REVIEW

Aronia melanocarpa
a.k.a. black chokeberry, Photinia melanocarpa.

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**Taxonomic Hierarchy**:  

**Description and Cultivation**:  
Aronia melanocarpa originates from North America. Its cultivation in Bulgaria began in the late 70s of the last century. Aronia is a genus of deciduous shrubs. It is about 1 m tall and 3 m wide. The leaves are not more than 6 cm wide. The flowers are white or pale pink, 1.5 cm wide, with glabrous sepals. The fruit is black, 6–10 mm wide. Aronia is considered cold hardy and heat tolerant. Black chokeberry is an adaptable and tough because of its hardiness and wide tolerance to a variety of soil textures, densities, pH levels, and moisture conditions. It is also resistant to drought, insects and disease. In cultivated landscapes chokeberries become strongly suckering plants. Because of that and its tolerance to wet soils, this species is typically used in mass planting, for erosion control, in windbreaks, and in landscapes with excessively wet soils. The clean black soil and the sunny summer days, essential for the proper development and maturation of the black berries, contribute to the persistent high quality of the **bulgarian aronia melanocarpa**.

**Products and Uses**:  
The well-ripened black chokeberries have **sweet and lightly acerb taste**. The lack of sufficient sunshine during the maturation process in the summer can result in the bitter taste of the unripe harvested aronia fruits. Aronia is commonly used to produce fruit syrup, fruit juice, soft spreads, fruit jellies and tea. The berries can be consumed fresh, dried, or in the form of powder (added to yogurt or to the flour in different cakes etc.). Black berry is known for its high content of sorbitol, which is sugar substitute recommended for diabetic patients (Diabetes mellitus). Aronia is often used in diet foods and is known to act as a weak nonstimulant laxative. **Anthocyanin extracts** from Aronia melanocarpa are increasingly used as food ingredients because of their antioxidant effect, beneficial for the improvement of the human health and its sustaining.
The deep purple pigment resulting from the high content of anthocyanin in the black chokeberry fruits is used as a natural food coloring.

Chokeberries, have a long tradition in European and North American folk medicine.

Characteristical chemical composition:

The components of the chokeberries are dependent on a series of factors such as maturation of the berries, harvest date, habitat/location etc. The chemical composition of aronia berries or freshly pressed juice distinguishes from other berries by high contents of sorbitol and polyphenols.

<table>
<thead>
<tr>
<th>CONSTITUENTS</th>
<th>NUTRIENT VALUE PER 100G FW</th>
<th>CONSTITUENTS</th>
<th>NUTRIENT VALUE PER 100G FW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASIC COMPONENTS</strong></td>
<td></td>
<td><strong>VITAMINS</strong></td>
<td></td>
</tr>
<tr>
<td>Glucose and Fructose</td>
<td>13.0-17.6 g</td>
<td>Dry matter, %</td>
<td>15.6-28.8</td>
</tr>
<tr>
<td>Dietary fibre</td>
<td>5.6g</td>
<td>pH</td>
<td>3.3-3.7</td>
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<tr>
<td>Pectins</td>
<td>0.34-0.58g</td>
<td>Vitamin C</td>
<td>13.0-27.0 mg</td>
</tr>
<tr>
<td>Fat</td>
<td>0.14%</td>
<td>Folate</td>
<td>20.0 µg</td>
</tr>
<tr>
<td>Protein</td>
<td>0.7%</td>
<td>Vitamin B1</td>
<td>18.0 µg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vitamin B2</td>
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<tr>
<td></td>
<td></td>
<td>Vitamin B6</td>
<td>28.0 µg</td>
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<tr>
<td></td>
<td></td>
<td>Vitamin B3</td>
<td>24.2 µg</td>
</tr>
<tr>
<td><strong>MINERALS</strong></td>
<td></td>
<td><strong>Tocopherols</strong></td>
<td>1710.0 µg</td>
</tr>
<tr>
<td>Ash</td>
<td>440-580 mg</td>
<td>Niacin</td>
<td>300.0 µg</td>
</tr>
<tr>
<td>Na</td>
<td>2.6 mg</td>
<td>Pantotheneic acid</td>
<td>279.0 µg</td>
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<tr>
<td>K</td>
<td>218.0 mg</td>
<td>Tocopherols</td>
<td>1710.0 µg</td>
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<tr>
<td>Ca</td>
<td>32.2 mg</td>
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<tr>
<td>Mg</td>
<td>16.2 mg</td>
<td>Carotinoids</td>
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<td>Fe</td>
<td>0.93 mg</td>
<td>Phenols</td>
<td>6902 mg</td>
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<tr>
<td>Zn</td>
<td>0.147 mg</td>
<td>Amygdalin</td>
<td>20.1 mg</td>
</tr>
</tbody>
</table>

