Bioactive Compounds and Antioxidant Activity in Different Types of Berries

Sona Skrovankova 1,*, Daniela Sumczynski 1, Jiri Mlcek 1, Tunde Jurikova 2 and Jiri Sochor 3

1 Department of Food Analysis and Chemistry, Faculty of Technology, Tomas Bata University in Zlin, nam. T.G. Masaryka 5555, CZ-760 01 Zlin, Czech Republic; E-Mails: sumczynski@ft.utb.cz (D.S.); mlcek@ft.utb.cz (J.M.)
2 Institut for Teacher Training, Faculty of Central European Studies, Constantine the Philosopher University in Nitra, Drazovska 4, Nitra SK-949 74, Slovakia; E-Mail: tjurikova@ukf.sk
3 Department of Viticulture and Enology, Faculty of Horticulture, Mendel University in Brno, Valticka 337, CZ-691 44 Lednice, Czech Republic; E-Mail: sochor.jirik@seznam.cz

* Author to whom correspondence should be addressed; E-Mail: skrovankova@ft.utb.cz; Tel.: +420-576-031-524.

Academic Editor: Maurizio Battino

Received: 30 July 2015 / Accepted: 23 September 2015 / Published: 16 October 2015

Abstract: Berries, especially members of several families, such as Rosaceae (strawberry, raspberry, blackberry), and Ericaceae (blueberry, cranberry), belong to the best dietary sources of bioactive compounds (BAC). They have delicious taste and flavor, have economic importance, and because of the antioxidant properties of BAC, they are of great interest also for nutritionists and food technologists due to the opportunity to use BAC as functional foods ingredients. The bioactive compounds in berries contain mainly phenolic compounds (phenolic acids, flavonoids, such as anthocyanins and flavonols, and tannins) and ascorbic acid. These compounds, either individually or combined, are responsible for various health benefits of berries, such as prevention of inflammation disorders, cardiovascular diseases, or protective effects to lower the risk of various cancers. In this review bioactive compounds of commonly consumed berries are described, as well as the factors influencing their antioxidant capacity and their health benefits.

Keywords: berry; bioactive compounds; antioxidant activity; phenolic compounds; anthocyanins; health benefits
1. Introduction

In the last few decades there has been a constant increase of popularity and an interest regarding
research of all kinds of fruits. Particularly fruit berries are well studied, as they contain the best dietary
sources of bioactive compounds (BAC) [1–4]. They are abundant especially in highly-colored berries.
To the species that contain the most BAC belong members of several families, such as Rosaceae
(strawberry, raspberry, blackberry), and Ericaceae (blueberry, cranberry). They are globally known and
consumed, and berries' BAC are used as functional food ingredients. Additionally, grape berries
(genus Vitis) and their products (juice, wine) are great sources of BAC [5–9]. To the berry group
belong other relevant types of berries with low to medium BAC content, but less noted or applied as
nutraceuticals, such as bilberries (Vaccinium myrtillus) [10,11], elderberries (Sambucus spp.) [12,13],
gooseberries (Ribes uva-crispa) [14], cape gooseberries (Physalis peruviana) [15], chokecherries
(Prunus virginiana) [16], arctic brambles (Rubus arcticus) [17], cloudberries (Rubus chamaemorus) [18],
crowberries (Emetrum nigrum, E. hermaphroditum) [19], lingonberries (Vaccinium vitis-idaea) [20],
loganberries (Rubus loganobaccus), marionberries (Rubus spp.) [21], honeyberries (Lonicera caerulea) [22],
Saskatoon berries (Amelanchier alnifolia) [23], Rowan berries (Sorbus spp.) [24], maqui [25], and sea
buckthorn (Hippophae rhamnoides) [26].

Berries, fruits full of BAC, are also very delicious, have low energy, and are often consumed in
fresh form when the most BAC are still active and in the greatest amount. To the BAC group in berries
belong antioxidants such as phenolic compounds and fruit colorants (anthocyanins and carotenoids).
Berries' phenolics represent a diverse group of compounds including phenolic acids, such as
hydroxybenzoic and hydroxycinnamic acid conjugates; flavonoids, such as flavonols, flavanols, and
anthocyanins. In addition, tannins, divided into condensed tannins (proanthocyanidins) and hydrolyzable
tannins, are reported to be important BAC. To bioactive compounds belong other antioxidants such as
vitamins (ascorbic acid) and minerals with antioxidant properties. These compounds are of great
interest for nutritionists and food technologists due to the opportunity to use BAC as functional foods
ingredients. Nutraceuticals and functional foods have become very popular for people due to the
consumer demands for healthy nutraceutical foods that could possibly reduce some health risks and
improve various health conditions. Due to the market for functional foods in the EU having grown, the
years 1999 to 2006 saw the market increase from about $1.8 billion to $8 billion [27].

Many BAC, individually or combined, possess high antioxidant capacity. Antioxidants are the
substances that can scavenge free radicals. These radical forms have an unpaired electron in the outer
orbit that results in their instability and reactivity. The human body possesses defense mechanisms
against free radical-induced damage, such as "oxidative stress", but cumulative oxidative damage leads
to various diseases. Additionally, some dietary antioxidants may help to decrease the incidence of
oxidative stress-induced damage. It is supposed that there is an association between antioxidant-rich
diets and the reduction of oxidative damage to DNA. Therefore, antioxidants could be a prevention of
some crucial points in carcinogenesis [28,29]. However, the effective physiological relevance of
foods with antioxidant intake is uncertain as many investigations are mainly based on in vitro assays.
Therefore, their findings do not necessarily correspond with human physiological mechanisms in vivo [30].
Therefore, the effects of dietary antioxidants in vivo should be studied intensively to know their
physiological effects.
This review will be aimed mainly at BAC and antioxidant capacity of globally known, commonly-consumed fruit berries with the highest content of BAC, such as strawberries, blackberries, raspberries, blueberries, and cranberries. Berries are a profitable source of BAC, and both phenolics and ascorbate. Considering that berry fruits are often consumed in fresh form, their antioxidant capacity is not reduced due to any contrarious influences during processing, such as heat or oxidation [31]. Berry phenolics are transformed by the human metabolism and by colonic microflora into related molecules that can persist in vivo and gather in target tissues. There, they can promote the abundant biological effects of berries [32].

**Chemical Composition of Berries and BAC**

The chemical composition of represented berries is variable depending on the cultivar and variety, growing location and environmental conditions, plant nutrition, ripeness stage, and time of harvest, as well as subsequent storage conditions. Therefore, the content of each individual component and the quality of the fruits is highly variable.

Berries, in general, are rich in sugars (glucose, fructose), but low in calories. They contain only small amounts of fat, but a high content of dietary fiber (cellulose, hemicellulose, pectin), organic acids, such as citric acid, malic acid, tartaric, oxalic and fumaric acid, certain minerals in trace amounts (i.e., 100 g of edible portion of raspberries, blackberries, or blueberries could provide more than 50% of Recommended Dietary Allowance (RDA) for manganese [33,34]), some vitamins (ascorbic acid and folic acid), and phytochemicals, such as phenolic compounds. These compounds could be a good option for the food industry to use as functional foods ingredients.

Phenolic compounds belong to a wide and heterogeneous group of chemical components that possess one or more aromatic rings with a conjugated aromatic system and one or more hydroxyl groups. They tend to donate an electron or a hydrogen atom to a free radical and convert it into an inoffensive molecule. Therefore, phenolics have relevant in vitro and in vivo antioxidant activities. Phenolic compounds occur in free and conjugated forms with sugars, acids, and other biomolecules as water-soluble (phenolic acids, flavonoids and quinones) or water-insoluble compounds (condensed tannins).

To the relevant BAC in berries belong phenolic compounds that include flavonoids, such as anthocyanins (i.e., cyanidin glucosides and pelargonidin glucosides), flavonols (quercetin, kaempferol, myricetin), flavanols (catechins and epicatechin). Furthermore, phenolic acids (hydroxybenzoic acids and hydroxycinnamic acids) and hydrolysable tannins, such as ellagitannins, act as important BAC. These components, either individually or combined, are mainly responsible for berry health benefits and are also associated with their antioxidant properties.

In addition to these components, ascorbic acid could be a very potent antioxidant occurring in significant amounts in fresh berries. Ascorbic acid is an essential water-soluble vitamin with excellent reducing properties, well known by its high antioxidant activity due to the neutralization of free radicals and other reactive oxygen species, formed via cell metabolism, which are associated with several forms of tissue damage and diseases. It is also considered as the nutrient quality indicator during processing and storage as it is known that if ascorbic acid is well-retained, the other nutrients could stay in foods with minimum changes and losses, too. The loss in ascorbic acid content is also cultivar-dependent [35]. However, this vitamin is a great reducing agent with high antioxidant activity [36];
in many studies it was evaluated to contribute only a small amount (up to 10%) to the total antioxidant capacity of the fruits [37–40].

2. Strawberries

Strawberries (family: Rosaceae, genus Fragaria, cultivated: F. × ananassa, wild: F. virginiana) belong to berries that are popular due to their desirable sweet taste and attractive aroma, with smooth texture and red color. The plant is acclimatized to different environments and, therefore, could be cultivated worldwide, intensively in Europe and North America in open fields, whereas in China it is cultivated mainly in greenhouses [41]. There were more than 600,000 acres and 3.9 million tons of strawberries produced worldwide in 2005. The area of more than half of that acreage was utilized for a strawberry farming in Europe. The next largest production regions for strawberries are the Russian Federation, and USA, which produced 1.1 million tons of strawberries [42].

Amongst the fruits, fresh strawberries are considered to be one with the highest content of ascorbic acid. Among the berry species, strawberries have similar content to raspberries, but about four-times more ascorbate than blueberries. Ascorbate content in strawberries is highly variable, and in fresh strawberries generally ranges from 5 to 50 mg/100 g fresh weight (fw) [37,43–45], in some cultivars up to 80 mg/100 g fw [46]. As it is known, there is a gradual decrease in ascorbate content as the storage temperature or duration increases. However, during a week of storage it was determined no ascorbate losses occurred in strawberries at various temperatures [37]. In contrast to that, the loss of ascorbic acid in fresh fruit juices increases with storage time, especially if the temperatures of storage are higher than the refrigerated conditions [45,46].

Strawberries have been referred in many sources of folk medicine and official pharmacopoeia as a potential remedy, i.e., due to their astringent and diuretic properties [47]. In the form of fruit paste they are used in folk medicine to heal skin diseases and wounds, and the juice for inflammation of the nerves and lungs [48]. The leaf extract of strawberries has anti-diabetic, antioxidant, anti-inflammatory, and anti-apoptosis effects [49–53]. Antioxidants in strawberries also help to lessen the risk of cardiovascular incidents by inhibition of LDL-cholesterol oxidation, or improved vascular endothelial function. This could reduce the risk of incidence of thrombosis [54,55]. It is known that some compounds present in strawberries, such as ellagic acid and quercetin [53,56–58], have demonstrated anti-cancer activity in their purified forms or fractions, sometimes enriched with specific components. Crude extracts of strawberries and pure compounds of anthocyanins (cyanidin-3-glucoside, pelargonidin, and pelargonidin-3-rutinoside) show antioxidant and human tumor cell anti-proliferative activities in vitro. Thus, they could suppress the growth of human oral, colon, and prostate cancer cells [59,60]. The preventative effect of berry fruits for human esophageal cancer is because of their potential to modify exposure of several genes relating to the progress of oral cancer [61]. The protection from tumorigenesis upon pre-treatment with strawberry extracts was observed for breast cancer in mice [62], too, but the mechanism by which it exerts the chemoprevention is still not clear. Protective effects of strawberry extracts on human dermal fibroblasts was also referred [63,64].

2.1. BAC in Strawberries

The relevant BAC in strawberries are presented in Table 1.
Table 1. Phenolic composition and factors influencing the composition of strawberries.

| Berry       | Major Phenolic Compounds                                                                 | Factors                                                                 | References |
|-------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------|
| Phenolic compounds |                                                                                       |                                                                       | [65–73]    |
| Growing location |                                                                                       |                                                                       | [65]       |
| Cultivar, genotype, variety |                                                                                       |                                                                       | [69,74–76] |
| Cultivation techniques  |                                                                                       |                                                                       | [66,72,77–79] |
| (conventional, organic) |                                                                                       |                                                                       |            |
| Cultivation condition  |                                                                                       |                                                                       |            |
| (greenhouse, plastic tunnel, open-field, light) |                                                                                       |                                                                       |            |
| Growing season, ripening |                                                                                       |                                                                       | [66,70,73,78] |
| Processing |                                                                                       |                                                                       | [80–83]    |
| Storage (time, temperature) |                                                                                       |                                                                       | [69,83]    |
| Flavonols |                                                                                       |                                                                       | [63,66,80,84,85] |
| Kaempferol glycosides |                                                                                       |                                                                       |            |
| (Kaempferol-3-glucoside, Kaempferol-glucuronide, Kaempferol-3-malonylglucoside, Kaempferol-coumaroyl-glucoside) |                                                                       |            |
| Quercetin glycosides |                                                                                       |                                                                       |            |
| (Quercetin-3-glucuronide, Quercetin-3-malonylglucoside, Quercetin-3-rutinoside = rutin, Quercetin-3-glucoside) |                                                                       |            |
| Strawberry |                                                                                       |                                                                       | [63,68,69,71,84–88] |
| Anthocyanins |                                                                                       |                                                                       |            |
| Cyanidin glycosides |                                                                                       |                                                                       |            |
| (Cyanidin-3-glucoside, Cyanidin-3-rutinoside, Cyanidin-3-galactoside, Cyanidin-3-malonylglucoside) |                                                                       |            |
| Pelargonidin glycosides |                                                                                       |                                                                       |            |
| (Pelargonidin-3-glucoside, Pelargonidin-3-rutinoside, Pelargonidin-3-galactoside, Pelargonidin-3-arabinoside, Pelargonidin-3-malonylglucoside, Pelargonidin-3-malylglucoside) |                                                                       |            |
| Peonidin glycosides (Peonidin-3-glucoside) |                                                                                       |                                                                       |            |
| Phenolic acids and Hydrolyzable tannins |                                                                                       |                                                                       | [63,71,83–85,89] |
| Ellagic acid and its glycosides |                                                                                       |                                                                       |            |
| Ellagitannins |                                                                                       |                                                                       |            |
| Gallic acid |                                                                                       |                                                                       |            |
| Gallotannins |                                                                                       |                                                                       |            |
| Caffeic acid |                                                                                       |                                                                       |            |
| p-coumaric acid and coumaroyl glycosides |                                                                                       |                                                                       |            |

The variability and an exact content of particular phenolic compounds of strawberries depend on many factors, such as genetic qualities, cultivation conditions, ripeness stage, storage time and
The content of the polyphenols such as cyanidin, pelargonidin, and quercetin glycosides displays are much more tightly regulated, supposing a consequent genetic control [90]. The identification of food phenolics is essential as their nature, size, solubility, degree, and position of glycosylation and conjugation, has an impact on their absorption, distribution, and metabolism in humans [84].

