Aronia Melanocarpa Products

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Due to factors such as cultivar, fertilization, maturation or climate conditions, as well as the date of their harvest, chokeberries (Aronia melanocarpa) differ in their content of minerals, vitamins, carbohydrates, amino acids, organic acids, fats, aroma compounds and especially polyphenols, substances exerting a beneficial impact on health.

Keywords: nutrition ; polyphenolic compounds ; antioxidant activity ; health benefits

1. Introduction

The medicinal use of herbs in the prevention and treatment of diverse diseases is an old practice that has been maintained over time and is currently being given special attention by researchers and consumers [1]. Chokeberry (Aronia melanocarpa) belongs to the Rosaceae family and originates from the eastern parts of North America [2]. Chokeberries were highly valued and utilized by Native Americans to make tea to cure colds and the bark was used as an astringent [3][4].

Two species of the Aronia genus can be distinguished: Aronia melanocarpa (Michx.) Elliot known as black chokeberry and Aronia arbutifolia (L.) Pers. (red chokeberry), whereas the third entity is a hybrid of the two mentioned species, called Aronia prunifolia , purple chokeberry [4]. Since its strong resistance to cold, the crop can be grown not only in milder climate conditions but also at temperatures below −35 °C [5]. The Aronia shrubs grow to a maximum height of 2–3 m and have umbels of 20–30 small white flowers, from May to June, that ripen into black berries 6–13 mm in diameter, weighing 0.5–2 g [6]. Because of the sour taste and astringent properties, the chokeberry pomes are rarely used in direct consumption as natural fresh fruits [2]. Chokeberries became popular mainly for the large-scale production of juices, jams, wines, liqueurs and schnapps [4].

Due to the presence and the high content of various bioactive components, such as vitamins, minerals and polyphenolic compounds, the chokeberry and leaves of Aronia melanocarpa exhibit a wide range of positive health effects [7][8]. Along with their high antioxidant capacity, the Aronia melanocarpa's main polyphenolic components also possess anti-inflammatory, anticancer, antimicrobial, antiviral, antidiabetic, antiatherosclerotic, hypotensive, antiplatelet and anti-inflammatory properties [2][3][4][7][8]. Polyphenols have been suggested to play a preventive role in the development of cancer and heart disease [9]. The black, dark violet and red color fruits are widely recognized as a valuable source of anthocyanins, one of the most widespread families of natural pigments in the plant kingdom and are, therefore used as a safe and natural food colorant with pro-health properties [6][10].

2. Chokeberries Nutritional Profile

The total fat content of berries was analyzed to be 0.14 g/100 g FW, where the largest amount was found in stones and skin fractions [4]. The content of fat in pomace amounted to between 3% and 14% DM, where the seed fractions of pomace were the richest in fat content [11]. According to [12] the seeds contained 19.3 g/kg FW glyceride oil. The oil obtained from Aronia melanocarpa was shown to be rich in phospholipids, sterols and tocopherols [12]. The fatty acids composition of dried pomace and seeds was characterized by a high content of polyunsaturated fatty acids (73.6% of total fatty acids) with linoleic acid as the main fatty acid [12][13].

The presence and amounts of organic acids strongly affect food acceptance. Chokeberries have a generally low organic acid content which varies between 1.1% to 1.4% [14][15]. The main acids identified in fresh berries were L-malic (13.1 g/kg), citric (2.1 g/kg) and quinic (5.9 g/kg) acid. Shikimic acid, oxalic acid, and succinic acid were found as minor components [4][15]. The content of free acids in pomace is low because they transfer to the juice with other soluble substances. According to [11], among the organic acids in pomace galacturonic acid is dominant (5–16 g/kg).

