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Review

Review of the Report on the Nutritional and Health-Promoting Values of Species of the *Rubus* L. Genus

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Abstract: The genus *Rubus* encompasses over 1000 species, including raspberries and blackberries, known for their rich nutritional and health-promoting properties. This review aims to provide a comprehensive overview of the nutritional values, health benefits, and potential medical and pharmaceutical applications of *Rubus* species. The fruits, roots, shoots, and leaves of these plants are distinguished by their high content of polyphenols, vitamins, and minerals, which contribute to their potent anti-oxidant, anti-inflammatory, anti-neurodegenerative, and anti-cancer effects. The diverse phytochemical profiles of the *Rubus* species support their use in the prevention and treatment of chronic diseases such as cardiovascular diseases, diabetes, and certain cancers. Additionally, the *Rubus* species are valuable as pharmaceutical raw materials due to their bioactive compounds. Despite the focus on a few widely cultivated species, numerous wild and lesser-known *Rubus* species offer significant untapped potential as functional foods, nutraceuticals, and pharmaceuticals. Future research should explore the detailed mechanisms of their bioactivities, develop effective extraction and formulation techniques, and integrate these findings into public health strategies. The genus *Rubus* represents a promising resource for enhancing human health and nutrition, as well as for pharmaceutical and medical applications, justifying increased cultivation and utilization of species from this genus.

Keywords: raspberry; blackberry; black raspberry; polyphenols; health; yellow raspberry

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1. Introduction

Defining what constitutes a healthy diet has been the subject of countless discussions over decades among the food-related community. As a result, numerous definitions of healthy food have emerged [1]. One partial cause of this problem is the wide variety of health issues for which different diets are used. A healthy diet should be free from harmful substances, without excess of any nutrients and health-promoting substances, and, above all, should result in high health outcomes and reduce the likelihood of diseases [2]. A diet rich in highly processed foods is characterized by low nutrient content, which results in a higher risk of chronic diseases [3]. Diseases caused by improper diets are currently a major cause of decreasing life expectancy and reduction in the quality of life [4]. Properly designed food systems can have a significant impact on the health of the entire human population; however, current food systems can pose a threat to both humans and the environment. The current food production system faces many problems, one of which is ensuring sufficient access to food for the entire world's population [5].

Plant-based foods, including fresh fruits, are a major component of a proper diet and can potentially have a significant impact on reducing the incidence of many diseases [6]. The benefits of consuming fruits and vegetables are now widely confirmed. The World Health Organization (WHO) recommends consuming at least five servings of fruits and vegetables daily [7]. The consumption of berry fruits is associated with lowering blood pressure and reducing the risk of diabetes and cardiovascular diseases. It has also been confirmed that berry fruits enhance resistance to viral diseases and play a role in their treatment.

Consumption of berry fruits rich in phytochemicals increases neuroplasticity, neurotransmission, and calcium buffering. Additionally, they possess anti-cancer, anti-oxidant, and anti-inflammatory properties, and they reduce age-related neurodegeneration [8,9].

To fully utilize the benefits of fruit consumption, changes in the food system are necessary [10]. Increasing fruit consumption and reducing the disparity in access to healthy food between adolescents from wealthier and less affluent families are crucial for public health [11].

The genus *Rubus* L. comprises over 1000 species [12]. Due to the large number of species, which are also difficult to identify, it is considered a very challenging genus for taxonomic classification [13]. This genus includes *Rubus idaeus* L., *R. strigosus* Michx., *R. occidentalis* L., *R. neglectus*, *R. xanthocarpus* Bur. et Fr. [14], *R. ursinus* Cham. et Schlecht., *R. candicans* Weihe, *R. alleghanensis* Porter, *R. plicatus* W. et N., and *R. lacinigtus* Willd. [15]. The distribution areas of species of the genus *Rubus* L. span six continents and include raspberries, blackberries, and their hybrids [16]. As early as ancient times, species belonging to the genus *Rubus* were associated with medicinal properties. They were used, among other things, in the treatment of colicky pain, inflammations, diarrhea, wounds, diabetes, and as anti-microbial agents [17]. Today, many species of the genus *Rubus* are used in the treatment of various diseases [18].

Due to their high nutritional and bioactive compound values, there has been an increased interest in the consumption of blackberries in recent years [19]. This growing interest also extends to red raspberries [8], whose fruits are noted for their appealing appearance, high content of beneficial compounds for human health, and delicious taste [20,21]. A key feature of consumable products in the context of health benefits is their anti-oxidant potential [22]. Species of the genus *Rubus* L. are considered valuable sources of polyphenols and bioactive compounds, fitting within the framework of functional foods and pharmaceutical raw materials. Their popularity among consumers is increasing, leading to greater market demand. This situation is mainly due to the nutritional and industrial significance of the fruits derived from these species. Knowledge regarding the biosynthesis pathways and mechanisms controlling the accumulation of valuable metabolites in raspberry fruits, as well as the role of individual phytochemicals, is rapidly advancing. Simultaneously, knowledge related to raspberry genetics is expanding, enabling the selection of varieties not only with high fruit flavor qualities but also with significant values that provide more effective protection against degenerative diseases [23].

The content of nutrients and bioactive compounds is influenced not only by the species or variety itself but also by the agricultural practices used in cultivating plants from the genus *Rubus*, which often play a fundamental role in this aspect. Similarly, the microclimate, despite the use of identical agricultural practices on closely located plantations, will lead to varied development at different sites, which will also determine the diverse content of nutrients and bioactive compounds.

This article primarily aims to review current knowledge and showcase the species diversity of the *Rubus* genus in the context of nutritional values, health benefits, and potential medical applications of the fruits, leaves, shoots and roots of these plants. This diversity is due to the large number of species within the genus, which are highly diverse in morphological, biological, and ecological characteristics, mainly resulting from their vast range and frequent interspecies hybridization. This diversity translates into numerous possibilities for utilizing these species not only for consumption but also for improving human health worldwide, with a very wide spectrum of potential effects.

2. Methodology

To prepare this review on the nutritional and health-promoting values of species from the genus *Rubus*, several databases were searched for relevant publications. The search was conducted using PubMed, Scopus, Web of Science, Google Scholar, and SpringerLink. To cover the topic as comprehensively as possible and minimize the chance of missing information on lesser-known species discussed in older publications, the search included publications from the year 2000 onwards. The search encompassed articles, review papers, and books. The keywords used for the search included the following phrases: phenols, polyphenols, *Rubus*, blackberry, raspberry, red raspberry, black raspberry, yellow raspberry, Korean raspberry. The use of five databases combined with ten keywords allowed for a comprehensive study of this topic, focusing primarily on the nutritional and health-promoting properties of the fruit of these plants, but also considering roots, shoots, and leaves. The review discusses the most widespread and cultivated species of this genus worldwide, while also considering lesser-known species that often occur only locally.

3. Nutritional Values

Species of the genus *Rubus* are characterized by high nutritional values, particularly for dietary fiber and vitamin C content, while being low in calories [24]. The fruits of *Rubus* species vary in their content of specific components, including fructose, glucose, minerals, protein, carotenoids, and ascorbic acid. Differences are especially noticeable in the group of phenolic compounds, particularly phenolic acids, anthocyanins, and other flavonoids. Generally, the most nutrient-dense and phenolic-rich species are *Rubus ulmifolius*, *R. idaeus*, and *R. fruticosus* [25]. Black raspberry fruits are notable for their high content of phosphorus, potassium, iron, organic acids, and vitamin C [26,27]. Red raspberry fruits are considered a rich source of pectin, fiber, calcium, potassium, iron, as well as vitamins C, E, B1, and B2 [28]. Similar to other berry species, raspberry fruits have a low glycemic index [29].