The total phenolic content (TPC) of strawberries is approximate to values in raspberries and blackberries, with variances due to the mentioned factors, but lower than in highbush and lowbush blueberries [37, 91]. The phenol content in strawberries decreases during fruit development from the unripe to the ripened stage. A significant decrease (nearly 89%) was observed in ripened fruits as compared to green fruits. To compare conventional cultivation techniques to organic cultivation, no coherent effects on phenolics abundance in strawberries [74–76] was found.

Strawberries are usually eaten in fresh form but they are highly perishable with rapid deterioration in quality due to rapid spoilage. Due to that fact, the relevant part of the strawberry production is processed. Strawberries are consumed in processed products such as jams, jellies, puree, either as canned fruit, or syrup, in drinks as juices, etc. Freshly-produced strawberry juices have higher TPC, anthocyanin, and proanthocyanidin content, than those stored for six months at 4 and 30 °C [81]. The processing of the clear juice showed extensive losses of all phenolics.

Anthocyanins in strawberries are the major known polyphenolic compounds, responsible for fruit color, and can be used as natural pigments (red and blue colors) for the food industry. The anthocyanin content of strawberries, compared to other common berries, is much lower than in blueberries and blackberries, and lower than in raspberries [37, 91]. Their occurrence is influenced by cultivar selection [68], environmental factors such as light, temperature, and agricultural methods. The degradation rate of anthocyanins is also time- and temperature-dependent [37]. An amount of strawberry anthocyanins rose to an average of 4.3-fold after a week of storage. The magnitude of that rise was attributed to temperature. After storage at 0 °C, anthocyanin content rose 1.7-fold, while at 30 °C storage, the obvious rise was 6.8-fold. Strawberry products, such as puree prepared under nitrogen or carbon dioxide, result in greater retention of anthocyanins than ones prepared under air. Thus, strict oxygen exclusion during strawberry processing appears to be convenient to improve anthocyanin stability, but some losses can occur under anaerobic conditions during storage [83]. Another factor affecting color and anthocyanin structure is pH. The pH modification can influence chemical reactions in phenolic compounds, such as anthocyanins. Lower pH (2.5) is better for the preservation of polyphenols in strawberry products during storage of a few months than higher values, as total anthocyanin content is correlated with antioxidant activity [92].

2.2. Antioxidant Capacity of Strawberries

The antioxidant capacity of berries, such as strawberries, is strongly related to the present effective oxygen radical scavengers. To those compounds belong phenolics, most of which express relevant in vitro and in vivo antioxidant activities and ascorbic acid. Considerable increases in the plasma total antioxidant capacity (TAC) and ascorbic acid during 16-day strawberry consumption (500 g of strawberries) were progressively observed after strawberry supplementation [93]. Plasma polyphenols, such as anthocyanins, after consuming strawberry beverages was also studied and pelargonidin-O-glucuronide was found as
the most abundant metabolite. Higher concentrations of key strawberry compounds and metabolites are achieved with eating more strawberries [94].

Total antioxidant capacity (TAC) of strawberries is influenced by several factors (Table 1).

In general, the TAC values of strawberries are similar to raspberries and blackberries and less than in blueberry species. However, TAC of strawberries could be influenced by storage time and temperature that is accompanied by increases in strawberry anthocyanins [37]. The antioxidant capacity of strawberry fruit during period of a week could increase by an average of 1.5-fold, with the highest increase occurring at 10 and 20 °C than TAC of those stored at lower temperatures (0 or 5 °C) [69]. TAC also increases with maturation from green to red fruit [67].

The TAC could be influenced by silvicultural treatment such as organic cultural systems. Organically-grown strawberries exhibited generally higher activities in antioxidant enzymes, antioxidant capacity, and higher levels of antioxidants, such as flavonoid content [69]. The antioxidant capacity decreases with proceeding processing [81], except heat processing, which partly causes a growth due to the formation of products that are effective as antioxidants. Pressing and pasteurization are the most problematic processes for the degradation of BAC [82].

3. Red Raspberries

Red raspberries (family: Rosaceae, genus Rubus, common cultivated variety: R. idaeus) belong to the red-colored Rubus fruit cultivars grown in Europe (European red raspberry), North America (American variety), and many different cultivars and varieties in Asia, i.e., R. hirsute’s growing in China [95]. Red raspberries are the fourth most significant fruit product in the world. The similarly planted areas of red raspberries include Europe and Asia. In 2005 Europe (Serbia and Montenegro, Poland) produced 231,000 tons, Asia (Russian Federation, mainly), 131,000 tons, while North America produced about 16% of the red raspberry tonnage in the world, in particular in the USA [42].

Raspberries are called bramble fruit and are an aggregate of drupelets. They have a very popular attractive flavor (taste and aroma) for consumers. They are also great source of vitamins such as ascorbic acid. Its content in fresh raspberries generally ranges from 5 to 40 mg/100 g fw. Among the berry species, raspberries have similar content to strawberries and blackberries, about three-times more ascorbate than blueberries have, but less than in red currants, and several times less than black currant vitamin content [37,96–99]. The content losses of ascorbate in raspberries (storage temperature or duration), by 44% after a week of storage, did not influence the antioxidant capacity of fruits [37].

The fruits have been used in traditional and alternative medicine for a long time to cure wounds, colic, diarrhea, and renal illnesses [100]. Raspberries could also be helpful in the diet targeted for managing early stages of type II diabetes and hypertension [101]. Raspberry extracts, some individual polyphenols (anthocyanins, ellagitannins, and ellagic acid) [102] or together with other compounds (i.e., ascorbic acid, carotenoids) for synergetic effects, could inhibit proliferation of cancer cells in vitro. Raspberry extracts have shown anti-proliferative effects to suppress the growth of human colon, prostate, breast, and oral tumor cells [103–107] and the effect is comparable with other common berry extracts.
3.1. BAC in Raspberries

The relevant BAC in raspberries are presented in Table 2.

Table 2. Phenolic composition and factors influencing the composition of red raspberries.

| Berry          | Major Phenolic Compounds                                                                 | Factors                                                                 | References                        |
|----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------|
| Phenolic compounds                                  | Cultivar, genotype, variety                                                             | [96,97,99,101, 108–116]                                                 |
|                | Growing location                                                                       | [97]                                                                   |                                   |
|                | Cultivation techniques (conventional, organic)                                          | [117]                                                                   |                                   |
|                | Cultivation condition (light, maturation)                                              | [118]                                                                   |                                   |
|                | Growing season                                                                         | [115]                                                                   |                                   |
|                | Processing (jam processing)                                                            | [119]                                                                   |                                   |
|                | Storage (time, material, atmosphere)                                                    | [99,108,120,121]                                                       |                                   |
| Flavonols and Flavons                               |                                                                                       | [109,110,113,117, 122–125]                                               |
| Red Raspberry | Kaempferol glycosides (Kaempferol-glucuronide, Kaempferol-hexoside)                    |                                                                                       |                                   |
|                | Quercetin glycosides (Quercetin-3-glucuronide, Quercetin-3-rutinoside = rutin, Quercetin-3-hexoside, Quercetin-3-rhamnosome, Quercetin-3-glucoside) |                                                                                       |                                   |
|                | Apigenin                                                                               |                                                                                       |                                   |
|                | Chrysin                                                                                 |                                                                                       |                                   |
|                | Naringenin                                                                              |                                                                                       |                                   |
| Anthocyanins                                          |                                                                                       | [112,113,117, 123–125]                                                       |
|                | Cyanidin glycosides (Cyanidin-3-glucoside, Cyanidin-3-rutinoside, Cyanidin-3-sophoroside) |                                                                                       |                                   |
|                | Pelargonidin glycosides (Pelargonidin-3-glucoside, Pelargonidin-3-rutinoside)           |                                                                                       |                                   |
| Phenolic acids and Hydrolyzable tannins              |                                                                                       | [99,109,110,113,122, 123,125]                                               |
|                | Ellagic acid and its glycosides                                                        |                                                                                       |                                   |
|                | Ellagitannins (sanguin H-6, lambertianin C)                                            |                                                                                       |                                   |
|                | Caffeic acid                                                                           |                                                                                       |                                   |
|                | p-coumaric acid and coumaroyl glycosides                                              |                                                                                       |                                   |

The total phenolic content of raspberries, among the berry species, is approximately the same as in strawberies, about half of the phenolics amount than in blackberries and about four-fold less content than in blueberries. Red currants and black currants have phenolic content of around 2.5–3 times higher than in raspberries [37,96]. Raspberries, comparing with other berries, are most influenced by storage. Changes due to storage time and temperature could be examined in all their varieties.
However, raspberry phenolics increased by about 1.5-fold after week storage. Additionally, the content of raspberry anthocyanins could increase by about 2.5-fold after a week of storage at 20 °C. Changes are minor after 10 and 30 °C storage and minimal at 0 °C. It is followed by an almost two-fold increase in antioxidant capacity [37].

Raspberries could be consumed fresh, but due to their short storage life, are limited by rot and loss of firmness [108]. More often they are utilized as processed products, such as jams, jellies, purees and juices, ice creams or used as ingredients or for flavoring of various food products (yoghurts, smoothies). The freezing process affects the values of TPC only slightly [99].

The composition of the raspberry predominant anthocyanins (Table 2) can be used to differentiate red Rubus species from each other by reason that cyanidin in cultivated red raspberry is typically glycosylated with 3-sophorose (56%). In wild red raspberry there is about 30% of this form, and cyaniding-3-glucose content is about 27% [113]. As for the anthocyanin amounts among the berry species, raspberries have similar content to red currants, little more than strawberries, but about 2.5-times fewer anthocyanins than blackberries and about six-times fewer than black currants. The anthocyanin content of the three berry species varied more than 25-fold with blueberry > raspberry > strawberry [37,96].

3.2. Antioxidant Capacity of Raspberries

The total antioxidant capacity of the raspberries species and strawberries are similar to each other, but it is about three-fold lower than in blueberries. During their storage there could be an increase of TAC at temperatures > 0 °C (followed by the rise of anthocyanins content and TPC) [37].

Antioxidant capacity of raspberries is influenced by several factors as listed in Table 2. Amounts of antioxidants in berries could be affected by pre-harvest climate conditions, such as light intensity, day length, and temperature [121]. During the ripe stage there exists a linear connection between TAC values and an anthocyanin amount and TPC [70,109], organic culture [117], and storage (low temperatures decrease TAC to 4%–26%) [99].

The antioxidant capacity of raspberries, similarly to other berries, is correlated with various bioactive compounds that have antioxidant properties. Anthocyanins, tannins, total phenolics, and ascorbic acid were studied widely due to their possible correlation. Phenolic compounds, such as p-coumaric acid or ellagic acid and their esters, are supposed to be more highly correlated to antioxidant capacity than anthocyanins, than ascorbic acid [96,111,126]. However, the overall antioxidant capacity may be clarified by insight into the connection of different BAC, working additively or synergistically in relation to the total antioxidant capacity of raspberry. Raspberries with higher contents of phytochemicals showed higher antioxidant capacity [112].

4. Blackberries

Blackberries (family: Rosaceae, genus Rubus, common cultivated variety: Rubus fruticosus) have a similar morphology to raspberries; it is an aggregate fruit consisting of many drupelets.

The popularity of blackberries is rising worldwide. They are cultivated mainly in Europe and North America (USA), with similar planted areas. The largest blackberry production regions in Europe are Serbia (90% of their production is processed and exported), and Hungary. Additionally, wild blackberries make a significant contribution to worldwide production (15,000 tons harvested in 2005) [42].
Blackberries are known for curing and preventing a wide variety of ailments, such as colitis, in folk medicine [127]. Blackberries are considered to be a promising sources of active compounds with neuroprotection qualities against age-related diseases, such as neurodegeneration. Digested metabolites from wild blackberries (R. brigantinus and R. vagabundus), in quantities that could be found in human plasma, could protect neuronal cells against oxidative damage that is an influential attribute of neurodegeneration [128]. Polyphenol extracts from blackberry also possess anti-inflammatory properties [129,130]. Blackberry polyphenol extract strongly inhibits NO production without cytotoxicity and can also inhibit colon tumor cell growth in a concentration-dependent manner in \textit{in vitro} cell culture [131]. To obtain the therapeutic amounts of anthocyanins, Dai \textit{et al.} [131] are trying to develop formulations containing blackberry extract to transfer anthocyanins to tumors in a more suitable way. Oral capsules containing blackberry extract may then be transferred to the colon to release a high local concentration of anthocyanins at a tumor or pre-tumor site.

The best flavor quality of blackberries is at full maturity when their color changes from glossy black to dull black with optimum firmness. The firmness is cultivar-dependent and decreases in the later stages of maturation. Fresh blackberries are only seasonally available. Most of the blackberries are consumed in frozen or thermally-processed forms. In processed products, such as canned products, there are significant amounts of polyphenol antioxidants (anthocyanins) leached out of the berries into the brine (21\%–33\%) during processing and storage [132].

