Aronia superberries, black power of Nature

Iwona Wawer
Piotr Eggert
Paweł Eggert

Disclaimer.

The book is dedicated to the consumers willing to learn about Aronia berries. The information in this book is not intendent to be taken as medical advice.

Introduction

Do you know aronia? The bunches of aronia berries (chokeberries) include 10-15 small, black berries.

Aronia berries processed as juice, jam, syrup, wine or powdered extract are beneficial for human health. The juice is of burgundy red color, similar to red wine.

The cardioprotective effect of red wine has been attributed to the polyphenolic compounds, mainly anthocyanins. The homeland of tea, another plant important for human health, is China. Tea contains polyphenols called catechins. Aronia combines beneficial health properties of red wine and green tea – the berries contain both types of polyphenols: anthocyanins and catechins.

Two great civilizations: the Mediterranean one, cultivating grapes and the Far-Eastern one cultivating tea trees are complemented by the North-European and North-American ones – cultivating and appreciating berries, such as blueberries, aronia, black currant, strawberry, elderberry and many others. The use of wild berries has a long tradition in cooking and for therapeutical purposes. Nowadays, scientists confirmed that berries rich in polyphenolic compounds are precious for human health. The high consumption of berries can reduce the incidence of cardiovascular disease, neurodegenerative diseases and cancers.

Small, dark berries are now called "superberries". A "superberry" is a fruit that is known to have exceptionally high levels of nutrients, antioxidants and potential health benefits. **Aronia berries rank as number one among dozens of fruits, vegetables and juices tested for the antioxidant capacity and polyphenols content**. They are gaining recognition as the nature's antioxidant powerhouse [1, 2].

Everybody can eat berries and drink fruit juices -such juice can be consumed by school children and seniors, and served at any meal. Scientists from the Medical Universities in Poland and the USA started to drink aronia juice every day.

Aronia - wild in North America, cultivated in Europe

Aronia or black chokeberry belongs to the family *Rosaceases*; it is a shrub, native to the north-eastern United States and Canada. In its homeland, three kinds of aronia species exist: *Aronia melanocarpa*, with black fruits, *Aronia arbutifolia* with red fruits, similar to rowanberries and *Aronia prunifolia*. At the beginning of the 20th century aronia came to Europe -first to Russia and Scandinavia and later to Poland. The Russian popular name of aronia can be translated as "black rowanberry", while the Germans call it "schwarze Apfelbeere" – dark berry really resembles small apple. However, in Western European countries aronia remained little known.

Aronia is a shrub 2-2.5 m high, but in fertile soils it may grow up to 3 m. It likes the sun and buoyant air circulation. In home gar-

dens, aronia shrubs blossoming with white flowers, are very decorative; likewise in autumn, when the leaves turn to the orange-red color.

Aronia fruits become dark-blue and ripe after circa 3 months, and the crops are collected in August, or at the beginning of September. One bunch includes up to 15 berries of 1-1.5 g each.

Anywhere from 10 to over 15 kg may be harvested from a single bush. The plantation can be cultivated even for up to15-20 years. The twigs between 2 to 6 years old are most productive; older ones shall be removed because they are not elastic enough for harvesting machinery.

Aronia blossoms in the middle of May, later than for all other fruit trees. For this reason, aronia is usually not damaged by the spring frosts. Aronia orchards produce fruit every year. Yields vary, depending on the growing conditions and the cultivar but for a typical sea-

Aronia berries

son they amount to 7 tons from a hectare. Frequently they reach even 10-15 tons. Nowadays, berries are mostly harvested mechanically. A machine called a shaker sends a vibration through the twigs sufficient to cause the berries to fall. They fall onto canvas from where they are sent by a conveyor belt to a container box.

The best aronia cultivars were selected over the years, and the experimental stations produced several millions of seedlings, which enabled the production of berries on a large scale. Polish industrial farms cover now a thousand hectares. **Poland is currently the largest producer of aronia berries in the world!**

The cultivar "Nero-Eggert" registered in 2022 is characterized by very good fertility -the berries ripen simultaneously, which is important when using combine harvesters.

Aronia does not require chemical protection against pathogens, pests and diseases, therefore fruits do not contain traces of pesticides. It is an ecological type of fruit.

The majority of juice manufacturers have aronia juice amongst their products and the demand for aronia fruit increased. Actually, in Poland a series of aronia products are on the market: fresh and frozen berries, juice, juice concentrate and dry extract rich in anthocyanins. Greenvit, manufacturer of herbal extracts, produces innovative dry

extract; "Aronvit" superextract from superberies was presented in 2019 at Vitafoods in Geneva.

We want to encourage you to cultivate aronia, and the best solution seemed to be organic plantation. Besides money and healthy crops, organic plantation gives satisfaction, enables life in agreement with Nature. How to design and manage the plantation? The information can be found in the book of Piotr Eggert [3].

Local or global? We observe a comeback to traditional food. People are looking for sourdough bread, homemade jam and fresh fruit juice. Health depends greatly on the nutrition: „*You are what you eat*". So, eat fresh, unprocessed food, not the products containing plenty of preservatives. *Eat local* and eat slow, not in a hurry. "*Slow food*" is an alternative to "*fast food*". It focuses on food quality.