The glycemic index (GI) of carbohydrate-containing foods is used to determine the rate at which these carbohydrates are broken down during digestion and the speed of their absorption into the blood [30]. Carbohydrate-rich foods that break down quickly and are rapidly absorbed into the blood have a high GI. Foods with a high GI lead to rapid spikes in blood glucose and insulin levels after consumption. In contrast, low-GI foods, which are digested more slowly, have a smaller impact on postprandial blood glucose levels and the insulin response [31].

Table 1 presents the nutritional composition of raspberries and blackberries, gathered from the database FoodData of the Central United States Department of Agriculture. Both raspberries and blackberries are rich sources of energy, calcium, iron, magnesium, and vitamins, such as vitamin C, vitamin K, and B-group vitamins. Comparing the two species, raspberries have a slightly higher calorie and carbohydrate content than blackberries, which are richer in protein. Blackberries have higher levels of vitamin E, and raspberries have higher levels of fatty acids, lutein and zeaxanthin. Both fruits are also good sources of dietary fiber, which may have a beneficial impact on gastrointestinal health. It is also worth noting that blackberries and raspberries, according to the presented data, contain high levels of vitamins C, A, E and B, making them a valuable source of food that has a positive effect on the immune system.

Table 1. Raspberry and blackberry fruit nutrients [32,33].

Common Name	Energy (kcal)	Protein (g)	Total Lipid (g)	Carbohy-Drate (g)	Fiber (g)	Sugars (g)	Ca (mg)	Fe (mg)	Mg (mg)
Blackberries	43	1.39	0.49	9.61	5.3	4.88	29	0.62	20
Raspberries	52	1.2	0.65	11.9	6.5	4.42	25	0.69	22
Common name	**P (mg)**	**K (mg)**	**Na (mg)**	**Zn (mg)**	**Cu (mg)**	**Se (µg)**	**Lutein + zeaxanthin (µg)**	**Thiamin (mg)**	**Fatty acids (g)**
Blackberries	22	162	1	0.53	0.165	0.4	118	0.02	0.014
Raspberries	29	151	1	0.42	0.09	0.2	136	0.032	0.019
Common name	**Riboflavin (mg)**	**Niacin (mg)**	**Vit B-6 (mg)**	**Folate (µg)**	**Choline (mg)**	**Vit A (µg)**	**Vit E (mg)**	**Vit K (µg)**	**Vit C (mg)**
Blackberries	0.026	0.646	0.03	25	8.5	11	1.17	19.8	21
Raspberries	0.038	0.598	0.055	21	12.3	2	0.87	7.8	26.2

4. Health-Promoting Properties and Use in Medicine

Species of the genus *Rubus* have provided food and sources of medicinal raw materials for indigenous communities since the post-glacial period [16]. Raspberry fruits are widely regarded as an excellent source of bioactive compounds, including phenolic compounds, which are natural anti-oxidants with positive health effects [34]. Various species belonging to the genus *Rubus* possess significant application potential due to their high content of polyphenols, ellagitannins, and anthocyanins. These substances are valuable sources of natural plant-based anti-oxidants. Polyphenols are one of the most abundant chemical compounds in the *Rubus* genus, characterized by significant health-promoting properties [24].

Polyphenols are chemical compounds found in plants, characterized by the presence of one or more aromatic rings and at least one hydroxyl group [35]. Polyphenols can be broadly divided into two main types, flavonoids and non-flavonoids, primarily include phenolic acids, or are classified into many subcategories based on the number of phenolic units in their molecular structure, types of substituent groups, and types of bonds between these units. These compounds are commonly found in plant tissues, where they typically exist as glycosides or aglycones. The structural diversity of flavonoids results from differences in hydroxylation and oxidation levels, leading to various compound types, such as flavanols, anthocyanidins, anthocyanins, isoflavones, flavones, flavonols, flavanones, and flavanonols [36]. Flavonoids are among the most common dietary anti-oxidants and are widely present in plants and plant products, including fruits. In recent decades, there has been increasing scientific interest in their various health benefits, as polyphenols exhibit diverse bioactivities. In vitro and in vivo studies conducted over the past few decades have demonstrated that a diet rich in polyphenols or polyphenol-containing products contributes to improved human health and is associated with a reduced risk of chronic diseases. Furthermore, the development of new technologies, such as multi-omics, bioinformatics, and artificial intelligence, opens new possibilities for elucidating the molecular

mechanisms by which polyphenols can support the treatment of chronic diseases [37]. Additionally, polyphenols are used in medicine to treat various ailments due to their numerous health properties. These compounds can mitigate oxidative effects in the human body, prevent damage to organs and cellular structures, and protect their functionality. Their health-promoting abilities stem from intense bioactivity, translating into strong anti-oxidant, anti-hypertensive, immunomodulatory, anti-bacterial, anti-viral, and anti-cancer properties [38].

Due to the medicinal properties of the fruits and leaves of *Rubus idaeus*, interest in this species is growing among dietitians, pharmacognosists, and phytochemists. Raspberry seed oil is also gaining popularity among consumers as a valuable source of essential unsaturated fatty acids, vitamins, and anti-oxidants [28]. Eleven anthocyanins have been identified in red raspberry fruits, including cyanidin-3-sophoroside, cyanidin-3-(2G-glucosylrutinoside), cyanidin-3-glucoside, cyanidin-3-rutinoside,pelargonidin-3-sophoroside, pelargonidin-3-(2G-glucosylrutinoside), and pelargonidin-3-glucoside. These fruits also contain ellagic acid, ellagitannin, lambertianin C, and sanguiin H-6 [39]. Among the phenolic compounds in *Rubus idaeus* fruits, anthocyanins, particularly cyanidin-3-sophoroside and cyanidin-3-glucoside, are noteworthy [21]. These compounds have chemo-preventive potential and anti-oxidant properties [40]. Additionally, they can be used to extract natural dyes efficiently and cost-effectively via ultrasound, offering an alternative to synthetic counterparts [41]. Red raspberries owe their anti-oxidant properties primarily to high levels of anthocyanins, vitamin C, and ellagic acid derivatives [42]. Yellow and red raspberry varieties contain carotenoids, mainly lutein esters, which in red raspberries are masked by anthocyanins [43]. *Rubus idaeus* leaf infusions are used to facilitate childbirth, cleanse the blood, and treat intestinal issues [44]. Extracts from *Rubus rugosus* leaves have astringent and emmenagogic effects, while those from *Rubus idaeus* show astringent, spasmolytic, and carminative properties. Extracts from the leaves and fruits of wild raspberry *Rubus idaeus* contain numerous secondary metabolites with anti-cancer, anti-oxidant, and anti-microbial activities [45]. Studies on *R. idaeus* shoots revealed that they are rich in compounds, such as ellagic acid and sanguiin H-6. The extracts from these shoots exhibit strong anti-oxidant, anti-microbial (especially against *Corynebacterium diphtheriae*), and cytotoxic properties, particularly effective against HL-60 cancer cells. The use of comprehensive LCxLC methods has allowed for effective separation and identification of present polyphenolic compounds, revealing their diversity and biological significance [46]. The shoots of this species are also used to treat fever, colds, and flu-like infections [16]. Studies on the properties of wild raspberry (*R. idaeus*) fruits from the Kelkit Valley in Turkey revealed their high content of active phenolic compounds and flavonoids, along with strong anti-bacterial properties, particularly against *Pseudomonas aeruginosa* bacteria, suggesting their potential application in cultivation and as raw material for pharmaceutical research [47]. Freeze-dried *R. idaeus* fruits are also an exceptional source of nutrients, including vitamin C, potassium, and magnesium, as well as bioactive compounds, such as proanthocyanidins, ellagitannins, and anthocyanins, making them comparable to fresh raspberries in terms of nutritional value. The main bioactive compounds among the ellagitannins are isomers of sanguiin H-6, lambertianin C, and sanguiin H-10, while the dominant anthocyanins include cyanidin-3-sophoroside, cyanidin-3-glucoside, and cyanidin-3-sambubioside [48]. Studies also indicate that daily consumption of raspberries significantly reduces serum glucose levels and post-prandial inflammatory biomarkers, such as interleukin-6 and tumor necrosis factor-alpha. These results suggest that raspberries may be beneficial in alleviating hyperglycemia and inflammation in individuals with diabetes, warranting further investigation [49]. Research confirms the potential use of *Rubus hirsutus* berries, characterized by high anti-oxidant activity, as functional food ingredients and sources of phytochemicals for nutraceutical production [50]. Extracts from the fruits and leaves of *Rubus chingii* are notable for regulating the central nervous system, and their hypoglycemic, anti-cancer, anti-thrombotic, anti-osteoporotic, anti-oxidant, anti-fungal, and anti-inflammatory properties [51].