The amounts of vitamins and minerals in chokeberries and their contribution to the recommended daily intake is shown in **Table 1** . Freshly squeezed juice contains vitamins such as B1 (25–90 µg/100 mL), B2 (25–110 µg/100 mL), B6 (30–85 µg/100 mL), ascorbic acid (5–100 mg/100 mL), pantothenic acid (50–380 µg/100 mL) and niacin (100–550 g/100 mL). The mineral content (ash values) of fresh chokeberry was found to be 4–6 g/kg [4], while the content in juice was 5 g/kg [16]. The total content of ash in the pomace was at the level of 1.4–3.9% in DM, where the seeds had the highest content of ash [11].

Table 1. Chokeberry Nutrients and Recommended Daily Intake.

Ingredient	Amount in 100 g [4]	Recommended Daily Intake [17]				Percent Daily Value
		1–4 Years Old	4–15 Years Old	After 15 Years Old	Average	%
Energy (kcal)						
Carbohydrates (Kcal)	60	1100–1300	1300–2900	2000–3400	2000	3
Proteins (g)	0.7	14	18–50	48–67	40	2
Fats (g)	0.14	-	-	-	-	
Minerals (mg)						
Sodium (Na)	2.6	400	500–1400	1500	950	0.3
Calcium (Ca)	32	600	750–1200	1200	900	4
Potassium (K)	218	1100	1300–3600	4000	2550	9
Magnesium (Mg)	16	80	120–310	350–400	240	7
Zinc (Zn)	0.2	3	4–12	11–16	10	2
Iron (Fe)	0.9	8	8–15	12–15	12	8
Vitamins (mg)						
Thiamin (B1)	0.02	0.6	0.7–1.2	1.1–1.4	1	2
Riboflavin (B2)	0.02	0.7	0.8–1.4	1.2–1.6	1	2
Pyridoxin (B6)	0.03	0.6	0.7–1.5	1.4–1.6	1	3
Niacin	0.3	8	9–15	13–17	12	3
Phantothenic acid	0.3	4	4–6	6	5	6
Ascorbic acid (C)	14	20	30–85	90–110	65	22
Tocopherols (E)	1.7	5–6	8–14	12–15	10	17
Folate/µg	20	120	140–300	300	210	10
Phyllochinon (K)/µg	24	15	20–50	60–80	48	50

Polymeric procyanidins were identified as the major class of polyphenolic compounds and represent 66% of the fruit's polyphenols. Polymeric flavan-3-ols are composed predominantly of (−)-epicatechin as constitutive units of procyanidins connected mainly with C4-C6 and C4-C8 bonds [5][9]. Research shows that almost 40% of the antioxidant activity of chokeberries is attributable to procyanidins [18]. The size of procyanidin molecules can be described by their degree of polymerization (DP) [19]. The free compound epicatechin is also present in black chokeberries, only its concentration is significantly lower compared to polymeric procyanidins [20]. The highest content of total procyanidins was observed for unripe fruits, while the content declined during fruit development [21]. In the pomace, the content of polymeric procyanidins was found to be higher than in juice and fresh chokeberries [9]. Research by authors [11] reported higher contents of procyanidins in the seedless fractions of pomace. Procyanidins, among other phenolic compounds, impart the astringent effect while consuming the fruit [9][21].

3. Beneficial Health Properties of Chokeberry Fruits

In order to evaluate the antioxidant activity of Aronia melanocarpa , the most commonly used assays include the inhibition of DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2-azino-bis (3-ethylbenzothiazoline-6-sulfonate)) radicals [9]. Chokeberries show one of the strongest in vitro radical scavenging activities among other berries [22]. The measurement of ability to scavenge DPPH and ABTS radicals [9] revealed notable variation between antioxidant activities (all expressed as radical equivalents per µM Trolox/100 g DW) of fresh fruit (279.38 for DPPH and 439.49 for ABTS radicals), juice (127.45 for DPPH and 314.05 for ABTS radicals) and pomace (301.89 for DPPH and 779.58 for ABTS radicals). The in vivo mechanisms of antioxidant activity of phenols themselves, after absorption, extend far beyond radical removal including, suppression of reactive nitrogen (RNS) and oxygen species (ROS), recovery of antioxidant enzymes, inhibition of prooxidants and cellular signaling to regulate antioxidant levels and enzymes [23][24].