In 2020, the outbreak of COVID-19 has highlighted the significance of food delivery and social contacts. COVID-19 has been a chance to slow down! Staying at home allows to buy and trade very locally. People are participating in community and backyard gardening. Owners of small gardens can plant 2-3 bushes in backyard of the house. The plants are decorative and aronia fruits can enrich everyday diet.

Plantation

Flowers and pollinator – honey bee

Why is aronia unique? Chemistry of berries

Water is the main component of all fruit; in the second place we find sugars. Ripe fruits of aronia have 74-83% of water and 17-26% of dry mass, circa 10% of fresh fruit mass are sugars.

Polyphenols have one or more OH groups linked to aromatic ring. Amongst polyphenolic compounds are flavonoids: fiavonols, flavanols, anthocyanins, catechin /epicatechin and the dimers or trimers (called procyanidins or proanthocyanidins) and high molecular mass polymers – tannins, as well as phenolic acids. On average, aronia fruits can have up to 1-2 g polyphenols in 100 g.

Anthocyanidins – (aglycones) are polyphenols and anthocyanins are glycosides (anthocyanidins linked to sugars). Their concentration is particularly high in the dark soft fruits and berries. The names of fruits are informative, as well: black currant, blackberries.

Aronia is one of the richest natural sources of anthocyanins, containing from 300 to 850 mg anthocyanins in 100 g of fruit, typi-

cally ca. 500 mg. Four anthocyanins have been found with only one aglycone cyanidin and the sugars: galactose, glucose, arabinose and xylose. The dominant anthocyanin is cyanidin-3-O-galactoside (60%); cyanidin-3-O-arabinoside is also a major constituent.

Tannins are high molecular polymers composed of flavan-3-ol units. Tannins of aronia are built up with molecules of (-)-epicatechin. Their content is high (over 1.5%), significantly higher than in other berries, and over 80% are those longer than 10 units. **This is the highest amount of tannins found in edible fruits!** Tannins give aronia fruits the special hardness of drying up the mouth; the effect is described by the name "chokeberry". Therefore, fresh aronia fruits are not suitable for consumption. The juice, jams and other sweetened products are tasty.

Usually, one type of polyphenolic antioxidant dominates in particular fruit. **The simultaneous presence of high amounts of anthocyanins and tannins is a unique feature of aronia berries.**

The total content of organic acids in aronia berries was determined as 1.1-1.3%, including: malic, tartaric, citric and succinic. **Aronia berries contain significant amounts of hydroxycinnamic acids**: chlorogenic (35.5 mg/100 g) and its isomer neochlorogenic acid (21.5 mg/100 g). Chlorogenic acids are widely occurring in plants and in many foods (e.g. coffee, apple juice); the acids are effective antioxidants and might contribute to the prevention of several diseases.

Aronia fruit is rich in amino acids and is a suitable raw material for wine production. Fruit must contains 5488 mg/l, whereas musts from apple only 693 mg/l.

Amygdalin is a cyanogenic glycoside found in the kernels of many fruits. This glycoside is responsible for the bitter-almond smell of the fresh aronia fruit. Resveratrol is present in fruits such as grapes, bilberry, blueberry. Grape skin and red wine are the best known sources of resveratrol. The studies performed at the Medical University in Warsaw revealed the presence of resveratrol in aronia fruits. Resver-

atrol gained the attention due to its beneficial cardiovascular effects. So, we can drink a glass of red wine or a glass of aronia juice.

Fruits of aronia contain carotenoids: β-carotene (16.7 mg/kg) and β-cryptoxantin (12.2 mg/kg) as main components. Nine carotenoids were detected: three carotenes and six xanthophylls.

Vitamins content of the berries: vitamin C 13 – 270 mg/kg, vitamins B: B1 180 μg/kg, B2 200 μg/kg, B6 280 μg/kg, niacin 3000 μg/kg, pantothenic acid 2790 μg/kg, folate 200 μg/kg; tocopherols 17.1 mg/kg, vitamin K 242 μg/kg.

Volatile compounds - pleasant smell of aronia fruits is a result of a mixture of volatile compounds, mainly of the ester type, of which over 20 have been identified.

Minerals - the mineral content of the berries (ash) was found to be 440 - 580 mg/100 g. Aronia fruits contain macro- and microelements, such as: potassium, calcium, phosphorus, iron, copper, manganese, zinc, iodine.

Aronia fibre - in the fresh fruits 56 g/kg of fibre was found, including 3,4-5,8 g/kg pectins. Dried powdered waste contain 85% fibre; unsoluble fraction (82%) contains 25% cellulose 20% hemicellulose, 20% lignins. The powdered aronia fibre is dark violet, almost black; its color suggests that this material is rich in anthocyanins. The powder obtained from berries' skins can be an additive for production of functional foods (e.g. bread, cakes).

Superfruits and superberries

A superfruit is a fruit that offers extremely high amounts of multiple nutrients beneficial for our health. There are dozens of very healthy fruits, and enough research has been done on: acai berries, aronia berries, blueberries, cranberries, goji berries, mangosteen fruit, noni fruit, pomegranate fruit, sea buckthorn berries, or currants. Note, that majority of superfruits are....berries! The berries had the highest levels of antioxidants among the fruits and provide the largest amount of valuable polyphenols according to serving size.