Drawing upon the data presented in the accompanying Table 2, this discussion elaborates on the multifaceted therapeutic potentials of *Rubus idaeus* (red raspberry) fruit extracts and derivatives. The extracts from *Rubus idaeus* have demonstrated a wide range of health benefits, spanning from cardiovascular and liver health to anti-inflammatory and antimicrobial effects. Drinking raspberry juice has been linked to the prevention of early atherosclerosis, primarily through improvements in anti-oxidant status and serum lipid profiles. This suggests that regular consumption could offer a natural strategy for managing and preventing this cardiovascular condition. In the realm of liver health, a natural phenolic compound extracted from *Rubus idaeus*, optimized through ethanol extraction and ultrasound, has shown efficacy in reducing inflammation and fatty liver disease caused by non-alcoholic fatty liver disease (NAFLD). This indicates its potential as a therapeutic agent in managing liver health. Moreover, red raspberry extracts have displayed significant synergistic anti-microbial activity, particularly when combined with conventional antibiotics, such as penicillin, cefoxitin, tetracycline, ciprofloxacin, and fusidic acid. This synergy enhances the effectiveness of these antibiotics, suggesting a role for raspberry flavonoids in anti-microbial treatments. The extracts are also notably effective against bacteria like *Pseudomonas aeruginosa*, *Bacillus cereus*, *Staphylococcus aureus*, and *S. saprophyticus*, underscoring their potential as natural anti-bacterial agents. Moreover, studies have shown that consumption of raspberries offers protective benefits against oxidative stress induced by diabetes, thanks to their polyphenol content and fiber, enhancing anti-oxidant defenses in a diabetic obesity model. In terms of inflammatory conditions, *Rubus idaeus* fruit extracts enriched with polyphenols have been shown to exhibit anti-arthritis effects and provide additional cartilage protection. These extracts inhibit key inflammatory pathways, such as NF-κB and MAPK, reducing joint inflammation, inhibiting osteophyte formation, and limiting joint destruction. They also decrease bone resorption and soft tissue swelling associated with joint diseases. Furthermore, raspberry ketone has been highlighted for its role in increasing norepinephrine-induced lipolysis in white adipocytes, which may help prevent obesity and fatty liver disease. This underlines the potential of raspberry components in weight management and metabolic health. Additionally, consumption of raspberries has been suggested to enhance detoxifying cellular defenses, offering protection against oxidative stress caused by conditions like diabetes. Lastly, extracts from *Rubus idaeus* leaves have also been utilized to relieve pain associated with osteoarthritis of the knee, presenting a safe and effective method for alleviating symptoms of this debilitating condition.

Based on the comprehensive data presented in the accompanying Table 3, red raspberries, where the species is not specified, have demonstrated potential health benefits in weight management and cardiovascular health. Research has shown that a concentrate obtained from red raspberry can limit weight gain induced by a high-fat and high-calorie diet. This highlights its potential utility in dietary interventions aimed at obesity prevention. Furthermore, red raspberry extracts have been noted for their anti-hypertensive effects, which are mediated by increasing the activation of nitric oxide and improving vascular endothelial function through their anti-oxidant actions. Additionally, raspberry ketone, a compound found in these berries, has shown the ability to reduce obesity caused by a high-fat diet by altering metabolism in adipocytes, indicating its promise for metabolic health enhancements. Moreover, red raspberry fruit extracts have also demonstrated protective properties against DNA damage, specifically limiting DNA cleavage induced by peroxinitrite and protecting against the formation of hydroxyl radicals. This protective effect against oxidative stress suggests potential for therapeutic use in preventing cellular damage. Specifically focusing on *Rubus chingii*, research has uncovered its notable anti-osteoporotic effects. Compounds such as kaempferol, quercetin, rubusin A, and B found in *Rubus chingii* fruits not only increase the activity of alkaline phosphatase but also inhibit the resorption of osteoclastic cells and stimulate osteoblastic activity, thereby potentially aiding in the treatment and prevention of osteoporosis. Furthermore, *Rubus chingii* fruit extract has shown promising anti-oxidant capabilities, specifically in scavenging DPPH and hydroxyl radicals and exhibiting a strong ability to reduce iron ions. This anti-oxidant capacity is

paired with significant anti-cancer potential, particularly in preventing and treating bladder cancer by inhibiting cell proliferation and inducing apoptosis in cancer cells.

Table 2. Health benefits and applications of red raspberry (*Rubus idaeus*).