FW - fresh weight; DW - dry weight.
DIETARY FIBER
Dietary fiber amounts to about 6% of the fresh weight of black chokberries. It contains anthocyanins, microcrystalline, cellulose, pectins, lignins, cutin-like polymers and condensed tannins.

ORGANIC ACID
Aronia berries have relative low content of organic acids (1–1.5% of FW). The main organic acids identified were L-malic acid and citric acid.

SUGAR
Aronia contains glucose, fructose (13–17.6 g/100 g FW) and sorbitol (80 g/L in a freshly pressed juice). Among a series of fruits and berries tested, aronia was found to contain the highest concentration of sorbitol.

FAT
The total fat content of the berries measures about 0.14% of their FW. The seeds contain nearly 19 g/kg glyceride oil (mainly linoleic acid) and about 2.8 g/kg phospholipids in the seed oil (mainly phosphatidylcholine, phosphatidylinositol and phosphatidylethanolamine). Sterols (1.2 g/kg DW) in aronia berries are represented by β-sitosterol, campesterol, α- and β-tocopherol (aka. Vitamin E), stigmasterol and Δ(5)-avenasterol.

PROTEIN
The protein fraction amounts to nearly 0.7 % of the FW. The main amino acid in the freshly pressed juice is asparagine.

MINERALS AND VITAMINS
The mineral content (ash values) of the fresh berries varies between 440 and 580mg/100g FW. Aronia shows relative high average amounts of potassium (K) and zinc (Zn). It is also a natural source for vitamin B1, B2, B6, C, E (α- and β-tocopherol), pantothenic acid (B5), niacin (B3), provitamin A carotenoids (β-carotene, β-cryptoxanthin).

AROMA COMPONENTS
Amygdalin, a cyanogenic glycoside isolated from the berries, was found responsible for the specific smell of the fresh fruits. The main volatile constituents of black chokeberry are
cyanohydrin, hydrocyanic acid and benzaldehyde. Other aroma substances include series of benzene derivatives like benzyl alcohol, 2-phenylethanol, phenylacetaldehyde, salicylaldehyde, acetophenone, 2-hydroxyacetophenone, 4-methoxyacetophenone, phenol, 2-methoxyphenol and methyl benzoate.

The concentration of the mentioned aroma compounds was identified to be in general below their individual threshold values.

PHENOLIC CONSTITUENTS

Perhaps the most important constituents present in Aronia, also responsible for many of its medicinal properties are the phenolic compounds (3440-7849 mg/100 g DW) procyanidins, anthocyanins and phenolic acids.