Looking at consumption per capita (g/day) it is clear that blueberries or cranberries are underutilized in an average American diet. In the North European countries domestic berries are consumed in abundance because other fruits grow poorly in the northern climate. Berries have long history in folk medicinal uses, now their potential health benefits are intensively studied. Compositional data on phenolic compounds in berries has been rapidly accumulating and included in the national food composition database.

Free radicals and antioxidants

What a radical really is? A free radical is a molecule (or its fragment) with an odd number of electrons (represented as dots near chemical formula, e.g. $OH^{\cdot}$). A majority of radicals live only a fraction of a second and are difficult to detect. Oxidation means a loss of an electron, reduction – a gain of an electron. The words **oxidant** and **antioxidant** can be frequently met in books, reviews and scientific publications. An antioxidant is a chemical compound which strongly inhibits oxidation process. Chemical reactions of oxidation and reduction accompany all life processes in plants, animals and humans. Oxygen-derived free radicals and cascades of other radicals are toxic for cells. The excess production of these radicals is called "**oxidative stress**". Oxidative stress contributes to neurodegenerative disorders, including Alzheimer's disease, Parkinson's disease and neuronal loss associated with the cognitive decline. The aging process has also been linked to cumulative effects of oxidative stress.

Evolution has developed effective antioxidant and antiradical systems. Healthy people consuming enough fruit and vegetables should not worry about free radicals.

Intensive physical exercise cause damage by means of the increased oxidative stress, the consequences of a hugely increased oxygen consumption by the working muscle. Constant psychological stress can make people sick. Everyone living under psychological or physical

(athletes) stress might benefit from a diet rich in antioxidants found in a wide range of fruits, including berries like aronia or blueberry.

Antioxidants and migrating birds. Humans undergo oxidative stress during exercises, and the same is true for birds. Some birds change their diets before winter migrations. The birds specialized for eating insects suddenly begin picking dark berries instead. This suggests that the birds might be deliberately seeking out foods high in antioxidants, which would help protect their bodies from the stresses of migration. The birds' favorite include arrowwood, winterberry, chokeberry and elderberry.

Dietary antioxidants

Is antioxidant-rich diet really necessary for human health? It could be proved, but not directly. Humans cannot be treated like mice: one group obtains fruit and vegetable and another does not. In most developed countries, high dietary intakes of saturated fat and cholesterol positively correlate with mortality from heart disease. In simple words it means: more fatty bacon - more heart attacks. However, with similar fat intakes as in the USA or UK, mortality rates in south France are significantly lower. Since **a distinguishing feature of the French diet is the consumption of red wine with meals, the discovery has become known as the "French paradox"**. French and Italian populations have also the benefits of a Mediterranean diet.

The recommendation that Americans and Europeans consume more fruits and vegetables appears well supported. **In the case of infection or inflammation it would be beneficial to consume more berries than bananas.** Consumption of ½ cup of blueberries or aronia gives more remarkable contribution to the antioxidant barrier of organism.

When buying fruit for dessert, we take into account the price and quality or preferences of our family. It is also worth considering the knowledge on chemical composition and antioxidant properties of

the fruits and berries. There are fruits characterized by particular high content of polyphenols and strong antioxidant properties, contributing significantly to the antioxidant defense barrier. To assess comparatively the antioxidant capacities of polyphenol-rich fruits, ORAC (oxygen radical absorbance capacity, in micro molar Trolox equivalents/100g fresh weight), FRAP (ferric reducing ability of plasma, in micro molar Fe^{+2} /100g of fresh fruit), and DPPH (free radical scavenging) assays are widely utilized.

The total antioxidant capacity, measured as ORAC and FRAP in the extracts of the different *Vaccinium* berries, raspberries, black currants was significantly lower than for aronia. **The highest ever obtained antioxidant capacity ORAC for fruits or berries is 160 µmol TE/g for aronia (chokeberry)!** The surprisingly high ORAC value for aronia berries corresponds with high content of anthocyanins and other polyphenolics.

Are the anthocyanins absorbed? Progress in analytical techniques enabled the detection of chemical compounds even at nanomol (10^{-9} M) level. Therefore, anthocyanins can be identified in body fluids. **Volunteers consumed approximately 20 g (!) chokeberry extract containing 1.3 g cyanidin 3-glycosides**. Blood and urine samples were collected and analyzed. The study confirmed that humans absorb cyanidin 3-glycosides, their average concentrations persisted in urine samples at levels of 12 nmol/l.

In the USA, the daily intake of anthocyanins was estimated at ca. 200 mg which is approximately ten times more than the intake of flavonoids (23 mg/day). The inhabitants of the northern countries generally consume more berries, and the consumption of ½ to 1 kg per day does not make any harm. For more than a thousand years people have consumed berries, including bilberry, blueberry, elderberry, cranberry without any limits and considered berries as healthy food. It confirms that anthocyanins are not toxic to humans.

Aronia in the medicine. Biological studies of aronia compounds

Biochemical reactions and activities could be characterized using cell cultures and tissues, laboratory animals or healthy volunteers. The most convincing are the results of epidemiological studies. Biologically active compounds present in the black aronia berries exhibit antioxidant, anti-inflammation, antiproliferative, antimicrobial and antiviral activities. Anthocyanins have been shown to prevent and cure diseases such as cardiovascular disease, obesity or diabetes. Moreover, anthocyanins can cross the blood-brain barrier (BBB) and delay aging-related degenerative diseases.