Common Name (Species)	Possibility of Use	Reference
Red raspberry (*R. ideaus*)	Extracts obtained from the fruits of *Rubus idaeus* have a strong anti-bacterial effect against *Pseudomonas aeruginosa*, *Bacillus cereu*, *Staphylococcus aureus* and *S. saprophyticus*	[52]
Red raspberry (*R. ideaus*)	Research results suggest that *Rubus idaeus* fruit extract enriched with polyphenols has an anti-arthritis effect and also provides additional cartilage protection.	[53]
Red raspberry (*R. ideaus*)	Red raspberry fruit extract has anti-inflammatory effects on joints, additionally inhibiting the formation of osteophytes and further joint destruction, and also reduces the degree of bone resorption and soft tissue swelling.	[54]
Red raspberry (*R. ideaus*)	Red raspberry extract with a high content of anthocyanin-rich fractions showed anti-inflammatory effects both in vitro and in vivo, primarily due to the inhibition of NF-κB and MAPK activation.	[55]
Red raspberry (*R. ideaus*)	Raspberry ketone (4-(4-hydroxyphenyl) butan-2-one), by increasing norepinephrine-induced lipolysis in white adipocytes, may prevent obesity and fatty liver disease	[56]
Red raspberry (*R. ideaus*)	The research showed the occurrence of synergism between fel compounds derived from red raspberry fruit concentrate and penicillin, cefoxitin, tetracycline, ciprofloxacin and fusidic acid. In turn, raspberry flavonoids themselves have shown potential for anti-microbial activity and may enhance the effect of conventional antibiotics.	[57]
Red raspberry (*R. ideaus*)	Based on the results, the authors of the study suggest the possibility of obtaining enhanced detoxifying cellular defense as a result of consuming raspberries, which leads to protection against oxidative stress caused by diabetes	[58]
Red raspberry (*R. ideaus*)	A study examining the impact of raspberry consumption on oxidative stress in obese mice with type 2 diabetes demonstrated that raspberries enhance anti-oxidant defense by reducing interleukin-6 levels and increasing glutathione peroxidase activity in the liver and blood. Although other disease risk biomarkers remained at similar levels, increases in total cholesterol and LDL cholesterol were observed. This first in vivo study using a rodent model suggests that regular consumption of raspberries may protect against oxidative stress induced by diabetes, attributed to the polyphenol and fiber content in the fruit.	[58]
Red raspberry (*R. ideaus*)	*Rubus idaeus* leaves can be used to produce an extract intended to relieve pain caused by osteoarthritis of the knee. Researchers also emphasize that it is a safe and, above all, effective method of alleviating the symptoms associated with this disease.	[59]
Red raspberry (*R. ideaus*)	Extracted and purified using ethanol extraction additionally supported by ultrasound, a natural phenolic compound (ketone) from *Rubus ideaus* fruit can reduce fatty liver disease and inflammation caused by non-alcoholic fatty liver disease	[60]

Table 3. Health benefits and applications of red raspberry (various *Rubus* species).

Common Name (Species)	Possibility of Use	Reference
Red raspberry (no data)	Raspberry ketone, due to its biological activity, can reduce obesity caused by a high-fat diet by changing the metabolism in 3T3-L1 adipocytes	[61,62]
Red raspberry (no data)	Red raspberry extracts, by increasing the activation of nitric oxide and improving vascular endothelial dysfunction through anti-oxidant action, have an anti-hypertensive effect	[63]
Red raspberry (no data)	It has been shown that red raspberry fruit extract limits DNA cleavage induced by peroxynitrite, while protecting against DNA damage and the formation of hydroxyl radicals	[64]
Red raspberry (*R. chingii*)	Research results suggest that kaempferol, quecentin, rubusin A and B found in *Rubus chingii* fruits have anti-osteoporotic effects, increase the activity of alkaline phosphatase, inhibit the resorption of osteoclastic cells and bones, and stimulate osteoblastic activity.	[65]

Table 3. *Cont.*

Common Name (Species)	Possibility of Use	Reference
Red raspberry (no data)	Limiting weight gain caused by a high-fat and high-calorie diet by consuming a concentrate obtained from red raspberry	[29]
Red raspberry (*R. chingii*)	*Rubus chingii* fruit extract has the ability to scavenge DPPH and OH- radicals and is also characterized by a strong ability to reduce iron ions. By inhibiting cell proliferation and cell apoptosis, this extract may help prevent and treat bladder cancer.	[66]

Blackberries are characterized by high biological potential, primarily due to their high flavonoid and polyphenol content [67]. They are a valuable source of bioactive compounds that can be utilized in both the prevention and treatment of various diseases, especially those related to oxidative stress [68]. These fruits contain significant amounts of anthocyanins, such as cyanidin-3-O-glucoside and cyanidin-3-O-arabinoside [69], as well as cyanidin-3-O-malonyl-glucoside, cyanidin-3-O-dioxalylglucoside, and cyanidin derivatives [70]. In the case of *Rubus laciniatus*, studies have also shown the presence of cyanidin-3-O-glucoside and cyanidin-3-O-rutinoside in the fruits [71]. For each species, *R. glaucus*, *R. alpinus*, and *R. alutaceus*, research has identified nine phenolic compounds: two catechins, pinocembrin, quercetin, and different concentrations of cyanidin 3-rutinoside, quercetin 3-glucoside, pelargonidin 3-glucoside, cyanidin, and kaempferol-3-glucoside. In the case of *R. alutaceus*, a phenolic marker was described for the first time, including kaempferol-3-glucoside as a potential chemotaxonomic marker for this species [72]. Polyphenol extracts from blackberries, containing proanthocyanidins, exhibit anti-inflammatory properties, suggesting that anthocyanins from these species could aid in wound healing [73]. Blackberries can be classified as functional foods due to their anti-diabetic and anti-oxidant properties [74]. Consuming their juice may reduce the risk of kidney disease, and some studies suggest it may also protect against urinary tract infections [75]. Due to the high phenol content and anti-oxidant, cytotoxic, and anti-bacterial activity against Gram-positive bacteria of the roots of *Rubus hyrcanus*, commonly known as Caspian blackberry, researchers highlight the potential of this raw material for producing plant products with bioactive properties [76]. Extracts from *Rubus fruticosus* plants have anthelmintic, relaxant, anti-diarrheal, and anti-inflammatory effects, and compresses made from the leaves are used on abscesses and skin ulcers [77–79]. Studies indicate that *Rubus fruticosus* fruit extract contains 42 compounds, with oleic acid being the most abundant. Among the 29 polyphenols in the extract, quercetin-3-O-glucoside is the most prevalent. Researchers highlight the enormous potential of this species' fruits as a source of natural anti-oxidants for nutraceutical production and as a component of functional foods [80]. Spreads made from blackberry pulp containing cream or cream cheese show increased anti-oxidant activity with higher blackberry pulp content, with equivalent anti-oxidant capacity increasing from 43.51% to 44.50%. These results suggest that spreads with higher blackberry pulp content can be considered functional and healthy foods due to their beneficial anti-oxidant and rheological properties [81]. Research on the anti-oxidant properties and bioactive components of blackberries from *R. fruticosus* and *R. laciniatus* species demonstrated that these fruits are rich in anthocyanins, primarily cyanidin-3-glucoside, and other phenolics. In particular, the "Loch Ness" and "Thorn Free" varieties, cultivated in northwestern Romania, stood out for their highest polyphenol content and greatest anti-oxidant capacity. The differences in anti-oxidant capacities among the seven studied varieties were significant, as confirmed by multivariate analysis. These findings underscore the potential of blackberries for use as functional foods or in the production of commercial products rich in bioactive compounds [82]. A study focused on analyzing the impact of different extraction solvents on the polyphenol, flavonoid, and tannin content in dried *Rubus armeniacus* leaves and their anti-oxidant activity. It was found that the 80% methanol extract showed the highest concentrations of TPC, TFC, and CTC and the most effective anti-oxidant activity according

to DPPH, reducing power, and β-carotene bleaching assays. These results suggest the potential application of *R. armeniacus* extracts in the food and pharmaceutical industries as natural anti-oxidants [83].

