, mg	14	16		
Zinc, mg	0.36	0.24	0.5	0.3
Iodine, mg			0.2	
Thiamin, mg)	0.037	0.02	0.01	ns
Riboflavin, mg	0.027	0.03	0.02	ns
Niacin, mg	0.36	0.3		0.8
Niacin equivalents, mg	0.56	0.53	1.1	1.1
Pantothenic acid, mg	0.39	0.35		
Pyridoxine, mg	0.05		0.01	
Biotin, µg	5.7	1.4		
Folate, natural, µg	34	36		
Total folates, µg	34	36	63	34
Dietary folate equivalents, µg	34	36		
Alpha carotene, µg	ns	ns		
Beta carotene, µg	28	150		
Cryptoxanthin, µg	ns	340		
Beta carotene equivalents, µg	28	320	301	25
Retinol, µg	ns	ns		
Retinol equivalents, µg	5	53	50	4
Vitamin C, mg	32	38	9	22
Alpha tocopherol, mg	0.8	1.4		
Vitamin E, mg	0.77	1.4		
Total polyunsaturated fatty acids, %	46.2			
, g	0.1	ns	0.5	
Total long chain omega-3 fatty acids, mg	ns		ns	
Cholesterol, mg	ns	ns	ns	

Source of data and year: ^a *Rubus idaeus* 1995 and 1998²; ^b *Rubus fruticosus* 1995 ^{2,19}; ^c 1992,1981³

Abbreviations- ns: not specified

Table 2: Summary of nutrient and bioactive content data for Raspberry obtained from scientific publications (2001-2011)

Study (country)*	Content
Natural sugars (carbohydrates)	
²⁰ (Turkey)	Fructose 32.2 g/kg, glucose 24.3g/kg, 9.1 g/kg sucrose
²¹ (Turkey)	Total soluble sugars 9.68-11.66 %,
²² (Serbia)	Glucose 38.3±1.33 mg/g, fructose 31.5±1.14 mg/g, sucrose 6.9±0.53 mg/g, citric acid 0.15±0.01 mg/g, 0.08±0.01 mg/g
Total fats and fatty acids	
²³ (Turkey)	Total lipid 0.40-0.63 %, C14:0 nd-0.33 %, C16:0 4.93-9.14 %, C18:0 nd-1.18 %, total saturated fatty acids 5.97-9.73 %, C16:1 0.54-1.47 %, C18:1 10.78-14.60 %, C20:1 0.19-0.45 %, C24:1 nd-0.17 %, total monounsaturated fatty acids 12.09-15.82 %, C18:2 42.18-52.61 %, C18:3 18.40-24.10 %, C20:3 0.72-1.69 %, total polyunsaturated fatty acids 66.99-75.91 %
Protein	
²⁴ (Austria)	Protein 0.15-1.00 ug/uL
Minerals	
²⁵ (Hungary)	Aluminium 1.02-1.17 mg/100 g, Boron 0.16-0.21 mg/100 g, Barium 0.03-0.06 mg/100 g, Calcium 29.88-39.90 mg/100 g, Copper 0.09-0.11 mg/100 g, Iron 0.52-0.62 mg/100 g, Potassium 153.42-171.84 mg/100 g, Magnesium 17.56-22.17 mg/100 g, Manganese 0.16-0.28 mg/100 g, Sodium 3.86-5.06 mg/100 g, Phosphorus 29.18-35.06 mg/100 g, Zinc 0.27-0.29 mg/100 g

Vitamins

²⁶ (Sweden)	Folate 46 ug/100 g
²⁷ (Belgium)	Alpha-tocopherol 4.3 mg/kg, delta-tocopherol 5.1 mg/kg, gamma-tocopherol 5.8 mg/kg (stage 5/ripe)
²⁸ (Scotland)	Vitamin C 1014±30 nmol/g
²¹ (Turkey)	Alpha-tocopherol 3.1-8.9 mg/kg, ascorbic acid 2.4-5.34 mg/kg
²⁹ (Scotland)	Vitamin C 672±11 (fresh), 671±14 (frozen)