Atherosclerosis and heart diseases

The intake of saturated fat, insufficient amount of fruit and vegetables, smoking, psychological stress, accelerate the development of atherosclerosis. Atherosclerosis results in decreasing blood supply to the heart or brain, leading to myocardial infarction and ischemic stroke, respectively.

Polyphenols of chokeberry can be useful in the protection, exerted relaxant and platelet anti-aggregation effect. The patients who survived infraction and have received statin therapy were given chokeberry extract for a period of 6 weeks. The extract contained anthocyanins (25%), procyanidins and phenolic acids. A significant lowering of systolic and diastolic blood pressure by an average of 11.0 and 7.2 mmHg was observed in supplemented persons. Chokeberry polyphenols reduce the severity of inflammation; regardless of statins, they can be used clinically for prevention of ischaemic heart disease.

The protective effect is partially explained by the inhibition of LDL oxidation and by reduced platelet aggregability. Some flavonols and oligomeric catechins also produce relaxant effect and reduce blood pressure. Aronia berries or aronia extract should be included

in the diet to inhibit atherosclerosis and thus to prevent heart attack and stroke.

Especially in the preventing atherogenesis, heart attack or brain infarct, **the role of aronia may be the "Polish antioxidant paradox"**. Increased consumption of aronia juice and administration of aronia extract (in capsules) can give protective effects and decrease the incidences of fatal myocardial infarction.

Fighting against cancers

Polyphenols of aronia can play an important role in prevention of cancer development since antioxidants modulate all three stages: initiation, promotion and progression of cancers. Following one of the healthy diets: Mediterranean (much fruit and vegetables, olive oil), Asian (high consumption of soy products) or vegetarian (almost exclusively plant-derived foods) may help to prevent and fight any cancers.

Fruits, vegetables and whole grain cereals are protective against cancers of digestion tract. Dietary fibers considered earlier only as the ballast materials now become appreciated as preventive agents. The grape, bilberry and chokeberry extracts were investigated for their potential preventive activity against colon cancer. All extracts inhibited the growth of cancer cells, with the chokeberry extract being the most potent inhibitor.

Cyanidin and cyanidin-glycosides showed a protective effect on the DNA. The results suggested that the antimutagenic influence of anthocyanins from aronia is exerted mainly by their free radicals scavenging action. The induction of apoptosis by anthocyanins as well as their anti-angiogenic action may be also the pivotal mechanisms. Anthocyanins are able to decrease the side effects after chemotherapy (cyclophosphamide therapy).

Anthocyanins of aronia cannot replace the therapy proposed by a physician. However, they may protect from cancer development

and may support endogenous defense systems. Their role as preventing agents is promising.

Neuroprotective activity

Oxidative stress contributes to Alzheimer's and Parkinson's disease, cerebral ischemia/ reperfusion injuries, neuroinflammation and the aging process. Oxidative stress-related neuronal decline can be inhibited by dietary intervention, supplementation of neuroprotective compounds. Studies on aged animals confirmed that dietary intervention are important for "neuronal health". Extracts prepared from spinach, strawberry and blueberry appeared to be effective in reversing certain age-related deficits in the neuronal and behavioral parameters, and the blueberry extract rich in anthocyanins was the most effective. Clinical trials with Alzheimer's disease patients have shown that they respond well to treatment with nutritional antioxidants.

The high apparent permeability of the some flavonoids, anthocyanins and phenolic acids across the blood-brain barrier (BBB) was observed. Anthocyanins are capable of crossing the barrier and then locating in different brain regions associated with cognitive performance. Extracts of blueberries were effective in the increasing of cognitive function, improving memory and learning. It stimulated the studies on other berries. The anthocyanins isolated from black chokeberry were used to investigate the neuroprotective effect against amyloid-β-induced memory damage. Rats receiving purified anthocyanins treatment showed improved spatial memory in a water maze test, and better protection of the hippocampus. The results demonstrate **that anthocyanins could serve as antioxidant and neuroprotective agents, with potential in the treatment of Alzheimer's disease**.

Parkinson's disease causes a progressive movement disorder. Polyphenols offer protection to the cardiovascular system - reduction

of deficits in oxygen and glucose delivery to the brain by increasing blood flow. This observation highlights possible neuroprotective effects of berry extracts.

Chronic alcohol consumption is known to cause oxidative damage to brain. A better alternative is to drink red wine than pure ethanol (vodka) – because antioxidants may counteract free radical cascade.

Healthy eyes in computer society

Special care should be taken to keep our eyes in good health. The most vital for vision is the retina, and at its center is the macula, a small area which selectively concentrates carotenoids, lutein and zeaxanthin. Oxidative stress is implicated in the development of age-related macular degeneration and in the initiation of maturity onset of cataract. Diets rich in antioxidants may help to slow these pathological processes. Anthocyanin extracts reduce capillary permeability and fragility and may improve symptoms associated with weak eyesight. Diabetic retinopathy is a side effect of diabetes that can cause blindness. Again, polyphenolics improving capillary elasticity may be helpful. Strong antioxidant properties of anthocyanins from aronia should be effective in preventing oxidative, degenerative changes of rodopsin dye in retina.

