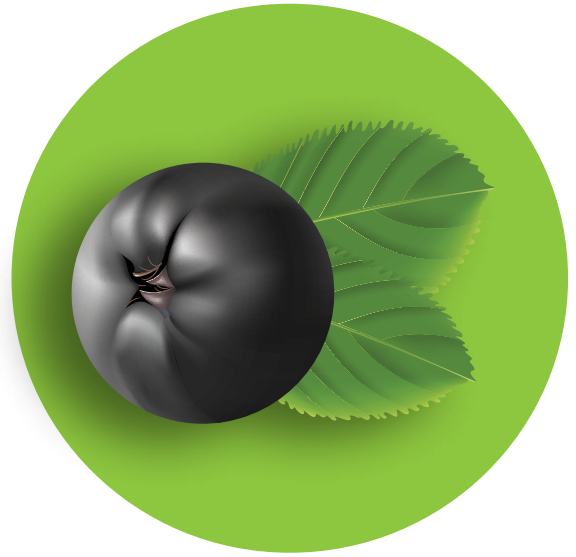


ARONIA, The Richest North American Fruit



A White Paper on the Benefits
of Aronia Berries

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Fruits and vegetables are believed to possess fundamental nutritional benefits in the prevention of degenerative diseases. While many of the proposed benefits have not been clinically proven nor accepted by regulatory agencies, fruit components are widely embraced by the consumer to provide substantial benefit from a health perspective. The nutritional benefits of fruits have drawn considerable interest from scientists and consumers alike to a variety of new berry fruits and their constituents. Many of these fruits have a long tradition in European and North American folk medicine.

In recent years, aronia or chokeberry (*Aronia melanocarpa*) has received increased interest and gained creditability from North American consumers due to its extremely high antioxidant levels and deep rich color. Aronia is a very sustainable crop due to its natural resistance to pests and simplicity to grow and harvest. Aronia has a greater content of phenolic constituents than most of the other black berries (23, 56) and these phenolic compounds give aronia high antioxidant values.

Originating in eastern North American, aronia berries have found major acceptance in European food applications due to their nutritional benefits, ability to blend with other fruits, their dark, elegant purple-red color and its sustainability with basic farming practices.

In the last five years, the US market has seen growing acceptance in new product development activities. The University of Nebraska-Lincoln Food Processing Center's 2013 Product Traffic Report shows more than 440 new products containing the aronia berry have been introduced - 60 of them in the US. New products include juice, supplement powders, baby food and many new wines and beverages. Aronia's outstanding nutritional attributes are creating more demand for new aronia products



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and food manufacturers are responding. Over the past five years, more than 965 new products containing aronia ingredients have entered the global market. Aronia products have been commonplace for quite some time in Europe, and can be found in jam, beverages and dairy products, especially yogurts and dairy desserts. Here in the United States, aronia has seen a significant surge in new product activity, increasing over 200 percent from 84 in 2010 to 233 new product SKUs in 2014.

Aronia has an earthy, sweet-tart taste that can serve as a “base” flavor in new product development. The flavor and sensory experience of aronia can be greatly modified by adding something sour, such as vinegar, lemon or lime juice, to the formula. The astringency of the aronia juice can also be reduced by the use of protein-based ingredients – the added proteins bind with the tannins to reduce astringency. Aronia will also complement a number of other fruit ingredients and many European products use herbs and spices to produce a superior sensory experience for aronia. Common pairings of aronia are:

FRUITS

- Blueberry
- Strawberry
- Apple
- Cherry
- Raspberry
- Cranberry
- Acai
- Pomegranate
- Citrus (orange, grapefruit, lemon/lime)
- Grape

SPICES AND HERBS

- Hibiscus
- Orange Peel
- Cinnamon
- Cloves
- Licorice Root
- Mint

In reviewing new aronia-based products, there are many ingredients that can be used to enhance the blendability of the aronia while taking advantage of its high nutrient content.



Characteristic Composition of Aronia Berries

As with many fruits, the composition of aronia berry is dependent on numerous factors such as variety, fertilization practices, maturation of the berries, harvest date or growing habitat or region (11). The proximate composition of aronia berries while similar to many other high nutrient dense fruits has characteristics that can benefit the developer.

Sugar

The soluble solids content of fresh aronia berries ranges between 16-20oB and is composed mainly of glucose and fructose, in roughly equal proportions, with trace amounts of sucrose.

This relatively high soluble solids content is supplemented with an unusually high concentration of sorbitol.

Sorbitol has been reported in levels between 6.0 to 8.0% range (11). Among a series of fruits and

berries tested, aronia was found to contain the highest sorbitol concentration, suggesting

its application as biomarker for juices blended with aronia. Sorbitol is a sugar substitute often

used in diet foods as well as a humectant which will

keep reduced moisture products softer and more pliable. The

characteristics can be used to the advantage of the developer in

creating clean label products.