Carotenoids

²⁷ (Belgium)	Lutein 2.8 mg/kg, beta-carotene <0.01 mg/kg, alpha-carotene 0.44 mg/kg, beta-ionone 1.72 mg/kg, alpha-ionone 0.62 mg/kg (stage 5/ripe)
³⁰ (Bulgaria)	Lutein 320±37 ug/100 g, zeaxanthin 11±2.6 ug/100 g, beta-cryptoxanthin 5.9±1.5 ug/100 g, alpha-carotene 24±1.9 ug/100 g, beta-carotene 9.3±3.3 ug/100 g, total carotenoids 370 ug/100 g

Anthocyanins (flavonoids)

⁵ (United States)	Total monomeric anthocyanins 1113.1±30.7 mg/100 g (fresh), 425±9.9 mg/100 g (juice non pasturised), 342±14.2 mg/100 g (juice pasturised), 14.0±0.6 mg/100 g (sediment)
⁶ (Finland)**	Cyanidin-3-glucoside 15.6 %, cyaniding-3-sophoroside 5.3 %, cyaniding-3-arabinose 59.4 %, pelargonidin-3-glucoside 0.9 %, perlargonidin-3-rutinoside 0.7 %, perlargonidin-3-sophoroside 2.5 %
⁴ (Croatia)	Total anthocyanins 242.90±3 mg/kg
³¹ (Croatia)	cyanidin-3-sophoroside 620.1±4 mg/kg, cy-3-glu 152.1±1 mg/kg, total

anthocyanins 772.2±5 mg/kg

³² (United States) Anthocyanin 0.17-57.60 mg/100 g

²⁹ (United Kingdom) Total anthocyanin 1037±8 nmol/g (fresh), 1049±14 (frozen) nmol/g, total anthocyanins 70±21 g/100 g (fresh), 782±31 g/100 g (frozen),

³³ (United Kingdom) Cyanidin-3-glucoside 5.66±0.18 mg/100 g, cyanidin-3-rutinoside 0.82±0.02 mg/100 g, cyanidin-3-soporoside 22.42±0.60 mg/100 g, p-coumaric glucose 2.87±0.17 mg/100 g

¹⁴ (New Zealand) Mean anthocyanin 1126-3814 ug/g

³⁴ (Poland) Cyanidin-3-O-sophoroside 22.74-80.03 mg/100 g, cyanidin-3-O-2Glucoside-O-glucosie 9.88-53.09 mg/100 g, cyanidin-3-O-gluoside 15.02-76.12 mg/100g, total anthocyanin 76.22-277.06 mg/100 g

Phenolic compounds

²⁸ (Scotland) lambertanin C 322±4 nmol/g, sanguin H-6 1030±107 nmol/g, ellagic acid 11±1 nmol/g

²⁰ (Turkey) Total phenolics average 2046ug GAE/g

²¹ (Turkey) Total phenolic acids 5.83-26.66 %, , caffeic acid 2.41-5.31 mg/kg, ferulic acid 4.90 mg/kg, syringic acid 0.1-7.32 mg/kg, ellagic acid 1.01-10.92 mg/kg, gallic acid 3.0-14.6 mg/kg

³⁵ (United States) Total ellagitannin 23.34±2.01 mg/100 g (fresh), 35.16±8.18 mg/100 g (quick frozen), 39.48±1.42 mg/100 g (canned in syrup), 44.39±1.18 mg/100 g (canned in water), 32.24±6.39 mg/100 g (pureed), 10.41±0.39 mg/L (non-clarified juice), 6.39±0.51 mg/L (clarified juice)