A diet rich in berries was recommended for pilots and professional drivers. Well known is the story that during World War II the pilots of British RAF consumed bilberry jam in order to keep proper vision during night flights. The hypothesis that anthocyanins improve night vision was not supported by evidence from rigorous clinical studies. However, anthocyanins may cross the blood/brain barriers and influence the functions of the brain - improve signal transmission in the cerebral cortex responsible for vision.

At present, more and more people work watching monitors or spend several hours at a computer desk. They are interested in maintaining visual acuity and may benefit from the polyphenols intake.

School children as well as adults watching fast changing images at a monitor or a TV screen can drink a glass of aronia juice with positive effect to eyes health. Anthocyanins from aronia, blueberry or bilberry may be beneficial for persons who work with computers and for car drivers frequently traveling long distances.

Diabetes

Diabetes is one of the major diseases concerning the people all over the world. Many studies have reported that anthocyanins are beneficial in diabetes due to their capacity to reduce oxidative stress and to stimulate insulin secretion. Anthocyanins may contribute to the prevention of obesity, which is associated with the reduction of sugars and lipids absorption in the digestive system.

Beneficial effects of long-term consumption of aronia juice on metabolic parameters including fasting plasma glucose and lipid profiles have been reported. Polyphenolic compounds of aronia have beneficial effects in reducing blood glucose levels due to inhibition of α-glucosidase and thus preventing the onset of diabetes by controlling postprandial hyperglycemia. Polyphenols extracted from black chokeberry and elderberries were administrated to diabetic Wistar rats for 16 weeks. Both extracts modulate specific and non-specific immune defense in insulin-deficiency diabetes and reduce the inflammatory status.

The ability of anthocyanins to stimulate insulin secretion from pancreatic beta cells *in vitro* have been also determined. The glucosides of cyanidin were the most effective among the anthocyanins. Chlorogenic acid has been proven to reduce the absorption of glucose and thus blood glucose levels. These results suggest that **aronia, rich in anthocyanins and chlorogenic acids, may be recommended to diabetics.** For an improvement of glucose metabolism, scientists recommended daily consumption of 200 ml of aronia juice for at least three months.

Skin care

As an organ permanently exposed to the environment, the skin is often a target for oxidative stress. Basically, there are two different approaches, which should be combined: (1) topical administration of an antioxidant (cosmetics: nourishing cream, lotion, body milk) and (2) oral ingestion of antioxidants (diversified foods, functional foods, dietary supplements).

Bioactive compounds from antioxidant-rich berry extracts are able to permeate through the stratum corneum into deeper skin layers, they contribute to the collagen and elastin regeneration. The premature aging of the skin repeatedly exposed to ultraviolet radiation is known as photoaging; such skin is characterized by wrinkles, is dry and rough. Polyphenolic compounds of aronia have maximum of absorption in UV range (at 280 nm), anthocyanins absorb visible light (maximum at 520 nm). When applied topically they act as chemical sunscreens, additionally to the radical scavenging activity.

Ingestion of polyphenols protects against an inflammation response. Planning a holidays on a sunny beach, one should consume more fruit and vegetables. **Drinking aronia juice or intake of encapsulated aronia extract several days before the travel allows for enjoying sunny weather longer without a harm to skin.**

Aronia and infertility

In many developed countries there is an increase in amount of couples, which should be treated due to infertility. One of the causes may be oligospermia. Men with oligospermia received the extract of anthocyanins from aronia (300 mg per day). Application of natural anthocyanins resulted in significant reduction of oxidative stress in plasma and increase of fructose level in sperm. Fructose is critical for movement of the sperm cells, induces their sudden mobility. **Anthocyanins from aronia, as natural antioxidants, may increase chances of having a baby.**

COVID-19 and post COVID

Nutraceutical and botanical treatment of infections with SARS-CoV-2 become important, especially interventions that modulate the immune system or impair viral replication. A coronavirus can be deadly because of its ability to uncontrolled release of pro-inflammatory cytokines, leading to cytokine storm and severe damage to respiratory epithelium. While recovering from COVID-19, some people experience depression, low mood, fatigue, stress and "brain fog", such symptoms are common part of long COVID. Berry juices and extracts rich in antioxidants may help!

Polyphenols (quercetin, catechins) are natural compounds which may counteract the COVID-19 inflammation-related problems. They inhibit the COVID-19 main protease (M^{pro}), which is necessary for viral replication. The antiviral activity of black chokeberry, elderberry, and pomegranate juice were determined against influenza A virus and SARS-CoV-2. **Oral rinsing with Aronia (chokeberry) juice reduce viral loads in the oral cavity which might prevent viral transmission.** To assess the in vitro antiviral ability, the blend of extracts from aronia and elderberry were tested against human respiratory tract viruses. Both extracts strongly inhibited A/H1N1 replication as well as HCoV-OC43 β-coronaviruses. A mechanism of action makes this blend the most relevant for potential drugs and supportive treatments.

Anthocyanins are capable of crossing the blood-brain barrier and may improve post-COVID brain functions. Neochlorogenic and chlorogenic acids also have beneficial effects, both might act as a natural anti-inflammatory agents for the treatment of acute pneumonia and alleviate oxidative stress. Chlorogenic acid is a potential inhibitor of COVID-19, blocking SARS-CoV-2 receptors, such as ACE2 and its co-expressed proteins considered as the key target of coronaviruses in entering the cells.

Aronia juice rich in anthocyanins and chlorogenic acids may support recovery after COVID-19 and should be recommended to convalescents.