Fat

The total fat content of the berries was analyzed to be less than 0.25% and is associated with the seeds and skins of the fruit. Aronia seeds, while a very minor component of the fresh or IQF

(individually quick frozen) fruit, have been found to contain 19.3% triglycerides with linoleic acid

as the main fatty acid. The content of phospholipids in the seed oil is 2.8%, represented mainly by

phosphatidylcholine, phosphatidylinositol, and phosphatidylethanolamine. These components

are at very low levels in the fresh or frozen berry and juice products, lending the aronia berry

useful as an ingredient for low/no fat products.

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Protein

The protein fraction of fresh or IQF fruit is extremely low and found to be a maximum of 0.7%. (11)

Dietary Fiber

Fresh or IQF aronia berries have been reported to contain 5.5 to 6.0% dietary fiber. After pressing and drying, the pomace has been reported to be a great source of dietary fiber along with residual anthocyanins and condensed tannins. The pectin content of aronia is relatively low at 0.3 – 0.6%.

Organic Acids

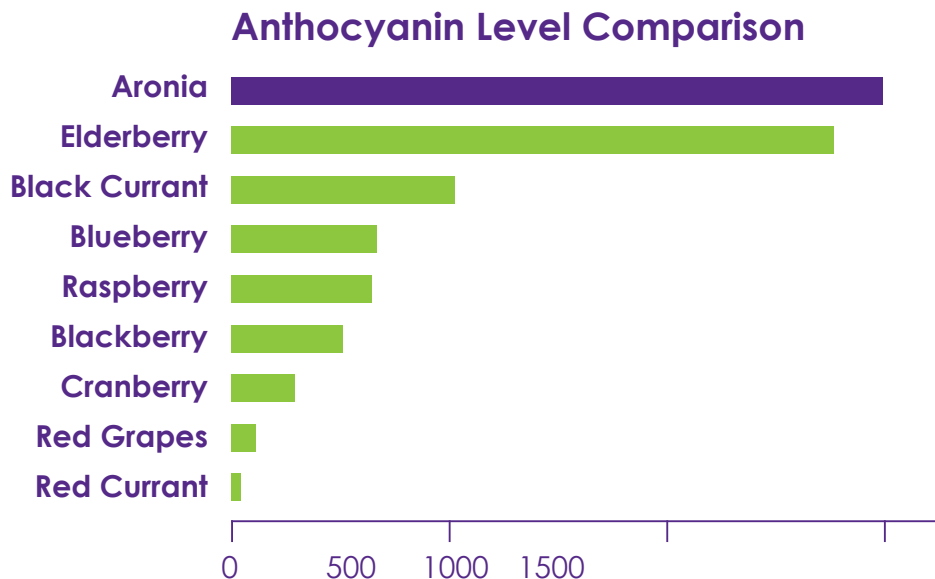
The total content of organic acids is relatively low as compared to other berries at around 1–1.5%. The main acids identified were L-malic acid and citric acid [9]. In freshly pressed juice prepared under laboratory conditions from different cultivars originating from different locations, the total amount of acids was found to lie between 5–19 g/L with L-malic acid being the main component. The resulting pH was observed to lie between 3.3–3.9, average values of 3.46 and 3.6 and a titratable acidity of 0.7 to 1.2%. (10) The organic acids lend themselves to easy formulation and blending to other fruits.

Compositional Analysis of Aronia		
NUTRIENTS	Aronia IQF	Aronia MicroDried®
<i>per 100 g</i>	<i>per 100g</i>	<i>per 100g</i>
Water	79 g	5 g
Calories	84	376
Total carbohydrates	19 g	87 g
Total fat	0.13 g	1.5 g
Protein	1.4 g	3.6 g
Dietary fiber	4 g	24 g
Vitamin A	900 IU	35,100 IU
Vitamin C	0.8 mg	< 1
Vitamin E	3.3 IU	3.6 IU
Vitamin K	20 ug	21 ug
B vitamins		
Niacin, B3	0.4 mg	2.6 mg
Pantothenic acid, B5	0.2 mg	4 mg
MINERALS		
Calcium	22 mg	140 mg
Iron	1 mg	4.4 mg
Manganese	0.3 mg	0.3 mg
Phosphorus	26 mg	28 mg
Potassium	269 mg	213 mg
Sodium	2 mg	6 mg

Pharmacologically Relevant Constituents

Aronia data in literature suggests that the fruit is rich source of pharmacologically relevant compounds. Polyphenols, especially anthocyanins and procyanidins, make up the main group of biologically active constituents in aronia berries. These compounds are responsible for the antioxidant properties of the plant. Total phenolic content ranges from approximately 2,000 to approximately 8,000 mg/100 g dry weight. Aronia is well known to contain some of the highest levels of antioxidants in fruits (8).