- **Procyanidins** were identified as the major class of polyphenolic compounds in chokeberries (5182mg/100 g DW). Aronia contains exclusively homogeneous B-type procyanidins with (–)epicatechin as the main subunit monomer.
- Aronia melanocarpa berries are one of the richest plant sources of anthocyanins (25% of the total polyphenols), mainly containing cyanidin glycosides such as cyanidin 3-O-galactoside (68.9%), cyanidin 3-O-arabinoside (27.5%), cyanidin 3-O-xiloside, cyanidin 3-O-glucoside and in trace pelargonidin 3-O-galactoside and pelargonidin arabinoside. This class of flavonoids is responsible for the pigments that give berries their dark colors.
- In a recent study, besides rowanberry, the best phenolic acid sources among berries were identified as chokeberry (7.5% of the total aronia berry polyphenols). Its main representatives are chlorogenic and neochlorogenic acids.
- The content of flavonols and (–)-epicatechin in aronia is relative low (1.3% of the total chokeberry phenolics). Five quercetin derivatives were identified in black chokeberries: 3-O-(6′-O-β-arabinosyl-β-glucoside), 3-O-(6′-α-rhamnosyl-β-galactoside), 3-O-6′-α-rhamnosyl-β-glucoside), 3-O-β-galactoside and 3-O-β-glucoside.

Potential Health Benefits:

*Scientific researches have shown that black chokeberries have positive influence on the health condition of patients suffering from various diseases. Aronia fruits have remarkable antioxidant, antimutagenic, antidiabetic, cardioprotective and hepatoprotective effects. The represented information about the potential health effects of Aronia melanocarpa is based on in vitro, animal and human scientific studies. For more information see the references below.*

ANTIOXIDANT EFFECTS

Fresh aronia berries possess the highest antioxidant capacity among berries and other fruits investigated so far as measured with ORAC (oxygen radical absorbance capacity). Aronia juice exhibits the highest antioxidant capacity among the polyphenol-rich beverages, its TEAC (trolox equivalent antioxidant capacity) values are four times higher than those of blueberry juice,
cranberry juice or red wine. The most important compounds which are responsible for the **radical scavenging activity** seem to be the main phenolic constituents.

Procyanidins and anthocyanidins containing o-dihydroxyphenyl groups are also excellent **metal chelators** and form complexes with, e.g., iron(III) and copper(II). The presence of free state iron and copper in biological systems catalyses free radical reactions. The ability of phenolic components to bind bivalent transition metals effectively reduces the concentration of these cations and thus the extent of their prooxidative activity.

Chokeberry anthocyanins **decrease lipid peroxidation** and enhance the activity of enzymes which are involved in the antioxidant defence system.

The red pigment fraction of chokeberry fruits composed of cyanidin derivatives is a potent **scavenger of DPPH radicals** in both in vitro and in vivo systems. It is also able to prevent in a dose-dependent manner gastric mucosal damage that was induced by the subsequent application of ethanol. The authors suggested that one of the mechanisms by which the extract **suppresses the development of the gastric mucosal damage** is the scavenging of active oxygen by its cyanidin derivatives since the suppression of gastric acid secretion was not observed.

An antioxidant effect was also found in human study, where a dietary supplementation with chokeberry juice **limits the exercise-induced oxidative damage to red blood cells** in rowers.

**INHIBITION OF CANCER CELL PROLIFERATION**

Many reports suggest **anti-proliferative or protective effects** of chokeberries and/or chokeberry extracts against colon cancer (based on in vitro and animal studies).

An anthocyanin-rich extract from aronia melanocarpa was **shown to inhibit the growth as well as to stimulate apoptosis of human HT-29 colon cancer cells** but exerted only little effect on the growth of non-transformed NCM460 colonic cells.

Exposure to chokeberry juice **inhibited Caco-2 cell proliferation by causing G2/M cell cycle arrest**. Gene expression analysis revealed that the tumor suppressor carcinoembryonic antigen related cell adhesion molecule 1 (CEACAM1) was up-regulated in the Caco-2 cells following repetitive exposure to dietary levels of chokeberry juice. CEACAM1’s expression is known to be reduced in most early adenomas and carcinomas.

An anthocyanin-rich extract from chokeberry **inhibited the formation of the azoxymethane-induced aberrant crypt foci**, tentative marker of dysplasia and malignant transformation, and decreased the colonic epithelial cell proliferation rate as well as the fecal bile acid concentration in rats.