Other diseases

Besides virus and bacterial infections, like influenza (flu) and cold, the list of diseases of free radical etiology includes: rheumatoidal arthritis, allergies, gastric ulcer, inflammation of pancreas, cadmium intoxication, military gases intoxication or radiation sickness.

Strong antioxidative properties of anthocyanin-rich extract from aronia can be beneficial in the treatment of intoxications by petrol ingredients or heavy metals (Cd, Pb). Anthocyanins from aronia have been administrated for two months in personnel of gasoline stations, professionals who have to inhale petrol products and car exhaust for several hours per day. The berries of aronia may be useful in the treatment of acute intoxications by mustard gas and other agents (deposited in Baltic sea after World War II), as well as permanent exposition to benzene hydrocarbons, chlorinated hydrocarbons etc.

Radioprotective properties of aronia

Anthocyanins from aronia are effective radioprotectors, when administrated orally in proper dosage may have a beneficial influence in radiation sickness.

On April 25/26, 1986 the world's worst nuclear power accident occurred at Chernobyl in the Ukraine. On March 11, 2011, the tsunami that followed the earthquake devastated Japan's coast and the nuclear power plants at Fukushima. To be precise: radioactive fission byproducts were released as a result of a subsequent failure of emergency power.

We do hope that no disaster will occur in future but there are still numerous nuclear power plants working in Europe and America.

Successful treatment of men should be indispensable in every emergency plan considering accidents and exposures to radiation sources. **A reasonable plan in the cases of irradiation accident is to administrate high dose of effective antioxidants, such as extracts of aronia.**

The radioprotective effects of aronia's anthocyanins have been confirmed in the experiments performed on cells and laboratory animals (mice, rabbits). Chemical compounds present in aronia extract are effective antioxidants and free radical scavengers; they are able to counteract oxidative stress in cells after γ-irradiation.

Cosmic radiation

Earth and its inhabitants are constantly bombarded by radiation from space that originates in the sun and the galaxies. The amount of cosmic radiation increases with altitude. Airline crews and passengers flying high latitude routes at 10-11 km can be exposed to extra radiation. How to protect the airline crew? There are no practical ways to shield humans during a flight. However, an adequate intake of antioxidants (vitamins, carotenoids, polyphenols) seems to be essential to prevent free radical-related disorders as well as an efficient function of the immune system. **Frequent fliers should add high antioxidant foods to their diet.**

Aronia for airline passengers

Long flight may cause upset to digestion and other physiological functions. How to reduce the cabin's negative effect? Superior classes of protectors are superberries, such as aronia. Our advice is to drink fruit juice - to fill the body with water and antioxidants. Swollen legs and blood circulation problems challenge the attempts to stay healthy while flying. People who are overweight, elderly, smokers, women on estrogen pills and pregnant are especially at risk. Natural, safer blood thinning agents are berry extracts rich in polyphenols. Aronia

juice may play an important role in prevention, reduce platelet adhesion and aggregation. Stress or fear of flying constricts veins and increases blood clotting factors. So, drink a glass of aronia juice and relax. Hundreds of people in the aircraft cabin – it is the environment which allows airborne bacteria and viruses to spread. **The best way to provide protection is boosting immunity and generous intake of berry fruit juice. Now, aronia juice can be recommended to drink onboard.**

Human missions to Moon and Mars with aronia

US, European, and Asian agencies are developing proposals for human missions to Moon and Mars, from scientific expeditions of astronauts to the permanent colonization. However, outside our planet the environment is deadly for human beings: cosmic rays, prolonged weightlessness, blood flow problems, psychological effects of isolation. Proper medicinal food and dietary supplements rich in antioxidants would be necessary in order to keep a crew healthy over a long period of time. **Dry aronia powder should be available onboard for coping not only with radiation sickness but also to support the adaptive responses of the human body in space.**

Aronia in food and cosmetic industry

Agricultural companies in Poland produce over 15,000 ton of aronia fruits every year. The fruits are used for production of juices, jams, fruit-and-herbal teas and alcoholic beverages: aronia wine and liquor. Food companies from Germany, Scandinavia and Austria are buying fresh fruits from Polish growers. Manufacturers of functional foods from the USA, South Korea and Japan are interested in the aronia juice concentrate. Poland, as a member of the UE, may easily introduce aronia products to other European countries and popularize this berries worldwide. The increasing demand for the aronia berries is a chance for farmers and also for small agricultural enterprises.

Aronia berries are a valuable raw material for manufacturing juices and its concentrates because they are characterized by a deeply red, intense color, which is relatively stable in time. Polish manufacturers of aronia products sell pure aronia juice, mixed apple-aronia juice and aronia jam, which are amongst the most popular products. Manufacturing of anthocyanin-rich products is not an easy task from a technological point of view. The juice is obtained by a mechanical process, according to the Codex Alimentarius Standard.

Fruit waste is a valuable material, containing dietary fibers, pectins and antioxidants. It may be further manufactured in order to obtain a natural dye or add to some food products.

The powdered aronia fibre is dark violet, almost black; its color suggests that this material is rich in anthocyanins. The powder obtained from berries skins can be an additive for production of functional foods (bread, cakes). Bread with aronia fiber is promoted as "bread for your heart", although it is beneficial mainly for the digestion tract.