Compounds, such as BAC, extracted from blackberries could also be used to the production of functional foods [133] to increase their biological value. They may positively impact on human health in the prevention of various illnesses. Additionally, ascorbic acid from blackberries could contribute to the positive effects of these berries. The amount is in the interval of 5–30 mg/100 mg fw [96–98,134]. Presumably, it is also affected by the environment, such as growth conditions [90]. The exact contents are similar to contents of raspberries but less than in strawberries and about 2–3-fold to the content in red currants and about 8–9-fold less than in black currants [90].

For functional foods the effective processing of bioactive components could be profitable for future advances to increase the recovery of polyphenolic compounds (such as ellagitannins) from fruits [135]. Continuous pressing and the use of enzymatic pretreatment are suitable for products with higher content of polyphenolic compounds, in particular that of ellagitannins and anthocyanins [136].

4.1. BAC in Blackberries

The composition profiles of blackberry polyphenolics are qualitatively similar, yet quantitatively very different [137]. The relevant BAC in blackberries are presented in Table 3.
Table 3. Phenolic composition and factors influencing the composition of blackberries

| Berry   | Major Phenolic Compounds                                                                 | Factors                                      | References                                      |
|---------|------------------------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------|
|         | **Phenolic compounds**                                                                    |                                              |                                                 |
|         |                                            Cultivar, genotype                          | [96,137–141]                                 |                                                 |
|         |                                            Growing location                            | [97]                                         |                                                 |
|         |                                            Cultivation condition (maturation)         | [137]                                        |                                                 |
|         |                                            Processing (juicing, pureeing, canning, freezing) | [132,139,142,143]                           |                                                 |
|         |                                            Storage (time, temperature)                 | [120,132,139,142–144]                        |                                                 |
| Blackberry | **Flavonols and Flavons**                                                                 |                                              |                                                 |
|         |                                            Kaempferol glycosides (Kaempferol-gacetylgalactoside, Kaempferol-glucoside) | [145–147]                                   |                                                 |
|         |                                            Quercetin glycosides (Quercetin-3-galactoside, Quercetin-3-glucuronide, Quercetin-3-glucoside, Quercetin-3-rutinoside = rutin, Quercetin-3-rhamnoside) | [137,140,143,145–147]                      |                                                 |
|         |                                            Myricetin glycosides (Myricetin-3-galactoside, Myricetin-3-glucoside) | [137,140,143,145–147]                      |                                                 |
|         | **Anthocyanins**                                                                          |                                              |                                                 |
|         |                                            Cyanidin glycosides (Cyanidin-3-glucoside, Cyanidin-3-rutinoside, Cyanidin-3-arabinoside) | [137,140,143,145–147]                      |                                                 |
|         |                                            Pelargonidin glycosides (Pelargonidin-3-glucoside) | [142,143,145,147]                           |                                                 |
|         | **Phenolic acids and Hydrolyzable tannins**                                              |                                              |                                                 |
|         |                                            Ellagic acid and its glycosides                |                                              |                                                 |
|         |                                            Ellagitannins (sanguin H-6 and lambertianin C) |                                              |                                                 |
|         |                                            Gallic acid and galloyl esters                |                                              |                                                 |
|         |                                            p-coumaric acid and coumaroyl glycosides      |                                              |                                                 |

Values are slightly decreasing from underripe to ripe stages. Contents of ellagitannins and ellagic acid derivatives dropped in fully ripe fruit, as did flavonols which decreased to half values compared to the unripe stage. Consequently, values for total phenolic compounds decreased, but only slightly, showing no specific trend [148]. The content of total anthocyanin pigments at different maturity stages is different and the increase is about 2–4-fold from underripe to overripe stages of blackberries with the qualitatively same composition [137]. Contents of major anthocyanin pigments increased about seven-fold in fully-ripe fruit [148].

The amounts of total polyphenols are different due to various factors (Table 2), such as environmental factors, light, temperature, and agronomic practices [96,97,137,146].
Processing of blueberries (canning in syrup, water, pureeing, and juicing) and storage are responsible for the significant losses of procyanidins. The least-retained content was in juices, and the most retained in berries canned in syrup and water [149]. These processing methods had insignificant effects on ellagitannins, but juice processing of berries resulted in total ellagitannin losses of about 70%–82%. This could happen due to ellagitannin-rich seeds being removed in the presscake [142]. Additionally, hot-air drying of blueberries resulted in lower TPC [139]. The ellagitannin amount and composition of frozen berries remain stable during storage. Thermal processes, especially blanching, significantly reduce anthocyanin content in blueberries. The final products show decreased values for the anthocyanins cyanidin-3-glucoside (by 52%) and cyanidin-3-malonyl glucoside (64%). Anthocyanins continue to decline during storage, especially if temperatures are high [143]. Juice processing resulted in the largest losses (~67%) over six months of storage, whereas canned products were the least influenced by processing (17.8% and 10.5% losses) for canned-in-water and canned-in-syrup blended cans, respectively. Thermal processing of purees resulted in 27.4% loss in anthocyanins. In canned products considerable amounts of anthocyanins leached out of the berries into the brine (between 21% and 33%) during processing and storage [132,144].

4.2. Antioxidant Capacity of Blackberries

Antioxidant capacity of blackberries is influenced by several factors as listed in Table 3.

The antioxidant capacity of blackberries is affected by concentrations of the extract [150] that could be applicable into functional foods as a natural pigment. Ascorbic acid is not an influential contributor to the antioxidant capacity [37,96,144]. A relevant correlation was observed between total polyphenols and TAC, and/or total anthocyanins. The relationship between radical scavenger activity and total polyphenols is qualified as being closer than that between the radical scavenging activity and total anthocyanins [37,96,144,151]. Therefore, both phenolics and anthocyanins influence antioxidant activity considerably.

5. Blueberries

Blueberries, blue colored fruits, belong to the genus Vaccinium, family Ericaceae. Rabbit eye blueberries (Vaccinium ashei), Vaccinium angustifolium Aiton (lowbush blueberry) and Vaccinium corymbosum L. (highbush blueberry) are classified as commercially-grown plants. In the last decade blueberries have become more popular due to their well-known health benefits, nutritional value, and excellent sensory evaluation.

Worldwide, the USA ranks first in the production of blueberries, supplying 166,786 tons in 2009. In addition to the USA, Australia and Canada are also dominant in blueberry cultivation and production. South Korea is one of the leaders in Asia, and in China and Turkey blueberries have become an important crop [140,152]. The fruit is also native to Europe.

Vaccinium berries are known as a significant source of vitamins and other bioactive substances of pharmaceutical interest. Blueberries are among the richest fruits in ascorbic acid. The content is usually in quite wide intervals, between 10–100 mg/100 g fw [2,153–156]. The concentration of ascorbic acid decreases during storage depending on the storage conditions, such as oxygen level,
temperature, and light. Even after short storage the content decreases; after 10-days of fridge storage it decreased to about of 73% of fresh fruit [157,158].

Blueberries have been reported to have a pharmacological impact against ophthalmologic disorders. They improve blood and oxygen delivery to the eye and scavenge free radicals, which contribute to cataract and macular degeneration [159]. Blueberries containing proanthocyanidins, anthocyanins, and flavonols are beneficial in bone protection, too [160]. Blueberries also exhibit anti-diabetic properties and protection of pancreatic \( \beta \)-cells from glucose-induced oxidative stress [161,162]. Clinical study with volunteers consuming blueberry beverages have demonstrated improved insulin sensitivity in insulin-resistant subjects [163]. Blueberries could also be used for decreasing blood pressure, decreasing of blood cholesterol and, therefore, lowering of cardiovascular risk and atherosclerosis prevention [164–166]. Del Bo’ et al. [167] referred to the effect of 300 g of blueberries intake on selected markers of oxidative stress and antioxidant protection (endogenous and oxidatively-induced DNA damage) and of vascular function (changes in peripheral arterial tone and plasma nitric oxide levels) in males. Blueberries considerably reduced \( \text{H}_2\text{O}_2 \)-induced DNA damage after blueberry intake. Blueberry phytochemicals could inhibit growth and metastatic potential of breast and colon cancer cells [168,169]. The synergistic effect of polyphenol compounds and ascorbic acid correlate with inhibition of cancer cell proliferation, inhibit the growth of tumor cells, and induce apoptosis [170–172]. It was assessed that pure anthocyanins, such as cyanidin 3-glucoside, delphinidin, as well as peonidin 3-glucoside, suppressed growth of human tumor cells and apoptosis of colon and breast cell lines [173,174].

Short shelf life of berries is a common problem, which limits availability and consumption. Blueberries have quite a quick harvest season. They can be stored only six weeks under controlled atmospheric conditions. Generally, blueberries are sold in fresh, frozen, and processed forms (dried and canned fruits, juices and jams, in beverages, yoghurts) for various food applications. More than 50% of mature blueberries are processed into different products. Processing and preservation methods, such as hot air drying, freezing/thawing, freezing/osmotic pretreatment, and microwave drying [175–178] are popular techniques for blueberry preserving. At present, modified atmosphere packaging, cold and freezer storage, UV irradiation, and sulfur dioxide fumigation are among the postharvest preservation techniques used to eliminate postharvest deterioration, prolong shelf-life, and maintain the biological nutrition of fresh blueberries [179].

5.1. BAC in Blueberries

There are relevant variances in the anthocyanins content, TPC, and TAC between individual blueberry species, as well as between varieties and within other \textit{Vaccinium} species. The relevant BAC in blueberries are presented in Table 4.
Table 4. Phenolic composition and factors influencing the composition of blueberries.

| Berry | Major Phenolic Compounds | Factors | References |
|-------|--------------------------|---------|------------|
| Phenolic compounds | | | [91,125,138,146,156,180–185] |
| | Cultivar, genotype | | [140] |
| | Growing location | | [184] |
| | Cultivation techniques (conventional, organic) | | [182,185] |
| | Cultivation condition (maturation) | | [149,175,186–188] |
| | Processing (juicing, pureeing, canning, freezing, blanching) | | [149,153,186] |
| | Storage (time, temperature) | | |
| Flavonols | | | [123,180,189,190] |
| Blueberry | Myricetin glycosides (Myricetin-3-glucoside, Myricetin-3-rhamnoside) | | |
| | Quercetin glycosides (Quercetin-3-galactoside, Quercetin-3-glucoside, Quercetin-3-rutinoside) | | |
| Anthocyanins | | | [39,123,140,146,155,180,183,186,188–194] |
| | Cyanidin glycosides (Cyanidin-3-galactoside, Cyanidin-3-glucoside, Cyanidin-3-arabinoside) | | |
| | Delphinidin glycosides (Delphinidin-3-galactoside, Delphinidin-3-arabinoside, Delphinidin-3-glucoside) | | |
| | Malvidin glycosides (Malvidin-3-galactoside, Malvidin-3-arabinoside, Malvidin-3-glucoside) | | |
| | Petunidin glycosides (Petunidin-3-galactoside, Petunidin-3-arabinoside, Petunidin-3-acetylglucoside) | | |
| | Peonidin glycosides (Peonidin-3-galactoside, Peonidin-3-arabinoside) | | |

The values of total phenolic quantitative analysis in blueberries are in quite a wide interval; in various studies the contents are upwards of 10-times higher or lower, depending on the method used for analysis [2,140,175,195].

It is generally known that the phenolic content in blueberries is influenced by the degree of maturity at harvest, growing practices, and growing locations [182]. The maturity stages increased anthocyanin content [185], on average by 34% [182]. It is suggested that during blueberry ripening there is phenolic conversion toward anthocyanin synthesis that results in an overall decrease of other phenolic compound content.
Regarding the influence of processing methods on blueberry BAC, a slight increase in total anthocyanin value after some thermal pre-treatment processings was examined. Blanching of blueberries at 85 °C for three minutes resulted in about 7% growth of anthocyanin content [175]. However, the anthocyanin content of thermally-treated blueberries, osmodehydrated, or air dried at 70 °C, decreased by about 30% [187]. The amount of anthocyanins after freeze-drying is also lower probably due to their degradation [155]. It could be concluded that air drying treatment has a negative effect on anthocyanins, while blanching and freezing may increase the extractability of anthocyanins from thermally-treated skins.

The influence of storage conditions on anthocyanin stability for blueberries stored frozen was also investigated and an average of about 59% degradation of the anthocyanins was found after six months of storage. Delphinidin-3-glucoside was the compound showing the greatest degradation (almost 80%), whereas pelargonidin-3-glucoside was the most stable (9% loss) [186].

### 5.2. Antioxidant Capacity of Blueberries

Blueberries are fruits with one of the highest antioxidant capacities. The antioxidant capacity of blueberries is influenced by several factors, as listed in Table 4.

The antioxidant activity of blueberry depends on their phytochemical complex, being mainly represented by anthocyanins, procyanidins, chlorogenic acid, and other flavonoid compounds [187]. It is supposed that the major contributors to their antioxidant activity are mainly anthocyanins, responsible for about 84% of TAC, and not ascorbic acid [123]. Ascorbic acid, which is present in blueberries in a significant amount, was found to contribute to antioxidant capacity only with a small portion up to 10% [196,197].

In contrast with some other berries, antioxidant activity of blueberries is higher in early maturation stages and during initial pigmentation than in the ripe stage. This is related to a high level of hydroxycinnamic acids and flavonols before ripening. The lesser antioxidant capacity of mature blueberries may indicate that anthocyanins have lower antioxidant potential than other phenolic compounds, such as flavonols [182].

Regarding cultivar variance, for rabbiteye blueberries it was hypothesized that they could have higher antioxidant activity than lowbush and highbush varieties. This might be due to their thicker skin having higher concentrations of anthocyanins. The variances in total phenolic content between cultivars and maturity stages are relevant for the obtained changes of the antioxidant activity. The contribution of each individual phenolic compound to the total antioxidant capacity may vary [181].

The effect of blueberry processing on TAC was not observed for blanching (85 °C for three minutes) [175] or drying with osmotic treatment [177]. Freezing of the blueberry fruits increased the antioxidant capacity during the first three months of storage, followed by a reduction up to the end of the six months of storage [186].
6. Cranberries

The cultivated cranberry (Vaccinium macrocarpon Ait., lowbush cranberry), which is also named the American cranberry, belongs to the Ericaceae family. More than 90% of the total world production is produced in the USA (mainly the northeastern part of North America) and Canada. A smaller amount of cranberry production belongs to Chile [198].