The extensive data from the Table 4 showcase the diverse health benefits and therapeutic applications associated with various species of blackberries, including studies on multiple species, such as *Rubus fruticosus*, *Rubus liebmannii*, *Rubus palmeri*, *Rubus discolor*, *Rubus apetalus*, *Rubus imperialis*, and the hybrid *Rubus loganobaccus* × *baileyanus* (Boysenberry). Insights also include findings on unspecified blackberries and a combination study involving blackberries, Korean raspberries, and black raspberries. Ethanol extracts and anthocyanin fractions from these *Rubus* fruits have demonstrated protective effects against H_2O_2-induced cytotoxicity by reducing intracellular reactive oxygen species levels and enhancing anti-oxidant enzyme activity, while also suppressing the activation of inflammatory pathways, highlighting their potential as natural anti-inflammatory and anti-oxidant agents. Numerous studies have shown that blackberry extracts can increase glucose metabolism, prevent oxidative stress from exogenous pollutants, improve memory through anti-oxidant and anti-cholinesterase properties, regulate vascular functions, and inhibit telomerase in colorectal cancer cells, suggesting their utility in managing diabetes, protecting against neurodegenerative diseases, reducing thrombosis, and offering anti-cancer benefits. Additionally, recent studies on *Rubus erlanrige* leaf extract have confirmed its anti-diabetic properties, significantly reducing blood glucose levels in diabetic models without inducing hypoglycemia in normal subjects, suggesting a safe and effective profile for managing diabetes. Specifically, *Rubus fruticosus* extracts reduce cell damage by activating anti-oxidant enzymes and removing reactive oxygen species in HepG2 cells. Anthocyanin-enriched fractions from *Rubus liebmannii* and *Rubus palmeri* induce apoptotic responses in glioma cells, suggesting potential as a therapeutic raw material. *Rubus discolor* extracts have been used in the green synthesis of silver nanoparticles, showing anti-bacterial activity against multidrug-resistant bacteria and cytotoxic effects on cancer cell lines. *Rubus apetalus* extracts improve fertility parameters and reduce oxidative stress in rats with cryptorchidism, indicating potential for treating male infertility. *Rubus imperialis* extracts exhibit protective effects against stomach ulcers due to their anti-secretory properties. Boysenberry fruit extracts have shown in vivo anti-oxidant properties, enhancing serum anti-oxidant status and reducing oxidative damage markers, although these effects were influenced by diet. The broad scope of research across these diverse blackberry species highlights their significant potential in pharmaceutical and nutraceutical applications, addressing a wide array of health issues from oxidative stress and inflammation to cancer and fertility, supporting further exploration and development of these berries in health-related fields.

Table 4. Health benefits and applications of various *Rubus* species.

Common Name (Species)	Possibility of Use	Reference
Boysenberry (*R. loganobaccus* × *baileyanus*)	The research findings indicated that the extract from Boysenberry fruits (*Rubus loganobaccus* × *baileyanus* Britt) acted in vivo as an anti-oxidant, elevating serum anti-oxidant status. Concurrently, a reduction in certain oxidative damage markers was observed; however, this effect was significantly modified by the basal diet.	[84]
Blackberry (*R. imperilis*)	The extract from the aerial parts of *Rubus imperialis* and the isolated niga-ichigoside F1 and 2β,3β-19-α-trihydroxyursolic acid have protective properties on the stomach against damage caused by ulcers. Researchers suggest that this ability is related to its anti-secretory effect	[85]

Table 4. *Cont.*

Common Name (Species)	Possibility of Use	Reference
Blackberry, Korean raspberry, Black raspberry (no data)	The studies demonstrated that ethanol extracts (E) and anthocyanin fractions (AF) from *Rubus* fruits, including blackberries, Korean raspberries, and black raspberries, protect RAW 264.7 cells from H_2O_2-induced cytotoxicity by significantly reducing intracellular ROS levels and enhancing the activity of anti-oxidant enzymes, such as SOD and GPx. Additionally, AF markedly reduced DNA oxidation and inhibited the production of inflammatory mediators, such as NO and PGE2, decreasing the expression of pro-inflammatory proteins iNOS and COX-2 in LPS-stimulated cells. Furthermore, anthocyanin fractions effectively suppressed the activation of the NF-κB pathway, indicating their potential as natural anti-inflammatory and anti-oxidant agents.	[86]
Blackberry (*R. fruticosus*)	Blackberry fruit extract reduces H_2O_2-induced cell damage by activating the anti-oxidant enzyme SOD in HepG2 cells and removing reactive oxygen species	[87]
Blackberry (no data)	Blackberry fruit extract, by regulating the active substance of the vascular endothelium, as well as its anti-thrombotic effect and activation of blood flow, can reduce the formation of thrombi	[88]
Blackberry (no data)	It has been shown that blackberry extract can be used to prevent oxidative stress caused by exogenous pollutants. Study results also suggest improved effectiveness in mitigating oxidative damage when blackberries undergo gastrointestinal digestion.	[89]
Blackberry (no data)	Blackberry fruit extract, by reducing the expression of hTERT and methylating its promoter in colorectal cancer cell lines, has a telomerase inhibitory effect, thus having anti-cancer effects in CRC cells	[90]
Blackberry (no data)	Research results suggest that consuming blackberries through their neuroprotective, anti-oxidant and anti-inflammatory properties may reduce or help prevent the occurrence of manic episodes	[91]
Blackberry (*R. liebmannii* and *R. palmeri*)	Fractions enriched in anthocyanins derived from the fruits of wild blackberry species from Mexico have the ability to induce an apoptotic response in the cells of the most lethal primary brain tumor, glioma. The authors of the study suggest the possibility of using anthocyanins present in these fruits as a valuable raw material for the development of alternative therapies to increase the survival of patients suffering from this disease.	[92]
Blackberry (*R. apetalus*)	The research conducted on rats demonstrated that cryptorchidism (CPT) significantly affects male fertility parameters, such as testicular mass, sperm density, and levels of sex hormones, while also inducing oxidative stress. However, extracts from *Rubus apetalus* counteract these effects by improving sperm parameters, reducing oxidative stress, and increasing pregnancy and fertility rates in rats with CPT, suggesting the potential application of this plant as an alternative treatment for male infertility associated with cryptorchidism.	[93]
Blackberry (*R. erlanrige)*	Studies on the extract from *Rubus erlanrige* leaves have demonstrated its anti-diabetic potential in both in vitro and in vivo experiments. In vitro, the extract exhibited α-amylase inhibitory activity and anti-oxidant properties while, in vivo, it significantly reduced blood glucose levels in mice with streptozotocin-induced diabetes, without causing hypoglycemia in healthy mice. These results indicate that the extract, likely through the synergy of its secondary metabolites, offers a promising anti-diabetic effect with minimal risk of hypoglycemia.	[94]
Blackberry (no data)	Blackberry fruit extract has anti-oxidant properties and prevents the decrease in the activity of ketalase in brain structures and superoxide dismutase in the striatum. These results suggest the possibility of using this extract as an agent to prevent damage caused by inflammation of the nervous system	[95]
Blackberry (no data)	Research results suggest that consuming blackberry juice increases glucose metabolism by increasing insulin levels and improving the activity of enzymes responsible for glucose metabolism, which may translate into improved health of people with diabetes.	[96]
Blackberry (no data)	Research shows that blackberry fruit extract, thanks to its anti-oxidant and anti-cholinesterase properties, has a memory-improving effect and can be used as an agent in the treatment of neurodegenerative diseases	[97]