Dried aronia berries (cut or powdered) are favorable ingredients of fruit-and-herbal teas. The teas are tasty and exhibit strong radical scavenging properties. Anthocyanin dyes give them the beautiful red color and add significant contribution to the antioxidant capacity. The consumed polyphenolic compounds are soluble in hot water, and absorbed from the digestive tract.

The condensed juice of aronia with a high content of sugar is popular as syrup, used for homemade beverages. Syrups of aronia berries may contain other ingredients, such as honey or vitamin C.

Anthocyanin extracts of aronia are used in cosmetics mainly due to its strong antioxidant and radical scavenging activity. Gels containing 0.01 do 0.1 % of anthocyanin extract protect skin for UV radiation. Their protection effects can be compared to those achieved using sun creams with protecting factor (PF) equal to 18.

Aronia in the kitchen

Being an owner of 2-3 shrubs of aronia in the home garden one can pick up several kilos of berries in September. Some berries may be left on the shrub, for birds. Good idea is to freeze aronia in small plastic bags and store them for several months in the freezer.

A portion of frozen aronia berries mixed with sugar and yoghurt is excellent, healthy dessert for winter days.

Berry yogurt: a cup of frozen berries or 1 spoon aronia juice concentrate and a cup of plain yogurt. Add about 1/2 pinch of stevioside and mix.

Cocktails (shakes)

1. Summer cocktail with aronia juice: mix 1 cup of yoghurt, 1 cup of juice, ½ cup of ice cubs, 1 teaspoon of sugar.
2. Mix 1 cup of frozen berries, 2 cups of milk, 2 cups of ice cubes, 2 spoons of sugar, 1 teaspoon of vanilla sugar.
3. Mix ½ cup of frozen aronia, 2 sliced apples, 2 spoons of sugar, 1 cup of milk and 2 pinches of cardamom.
4. Mix: 1 cup of aronia fruits, 1 cane of peaches in light syrup, 2 spoons honey. Peaches can be replaced by pears or banana.

Homemade jam

Jams with aronia and apples (pears, plums): 2 kg of aronia, 1 kg of other fruit, ½ kg sugar. Cook fruits for 1h and stir the entire mix. Pour into the jars and close tightly (pasteurize for 20 min).

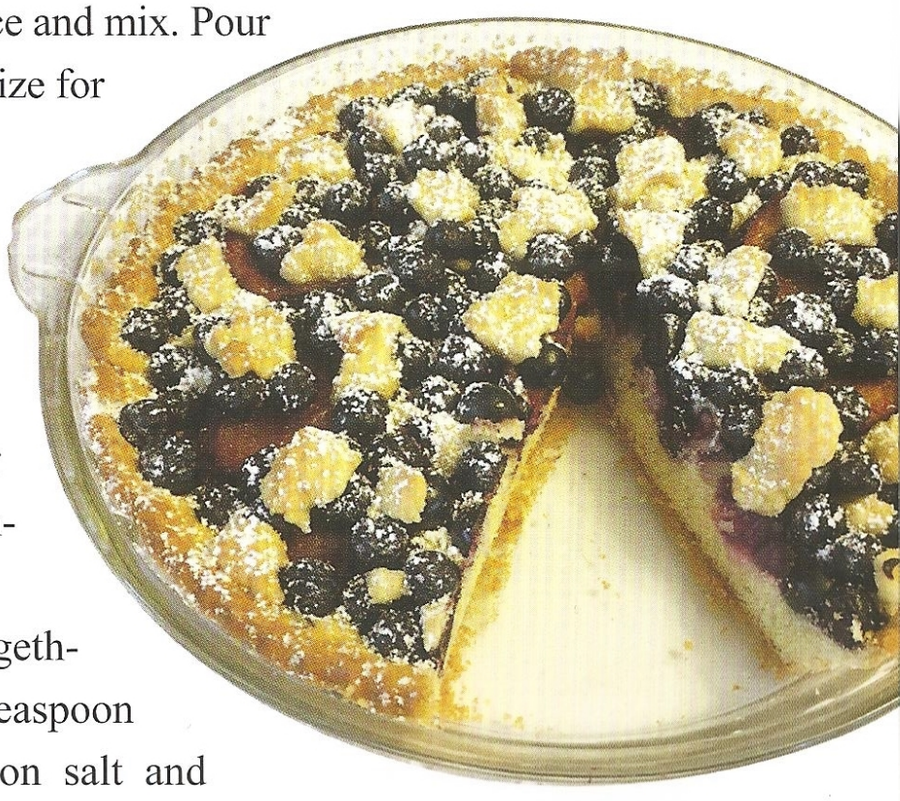
Homemade aronia juice

2 kg aronia fruits, 3 l water, 5 dkg cherry leaves, 1/2 kg sugar (or ½ l honey), lemon juice. Aronia fruit and the leaves cover with water, cook gently for 1 h and strain. Then add sugar and lemon juice and stir the entire mix. Pour into the bottles and pasteurize for 20 min.

Sour juice: 2 kg aronia fruits, 3 l water, lemon juice. Aronia fruit cover with water and cook gently for ½ h. Leave to cool down and

strain. Then add lemon juice and mix. Pour into the bottles and pasteurize for 20 min.

Cakes: sponge biscuit, shortcake, yeast-raised cake and other fruit cakes are tasty with aronia berries. Popular tarts are with plums, peaches, and strawberry.