Isolated cyanidin 3-O-glucoside exhibited **chemopreventive activities**.

**ANTIMUTAGENIC EFFECTS**
Phenolic compounds isolated from berries of Aronia melanocarpa were found to exert an antimitogenic activity.

Anthocyanins isolated from aronia markedly inhibited the mutagenic activity of benzo[a]pyrene and 2-aminofluorene in the Ames test as well as in the sister chromatid exchange assay with cultured human lymphocytes.

Aronia juice intake was shown to inhibit the endogenous generation of N-nitrosamines in rats treated with aminopyrine plus sodium nitrite. In consequence, histopathological changes observed in livers of rats fed with nitrosamine precursors were prevented by co-treatment with aronia juice.

HEPATOPROTECTIVE EFFECTS

In an animal study, anthocyanins from chokeberry decreased the toxicity and accumulation of cadmium in the liver and kidney of rats receiving both these components in their diet. Anthocyanins probably chelate metal ions which in consequence may decrease the damages caused by cadmium.

Interestingly, a hepatoprotective effect of aronia juice was also observed in rats after acute exposure to carbon tetrachloride (CCl₄). The liver cytotoxicity from CCl₄ depends on its conversion to the highly reactive CCl₃ (trichloromethyl free radicals) by cytochrome P450. The reaction of CCl₃ radical with oxygen initiates lipid peroxidation which results ultimately in the cell death. Aronia juice prevented the CCl₄-induced increase of lipid peroxidation as measured by the malondialdehyde content in rat liver and plasma.

CARDIOPROTECTIVE EFFECTS

It is proven that aronia berries have positive influence over several risk factors for cardiovascular diseases.

In vitro experiments demonstrate that the phenolic constituents contribute to the protection and restoration of endothelial cells and consequently to their function. Furthermore, anti-platelet effects as well as vasoactive and vasoprotective properties in porcine coronary arteries were observed. In an experimental model of hyperlipidemia in rats aronia fruit juice hindered the dietary-induced elevation of plasma total cholesterol, LDL cholesterol and plasma lipids.

In men with a mild hypercholesterolemia regular chokeberry juice drinking (250 mL per day) for six weeks resulted in a significant decrease in serum total cholesterol, LDL cholesterol and triglyceride level whereas the HDL2 cholesterol level was increased, furthermore, a moderate but significant decrease in serum glucose, homocysteine and fibrinogen concentration was noted. The metabolic changes were associated with a reduction in systolic and diastolic blood pressure. A similar hypotensive effect of a flavonoid-rich extract from chokeberry fruits was also observed in patients after myocardial infarction, treated simultaneously with statins and in patients with diabetes mellitus type II.
Other effects studied include enhanced **reduction in cardiovascular risk markers** in patients after myocardial infarction suggesting a possible clinical use for secondary prevention of ischemic heart disease.

**ANTIDIABETES EFFECTS**

Researches has demonstrated that Aronia melanocarpa anthocyanins might be useful in the **prevention and control of diabetes mellitus type II and diabetes-associated complications**.

In an animal model the administration of aronia fruit juice to diabetic rats appeared to **attenuate hyperglycemia and hypertriglyceridemia**. In a human intervention study the daily intake of 200 mL *aronia* juice over a period of 3 months effectively **lowered the fasting glucose levels** in patients with non-insulin dependent diabetes. Human studies suggest that *aronia* juice could be used in the **treatment of obesity disorders**.

**NB!**

Popular advices given by authors:

- Aronia juice is **not recommended for people suffering from stomach/duodenal ulcer or gastritis** with increased acidity of stomach juice.
- The consumption of chokeberries is to be avoided by **pregnant/breastfeeding women**, and by **people with known history of oxalate urinary tract stones**.

**However, there is no available scientific information about any unwanted and toxic effects of aronia melanocarpa berries, juice or extracts.**
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