Cranberries product range includes fresh fruits, dried fruits, and products such as juices or food ingredients in cereals, meat and milk products, and sauces.

Cranberries contain a lot of biologically active substances, which came to be thought of as one of the novel functional foods and nutraceuticals. They are known as a good source of vitamins, such as ascorbic acid. Its content in cultivated cranberries is, on average, 10 mg/100 g dry matter (dm), which is about 21% less than in wild cranberries [199]. In fresh cranberries it was evaluated that the content reached about 134 mg/100 g dm. This vitamin is present in great amount in cranberry juice, at an amount of 897 mg/L [200]. As for the amount of vitamin C in processed cranberry products, the freeze-drying processes causes a decrease in the content. With an increase of drying temperature, a decrease of ascorbic acid content was observed (from 134 mg/100 g dm to 64 mg/100 g dm, on average) [201].

Cranberries exhibit various health benefits. As for the consumption of cranberries (juice and various concentrated products), it was investigated that after a single serving of cranberry juice intake the plasma antioxidant level significantly increased for up to 7 h [202]. For an increase of plasma phenolic content and plasma antioxidant capacity the intake of 500 mL of cranberry juice is satisfactory [203]. Cranberries (juice, concentrated powders, capsule formulations, and tablets) are known that could prevent and treat an occurrence of urinary tract infections. This effect is achieved by proanthocyanidins contained in cranberries that can prevent adhering of Escherichia coli to uroepithelial cells in the urinary tract [204,205]. Due to this fact, cranberries could also be used for stomach ulcers [206]. Another potential health effect of cranberries is the finding that extracted compounds from cranberry have shown the prevention and reduction of the cardiovascular disease risks and protection against lipoprotein oxidation [207,208]. It has been demonstrated that the hydroxycinnamic acid derivatives and flavonoids from cranberry juice can reduce not only the oxidation of LDL but also its mobility and, thus, reduce one of the significant critical steps in the atherosclerotic process, which is oxidation of LDL-cholesterol. In addition, cranberry extract could significantly elevate synthesis of hepatic LDL receptors. The synergistic effect of phenolics is then responsible for increasing uptake of cholesterol by hepatocytes [202,209]. In the last decade, in vitro anti-cancer activity, anti-mutagenic effects or anti-tumorigenic activity of cranberries has been examined [210–213]. Some of these biological effects have been generally linked to the incidence of phenolics in cranberries [214].

6.1. BAC in Cranberries

Quercetin is the one of the major significant flavonoids occurring in cranberries. Ellagic acid in cranberries represents 51% of the total phenolic compounds in the berries. This constituent occurs in the free form, linked as ellagitannins esterified with glucose or glucosides alone [34]. The relevant BAC in cranberries are presented in Table 5.
Table 5. Phenolic composition and factors influencing the composition of cranberries.

| Berry   | Major Phenolic Compounds                                                                 | Factors                              | References               |
|---------|------------------------------------------------------------------------------------------|--------------------------------------|--------------------------|
| Phenolic compounds |                                             | Cultivar, genotype                   | [215–217]               |
|         |                                             | Growing season                       | [218]                    |
|         |                                             | Cultivation condition (maturation)    | [185,219]                |
|         |                                             | Processing (juicing)                 | [220,221]                |
|         |                                             | Storage (time)                       | [216,222]                |
| Flavonols |                                             |                                      |                          |
| Kaempferol glycosides (Kaempferol-3-glucoside) |                             |                                      | [123,125,223]           |
| Quercetin glycosides (Quercetin-3-galactoside, Quercetin-3-arabinoside, Quercetin-3-rhamnoside) |                             |                                      |                          |
| Cranberry | Anthocyanins                                |                                      | [123,224,225]           |
| Cyanidin glycosides (Cyanidin-3-glucoside, Cyanidin-3-galactoside, Cyanidin-3-arabinoside) |                             |                                      |                          |
| Peonidin glycosides (Peonidin-3-glucoside, Peonidin-3-galactoside, Peonidin-3-arabinoside) |                             |                                      |                          |
| Pelargonidin glycosides (Pelargonidin-3-galactoside, Pelargonidin-3-arabinoside) |                             |                                      |                          |
| Malvidin glycosides (Malvidin-3-galactoside, Malvidin-3-arabinoside) |                             |                                      |                          |
| Delphinidin glycosides (Delphinidin-3-arabinoside) |                             |                                      |                          |
| Petunidin glycosides (Petunidin-3-galactoside) |                             |                                      |                          |
| Phenolic acids |                                             |                                      | [221]                    |
| p-coumaric acid |                                             |                                      |                          |

As for the total phenolic values during cranberry maturation from green to dark red stages, they decreased in cranberries to half values. Additionally, the amount of monomeric anthocyanins had risen from unripe to ripe stages, more than 100-fold [219].

The conditions during cranberry juice processing (light, oxygen, enzymatic reactions), as well as heating treatment, can influence the stability of the cranberry bioactive compounds. Freezing, in comparison to thermal processing, is better for retention of phenolics, as TPC in frozen cranberries was more than four-fold higher (depending on the type of extraction solution) than in the juice samples (initial pressed juice, clarified juice, and concentrate) [213]. The total phenolic content of cranberries after heat processing slowly decreases, and after 70 minutes of drying is less than 70%; the total anthocyanins were about half of the original ones [201].
6.2. Antioxidant Capacity of Cranberries

The great antioxidant properties of cranberries ranks them as one of the best among many other fruits due to phytochemicals, such as benzoic and cinnamic acid derivatives, and flavonols. Antioxidant capacity of cranberries is influenced by several factors as listed in Table 5. Cranberry extracts (processed cranberry juice) differ in their range of phenolic compounds (polar, non-polar, and anthocyanins) and their capacity to scavenge free radicals [220]. TAC of cranberries begins to increase when the cranberries cumulate more anthocyanins [219]. The antioxidant activity in cranberries might increase with the time of drying. The measured increase after drying was about 1.3-times higher than before drying [201].

7. Conclusions

Berries, especially members of several families, such as Rosaceae (strawberry, raspberry, blackberry), and Ericaceae (blueberry, cranberry) are great dietary sources of bioactive compounds (BAC). BAC (phenolic compounds such as phenolic acids, flavonoids-flavonols, anthocyanins, tannins, and ascorbic acid) are contained in berries in great amount, and may act as strong antioxidants and, thus, could help in the prevention of inflammation disorders, cardiovascular diseases, or have protective effects to lower the risk of various cancers. The composition and content of BAC in berries is variable depending on the cultivar and variety, growing location, and environmental conditions, plant nutrition, ripeness stage, and time of harvest, as well as subsequent storage conditions or processing methods. This review gives comprehensive information about BAC in each of the selected berries and the factors that influence their antioxidant capacity. The bioactive compounds are of great interest for nutritionists and food technologists due to the opportunity to use BAC as functional food ingredients.

Acknowledgments

This study was funded by internal grant agency of Tomas Bata University in Zlín, project no. IGA/FT/2015/010.

Author Contributions

All authors designed review; Sona Skrovankova and Daniela Sumczynski wrote the paper, Jiri Mlcek, Tunde Jurikova, Jiri Sochor read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Halvorsen, B.L.; Holte, K.; Myhrstad, M.C.; Barikmo, I.; Hvattum, E.; Remberg, S.F.; Wold, A.B.; Haffner, K.; Baugerød, H.; Andersen, L.F.; et al. A systematic screening of total antioxidants in dietary plants. *J. Nutr.* **2002**, *132*, 461–471.
2. De Souza, V.R.; Pereira, P.A.; da Silva, T.L.; de Oliveira Lima, L.C.; Pio, R.; Queiroz, F. Determination of the bioactive compounds, antioxidant activity and chemical composition of Brazilian blackberry, red raspberry, strawberry, blueberry and sweet cherry fruits. *Food Chem.* 2014, 156, 362–368.

3. Slatnar, A.; Jakopic, J.; Stampar, F.; Veberic, R.; Jamnik, P. The effect of bioactive compounds on *in vitro* and *in vivo* antioxidant activity of different berry juices. *PLoS ONE* 2012, 7, 10.

4. Namiesnik, J.; Vearasilp, K.; Nemirovski, A.; Leontowicz, H.; Leontowicz, M.; Pasko, P.; Martinez-Ayala, A.L.; Gonzalez-Aguilar, G.A.; Suhaj, M.; Gorinstein, S. *In vitro* studies on the relationship between the antioxidant activities of some berry extracts and their binding properties to serum albumin. *Appl. Biochem. Biotechnol.* 2014, 172, 2849–2865.

5. Yoo, Y.; Saliba, A.J.; Prenzler, P.D. Should red wine be considered a functional food? *Comp. Rev. Food Sci. Food Saf.* 2010, 9, 530–551.

6. Yoo, Y.J.; Prenzler, P.D.; Saliba, A.J.; Ryan, D. Assessment of Some Australian Red Wines for Price, Phenolic Content, Antioxidant Activity, and Vintage in Relation to Functional Food Prospects. *J. Food Sci.* 2011, 76, 1355–1364.

7. Yoo, Y.J.; Saliba, A.J.; MacDonald, J.B.; Prenzler, P.D.; Ryan, D. A Cross-cultural Study of Wine Consumers with Respect to Health Benefits of Wine. *Food Qual. Pref.* 2013, 28, 531–538.

8. Anastasiadi, M.; Pratsinis, H.; Kletsas, D.; Skaltsounis, A.-L.; Haroutounian S.A. Bioactive non-coloured polyphenols content of grapes, wines and vinification by-products: Evaluation of the antioxidant activities of their extracts. *Food Res. Int.* 2010, 43, 805–813.

9. Toaldo, I.M.; Cruz, F.A.; de Lima Alves, T.; de Gois, J.S.; Borges, D.L.G.; Cunha, H.P.; da Silva, E.L.; Bordignon-Luiz, M.T. Bioactive potential of *Vitis labrusca* L. grape juices from the Southern Region of Brazil: Phenolic and elemental composition and effect on lipid peroxidation in healthy subjects. *Food Chem.* 2015, 173, 527–535.

10. Lätti, A.K.; Rininen, K.R.; Jaakola, L. Phenolic compounds in berries and flowers of a natural hybrid between bilberry and lingonberry (*Vaccinium × intermedium* Ruthe). *Phytochemistry* 2011, 72, 810–815.

11. Garzón, G.A.; Narváez, C.E.; Riedl, K.M.; Schwartz, S.J. Chemical composition, anthocyanins, non-anthocyanin phenolics and antioxidant activity of wild bilberry (*Vaccinium meridionale* Swartz) from Colombia. *Food Chem.* 2010, 122, 980–986.

12. Duymuş, H.G.; Göger, F.; Başer, K.H.C. *In vitro* antioxidant properties and anthocyanin compositions of elderberry extracts. *Food Chem.* 2014, 155, 112–119.

13. Casati, C.B.; Baëza, R.; Sanchez, V.; Catalano, A.; López, P.; Zamora, M.C. Thermal degradation kinetics of monomeric anthocyanins, colour changes and storage effect in elderberry juices. *J. Berry Res.* 2015, 5, 29–39.

14. Chiang, C.-J.; Kadouh, H.; Zhou, K. Phenolic compounds and antioxidant properties of gooseberry as affected by *in vitro* digestion. *LWT Food Sci. Technol.* 2013, 51, 417–422.

15. Rop, O.; Milcêk, J.; Jurikova, T.; Valsíková, M. Bioactive content and antioxidant capacity of Cape gooseberry fruit. *Cent. Eur. J. Biol.* 2012, 7, 672–679.

16. Aladedunye, F.; Przybylski, R.; Niehaus, K.; Bednarz, H.; Matthäus, B. Phenolic extracts from *Crataegus × mordenensis* and *Prunus virginiana*: Composition, antioxidant activity and performance in sunflower oil. *LWT Food Sci. Technol.* 2014, 59, 308–319.
17. Heinonen, I.M.; Lehtonen, P.J.; Hopia, A.I. Antioxidant Activity of Berry and Fruit Wines and Liquors. *J. Agric. Food Chem.* 1998, 46, 25–31.

18. Kahkonen, M.; Kylli, P.; Ollilainen, V.; Salminen, J.P.; Heinonen, M. Antioxidant activity of isolated ellagitannins from red raspberries and cloudbberries. *J. Agric. Food Chem.* 2012, 60, 1167–1174.

19. Ogawa, K.; Sakakibara, H.; Iwata, R.; Ishii, T.; Sato, T.; Goto, T.; Shimoi, K.; Kumazawa, S. Anthocyanin Composition and Antioxidant Activity of the Crowberry (*Empetrum nigrum*) and Other Berries. *J. Agric. Food Chem.* 2008, 56, 4457–4462.

20. Wang, S.Y.; Feng, R.; Bowman, L.; Penhallegon, R.; Ding, M.; Lu, Y. Antioxidant Activity in Lingonberries (*Vaccinium vitis-idaea* L.) and Its Inhibitory Effect on Activator Protein-1, Nuclear Factor-κB, and Mitogen-Activated Protein Kinases Activation. *J. Agric. Food Chem.* 2005, 53, 3156–3166.

21. Asami, D.K.; Hong, Y.J.; Barrett, D.M.; Mitchell, A.E. Comparison of the total phenolic and ascorbic acid content of freeze-dried and air-dried marionberry, strawberry, and corn grown using conventional, organic, and sustainable agricultural practices. *J. Agric. Food Chem.* 2003, 51, 1237–1241.

22. Junikova, T.; Sochor, J.; Mlcek, J.; Balla, S.; Erçisli, S.; Durisova, L.; Kynicky, J. Polyphenolic Compounds and Antioxidant Activity in Berries of Four Russian Cultivars of *Lonicera kantschatica* (Sevast.) Pojark. *Erwerbs Obstbau* 2014, 56, 117–122.

23. Rop, O.; Řezníček, V.; Mlček, J.; Junikova, T.; Sochor, J.; Kizek, R.; Humpolíček, P.; Balík, J. Nutritional values of new Czech cultivars of Saskatoon berries (*Amelanchier alnifolia* Nutt.). *Hort. Sci.* 2012, 39, 123–128.