Table 4. *Cont.*

Common Name (Species)	Possibility of Use	Reference
Blackberry (*R. discolor*)	The study focused on the green synthesis of silver nanoparticles (AgNPs) using an extract from the leaves of *Rubus discolor*, resulting in the formation of stable nanoparticles with an approximate diameter of 37 nm. The AgNPs demonstrated effective anti-bacterial activity against multidrug-resistant strains of Escherichia coli and *Pseudomonas aeruginosa*, as well as significant cytotoxic effects on selected cancer cell lines, including cytotoxic activity on A431, MCF-7, and HepG2 cells.	[98]

In the case of *Rubus occidentalis* fruits, five anthocyanins are notable: pelargonidin-3-rutinoside, cyanidin-3-sambubioside, cyanidin-3-glucoside, with cyanidin-3-rutinoside and cyanidin-3-xylosylrutinoside being the most abundant and potent phenolic anti-oxidants. Due to the biological activity of these two anthocyanins, there is potential for their use in cancer treatment [99]. Fermented juice from *Rubus occidentalis* fruits using the lactic acid method with the Lactobacillus plantarum GBL17 strain shows potential as a functional beverage [100]. Among extracts from blackberry, strawberry, blueberry, cranberry, and black raspberry fruits, those from black raspberries and strawberries exhibited the strongest inhibitory properties against cancer cell lines of the colon, prostate, and oral cavity [9]. The extract obtained from flour made from black raspberry seeds has anti-proliferative effects, confirmed by the inhibition of HT 29 colon cancer cell proliferation. Researchers also suggest the possibility of using this flour as a natural source of anti-oxidants and anti-proliferative compounds, as an element of diets that ensure optimal human health [101]. Phytochemicals derived from the consumption of raspberry fruits, upon reaching the colon, can inhibit colon carcinogenesis in vitro [102].

The data from Table 5 present an extensive evaluation of the potential uses of black raspberry (*Rubus occidentalis*) extracts across a range of medical and health-related applications. Black raspberry extracts have been studied for their effects on various diseases and conditions. Not only promising for chemoprevention, they also show potential in the management of colorectal cancer, chronic muscle pain, benign prostatic hyperplasia, possibly even esophageal cancer, and in supporting diabetes management, as suggested by the beneficial effects of *R. occidentalis* extract on glucose control in pre-diabetic patients. This broad therapeutic potential makes black raspberry extracts a significant subject of interest for further pharmacological studies. The table highlights multiple mechanisms through which black raspberry extracts exert their effects, including modulation of gene expression, immunomodulation, apoptosis induction, tumor angiogenesis inhibition, DNA demethylation, and effects on the microbiome. These diverse mechanisms suggest that black raspberry extracts could interact with biological systems at multiple levels, which could be harnessed to develop multifaceted treatment strategies. The table also references several innovative delivery methods for black raspberry extracts, such as PLA ilicylindrical implants and gel preparations for local delivery, underlining the importance of pharmaceutical formulation in enhancing the efficacy and application of phytochemicals in clinical settings. Beyond their therapeutic effects, black raspberry extracts show promise in preventive health, with potential benefits in lowering cholesterol, preventing atherosclerosis, and even reducing DNA methylation in cancer suppressor genes. This preventive aspect could be pivotal in public health strategies, especially in dietary recommendations or supplemental formulations. The data suggest numerous avenues for future research, including further exploring the immunological effects, optimizing extract formulations for better bioavailability and efficacy, and conducting long-term clinical trials to validate the preventive and therapeutic benefits of black raspberry extracts.

Table 5. Health benefits and applications of black raspberry (*Rubus occidentalis*).

Common Name (Species)	Possibility of Use	Reference
Black raspberry (*R. occidentalis*)	Black raspberry extract has an inhibitory effect on the growth of pre-cancerous and malignant cells of the oral cavity. Researchers suggest that this action is related to specific compounds that target aberrant signaling pathways that regulate cell cycle progression	[103]
Black raspberry (*R. occidentalis*)	The chempreventive properties of black raspberry fruits and the obtained research results indicate the possibility of using them as an alternative to chemopreventive drugs in the treatment of esophageal cancer in humans.	[104]
Black raspberry (*R. occidentalis*)	Possibility of developing gel preparations containing dried black raspberries with chemopreventive effects for local delivery to the tissues of the oral mucosa with good absorption	[105]
Black raspberry (*R. occidentalis*)	Research indicates that the optimal dosage form for prolonged and continuous delivery of FBR chemopreventive anthocyanins to the body for a period of one month is the method of injecting PLA ilicylindrical implants containing RE:TA-β-CD IC	[106]
Black raspberry (*R. occidentalis*)	Taking black raspberry powder resulted in a reduction in profiling, as well as an increase in apoptosis of colorectal cancer cells and inhibition of tumor angiogenesis. Treatment with this method also reduced the expression of β-catenin and increased the expression of E-cadherin in colorectal cancer cells. DNA methylation studies indicate that ingredients derived from black raspberry fruits are able to demethylate tumor suppressor genes related to the Wnt pathway, partially inhibiting the expression of DNMT1 and DNA methyltransferase, which is overexpressed in colorectal cancer cells.	[107]
Black raspberry (*R.occidentalis*)	Black raspberry extracts and their metabolites contain phytochemicals that influence immune processes related to carcinogenesis and immunotherapy. Additionally, specific ingredients and their metabolites derived from black raspberries may in the future be used as a key source of raw material for the development of drugs with immunological effects and inhibition of specific STAT-regulated signaling pathways	[108]
Black raspberry (*R. occidentalis*)	Research results suggest that the extract of unripe *Rubus occidentalis* fruit may serve as an agent in the treatment of benign prostatic hyperplasia by inhibiting it.	[109]
Black raspberry (*R. occidentalis*)	Research suggests the possibility of using *Rubus occidentalis* fruit extract to reduce induced chronic muscle pain thanks to its anti-nociceptin effect	[110]
Black raspberry (*R. occidentalis*)	In a 12-week, randomized, double-blind, placebo-controlled trial, the impact of *Rubus occidentalis* (RO) extract on metabolic parameters in pre-diabetic patients was examined. It was found that high doses of the extract (1800 mg per day) significantly improved glucose control and inflammatory markers compared to the placebo group. These results suggest that RO extract may be beneficial in modulating glucose and lipid levels, which is promising for individuals at risk of developing type 2 diabetes.	[111]
Black raspberry (*R. occidentalis*)	Consuming raspberry juice may prevent the formation of fatty streaks in the aorta	[112]
Black raspberry (*R. occidentalis*)	Black raspberry fruit extract may influence cholesterol efflux and clearance by increasing hippuric acid levels in the cecum and modifying the intestinal microbiome, which then results in effects on microbial metabolites and cholesterol metabolizm	[113]
Black raspberry (*R. occidentalis*)	The results indicate the potential use of black raspberry extract in changing intestinal bacteria, lowering cholesterol levels by regulating gene expression and modulating bile acids.	[114]

For the species *Rubus fraxinifolius*, the leaf extract exhibited the highest anti-oxidant activity among extracts from the fruits, leaves, and shoots. The researchers identified it as a potential natural anti-oxidant for health improvement [115]. In China, *Rubus alceaefolius* is used as an herb in the treatment of osteoma, nasopharyngeal cancer, liver cancer, and lung cancer [116]. The aerial parts of *Rubus ulmifolius* contain flavonoids. The crude methanol extract and the flavonoid-rich fraction from this species exhibit anti-oxidant and anti-pyretic effects. This suggests the potential future use of this plant as a source of raw material for the production of anti-pyretic and anti-oxidant drugs, provided that pharmacologically active

substances are isolated from this species [117]. Moreover, the fruits of *R. ulmifolius* are rich in nutrients and bioactive compounds, primarily cyanidin-3-O-glucoside and pentoside, and glucuronide of ellagic acid. They exhibit anti-microbial activity, making them a potentially valuable addition to the daily diet for its diversification and enrichment. Research findings suggest that these wild fruits can contribute to human health due to their high content of various health-promoting compounds, including phenols and anthocyanins [118]. The fruits of *Rubus coreanus* are widely used in East Asia, especially in Korea, China, and Japan, as a medicinal ingredient in traditional medicine for treating conditions such as cancer, diarrhea, and asthma (Seo et al. 2019). The leaves of *Rubus corchorifolius* are used as raw material for producing leaf tea, which provides hypoglycemic material [119].