⁴ (Croatia)	Total polyphenols 1256.16±133 mg/kg
³⁶ (Croatia)	Catechin 11.10±0.95 mg/L, epicatechin 13.6±1.11 mg/L, total flavonols 24.6 mg/L, quercetin 1.18±0.15 mg/L, chlorogenic acid 20.20±2.15 mg/L, caffeic acid 14.20±0.95 mg/L, p-coumaric acid 8.96±0.71 mg/L, ferulic acid 4.19±0.12 mg/L, gallic acid 13.10±1.02 mg/L, p-hydroxybenzoic acid 19.10±1.15 mg/L, ellagic acid 163.20±7.25 mg/L, total phenolic compounds 268.70 mg/L
³² (United States)	Total phenolics 3.59-512 mg/100 g, 63.5-103.4 mg/100 g
³⁷ (Finland)	p-coumaric acid 1-2 mg/kg, p-coumaroyl esters 7-13 mg/kg, caffeoyl esters 1-6 mg/kg, galloyl esters 5 mg/kg, ellagitannins 977-1560 mg/kg, ellagic acid 12-112 mg/kg, catechin 2 mg/kg, epicatechin 3-11 mg/kg, quercetin-3-glu 1-5 mg/kg
²⁹ (United Kingdom)	Total phenolics 3383±230g/ 100g (fresh), 3321±103g/98g, ellagic acid 3.5±0.1 g/100 g (fresh), 3.9±0.1 g/100 g (frozen)

Flavanols

²¹ (Turkey)	quercetin 80.0 mg/kg quercetin-3-O-glucoside 28±4 nmol/g
²⁸ (United Kingdom)	Total flavonoids 1.77-6.09 %, quercetin 80.0 mg/kg, catechol 2.12-12.1 mg/kg, progallol 2.02-9.7 mg/kg, vanillin 3.0-4.41 mg/kg, p-coumaric acid 67.03-2792.60 mg/kg,
³¹ (Croatia)	p-coumaric acid 0.5±0.1 mg/kg, ferulic acid 0.9±0.1 mg/kg, ellagic acid 22.7±1.8 mg/kg, catechin 14.9±1.3 mg/kg, epicatechin 18.1±1.5 mg/kg, quercetin 0.3±0.1 mg/kg, total flavonols 57.4±4.9 mg/kg,
³⁸ (Thailand)	Catechin 125.63±1.08 mg/100 g, epicatechin 74.61±2.35 mg/100 g, rutin 20.45±0.44 mg/100 g, myricetin 0.74±0.11 mg/100 g, resveratrol 5.88±0.10

mg/100 g, quercetin 6.92±0.11 mg/ 100g, naringenin 0.90±0.01 mg/100 g,
kaempferol 0.34±0.11 mg/100 g

Phytoestrogens

¹⁰ (Europe, ns) Enterodiol 191.9 nmol/g, Enterolactone 55.6 nmol/g, Total enterolignans 227.9
nmol/g (dry weight)

* country of harvest, ** aggregated data, nd-Not detected, ns- Not further specified

Table 3: Summary of nutrient and bioactive content data for Blackberries obtained from scientific publications (2001-2011)

Study	Content
Natural sugars (carbohydrates)	
¹¹ (Costa Rica)	Glucose 228±10 g/kg, fructose 228±10 g/kg, sucrose 8±1 g/kg
¹² (Brazil)	Moisture 90.88-93.25 %, carbohydrate 3.07-5.92 %, glucose 1.69-2.60 g/100 g, fructose 1.15-2.11g/100 g, sucrose nd-0.7g/100 g, total soluble sugars 2.75-4.78 g/100 g
Protein	
²⁴ (Austria)	Protein 0.12-0.72 ug/uL
Vitamins	
¹¹ (Costa Rica)	Ascorbic acid 44±2 mg/100 g
¹² (Brazil)	Vitamin C 9.9-15.6 mg/100 g
Carotenoids	
³⁰ (Bulgaria)	Lutein 270±33 ug/100g, zeaxanthin 29±0.8 ug/100 g, beta-cryptoxanthin 30±3.7 ug/100 g, alpha-carotene 9.2±0.7 ug/100 g, beta-carotene 100±13 ug/100 g, total carotenoids 440ug/100 g
Anthocyanins (flavonoids)	
¹¹ (Costa Rica)	Cyaniding 3-glucoside 1189±55 mg/L,
¹² (Brazil)	Anthocyanins 116.0-194.0 mg/100 g
⁴ (Croatia)	Total anthocyanins 1108.87±6 mg/kg
³¹ (Croatia)	Total anthocyanins 976.5±5 mg/kg, cy-3-glu 976.5±5 mg/kg