24. Hukkanen, A.T.; Pölönen, S.S.; Kärenlampi, S.O.; Kokko, H.I. Antioxidant capacity and phenolic content of sweet rowanberries. *J. Agric. Food Chem.* 2006, 54, 112–119.

25. Fredes, C.; Robert, P. The powerful colour of the maqui (*Aristotelia chilensis* [Mol.] Stuntz) fruit. *J. Berry Res.* 2014, 4, 175–182.

26. Rop, O.; Erçisli, S.; Mlček, J.; Junikova, T.; Hoza, I. Antioxidant and radical scavenging activities in fruits of 6 sea buckthorn (*Hippophae rhamnoides* L.) cultivars. *Turk. J. Agric. For.* 2014, 38, 224–232.

27. Basu, S.K.; Thomas, J.; Acharya, S.N. Prospects for growth in global nutraceutical and functional food markets a canadian perspective. *Aust. J. Basic Appl. Sci.* 2007, 1, 637–649.

28. Lobo, V.; Patil, A.; Phatak, A.; Chandra, N. Free radicals, antioxidants and functional foods: Impact on human health. *Pharmacol. Rev.* 2010, 4, 118–126.

29. Limberaki, E.; Eleftheriou, P.; Vagdatli, E.; Kostoglou, V.; Petrou, C. Serum antioxidant status among young, middle-aged and elderly people before and after antioxidant rich diet. *Hippokratia* 2012, 16, 118–123.

30. Halliwell, B.; Rafter, J.; Jenner, A. Health promotion by flavonoids, tocopherols, tocotrienols, and other phenols: Direct or indirect effects? Antioxidant or not? *Am. J. Clin. Nutr.* 2005, 81, 268–276.

31. Patras, A.; Brunton, N.P.; O'Donnell, C.; Tiwari, B.K. Effect of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. *Trends Food Sci. Technol.* 2010, 21, 3–11.
32. Verotta, L.; Macchi, M.P.; Venkatasubramanian, P. Connecting Indian Wisdom and Western Science: Plant Usage for Nutrition and Health, CRC Press: Boca Raton, FL, USA, 2015; pp. 264–266.
33. Kowalenko, C.G. Accumulation and distribution of micronutrients in Willamette red raspberry plants. Can. J. Plant. Sci. 2005, 85, 179–191.
34. Nile, S.H.; Park, S.W. Edible berries: Bioactive components and their effect on human health. Nutrition 2014, 30, 134–144.
35. Koyuncu, M.A.; Dilmacunal, T. Determination of Vitamin C and Organic Acid Changes in Strawberry by HPLC during Cold Storage. Not. Bot. Horti Agrobot. Cluj 2010, 38, 95–98.
36. Proteggente, A.R.; Pannala, A.S.; Paganga, G.; van Buren, L.; Wagner, E.; Wiseman, S.; van de Put, F.; Dacombe, C.; Rice-Evans, C.A. The Antioxidant Activity of Regularly Consumed Fruit and Vegetables Reflects their Phenolic and Vitamin C Composition. Free Radic. Res. 2002, 36, 217–233.
37. Kalt, W.; Forney, C.F.; Martin, A.; Prior, R.L. Antioxidant Capacity, Vitamin C, Phenolics, and Anthocyanins after Fresh Storage of Small Fruits. J. Agric. Food Chem. 1999, 47, 4638–4644.
38. Atala, E.; Vásquez, L.; Speisky, H.; Lissi, E.; López-Alarcón, C. Ascorbic acid contribution to ORAC values in berry extracts: An evaluation by the ORAC-pyrogallol red methodology. Food Chem. 2009, 113, 331–335.
39. Battino, M.; Beekwilder, J.; Denoyes-Rothan, B.; LaMer, M.; McDougall, G.J.; Mezzetti, B. Bioactive compounds in berries relevant to human health. Nutr. Rev. 2009, 67, 145–150.
40. Giampieri, F.; Tulipani, S.; Alvarez-Suarez, J.M.; Quiles, J.L.; Mezzetti, B.; Battino, M. The strawberry: Composition, nutritional quality, and impact on human health. Nutrition 2012, 28, 9–19.
41. Wang, Z.; Cang, T.; Qi, P.; Zhao, X.; Xu, H.; Wang, X.; Zhang, H.; Wang, X. Dissipation of four fungicides on greenhouse strawberries and an assessment of their risks. Food Control. 2015, 55, 215–220.
42. Strik, B.C. Berry crops: Worldwide area and production systems. In Berry Fruit: Value-Added Products for Health Promotion, 1st ed.; Zhao, Y., Ed.; CRC Press: Boca Raton, FL, USA, 2007; pp. 3–51.
43. Odnozola-Serrano, I.; Soliva-Fortuny, R.; Gimeno-Añó, V.; Martin-Belloso, O. Kinetic Study of Anthocyanins, Vitamin C, and Antioxidant Capacity in Strawberry Juices Treated by High-Intensity Pulsed Electric Fields. J. Agric. Food Chem. 2008, 56, 8387–8393.
44. Škrovánková, S.; Kramářová, D.; Šimánková, K.; Hoza, I. Determination of ascorbic acid by HPLC with electrochemical detection. Chem. Listy 2006, 100, 736.
45. Sapei, L.; Hwa, L. Study on the Kinetics of Vitamin C Degradation in Fresh Strawberry Juices. Procedia Chem. 2014, 9, 62–68.
46. Franke, A.A.; Custer, L.J.; Arakaki, C.; Murphy, S.P. Vitamin C and flavonoid levels of fruits and vegetables consumed in Hawaii. J. Food Comp. Anal. 2004, 17, 1–35.
47. Giampieri, F.; Forbes-Hernandez, T.Y.; Gasparini, M.; Alvarez-Suarez, J.M.; Afrin, S.; Bompardre, S.; Quiles, J.L.; Mezzetti, B.; Battino M. Strawberry as a health promoter: An evidence based review. Food Funct. 2015, 6, 1386–1398.
48. Kunwar, R.M.; Shrestha, K.P.; Bussmann, R.W. Traditional herbal medicine in Far-west Nepal: A pharmacological appraisal. J. Ethnobiol. Ethnomed. 2010, 6, 35–52.
49. Giampieri, F.; Alvarez-Suarez, J.M.; Battino, M. Strawberry and Human Health: Effects beyond Antioxidant Activity. *J. Agric. Food Chem.* 2014, 62, 3867–3876.

50. Ibrahim, D.S.; Abd El-Maksoud, M.A.E. Effect of strawberry (Fragaria × ananassa) leaf extract on diabetic nephropathy in rats. *Int. J. Exp. Pathol.* 2015, 96, 87–93.

51. Pinto Mda, S.; de Carvalho, J.E.; Lajolo, F.M.; Genovese, M.I.; Shetty, K. Evaluation of antiproliferative, anti-type 2 diabetes, and antihypertension potentials of ellagitannins from strawberries (Fragaria ananassa Duch.) using *in vitro* models. *J. Med. Food* 2010, 13, 1–9.

52. Alvarez-Suarez, J.M.; Giampieri, F.; Tulipani, S.; Casoli, T.; di Stefano, G.; González-Paramás, A.M.; Santos-Buelga, C.; Busco, F.; Quiles, J.L.; Cordero, M.D.; *et al.* One-month strawberry-rich anthocyanin supplementation ameliorates cardiovascular risk, oxidative stress markers and platelet activation in humans. *J. Nutr. Biochem.* 2014, 25, 289–294.

53. Ellis, C.L.; Edirisingle, I.; Kappagoda, T.; Burton-Freeman, B. Attenuation of meal-induced inflammatory and thrombotic responses in overweight men and women after 6-week daily strawberry (Fragaria) intake. *J. Atheroscler. Thromb.* 2011, 18, 318–327.

54. Basu, A.; Rhone, M.; Lyons, T.J. Berries: Emerging impact on cardiovascular health. *Nutr. Rev.* 2010, 68, 168–177.

55. Prasath, G.S.; Subramanian, S.P. Antihyperlipidemic Effect of Fisetin, a Bioflavonoid of Strawberries, Studied in Streptozotocin-Induced Diabetic Rats. *J. Biochem. Mol. Toxicol.* 2014, 28, 442–449.

56. Chen, H.-S.; Bai, M.-H.; Zhang, T., Li, G.-D.; Liu, M. Ellagic acid induces cell cycle arrest and apoptosis through TGF-β/Smad3 signaling pathway in human breast cancer MCF-7 cells. *Int. J. Oncol.* 2015, 46, 1730–1738.

57. Duo, J.; Ying, G.G.; Wang, G.W.; Zhang, L. Quercetin inhibits human breast cancer cell proliferation and induces apoptosis via Bcl-2 and Bax regulation. *Mol. Med. Rep.* 2012, 5, 1453–1456.

58. Edderkaoui, M.; Lugea, A.; Hui, H.; Eibl, G.; Lu, Q.Y.; Moro, A.; Pandol, S.J. Ellagic acid and embelin affect key cellular components of pancreatic adenocarcinoma, cancer, and stellate cells. *Nutr. Cancer* 2013, 65, 1232–1244.

59. Zhang, Y.; Seeram, N.P.; Lee, R.; Feng, L.; Heber, D. Isolation and Identification of Strawberry Phenolics with Antioxidant and Human Cancer Cell Antiproliferative Properties. *J. Agric. Food Chem.* 2008, 56, 670–675.

60. Casto, B.C.; Knobloch, T.J.; Galioto, R.L.; Yu, Z.; Accurso, B.T.; Warner, B.M. Chemoprevention of oral cancer by lyophilized strawberries. *Anticancer Res.* 2013, 33, 4757–4766.

61. Chen, T.; Yan, F.; Qian, J.; Guo, M.; Zhang, H.; Tang, X.; Chen, F.; Stoner, G.D.; Wang, X. Randomized phase II trial of lyophilized strawberries in patients with dysplastic precancerous lesions of the esophagus. *Cancer Prev. Res.* 2012, 5, 41–50.

62. Somasagara, R.R.; Hegde, M.; Chiruvella, K.K.; Musini, A.; Choudhary, B.; Raghavan, S.C. Extracts of Strawberry Fruits Induce Intrinsic Pathway of Apoptosis in Breast Cancer Cells and Inhibits Tumor Progression in Mice. *PLoS ONE* 2012, 7, 10.
63. Giampieri, F.; Alvarez-Suarez, J.M.; Mazzoni, L.; Forbes-Hernandez, T.Y.; Gasparini, M.; González-Paramás, A.M.; Santos-Buelga, C.; Quiles, J.L.; Bompadre, S.; Mezzetti, B.; et al. An anthocyanin-rich strawberry extract protects against oxidative stress damage and improves mitochondrial functionality in human dermal fibroblasts exposed to an oxidizing agent. *Food Funct.* **2014**, *5*, 1939–1948.

64. Giampieri, F.; Alvarez-Suarez, J.M.; Mazzoni, L.; Forbes-Hernandez, T.Y.; Gasparini, M.; González-Paramás, A.M.; Santos-Buelga, C.; Quiles, J.L; Bompadre, S.; Mezzetti, B.; et al. Polyphenol-Rich Strawberry Extract Protects Human Dermal Fibroblasts against Hydrogen Peroxide Oxidative Damage and Improves Mitochondrial Functionality. *Molecules* **2014**, *19*, 7798–7816.

65. Kim, Y.-J.; Shin, Y. Antioxidant profile, antioxidant activity, and physicochemical characteristics of strawberries from different cultivars and harvest locations. *J. Korean Soc. Appl. Biol. Chem.* **2015**, *58*, 587–595.

66. Gündüz, K.; Ozdemir, E. The effects of genotype and growing conditions on antioxidant capacity, phenolic compounds, organic acid and individual sugars of strawberry. *Food Chem.* **2014**, *155*, 298–303.

67. Mandave, P.C.; Pawar, P.K.; Ranjekar, P.K.; Mantri, N.; Kuvalakar, A.A. Comprehensive evaluation of *in vitro* antioxidant activity, total phenols and chemical profiles of two commercially important strawberry varieties. *Sci. Hortic.* **2014**, *172*, 124–134.

68. Fredericks, C.H.; Fanning, K.J.; Gidley, M.J.; Netzel, G.; Zabaras, D.; Herrington, M.; Netzel, M. High-anthocyanin strawberries through cultivar selection. *J. Sci. Food Agric.* **2013**, *93*, 846–852.

69. Jin, P.; Wang, S.Y.; Wang, C.Y.; Zheng, Y. Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries. *Food Chem.* **2011**, *124*, 262–270.

70. Ferreyra, R.M.; Viña, S.Z.; Mugridge, A.; Chaves, A.R. Growth and ripening season effects on antioxidant capacity of strawberry cultivar Selva. *Sci. Hortic.* **2007**, *112*, 27–32.

71. Tulipani, S.; Mezzetti, B.; Capocasa, F.; Bompadre, S.; Beekwilder, J.; de Vos, C.; Capanoglu, E.; Bovy, A.; Battino, M. Antioxidants, phenolic compounds, and nutritional quality of different strawberry genotypes. *J. Agric. Food Chem.* **2008**, *56*, 696–704.

72. Wang, S.Y.; Millner, P. Effect of Different Cultural Systems on Antioxidant Capacity, Phenolic Content, and Fruit Quality of Strawberries (*Fragaria × ananassa* Duch.). *J. Agric. Food Chem.* **2009**, *57*, 9651–9657.

73. Tulipani, S.; Marzban, G.; Herndl, A.; Laimer, M.; Mezzetti, B.; Battino, M. Influence of environmental and genetic factors on health-related compounds in strawberry. *Food Chem.* **2011**, *124*, 906–913.

74. Reganold, J.P.; Andrews, P.K.; Reeve, J.R.; Carpenter-Boggs, L.; Schadt, C.W. Fruit and Soil Quality of Organic and Conventional Strawberry Agroecosystems. *PLoS ONE* **2010**, *5*, 1–14.