Cyanidin-3- O -arabinoside possesses the strongest radical-scavenging properties among the anthocyanins present in Aronia melanocarpa , and it was shown to be a strong inhibitor of pro-oxidative enzymes, like 15-lipooxygenase and xanthine oxidase [20]. Quercetin showed the highest oxygen radical absorbance capacity (ORAC) and total radical-trapping antioxidant parameter (TRAP) antioxidant activity in fresh chokeberries, but due to the low quantity of flavonols in fresh chokeberries, their contribution to the antioxidant activity was shown to be less than 10% [23]. It was demonstrated that 40% of the in vitro antioxidant activity of chokeberries is due to the potency of proanthocyanidins, followed by anthocyanins (24%), hydroxycinnamic acids (18%) and epicatechin (11%). Procyanidins are considered superior antioxidants compared to their corresponding monomers [19]. The green, unripe chokeberries have the highest antioxidant activity due to the high content of procyanidins and flavonoids, in spite of the absence of anthocyanins [21]. The results obtained by [8] showed that leaves of the Aronia species also possess a strong antioxidant capacity and are of potential therapeutic and dietary interest. [25] reported that the daily consumption of 150 mL of juice by rowers performing physical exercise during a 1-month training camp decreased the exercise-induced oxidative damage to the red blood cells.

The anti-inflammatory properties of Aronia melanocarpa fruit are related to the prevention of the development of chronic diseases, such as diabetes, cardiovascular diseases and chronic problems with the immune system [7]. Cyclooxygenases (COXs) and inducible nitric oxide synthase (iNOS) are the key pro-inflammatory enzymes responsible for the synthesis of lipid mediators and nitric oxide, associated with the progression of many inflammatory diseases [10]. The study by [26] showed an anti-inflammatory activity of Aronia melanocarpa extract on endotoxin-induced uveitis in rats. The in vitro experiment indicates that anti-ocular inflammatory action may involve inhibition of nitric oxide, prostaglandin, and tumor necrosis factor-α (TNF-α) production, resulting from suppressed expression of iNOS and COX-2-enzymes. The study by [27] demonstrated new evidence that the extract can inhibit the pro-inflammatory response of human aortic endothelial cells. [28] provide the first experimental support for the therapeutic application of the bioactive fraction against various inflammatory airway disorders. Besides the decreased expression of iNOS and COX-2, their study provided clear evidence for the anti-inflammatory activity through attenuation of ROS secretion and induced cell cycle arrest.

Research [29] reported that Aronia melanocarpa extract intake regulates thermogenesis in healthy women with a cold constitution. It was suggested that Aronia melanocarpa intake improves the maintenance of body temperature through the regulation of noradrenalin and oxidative stress levels. The leaf extracts showed an acetylcholinesterase and butyrylcholinesterase inhibition rate of around 60–70%, which could be important in the development of natural materials as a treatment for neurodegenerative disorders such as Alzheimer’s disease, Parkinson’s disease and dementia [30]. Many in vitro and in vivo experiments indicate that extract and juice from chokeberries and their leaves may protect from toxic effects connected with pro-oxidative and pro-inflammatory properties of some drugs, tobacco smoke and its components, radiation and other xenobiotics [2].

4. Conclusions

The main nutrition- and health-relevant Aronia melanocarpa components are polyphenols, sugars, minerals and vitamins. Many in vitro and in vivo investigations confirm these substances are producing numerous nutritional and physiological activities like antioxidative, anti-inflammatory, hypotensive, antiviral, anticancer, antiplatelet, antidiabetic and antiatherosclerotic. Aronia melanocarpa products and by-products require a wide range of studies to further confirm their safety, efficacy and stated mechanism of action, especially in the nowadays very popular antiviral activities. A better understanding of the role of Aronia melanocarpa products and by-products in human nutrition and their contribution to human health could be of great importance, as well. The data existing in the literature demonstrate the potential of Aronia melanocarpa as a nutritionally rich and healthy dietary food with many functionalities and benefits.

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