³⁹ (Costa Rica) Cyanidin-3-glucoside 380-680 mg/100g, cy-3-rut nd-630 mg/100 g, lambertianin 520-598 mg/100 g, sanguin 420-2450 mg/100 g

⁴⁰ (United States) Cyanidin 3-glucoside 852.1-1583.3 mg/kg, cy-3-rut 13.4-138.1 mg/kg, cy-3-xyl 46.0-178.1 mg/kg, cy-3-mal 23.8-55.0 mg/kg, cy-3-dio 35.7-193.4 mg/kg, total anthocyanins 1143-2415 mg/kg

¹³ (United States) Total anthocyanins 8.0-16.6 mg/g

¹⁴ (New Zealand) Mean anthocyanin 1499 ug/g

⁴¹ (United States) Total anthocyanins 131-221 mg Cy-3-glu/100 g (ripe)

Phenolic compounds

⁴² (New Zealand) Total phenolic mean content 373-513 mg/100g

¹² (Brazil) Total phenolics 341-499 mg/100g

⁴ (Croatia) Total polyphenol 2484.87±234 mg/kg

⁴³ Total pheolics 2922-4440 mg/kg

¹³ (United States) Total phenols 14.2-35.1umol CE/g

⁴¹ Total phenolics 903-960 mg GAE/100 g (ripe)

⁴⁴ Ellagitannins and ellagic acid derivatives 3547±659 mg EAE/kg

⁴⁵ Total phenolic acids 3255.2±160.0 mg/kg

Flavanols

- ¹² Quercetin 7.8-19.0 mg/100 g, cyanidin 91.0-157.0 mg/100 g, epicatechin 20.7-63.0 mg/100 g, total flavonoid 123.29-233.34 mg/100 g
- ³¹ ellagic acid 19.5±0.7 mg/kg, catechin 1.9±0.1 mg/kg, epicatechin 24.6±1.35 mg/kg, quercetin 1.8±0.2 mg/kg, total flavonols 63.8±3.4 mg/kg
- ³⁹ Gallic acid 0.46-1.8 mg/100 g, caffeoyl esters 1-2.6 mg/100 g, p-coumaroyl esters 4.2-6.3 mg/100 g, feruloyl esters 1.54-3.8 mg/100 g, epicatechin 5.1-6.3 mg/100 g, ellagic acid nd-2 mg/100 g, quercetin glucuronide 51-57 mg/100 g
- ⁴³ (United States) Quercetin-3-rut 7.3-20.2 mg/kg, quercetin 3-gal 9.0-49.3 mg/kg, quercetin 3-meth 4.1-17.2 mg/kg, quercetin 3-glu 15.1-41.5 mg/kg, quercetin 3-b-galac 12.8-41.9 mg/kg, quercetin 3-gluco 3.9-4.5 mg/kg, quercetin 1.89.6 mg/kg, total flavonols 99-150 mg/kg
- ⁴⁵ (Poland) Gentisic acid 136.6±10.8 mg/kg, gallic acid 89.0±5.0 mg/kg, o-pyrocatechuic acid 0.2±0.1 mg/kg, protocatechuic acid 129.5±10.5 mg/kg, salicylic acid 524.1±79.0 mg/kg, vanillic acid 45.1±5.3 mg/kg, caffeic acid 105.5±4.0 mg/kg, m-coumaric acid 596.6±75.1 mg/kg, 3,4-dimethylxycinnamic acid 501.9±7.3 mg/kg, fruilic acid 55.3±7.5 mg/kg, hydroxycaffeic acid 627.6±75.0 mg/kg, sinapic acid 627.6±7.0 mg/kg

EAE: Ellagic acid equivalents