75. Crecente-Campo, J.; Nunes-Damaceno, M.; Romero-Rodriguez, M.A.; Vazquez-Odériz, M.L. Color, anthocyanin pigment, ascorbic acid and total phenolic compound determination in organic versus conventional strawberries (*Fragaria × ananassa* Duch, cv Selva). *J. Food Comp. Anal.* **2012**, *28*, 23–30.
76. Fernandes, V.C.; Domingues, V.F.; de Freitas, V.; Delerue-Matos, C.; Mateus, N. Strawberries from integrated pest management and organic farming: Phenolic composition and antioxidant properties. *Food Chem.* **2012**, *134*, 1926–1931.

77. Xu, F.; Shi, L.; Chen, W.; Cao, S.; Su, X.; Yang, Z. Effect of blue light treatment on fruit quality, antioxidant enzymes and radical-scavenging activity in strawberry fruit. *Sci. Hortic.* **2014**, *175*, 181–186.

78. Fan, L.; Dubé, C.; Fang, C.; Roussel, D.; Charles, M.T.; Desjardins, Y.; Khanizadeh, S. Effect of production systems on phenolic composition and oxygen radical absorbance capacity of “Orléans” strawberry. *LWT Food Sci. Technol.* **2012**, *45*, 241–245.

79. Fan, L.; Yu, C.; Fang, C.; Zhang, M.; Ranieri, M.; Dubé, C. The effect of three production systems on the postharvest quality and phytochemical composition of “Orléans” strawberry. *Can. J. Plant Sci.* **2011**, *91*, 403–409.

80. Levaj, B.; Bursač-Kovačević, D.; Bituh, M.; Dragović-Uzelac, V. Influence of Jam Processing Upon the Contents of Phenolics and Antioxidant Capacity in Strawberry fruit (*Fragaria ananassa ×* Duch.). *Croatian J. Food Technol. Biotechnol. Nutr.* **2012**, *7*, 18–22.

81. Oszmiański, J.; Wojdyło, A. Comparative study of phenolic content and antioxidant activity of strawberry puree, clear, and cloudy juices. *Eur. Food Res. Technol.* **2009**, *228*, 623–631.

82. Hartmann, A.; Patz, C.D.; Andlauer, W.; Dietrich, H.; Ludwig, M. Influence of processing on quality parameters of strawberries. *J. Agric. Food Chem.* **2008**, *56*, 9484–9489.

83. Howard, L.R.; Brownmiller, C.; Prior, R.L. Improved color and anthocyanin retention in strawberry puree by oxygen exclusion. *J. Berry Res.* **2014**, *4*, 107–116.

84. Da Silva, F.L.; Escribano-Bailón, M.T.; Pérez Alonso, J.J.; Rivas-Gonzalo, J.C.; Santos-Buelga, C. Anthocyanin pigments in strawberry. *LWT Food Sci. Technol.* **2007**, *40*, 374–382.

85. Canuto, G.A.; Oliveira, D.R.; da Conceição, L.S.; Farah, J.P.; Tavares, M.F. Development and validation of a liquid chromatography method for anthocyanins in strawberry (*Fragaria spp*) and complementary studies on stability, kinetics and antioxidant power. *Food Chem.* **2016**, *192*, 566–574.

86. Van De Velde, F.; Tarola, A.M.; Güemes, D.; Pirovani, M.E. Bioactive Compounds and Antioxidant Capacity of Camarosa and Selva Strawberries (*Fragaria × ananassa Duch*.). *Foods* **2013**, *2*, 120–131.

87. Stewart, D.; McDougall, G.J.; Sungurts, J.; Verrall, S.; Graham, J.; Martinus sen, I. Metabolomic approach to identifying bioactive compounds in berries: Advances toward fruit nutritional enhancement. *Mol. Nutr. Food Res.* **2007**, *51*, 645–651.
91. Fredes, C.; Montenegro, G.; Zoffoli, J.P.; Santander, F.; Robert, P. Comparison of the total phenolic content, total anthocyanin content and antioxidant activity of polyphenol-rich fruits grown in Chile. *Cienc. Inv. Agr.* 2014, 41, 49–60.

92. Oliveira, A.; Gomes, M.H.; Alexandre, E.M.; Poças, F.; Almeida, D.P.; Pintado, M. Phytochemicals preservation in strawberry as affected by pH modulation. *Food Chem.* 2015, 170, 74–83.

93. Tulipani, S.; Alvarez-Suarez, J.M.; Busco, F.; Bompadre, S.; Quiles, J.L.; Mezzetti, B.; Battino, M. Strawberry consumption improves plasma antioxidant status and erythrocyte resistance to oxidative haemolysis in humans. *Food Chem.* 2011, 128, 180–186.

94. Banaszewski, K.; Park, E.; Edirisinghe, I.; Cappozzo, J.C.; Burton-Freeman, B.M. A pilot study to investigate bioavailability of strawberry anthocyanins and characterize postprandial plasma polyphenols absorption patterns by Q-TOF LC/MS in humans. *J. Berry Res.* 2013, 3, 113–126.

95. Fu, Y.; Zhou, X.; Chen, S.; Sun, Y.; Shen, Z.; Ye, X. Chemical composition and antioxidant activity of Chinese wild raspberry (*Rubus hirsutus* Thunb.). *LWT Food Sci. Technol.* 2015, 60, 1262–1268.

96. Benvenuti, S.; Pellati, F.; Melegari, M.; Bertelli, D. Polyphenols, anthocyanins, ascorbic acid, and radical scavenging activity of Rubus, Ribes, and Aronia. *J. Food Sci.* 2004, 69, 164–169.

97. Rotundo, A.; Bounous, G.; Benvenuti, S.; Vampa, G.; Melegari, M.; Soragni, F. Quality and yield of Ribes and Rubus cultivars grown in Southern Italy hilly locations. *Phytother. Res.* 1998, 12, 135–137.

98. Romero Rodriguez, M.A.; Vazquez Oderiz, M.L.; Lopez Hernandez, J.; Simal Lozano, J.S. Determination of vitamin C and organic acids in various fruits by HPLC. *J. Chromatogr. Sci.* 1992, 30, 433–437.

99. De Ancos, B.; González, E.M.; Cano, M.P. Ellagic acid, vitamin C, and total phenolic contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *J. Agric. Food Chem.* 2000, 48, 4565–4570.

100. Zhang, Y.; Zhang, Z.; Yang, Y.; Zu, X.; Guan, D.I.; Guan, Y. Diuretic Activity of Rubus idaeus L (Rosaceae) in Rats. *Trop. J. Pharm. Res.* 2011, 10, 243–248.

101. Cheplick, S.; Kwon, Y.; Bhowmik, P.; Shetty, K. Clonal variation in raspberry fruit phenolics and relevance for diabetes and hypertension management. *J. Food Biochem.* 2007, 31, 656–679.

102. McDougall, G.J.; Ross, H.A.; Ikeji, M.; Stewart, D. Berry Extracts Exert Different Antiproliferative Effects against Cervical and Colon Cancer Cells Grown in Vitro. *J. Agric. Food Chem.* 2008, 56, 3016–3023.

103. Cerda, B.; Tomas-Barberan, F.A.; Espin, J.C. Metabolism of antioxidant and chemopreventive ellagitannins from strawberries, raspberries, walnuts, and oak-aged wine in humans: Identification of biomarkers and individual variability. *J. Agric. Food Chem.* 2005, 53, 227–235.

104. Seeram, N.P.; Adams, L.S.; Zhang, Y.; Lee, R.; Sand, D.; Scheuller, H.S.; Heber, D. Blackberry, Black Raspberry, Blueberry, Cranberry, Red Raspberry, and Strawberry Extracts Inhibit Growth and Stimulate Apoptosis of Human Cancer Cells in Vitro. *J. Agric. Food Chem.* 2006, 54, 9329–9339.

105. Wedge, D.E.; Meepagala, K.M.; Magee, J.B.; Hope Smith, S.; Huang, G.; Larcom, L.L. Anticarcinogenic Activity of Strawberry, Blueberry, and Raspberry Extracts to Breast and Cervical Cancer Cells. *J. Med. Food* 2001, 4, 49–51.
106 Bowen-Forbes, C.S.; Zhang, Y.; Nair, M.G. Anthocyanin content, antioxidant, anti-inflammatory and anticancer properties of blackberry and raspberry fruits. *J. Food Comp. Anal.* 2010, 23, 554–560.
107 Ross, H.A.; McDougall, G.J.; Stewart, D. Antiproliferative activity is predominantly associated with ellagitannins in raspberry extracts. *Phytochemistry* 2007, 68, 218–228.
108 Haffner, K.; Rosenfeld, H.J.; Skrede, G.; Wang, L. Quality of red raspberry Rubus idaeus L. cultivars after storage in controlled and normal atmospheres. *Postharvest Biol. Technol.* 2002, 24, 279–289.
109 Dragišić Maksimović, J.J.; Milivojević, J.M.; Poledica, M.M.; Nikolić, M.D.; Maksimović, V.M. Profiling antioxidant activity of two primocane fruited red raspberry cultivars (Autumn bliss and Polka). *J. Food Comp. Anal.* 2013, 31, 173–179.
110 Gülçin, İ.; Topal, F.; Çakmakçı, R.; Bilsel, M.; Gören, A.C.; Erdoğan, U. Pomological Features, Nutritional Quality, Polyphenol Content Analysis, and Antioxidant Properties of Domesticated and 3 Wild Ecotype Forms of Raspberries (Rubus idaeus L.). *J. Food Sci.* 2011, 76, 585–593.
111 Bobinaitė, R.; Viškelis, P.; Rimantas Venskutonis, P. Variation of total phenolics, anthocyanins, ellagic acid and radical scavenging capacity in various raspberry (Rubus spp.) cultivars. *Food Chem.* 2012, 132, 1495–1501.
112 Chen, L.; Xin, X.; Zhang, H.; Yuan, Q. Phytochemical properties and antioxidant capacities of commercial raspberry varieties. *J. Funct. Foods* 2013, 5, 508–515.
113 Maatta-Riihinen, K.R.; Kamal-Eldin, A.; Torronen, A.R. Identification and quantification of phenolic compounds in berries of Fragaria and Rubus species (family Rosaceae). *J. Agric. Food Chem.* 2004, 52, 6178–6187.
114 Çekiç, C.; Özgen, M. Comparison of antioxidant capacity and phytochemical properties of wild and cultivated red raspberries (Rubus idaeus L.). *J. Food Comp. Anal.* 2010, 23, 540–544.
115 Mazur, S.P.; Nes, A.; Wold, A.-B.; Remberg, S.F.; Aaby, K. Quality and chemical composition of ten red raspberry (Rubus idaeus L.) genotypes during three harvest seasons. *Food Chem.* 2014, 160, 233–240.
116 Anttonen, M.J.; Karjalainen, R.O. Environmental and genetic variation of phenolic compounds in red raspberry. *J. Food Comp. Anal.* 2005, 18, 759–769.
117 Jin, P.; Wang, S.Y.; Gao, H.; Chen, H.; Zheng, Y.; Wang, C.Y. Effect of cultural system and essential oil treatment on antioxidant capacity in raspberries. *Food Chem.* 2012, 132, 399–405.
118 Wang, S.Y.; Chen, C.-T.; Wang, C.Y. The influence of light and maturity on fruit quality and flavonoid content of red raspberries. *Food Chem.* 2009, 112, 676–684.
119 Hassani, S.; Shariatpanahi, M.; Tavakoli, F.; Nili-Ahmadabadi, A.; Abdollahi, M. The changes of bioactive ingredients and antioxidant properties in various berries during jam processing. *Int. J. Biosci.* 2015, 6, 172–179.
120 Giovanelli, G.; Limbo, S.; Buratti, S. Effects of new packaging solutions on physico-chemical, nutritional and aromatic characteristics of red raspberries (Rubus idaeus L.) in postharvest storage. *Postharvest Biol. Technol.* 2014, 98, 72–81.
121 Ali, L.; Svensson, B.; Alsanius, B.W.; Olsson, M.E. Late season harvest and storage of Rubus berries-Major antioxidant and sugar levels. *Sci. Hortic.* 2011, 129, 376–381.
122. Pavlovic, A.V.; Dabic, D.C.; Momirovic, N.M.; Dojcinovic, B.P.; Milojkovic-Opsenica, D.M.; Tesic, Z.L. Chemical composition of two different extracts of berries harvested in Serbia. *J. Agric. Food Chem.* **2013**, *61*, 4188–4194.

123. Borges, G.; Degeneve, A.; Mullen, W.; Crozier, A. Identification of flavonoid and phenolic antioxidants in black currants, blueberries, raspberries, red currants, and cranberries. *J. Agric. Food Chem.* **2010**, *58*, 3901–3909.

124. Bradish, C.M.; Perkins-Veazie, P.; Fernandez, G.E.; Xie, G.; Jia, W. Comparison of Flavonoid Composition of Red Raspberries (*Rubus idaeus* L.) Grown in the Southern United States. *J. Agric. Food Chem.* **2012**, *60*, 5779–5786.

125. Zorița, D.; Florica, R.; Rugină, D.; Lucian, C.; Socaciu, C. HPLC/PDA–ESI/MS Identification of Phenolic Acids, Flavonol Glycosides and Antioxidant Potential in Blueberry, Blackberry, Raspberries and Cranberries. *J. Food Nutr. Res.* **2014**, *2*, 781–785.

126. Dobson, P.; Graham, J.; Stewart, D.; Brennan, R.; Hackett, C.A.; McDougall, G.J. Over-seasons Analysis of Quantitative Trait Loci Affecting Phenolic Content and Antioxidant Capacity in Raspberry. *J. Agric. Food Chem.* **2012**, *60*, 5360–5366.

127. Hatfield, G. *Encyclopedia of Folk Medicine: Old World and New World Traditions*, 1st ed.; ABC-CLIO: Santa Barbara, CA, USA, 2004; p. 392.

128. Tavares, L.; Figueira, I.; McDougall, G.J.; Vieira, H.L.; Stewart, D.; Alves, P.M.; Santos, C.N. Neuroprotective effects of digested polyphenols from wild blackberry species. *Eur. J. Nutr.* **2013**, *52*, 225–236.