Cake with plums and aronia, baked by Krystyna Eggert

Aronia bread: Sift together 2 cups flour, 1 1/2 teaspoon baking powder, 1 teaspoon salt and 1/2 teaspoon baking soda. In blender, combine 1 egg, 1/8 cup shortening, 3/4 cup orange juice, and 1 cup sugar. Add 1 cup aronia berries and nuts and chop briefly. Empty into flour mixture and mix by hand until moistened. Bake in a greased pan at 350F (170-180 C) for 50 to 60 minutes.

Aronia sweets: candied berries, berries in chocolate – tasty and healthy.

Aronia in Poland and abroad

We recommend the cultivar "Nero-Eggert", registered in 2022, suitable for machine harvesting, characterized by heavy production of berries which ripen simultaneously.

The plants start to grow in a nursery.

The team of the authors hopes that your plantation will look great and produce plenty of these healthy berries.

Cuttings of Aronia –Eggert cultivar in a nursery

Cuttings with good root system, ready to plant outdoors

Aronia cultivar "Nero-Eggert", cuttings prepared for the travel abroad

From cuttings to the crops. We wish you a success!

Aronia in the world

Aronia in Russia

Aronia was grown in Russian botanical gardens. In the 1930s it became a subject of interest of Russian botanist Ivan Mitchurin who was looking for fruits resistant to cold climate. Russian genotype was named *Aronia mitschurinii*. Aronia is cultivated on an industrial scale near Moscow and St. Petersburg, as well as in the Altai Mountains. Aronia (*Aronia mandschurica*) gave there good crops.

Aronia in Germany

Commercial cultivation of aronia began in 1976 in East Germany close to Bautzen and Dresden. Now there are plantations in Hesse, Sachsen, near Coswig and Dresden. Aronia grows successfully on the hills of Bayern/Bavaria. An organic plantation near Passau produces certified aronia juice.

Aronia in the Turkey

Dr. Aronia started with small plantation and now it is the biggest aronia plants distributor in Turkey. From high mountains to three seas. The company is run by Aylin Kalafatoglu. One part of business are aronia products such as aronia salt, helva aronia cream, and sweets.

Aronia in America

The homeland of aronia is the eastern United States and Canada. Natives and early settlers in America used the berries as medicine, food and dye, but the berries did not become popular for commercialization in the U.S. until recently. Growing a few bushes at the backyard is a very good investment in family health.

Aronia is an excellent crop for alternative farming. In Iowa and Nebraska the shrubs grew well in an organic situation and the maintenance is easy. Popular cultivars, sold by some nurseries in the USA

are "McKenzie", "Viking" and "Nero". The farmers said they see the market increasing, as more people learn about the benefits of the fruit.

Aronia in Canada

Aronia products are available in several locations in Canada, but it is worth to drive to Silvios Aronia Farm in Fort Perry, Ontario. Silvio Mattacchione invites to "Pick-Your-Own-Aronia Berries" in September.

Aronia in South Korea

The climate in South Korea with humid warm summers and cold winters is suitable for growing aronia. Korea started to grow aronia in the Danyang Province. In 2013 The Danyang Aronia Agricultural Association Corporation organized first international symposium and opened fruit processing plant. Danyang-gun, which has been famous as a garlic growing district, is now rising fast as a producer of aronia berries. The berries are called "King's fruit"! One can buy few seedlings for the garden and thousands of plants from the nursery in Gyeonggi Province.

Aronia in Japan

In 1976, aronia was introduced to Japan from the former Soviet Union. In 2001, the berries harvested in Hokkaido were studied in Hokkaido Food Processing Research Center. The extract of Japanese black aronia was rich in anthocyanins and other polyphenols. The scientists from Hokkaido University School of Medicine, Sapporo, showed anti-inflammatory effects of the extract.

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About the authors

Iwona Wawer - Professor emeritus, in 1995-2017 the Head of the Department of Physical Chemistry, Faculty of Pharmacy, the Medical University of Warsaw. The Head of Scientific Committee of the Polish Council for Supplements and Nutritional Foods. Her research interests include studies of bioactive compounds isolated from plants using multinuclear NMR and ESR spectroscopy. The author of over 200 scientific papers and books on Aronia and dietary supplements.

Piotr Eggert - M.Sc. Eng., the pioneer aronia cultivator in Poland. He graduated from the Warsaw University of Life Sciences and has been involved in the studies on this plant since 1975 – first as a researcher at the Research Institute of Forestry and now carrying out research in his own nursery "Aronia Eggert". 45 years of plant selection and production resulted in developing the company's own Aronia variety "Nero Eggert". Piotr Eggert is an author of numerous publications on aronia in which he shares his unique expertise with a larger public.

Paweł Eggert – M. Sc. graduated from the Warsaw University (Biotechnology, Horticulture). He is a co-owner of "Aronia Eggert" and also an owner of a company focused on organic food production. His main interest is developing and searching for new markets for aronia products. Paweł is a driving force behind the "Polish Superfruits" project, unifying the efforts to promote innovation and marketing of Aronia products.

ARONIA EGGERT

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&
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Kolonia Bądków 8a
05-610 Goszczyn
tel. 605 361 101
tel. 793 003 259
email: eggert@aronia.org.pl

www.aronia.org.pl