Drawing on data presented in the accompanying Table 6, this discussion elaborates on the multifaceted therapeutic potentials of *Rubus coreanus* fruit extracts. The fruit extracts of *Rubus coreanus* are noted for their capacity to inhibit the growth of specific cancers, including hepatocellular and gastric cancers. These findings suggest a potential for these extracts in both therapeutic and preventive oncology settings, leveraging their natural compounds to target and inhibit cancer cell proliferation. Extracts from *Rubus coreanus* have shown strong anti-inflammatory effects, particularly effective in treating colon damage induced by DSS (Dextran Sulfate Sodium) and reducing inflammation triggered by LPS (Lipopolysaccharides). The isolated triterpenoid-rich fractions from the plant have demonstrated significant efficacy in alleviating symptoms and possibly providing therapeutic benefits in the treatment of inflammatory bowel diseases, such as colitis. Clinical studies have highlighted the effectiveness of freeze-dried *Rubus coreanus* fruit extract in capsule form for significantly reducing high blood cholesterol levels and managing lipid disorders. This suggests its potential as a natural alternative or complement to traditional lipid-lowering medications, offering a plant-based approach to managing cardiovascular risk factors. The extracts from both ripe and unripe fruits, as well as the leaves of *Rubus coreanus*, exhibit anti-bacterial activities, particularly against Gram-positive rod-shaped bacteria like *Bacillus cereus*. This anti-bacterial property underlines the potential of *Rubus coreanus* in developing natural anti-bacterial agents or supplements that could support the treatment or prevention of bacterial infections. The compounds in *Rubus coreanus* have been implicated in physiological changes in retinal pigment epithelium cells that may help counteract age-related macular degeneration. The reduction in vascular angiogenesis in these cells, alongside hypocholesterolemic effects that lower cholesterol levels, points to the neuroprotective and vision-supporting potential of these extracts. Other studies on black raspberry where the species is not specified suggest additional health benefits. Extracts have shown potential in improving intestinal health through probiotic strains and in modulating harmful effects of sunlight on the skin, acting as chemopreventive agents against non-melanoma skin cancer. Moreover, anthocyanins derived from these black raspberries are noted for their role in the cessation of the colorectal cancer cell cycle, reducing inflammation and apoptosis.

Table 6. Health benefits and applications of black raspberry (Various *Rubus* species).

Common Name (Species)	Possibility of Use	Reference
Black raspberry (*R. coreanus*)	Niga-ichigoside F1 (1,23-hydroxytormentic acid 28-O-glc) obtained from the fruit of *Rubus coreanus* and aglyconic-23-hydroxytormentic acid (1a) produced by hydrolysis in NaOH solution from the first compound have anti-nociceptive and anti-inflammatory effects	[120]
Black raspberry (no data)	Possibility of using black raspberries in modulating the harmful effects of sunlight on the skin as a chemopreventive/chemotherapeutic agent against non-melanoma skin cancer	[121]

Table 6. *Cont.*

Common Name (Species)	Possibility of Use	Reference
Black raspberry (*R. coreanus*)	Soluble compounds contained in ethanol may induce changes at the physiological level in retinal pigment epithelium cells and also counteract age-related macular degeneration. The mechanisms responsible for these effects are: decreased vascular angiogenesis in RPE cells, hypocholesterolemic effects caused by lowering cholesterol levels, and cellular cholesterol biosynthesis and lipoprotein uptake	[122]
Black raspberry (*R. coreanus*)	The isolated triterpenoid-rich fraction from *Rubus coreanus* has a strong anti-inflammatory effect on colon damage due to DSS, as well as macrophage activation due to LPS. Research also suggests therapeutic and preventive properties in the treatment of colitis disease	[123]
Black raspberry (no data)	The obtained results suggest the possibility of using *Lactobacillus plantarum* strains GBL 16 and 17 isolated from black raspberry in the future as probiotics improving human intestinal health	[124]
Black raspberry (*R. coreanus*)	Research has confirmed the potential use of freeze-dried *Rubus coreanus* fruit extract in the form of capsules as a potential therapeutic agent for people with extremely high blood cholesterol levels and lipid disorders.	[125]
Black raspberry (no data)	The obtained results indicate that protein acetylation may play a key role in the development of colorectal cancer regulated by anthocyanins derived from black raspberry fruit, which affect the cessation of the cancer cell cycle, alleviating inflammation and apoptosis.	[126]

Extract from the roots of *Rubus fairholmianus* can be used in the synthesis of ZnO nanoparticles. The results suggest that this extract could serve as a raw material for the large-scale synthesis of metal nanoparticles with high purity and crystalline nature. This process is also considered environmentally friendly and without negative environmental impacts. The synthesized RE-ZnO nanoparticles exhibit anti-microbial activity [127]. Extracts from the fruits of the commonly found *Rubus ellipticus* species in the Himalayas have anti-microbial and anti-oxidant properties. Studies indicate greater effectiveness of polar extracts compared to non-polar extracts [128]. *R. ellipticus* is not only a valuable natural anti-oxidant but may also play an important role in treating skin diseases, wounds, and cancers [129], and is a source of nephroprotective, anti-inflammatory, analgesic, anti-pyretic, and cytotoxic compounds. Due to its properties, it is suggested to use this species as a raw material for the production of nutraceuticals [130–132]. The fruits, leaves, shoots, and roots of *R. ellipticus* are used as raw materials in traditional remedies to treat fever, ischemic heart disease, sore throat, abdominal pain, cough, wounds, fractures, cancers, and bacterial infections [133]. *Rubus imperialis*, found in Brazil, is used in the folk medicine of local populations to treat viral infections, diabetes, pain, and burns [18,85]. Studies also indicate its anti-inflammatory effects (Tonin et al. 2016). In traditional medicine in Cameroon, the aerial parts of *Rubus rigidus* are used to treat respiratory and cardiovascular diseases. The ethanol extract from this plant shows strong anti-oxidant properties [134]. Studies on the composition of *Rubus chamaemorus* leaves revealed the presence of tannins (4-O-α-L-arabinofuranosylolagowy acid, 2 [(–)-epicatechin]) and glucuronide flavonoids (quercetin 3-O-β-D-glucuronide (3), quercetin 3-O-β-D-2′′-galloglucuronide (4)), as well as kaempferol 3-O-β-D-glucuronide (5)). Due to the wide range of biological activities of these five compounds, researchers suggest their broad potential use as pharmacological ingredients, particularly for producing anti-cancer and anti-diabetic agents [135]. Research findings indicate an increased anti-bacterial, anti-viral, and anti-oxidant potential of honey enriched with ingredients derived from raspberry and blackberry leaves and fruits. The obtained honey could be a component of functional foods with high health-promoting value [136].