129. Feresin, R.G.; Zhang, J.; Elam, M.; Hooshmand, S.; Kim, J.; Arjmandi, B.J. Effects of blackberry and blueberry polyphenol extracts on NO, TNF-α, and COX-2 production in LPS-stimulated RAW264.7 macrophages. *Faseb J.* **2012**, *26*, 823.20.

130. Marquina, M.A.; Corao, G.M.; Araujo, L.; Butrago, D.; Sosa, M. Hyaluronidase inhibitory activity from the polyphenols in the fruit of blackberry (*Rubus fruticosus B.*) *Fitoterapia* **2002**, *73*, 727–729.

131. Dai, J.; Patel, J.D.; Mumper, R.J. Characterization of blackberry extract and its antiproliferative and anti-inflammatory properties. *J. Med. Food* **2007**, *10*, 258–265.

132. Hager, T.J.; Howard, L.R.; Prior, R.L. Processing and storage effects on monomeric anthocyanins, percent polymeric color, and antioxidant capacity of processed blackberry products. *J. Agric. Food Chem.* **2008**, *56*, 689–695.

133. Shipp, J.; Abdel-Aal, E.-S.M. Food Applications and Physiological Effects of Anthocyanins as Functional Food Ingredients. *Open Food Sci. J.* **2010**, *4*, 7–22.

134. Jiao, H.; Wang, S.Y. Correlation of antioxidant capacities to oxygen radical scavenging enzyme activities in blackberry. *J. Agric. Food Chem.* **2000**, *48*, 5672–5676.

135. Acosta, O.; Vaillant, F.; Pérez, A.M.; Dornier, M. Potential of ultrafiltration for separation and purification of ellagitannins in blackberry (*Rubus adnexitrusch Schltdl*.) juice. *Sep. Purif. Technol.* **2014**, *125*, 120–125.

136. Soto, M.; Acosta, O.; Vaillant, F.; Pérez, A. Effects of Mechanical and Enzymatic Pretreatments on Extraction of Polyphenols from Blackberry Fruits. *J. Food Process. Eng.* **2015**, doi:10.1111/jfpe.12240.
137. Siriwoharn, T.; Wrolstad, R.E.; Finn, C.E.; Pereira, C.B. Influence of Cultivar, Maturity, and Sampling on Blackberry (Rubus L. Hybrids) Anthocyanins, Polyphenolics, and Antioxidant Properties. *J. Agric. Food Chem.* 2004, 52, 8021–8030.

138. Kevers, C.; Pincemail, J.; Defragne, J.O.; Dommes, J. Antioxidant capacity of small dark fruits: Influence of cultivars and harvest time. *J. Berry Res.* 2014, 4, 97–105.

139. Wu, R.; Frei, B.; Kennedy, J.A.; Zhao, Y. Effects of refrigerated storage and processing technologies on the bioactive compounds and antioxidant capacities of “Marion” and “Evergreen” blackberries. *LWT Food Sci. Technol.* 2010, 43, 1253–1264.

140. Koca, I.; Karadeniz, B. Antioxidant properties of blackberry and blueberry fruits grown in the Black Sea Region of Turkey. *Sci. Hortic.* 2009, 121, 447–450.

141. Denardin, C.C.; Hirsch, G.E.; da Rocha, R.F.; Vizzotto, M.; Henriques, A.T.; Moreira, J.C.F.; Guma, F.T.C.R.; Emanuelli, T. Antioxidant capacity and bioactive compounds of four Brazilian native fruits. *J. Food Drug Anal.* 2015, doi:10.1016/j.jfda.2015.01.006.

142. Hager, T.J.; Howard, L.R.; Prior, R.L. Processing and storage effects on the ellagitannin composition of processed blackberry products. *J. Agric. Food Chem.* 2010, 58, 11749–11754.

143. Gancel, A.L.; Feneuil, A.; Acosta, O.; Pérez, A.M.; Vaillant, F. Impact of industrial processing and storage on major polyphenols and the antioxidant capacity of tropical highland blackberry (Rubus adenotrichus). *Food Res. Int.* 2011, 44, 2243–2251.

144. Wang, W.D.; Xu, S.Y. Degradation kinetics of anthocyanins in blackberry juice and concentrate. *J. Food Eng.* 2007, 82, 271–275.

145. Kolniak-Ostek, J.; Kucharska, A.Z.; Sokół-Lętowska, A.; Fecka, I. Characterization of phenolic compounds of thorny and thornless blackberries. *J. Agric. Food Chem.* 2015, 63, 3012–3021.

146. Cho, M.J.; Howard, L.R.; Prior, R.L.; Clark, J.R. Flavonoid glycosides and antioxidant capacity of various blackberry, blueberry, and red grape genotypes determined by high-performance liquid chromatography/mass spectrometry. *J. Sci. Food Agric.* 2004, 84, 1771–1782.

147. Mertz, C.; Cheynier, V.; Gunata, Z.; Brat, P. Analysis of phenolic compounds in two blackberry species (*Rubus glaucus* and *Rubus adenotrichus*) by high-performance liquid chromatography with diode array detection and electrospray ion trap mass spectrometry. *J. Agric. Food Chem.* 2007, 55, 8616–8624.

148. Acosta-Montoya, Ó.; Vaillant, F.; Cozzano, S.; Mertz, C.; Pérez, A.M.; Castro, M.V. Phenolic content and antioxidant capacity of tropical highland blackberry (*Rubus adenotrichus* Schltdl.) during three edible maturity stages. *Food Chem.* 2010, 119, 1497–1501.

149. Brownmiller, C.R.; Howard, L.R.; Prior, R.L. Processing and storage effects on procyanidin composition and concentration of processed blueberry products. *J. Agric. Food Chem.* 2009, 57, 1896–1902.

150. Jiao, Z.; Liu, J.; Wang, S. Antioxidant Activities of Blackberry Pigment Extract. *Food Technol. Biotechnol.* 2005, 43, 97–102.

151. Johnson, M.H.; de Mejia, E.G. Comparison of chemical composition and antioxidant capacity of commercially available blueberry and blackberry wines in Illinois. *J. Food Sci.* 2012, 77, 141–148.

152. Penney, B.G.; McRae, K.B.; Bishop, G.A. Second-crop N fertilization improves lowbush blueberry (*Vaccinium angustifolium* Ait.) production. *Can. J. Plant Sci.* 2003, 83, 149–155.
153. Harb, J.; Khrawesh, B.; Streif, J.; Reski, R.; Frank, W. Characterization of blueberry monodehydroascorbate reductase gene and changes in levels of ascorbic acid and the antioxidative capacity of water soluble antioxidants upon storage of fruits under various conditions. *Sci. Hortic.* 2010, 125, 390–395.

154. Sinelli, N.; Spinardi, A.; di Egidio, V.; Mignani, I.; Casiraghi, E. Evaluation of quality and nutraceutical content of blueberries (*Vaccinium corymbosum* L.) by near and mid-infrared spectroscopy. *Postharvest Biol. Technol.* 2008, 50, 31–36.

155. Paes, J.; Dotta, R.; Barbero, G.F.; Martinez, J. Extraction of phenolic compounds and anthocyanins from blueberry (*Vaccinium myrtillus* L.) residues using supercritical CO2 and pressurized liquids. *J. Supercrit. Fluids* 2014, 95, 8–16.

156. Gündüz, K.; Serçe, S.; Hancock, J.F. Variation among highbush and rabbiteye cultivars of blueberry for fruit quality and phytochemical characteristics. *J. Food Compos. Anal.* 2015, 38, 69–79.

157. Golding, J.B.; Bladesa, B.L.; Satyana, S.; Jessupa, A.J.; Spohra, L.J.; Harrisa, A.M.; Banosc, C.; Davies, J.B. Low dose gamma irradiation does not affect the quality, proximate or nutritional profile of ‘Brigitta’ blueberry and ‘Maravilla’ raspberry fruit. *Postharvest Biol. Technol.* 2014, 96, 49–52.

158. Barba, F.J.; Jäger, H.; Meneses, N.; Esteve, M.J.; Frigola, A.; Knorr, D. Evaluation of quality changes of blueberry juice during refrigerated storage after high-pressure and pulsed electric fields processing. *Innov. Food Sci. Emerg. Technol.* 2012, 14, 18–24.

159. Calò, R.; Marabini, L. Protective effect of *Vaccinium myrtillus* extract against UVA- and UVB-induced damage in a human keratinocyte cell line (HaCaT cells). *J. Photochem. Photobiol. B Biol.* 2014, 132, 27–35.

160. Shen, C.-L.; von Bergen, V.; Chyu, M.-C.; Jenkins, M.R.; Mo, H.; Chen, C.-H.; Kwun, I.-S. Fruits and dietary phytochemicals in bone protection. *Nutr. Res.* 2012, 32, 897–910.

161. Al-Awwadi, N.A.; Araiz, C.; Bornet, A.; Delbosc, S.; Cristol, J.P.; Linck, N.; Azay, J.; Teissedre, P.-L.; Cros, G. Extracts enriched in different polyphenolic families normalize increased cardiac NADPH oxidase expression while having differential effects on insulin resistance, hypertension, and cardiac hypertrophy in highfructose-fed rats. *J. Agric. Food Chem.* 2005, 53, 151–157.

162. Martineau, L.C.; Couture, A.; Spoer, D.; Benhaddou-Andaloussi, A.; Harris, C.; Meddah, B.; Leduca, C.; Burtc, A.; Vuonga, T.; Le, P.M.; et al. Anti-diabetic properties of the Canadian lowbush blueberry *Vaccinium angustifolium* Aiton. *Phytomedicine.* 2006, 13, 612–623.

163. Stull, A.J.; Cash, K.C.; Johnson, W.D.; Champagne, C.M.; Cefalu, W.T. Bioactives in blueberries improve insulin sensitivity in obese, insulin-resistant men and women. *J. Nutr.* 2010, 140, 1764–1768.

164. Basu, A.; Du, M.; Leyva, M.J.; Sanchez, K.; Betts, N.M.; Wu, M.; Aston, C.E.; Lyons, T.J. Blueberries decrease cardiovascular risk factors in obese men and women with metabolic syndrome. *J. Nutr.* 2010, 140, 1582–1587.

165. Prior, R.L.; Wu, X.; Gu, L.; Hager, T.; Hager, A.; Wilkes, S.; Howard, L. Purified berry anthocyanins but not whole berries normalize lipid parameters in mice fed an obesogenic high fat diet. *Mol. Nutr. Food Res.* 2009, 53, 1406–1418.
166. Wu, X.; Kang, J.; Xie, C.; Burris, R.; Ferguson, M.E.; Badger, T.M.; Nagarajan, S. Dietary blueberries attenuate atherosclerosis in apolipoprotein E-deficient mice by upregulating antioxidant enzyme expression. *J. Nutr.* 2010, 140, 1628–1632.

167. Del Bo′, C.; Riso, P.; Campolo, J.; Møller, P.; Loft, S.; Klimis-Zacas, D.; Brambilla, A.; Rizzolo, A.; Porrini, M. A single portion of blueberry (*Vaccinium corymbosum* L.) improves protection against DNA damage but not vascular function in healthy male volunteers. *Nutr. Res.* 2013, 33, 220–227.

168. Adams, L.S.; Phung, S.; Yee, N.; Seeram, N.P.; Li, L.; Chen, S. Blueberry phytochemicals inhibit growth and metastatic potential of MDA-MB-231 breast cancer cells through modulation of the phosphatidylinositol 3-kinase pathway. *Cancer Res.* 2010, 70, 3594–3605.

169. Samad, N.B.; Debnath, T.; Ye, M.; Hasnat, M.A.; Lim, B.O. *In vitro* antioxidant and anti-inflammatory activities of Korean blueberry (*Vaccinium corymbosum* L.) extracts. *Asian Pac. J. Trop. Biomed.* 2014, 4, 807–815.

170. Schantz, M.; Mohn, C.; Baum, M.; Richling, E. Antioxidative efficiency of an anthocyanin rich bilberry extract in the human colon tumor cell lines Caco-2 and HT-29. *J. Berry Res.* 2010, 1, 25–33.

171. Liu, J.; Zhang, W.; Jing, H.; Popovich, D.G. Bog bilberry (*Vaccinium uliginosum* L.) extract reduces cultured Hep-G2, Caco-2, and 3T3-L1 cell viability, affects cell cycle progression, and has variable effects on membrane permeability. *J. Food Sci.* 2010, 75, 103–107.

172. Srivastava, A.; Akoh, C.C.; Fischer, J.; Krewer, G. Effect of anthocyanin fractions from selected cultivars of Georgia-grown blueberries on apoptosis and phase II enzymes. *J. Agric. Food Chem.* 2007, 55, 3180–3185.

173. Chen, P.N.; Chu, S.C.; Chou, H.L.; Chiang, C.L.; Yang, S.F.; Hsieh, Y.S. Cyanidin 3-glucoside and peonidin 3-glucoside inhibit tumor cell growth and induce apoptosis *in vitro* and suppress tumor growth *in vivo*. *Nutr. Cancer* 2005, 53, 232–243.

174. Yun, J.M.; Afaq, F.; Khan, N.; Mukhtar, H. Delphinidin, an anthocyanidin in pigmented fruits and vegetables, induces apoptosis and cell cycle arrest in human colon cancer HCT116 cells. *Mol. Carcinog.* 2009, 48, 260–270.

175. Giovanelli, G.; Brambilla, A.; Rizzolo, A.; Simelli, N. Effects of blanching pre-treatment and sugar composition of the osmotic solution on physico-chemical, morphological and antioxidant characteristics of osmodehydrated blueberries (*Vaccinium corymbosum* L.). *Food Res. Int.* 2012, 49, 263–271.

176. Chong, C.; Law, C.; Figiel, A.; Wojdylo, A.; Oziembłowski, M. Colour, phenolic content and antioxidant capacity of some fruits dehydrated by a combination of different methods. *Food Chem.* 2013, 141, 3889–3896.

177. Lohachoompol, V.; Srzednicki, G.; Craske, J. The change of total anthocyanins in blueberries and their antioxidant effect after drying and freezing. *J. Biomed. Biotechnol.* 2004, 5, 248–252.