It has been suggested that a diet rich in fruit that contain high levels of antioxidants is beneficial in reducing the rates of degenerative diseases (11, 19). Although scientists have identified the specific antioxidant compounds and their health benefits, there is a lot that is not known about the antioxidants in food, how much should ideally be consumed to improve specific health parameters and what groups of people will benefit from specific compounds (13, 19, 20).



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Based on the high levels of antioxidants, popular health claims for aronia products are: 1: combat heart disease and other cardiovascular problems; 2: maintain a healthy urinary tract; 3: fight against bacteria and viruses, 4: help to decrease cholesterol associated with low density lipoproteins (LDL), 5: diabetes (13) and 6: cancer prevention (17, 7). The proposed effectiveness of aronia products in the treatment of many of these pathological conditions is the high levels of antioxidants found in aronia. Polyphenols, especially anthocyanins and procyanidins, make up the main group of biologically active constituents in aronia.(8, 11)



Antioxidant Effects

There have been numerous research papers showing the antioxidant effect of aronia berries, juice, extracts and dried products (10) These assays measured the antioxidant effect of aronia products with well know methodologies including oxygen radical absorbance capacity (ORAC) and trolox equivalence antioxidant capacity (TEAC) (13, 26, 27, 30, 24, 25) being the most routinely used. Fresh aronia berries possess the highest antioxidant capacity among berries and other fruits investigated so far as measured with ORAC (24, 26, 30, 31, 32, 33, 34). The most important compounds which are responsible for the radical scavenging activity seem to be the main phenolic constituents. The results of these studies are consistent with the observation that a good correlation exists between the total phenolic content and the ORAC or TEAC values of various berries and juices (24, 27, 35). The component that seems to be most correlated to the antioxidant effects are those of the anthocyanins.

Inhibition of Cancer Cell Proliferation

As reported by Kulling (10), many studies suggest anti-proliferative or protective effects of aronia and/or aronia extracts against colon cancer on the basis of in vitro studies (36, 37, 38) and in one animal study (39). 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 (36, 37). Interestingly, the chokeberry extract inhibited the growth to a greater extent than grape and bilberry anthocyanin-rich extracts when inhibition was compared at similar concentrations of monomeric anthocyanin (37).

Cardioprotective Activity

Numerous studies have been conducted on the cardioprotective activity of aronia. These have shown a beneficial effect on lipid lowering with the consumption of aronia (40, 43, 44). In other studies on the vasoactive properties of aronia products, there was a vasorelaxation with consumption of aronia products (47,48, 49). Aronia has also been shown to exert a significant anti-aggregatory effect on human platelets in vitro. Interestingly, this activity of aronia extract seems to be independent of its ability to inhibit platelet superoxide production in patients at risk of cardiovascular disease (48, 50, 51). The bioactive compounds found in chokeberry strengthen blood vessel walls and improve their elasticity.

Antidiabetic Activity

Several animal studies have shown that aronia consumption is a benefit in increasing uptake of glucose by certain cells, reducing fasting blood glucose level, and reduction of H1C hemoglobin protein (30, 52). Human studies have shown that consumption of sugar-free aronia juice over time results in a reduced fasting blood glucose level compared to a control group. The authors concluded that supplementation of the diet with aronia juice may exert beneficial supporting effects in diabetic patients (52). In a similar study the aronia juice showed a lowering effect on HbA1c-glycated hemoglobin, total cholesterol and lipid levels [25].

Antibacterial and Antiviral Activity

Antimicrobial properties of phenolic compounds from numerous berry species, such as cranberry, blueberry and raspberry, are well known and have been demonstrated in vitro. Numerous folk remedies have used fruits, such as cranberry, as an urinary tract infection preventative. Many theories have been proposed and new literature is published on mechanisms for the antibacterial and antiviral activity of fruits high in phenolic compounds. Aronia berry extracts have shown bacteriostatic activity in vitro against *Staphylococcus aureus* and *Escherichia coli*.

Additionally, aronia has shown antiviral activity against influenza A virus (52). Publications showing a particularly strong inhibitory effect for human intestinal pathogens from *Staphylococcus* and *Salmonella* with the proposal that the high phenolic content of aronia provided the antimicrobial action noted (54-56).



Toxicity

Currently, there is no data in the literature about any unwanted or toxic effects of aronia berries, juice or extracts (23).

Conclusion

Aronia has one of the highest contents of polyphenolic compounds which are excellent antioxidants. In the days of the Potawatomi Indians of Wisconsin, aronia was first recorded as a "cure" the common cold. Today, scientific evidence is mounting that aronia has many potential pharmaceutical applications and effects on the health and well being of the consumer. Because of these potential health promoting effects, aronia and its extracts may constitute a valuable dietary supplement for many people. Regular consumption of aronia products, considering their high antioxidant and antimutagenic potential, may exert positive, long-term effects for those consuming the fruit.



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