Based on the data extracted from the provided Table 7, this discussion elucidates the health benefits and therapeutic applications associated with three distinct raspberry species: *Rubus parvifolius* (Japanese Bramble), *Rubus ellipticus* (Yellow Raspberry), and *Rubus chamaemorus* (Cloudberry). *Rubus parvifolius* fruit extract has demonstrated significant anti-

proliferative activity against myeloid leukemia cells both in vitro and in vivo, suggesting its potential as a treatment for leukemia. Further research supports the use of total saponins extracted from the roots of this plant for developing drugs aimed at combating chronic myeloid leukemia. These saponins are characterized by their ability to limit tumor growth and induce apoptosis, contributing to their therapeutic potential. Additionally, *Rubus parvifolius* extracts, rich in phenolic compounds such as caffeic acid conjugates, ellagic acid glycosides, and flannel glycosides, have shown hepatoprotective and anti-oxidant properties. These extracts mitigate hepatotoxicity induced by CCl4 primarily through their anti-oxidant capacity, which involves scavenging free radicals, alleviating oxidative stress, and reducing lipid peroxidation. Research on *Rubus ellipticus* has led to the development of copper oxide nanoparticles synthesized using aqueous fruit extracts, which exhibited potent anti-microbial activity against pathogens, like *Bacillus subtilis*, *Rosellinia necatrix*, *Staphylococcus aureus*, and *Escherichia coli*, while maintaining low toxicity towards healthy cells. These nanoparticles also showed anti-cancer activity against colorectal cancer cell lines, indicating their potential applications in the pharmaceutical and medical industries. Additionally, acetone and methanol extracts from the fruits have strong anti-oxidant properties and the ability to neutralize various reactive radicals. These extracts have shown potential in treating cervical cancer due to their anti-filtering properties. Studies on *Rubus chamaemorus* extract have confirmed its robust anti-oxidant effect in bacterial cultures, facilitated through multiple pathways, such as the direct inhibition of reactive oxygen species, chelation of iron ions, and induction of anti-oxidant genes. Notably, these extracts have been shown to activate the OxyR-regulon genes and influence the activity of the general oxidative stress response system controlled by RpoS, illustrating their capacity to modulate oxidative stress at a genetic level.

Table 7. Health benefits and applications of yellow raspberry, japanese bramsle and cloudberry (*Rubus ellipticus*, *R. parvifolius*, *R. chamaemorus*).

Common Name (Species)	Possibility of Use	Reference
Yellow raspberry (*R. ellipticus*)	The obtained research results suggest the possibility of using acetone and methanol extracts obtained from *Rubus ellipticus* fruits in the treatment of cervical cancer due to their anti-filtering properties. Extracts from these fruits have very strong anti-oxidant properties and the ability to capture all reactive radicals, including DPPH, ABTS, superoxide radicals, linoleate peroxide free radicals	[137]
Japanese bramble (*R. parvifolius*)	*Rubus parvifolius* extract contains many phenolic compounds, including caffeic acid conjugates, ellagic acid glycosides and flannel glycosides, and research results suggest that they may have hepatoprotective and anti-oxidant properties. Protection against hepatotoxicity due to CCl4 is due in part to anti-oxidant capacity, and more specifically to the scavenging of free radicals, which alleviates oxidative stress and reduces lipid peroxidation.	[138]
Cloudberry (*R. chamaemorus*)	Studies have confirmed the simultaneous anti-oxidant effect of *Rubus chamaemorus* extract in bacterial cultures through several different pathways. Direct inhibition of reactive oxygen species, chelation of iron ions and induction of anti-oxidant genes have also been demonstrated. Researchers managed to prove for the first time that the *R. chamaemorus* extract has the ability to activate the OxyR-regulon genes and influence the activity of the general oxidative stress response system controlled by RpoS	[139]
Japanese bramsle (*R. parvifolius*)	*Rubus parvifolius* fruit extract showed anti-proliferative activity against myeloid leukemia cells (K562) in vitro and in vivo	[140]
Japanese bramsle (*R. parvifolius*)	Research suggests the possibility of using total saponins from the roots of *Rubus parvifolius* as a raw material for the production of drugs against chronic myeloid leukemia. Total saponins from *Rubus parvifolius* are characterized by limiting the rate of tumor growth and inducing cell death through apotosis	[141]
Yellow raspberry (*R. ellipticus*)	Synthesized copper oxide nanoparticles (Ru-Cu2O-NP) using aqueous extract of *Rubus ellipticus* fruits exhibited enhanced anti-microbial activity against various pathogens, such as *Bacillus subtilis*, *Rosellinia necatrix*, *Staphylococcus aureus*, and *Escherichia coli*, while showing no toxicity towards healthy cells at tested concentrations. Moreover, the nanoparticles demonstrated anti-cancer activity against the colorectal cancer cell line, indicating their potential application in the pharmaceutical and medical industries with maintained low toxicity.	[142]

The cultivation of the genus *Rubus* is primarily limited to a few species, overlooking a large number of other non-conventional and wild-growing representatives of this genus, resulting in a significant loss of their potential utility. Due to the exceptional characteristics of *Rubus* species, they can be termed "superfoods". It is crucial to expand cultivation to include new species while also achieving the full potential of both the already popular and lesser-known representatives, which are mainly appreciated by specific communities [143]. The primary step for wild species to become food plants is their popularization [144]. Currently, wild berries in Europe are gaining increasing significance in the context of the cultural role of ecosystems. An example of a locally used species that gained nationwide popularity is *Rubus caesius* (European dewberry, salmbär 'Solomon berries'), which has become an ingredient in many dishes, especially desserts. One such dish was even served at the Nobel Prize banquet in December 2014 [145].

5. Conclusions

In summary, species of the genus *Rubus* exhibit a wide range of nutritional and health-promoting properties, making them valuable components of a healthy diet. These plants, particularly raspberries and blackberries, are rich in polyphenols, flavonoids, vitamins, and minerals, contributing to their anti-oxidant, anti-inflammatory, anti-neurodegenerative, and anti-cancer effects. The diverse phytochemical composition of *Rubus* species supports their use in the prevention and treatment of various chronic diseases, including cardiovascular diseases, diabetes, and certain cancers. Research highlights the significant potential of lesser-known and wild-growing *Rubus* species, which are often overlooked in favor of more commonly cultivated varieties. These wild species, with their unique phytochemical profiles and health benefits, present untapped opportunities for expanding the range of functional foods and nutraceuticals available to consumers. The extensive bioactivity of *Rubus* species underscores the need for continued exploration and utilization of these plants in both dietary and medicinal contexts. Future studies should focus on the detailed mechanisms underlying their health benefits, the development of effective extraction and formulation techniques, and the integration of these findings into public health strategies and clinical practices. The genus *Rubus* represents a valuable resource for improving human health, and its increased cultivation and use could significantly contribute to global health and nutrition.

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