178. Zielinska, M.; Sadowski, P.; Błaszczyk, W. Freezing/thawing and microwave-assisted drying of blueberries (*Vaccinium corymbosum* L.). *LWT Food Sci. Technol.* 2015, 62, 555–563.

179. Yang, G.; Yue, J.; Gong, X.; Qian, B.; Wang, H.; Deng, Y.; Zhao, Y. Blueberry leaf extracts incorporated chitosan coatings for preserving postharvest quality of fresh blueberries. *Postharvest Biol. Technol.* 2014, 92, 46–53.
180. Taruscio, T.G.; Barney, D.L.; Exon, J. Content and profile of flavanoid and phenolic acid compounds in conjunction with the antioxidant capacity for a variety of northwest Vaccinium berries. *J. Agric. Food Chem.* 2004, 52, 3169–3176.

181. Pertuzatti, P.B.; Barcia, M.T.; Rodrigues, D.; da Cruz, P.N.; Hermosin-Gutiérrez, I.; Smith, R.; Godoy, H.T. Antioxidant activity of hydrophilic and lipophilic extracts of Brazilian blueberries. *Food Chem.* 2014, 164, 81–88.

182. Rodarte Castrejón, A.D.; Eschholz, I.; Rohn, S.; Kroh, L.W.; Huyskens-Keil, S. Phenolic profile and antioxidant activity of highbush blueberry (*Vaccinium corymbosum* L.) during fruit maturation and ripening. *Food Chem.* 2008, 109, 567–572.

183. Yousef, G.G.; Brown, A.F.; Funakoshi, Y.; Mbeunkui, F.; Grace, M.H.; Ballington, J.R.; Loraine, A.; Lila, M.A. Efficient quantification of the health-relevant anthocyanin and phenolic acid profiles in commercial cultivars and breeding selections of blueberries (*Vaccinium* spp.). *J. Agric. Food Chem.* 2013, 61, 4806–4815.

184. You, Q.; Wang, B.; Chen, F.; Huang, Z.; Wang, X.; Luo, P.G. Comparison of anthocyanins and phenolics in organically and conventionally grown blueberries in selected cultivars. *Food Chem.* 2011, 125, 201–208.

185. Forney, C.F.; Kalt, W.; Jordan, M.A.; Vinqvist-Tymchuk, M.R.; Fillmore, S.A.E. Blueberry and cranberry fruit composition during development. *J. Berry Res.* 2012, 2, 169–177.

186. Reque, P.M.; Steffens, R.S.; Jablonski, A.; Flóres, S.H.; de O Ros, A.; de Jong, E.V. Cold storage of blueberry (*Vaccinium* spp.) fruits and juice: Anthocyanin stability and antioxidant activity. *J. Food Compos. Anal.* 2014, 33, 111–116.

187. Giovanelli, G.; Brambilla, A.; Sinelli, N. Effects of osmo-air dehydration treatments on chemical, antioxidant and morphological characteristics of blueberries. *LWT Food Sci. Technol.* 2013, 54, 577–584.

188. Correa-Betanzo, J.; Padmanabhan, P.; Corredig, M.; Subramanian, J.; Paliyath, G. Complex Formation of Blueberry (*Vaccinium angustifolium*) Anthocyanins during Freeze-Drying and Its Influence on Their Biological Activity. *J. Agric. Food Chem.* 2015, 63, 2935–2946.

189. Buran, T.J.; Sandhu, A.K.; Li, Z.; Rock, Ch.R.; Yang, W.W.; Gu, L. Adsorption/desorption characteristics and separation of anthocyanins and polyphenols from blueberries using macroporous adsorbent resins. *J. Food Eng.* 2014, 128, 167–173.

190. Barnes, J.S.; Nguyen, H.P.; Shen, S.; Schug, K.A. General method for extraction of blueberry anthocyanins and identification using high performance liquid chromatography-electrospray ionization -ion-trap-time of flight-mass spectrometry. *J. Chromatogr. A* 2009, 1216, 4728–4735.

191. Rodriguez-Mateos, A.; Cifuentes-Gomez, T.; Tabatabaee, S.; Lecras, C.; Spencer, J.P.E. Procyanidin, Anthocyanin, and Chlorogenic Acid Contents of Highbush and Lowbush Blueberries. *J. Agric. Food Chem.* 2012, 60, 5772–5778.

192. Mehra, L.K.; MacLean, D.D.; Shewfelt, R.L.; Smith, K.C.; Scherm, H. Effect of postharvest biofumigation on fungal decay, sensory quality, and antioxidant levels of blueberry fruit. *Postharvest Biol. Technol.* 2013, 85, 109–115.

193. Wang, E.; Yina, Y.; Xuc, C.; Liu, J. Isolation of high-purity anthocyanin mixtures and monomers from blueberries using combined chromatographic techniques. *J. Chromatogr. A* 2014, 1327, 39–48.
194. Bunea, A.; Rugină, D.; Sconța, Z.; Pop, R.M.; Pintea, A.; Socaciu, C.; Tăbăran, F.; Grootaert, C.; Struijs, K.; VanCamp, J. Anthocyanin determination in blueberry extracts from various cultivars and their antiproliferative and apoptotic properties in B16-F10 metastatic murine melanoma cells. *Phytochemistry* 2013, 95, 436–444.

195. Stevenson, D.; Scalzo, J. Anthocyanin composition and content of blueberries from around the world. *J. Berry Res.* 2012, 2, 179–189.

196. Barberis, A.; Spissu, Y.; Fadda, A.; Azara, E.; Bazzu, G.; Marceddu, S.; Angioni, A.; Sanna, D.; Schirra, M.; Serra, P.A. Simultaneous amperometric detection of ascorbic acid and antioxidant capacity in orange, blueberry and kiwi juice, by a telemetric system coupled with a fullerene- or nanotubes-modified ascorbate subtractive biosensor. *Biosens. Bioelectron.* 2015, 67, 214–223.

197. Harasym, J.; Oledzki, R. Effect of fruit and vegetable antioxidants on total antioxidant capacity of blood plasma. *Nutrition* 2014, 30, 511–517.

198. Vattem, D.A.; Ghaedian, R.; Shetty, K. Enhancing health benefits of berries through phenolic antioxidant enrichment: focus on cranberry. *Asia Pac. J. Clin. Nutr.* 2005, 14, 120–130.

199. Dorofejeva, K.; Rakcejeva, T.; Galoburda, R.; Dukalska, L.; Kviessis, J. Vitamin C content in Latvian cranberries dried in convective and microwave vacuum driers. *Procedia Food Sci.* 2011, 1, 433–440.

200. Duthie, S.J.; McE Jenkinson, A.; Crozier, A.; Mullen, W.; Pirie, L.; Kyle, J.; Sheer Yap, L.; Christen, P.; Duthie, G.G. The effects of cranberry juice consumption on antioxidant status and biomarkers relating to heart disease and cancer in healthy human volunteers. *Eur. J. Nutr.* 2006, 45, 113–122.

201. Rudy, S.; Dziki, D.; Krzykowski, A.; Gawlik-Dziki, U.; Polak, R.; Rożilo, R.; Kulig, R. Influence of pre-treatments and freeze-drying temperature on the process kinetics and selected physico-chemical properties of cranberries (*Vaccinium macrocarpon* Ait.). *LWT Food Sci. Technol.* 2015, 63, 497–503.

202. Chu, Y.-F.; Liu, R.H. Cranberries inhibit LDL oxidation and induce LDL receptor expression in hepatocytes. *Life Sci.* 2005, 77, 1892–1901.

203. Pedersen, C.B.; Kyle, J.; McE Jenkinson, A.; Gardner, P.T.; McPhail, D.B.; Duthie, G.G. Effects of blueberry and cranberry juice consumption on the plasma antioxidant capacity of healthy female volunteers. *Eur. J. Clin. Nutr.* 2000, 54, 405–408.

204. Sun, J.; Maras, J.P.J.; Khoo, C.; LaPlante, K.; Vejborg, R.M.; Givskov, M.; Tølker-Nielsen, T.; Seeram, N.P.; Rowley, D.C. Cranberry (*Vaccinium macrocarpon*) oligosaccharides decrease biofilm formation by uropathogenic *Escherichia coli*. *J. Funct. Foods* 2015, 17, 235–242.

205. Ermel, G.; Georgeault, S.; Inisan, C.; Besnard, M. Inhibition of Adhesion of Uropathogenic *Escherichia coli* Bacteria to Uroepithelial Cells by Extracts from Cranberry. *J. Med. Food* 2012, 15, 126–134.

206. Burger, O.; Ofek, I.; Tabak, M.; Weiss, E.I.; Sharon, N.; Neeman, I. A high molecular mass constituent of cranberry juice inhibits Helicobacter pylori adhesion to human gastric mucus. *FEMS Immunol. Med. Microbiol.* 2000, 29, 295–301.

207. McKay, D.L.; Blumberg, J.B. Cranberries (*Vaccinium macrocarpon*) and cardiovascular disease risk factors. *Nutr. Rev.* 2007, 65, 490–502.
Novotny, J.A.; Baer, D.J.; Khoo, C.; Gebauer, S.K.; Charron, C.S. Cranberry juice consumption lowers markers of cardiometabolic risk, including blood pressure and circulating C-reactive protein, triglyceride, and glucose concentrations in adults. *J. Nutr.* 2015, 145, 1185–1193.

Kahlon, T.S.; Smith, G.E. In vitro binding of bile acids by blueberries (*Vaccinium* spp.), plums (*Prunus* spp.), prunes (*Prunus* spp.), strawberries (*Fragaria X ananassa*), cherries (*Malpighia punicifolia*), cranberries (*Vaccinium macrocarpon*) and apples (*Malus sylvestris*). *Food Chem.* 2007, 100, 1182–1187.

Seeram, N.P.; Adams, L.S.; Hardy, M.L.; Heber, D. Total cranberry extract versus its phytochemical constituents: Antiproliferative and synergistic effects against human tumor cell lines. *J. Agric. Food Chem.* 2004, 52, 2512–2517.

Vattem, D.A.; Jang, H.D.; Levin, R.; Shetty, K. Synergism of cranberry phenolics with ellagic acid and rosmarinic acid for antimutagenic and DNA protection functions. *J. Food Biochem.* 2006, 30, 98–116.

Sun, J.; Liu, R.H. Cranberry phytochemical extracts induce cell cycle arrest and apoptosis in human MCF-7 breast cancer cells. *Cancer Lett.* 2006, 241, 124–134.

Vu, K.D.; Carletti, H.; Bouvet, J.; Cote, J.; Doyon, G.; Sylvain, J.-F.; Lacroix, M. Effect of different cranberry extracts and juices during cranberry juice processing on the antiproliferative activity against two colon cancer cell lines. *Food Chem.* 2012, 132, 959–967.

Yan, X.; Murphy, B.T.; Hammond, G.B.; Vinson, J.A.; Neto, C.C. Antioxidant activities and antitumor screening of extracts from cranberry fruit (*Vaccinium macrocarpon*). *J. Agric. Food Chem.* 2002, 50, 5844–5849.

Carpenter, J.L.; Caruso, F.L.; Tata, A.; Vorsa, N.; Neto, C.C. Variation in proanthocyanadin content and composition among commonly grown North American cranberry cultivars (*Vaccinium macrocarpon*). *J. Sci. Food Agric.* 2014, 94, 2738–2745.

Wang, S.Y.; Stretch, A.W. Antioxidant Capacity in Cranberry Is Influenced by Cultivar and Storage Temperature. *J. Agric. Food Chem.* 2001, 49, 969–974.

Vollmannova, A.; Tomas, J.; Urminska, D.; Polakova, Z.; Melichacova, S.; Krizova, L. Content of Bioactive Components in Chosen Cultivars of Cranberries (*Vaccinium vitis-idaea* L.) *Czech. J. Food Sci.* 2009, 27, 248–251.

Van den Heuvel, J.E.; Autio, W.R. Early-season Air Temperature Affects Phenolic Production in “Early Black” Cranberry Fruit. *Hort. Sci.* 2008, 43, 1737–1741.

Çelik, H.; Özgen, M.; Serçec, S.; Kayad, C. Phytochemical accumulation and antioxidant capacity at four maturity stages of cranberry fruit. *Sci. Hortic.* 2008, 117, 345–348.

Côté, J.; Caillet, S.; Doyon, G.; Dussault, D.; Salmieri, S.; Lorenzo, G.; Sylvain, J.-F.; Lacroix, M. Effects of juice processing on cranberry antioxidant properties. *Food Res. Int.* 2011, 44, 2907–2914.

Biswas, N.; Balac, P.; Narlakanti, S.K.; Haque, M.D.E.; Hassan, M.D.M. Identification of Phenolic Compounds in Processed Cranberries by HPLC Method. *J. Nutr. Food Sci.* 2013, 3, 181–186.

Rodríguez-Pérez, C.; Quirantes-Piné, R.; Contreras Mdel, M.; Uberos, J.; Fernández-Gutiérrez, A.; Segura-Carretero, A. Assessment of the stability of proanthocyanidins and other phenolic compounds in cranberry syrup after gamma-irradiation treatment and during storage. *Food Chem.* 2015, 174, 392–399.
223. Mikulic-Petkovsek, M.; Slatnar, A.; Stampar, F.; Veberic, R. HPLC-MSn identification and quantification of flavonol glycosides in 28 wild and cultivated berry species. *Food Chem.* 2012, 135, 2138–2146.

224. Viskelis, P.; Rubinskiene, M.; Jasutiene, I.; Sarkinas, A.; Daubaras, R.; Cesoniene, L. Anthocyanins, antioxidative, and antimicrobial properties of American cranberry (*Vaccinium macrocarpon* Ait.) and their press cakes. *J. Food Sci.* 2009, 74, 157–161.

225. Brown, P.N.; Shipley, P.R. Determination of Anthocyanins in Cranberry Fruit and Cranberry Fruit Products by High-Performance Liquid Chromatography with Ultraviolet Detection. Single-Laboratory Validation. *J. AOAC Int.* 2011, 94, 459–466.

© 2015 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/4.0/).