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Aronia Berry: A Potential New Small Fruit and Alternative Crop for North Georgia

Abstract

Consumer demand for healthy foods - especially fruits and berries - is at an all-time high due to their potential well-being benefits and high content of antioxidants. Aronia, Chokeberry fits that bill. Limited knowledge exists in its culture in the Southeast, despite commercial production in the Midwest, and Northeast US. Since 2021 we have established replicated plantings of *Aronia* 'Viking' in Georgia in research setting and on a commercial farm. We have studied chill requirement, plant performance, culture, potential production issues, and yields under subtropical climate. Here, we share results from on-going projects and outreach activities. Plants established very well with limited inputs at all locations steadily increasing yield per bush. In Blairsville, GA experimental site yields increased from 0.41, 1.54, to 4.5 lb in 2022, 2023, and 2024 respectively. Fruit chemistry is comparable to values reported in the literature for northern grown crops. Based on these initial findings, we consider that Aronia berry holds promise as an alternative crop in north Georgia. We also discuss practical considerations for aronia culture on a commercial scale and marketing.

Keywords: antioxidants, chokeberry, Extension, native plants, functional food, superfood, value added

Abbreviations: GMREC, Georgia Mountain Research and Education Center; TSS, Total Soluble Solids; TTA, Total Titratable Acidity

Introduction

Antioxidant-containing foods are being recommended by medical professionals and dieticians as important additions to a healthy diet. Scientists agree that one of the best ways to protect against ageing is to consume a diet rich in fruits and vegetables. Aronia berry, also known as Chokeberry, meets many of these criteria; research has shown that *Aronia* berries have high nutraceutical content (antioxidants: phenolics, anthocyanins) (Shahin et al., 2019; Brand et al., 2017; Taheri et al., 2013; Wu et al., 2006). Aronia berries and extracts have been shown as promising agents with anti-inflammatory, anti-cancer, and cardioprotective effects (Ren et al., 2022; Kulling and Rawl, 2008).

Aronia berry can be consumed raw and as a fresh ingredient in ice cream, chili starters, tea, juices, jam, gummies, beer, salsa, soft spreads, and wine products. Additionally, aronia berry dry extract/powder has been used as colorant in fruit juice (Plocharski et al., 1989) and in dietary supplements (Sidor and Gramza-Michałowska, 2019; Hawkins et al., 2020). Fresh berries have a distinctive, pleasant flavor however, astringency is the most noticeable sensation, caused by tannins (polyphenols). This dry mouth feeling explains the common name, chokeberry. A taste panel study conducted in 2016 (Duffy et al., 2016) reported that aronia juice, even from berries picked at peak harvest, appealed to only a few adults (“sour likers or adventurous eaters”). Despite the objectionability of consuming fresh berries or juice, consumers were willing to purchase aronia when presented with positive health information (Hoke et al., 2017).

There are three aronia berry species, all native to the eastern United States (USDA, 2010). *Aronia melanocarpa* (black aronia), and *A. arbutifolia* (red aronia), and *A. prunifolia* (purple aronia), considered a naturally occurring hybrid between black and

red (Brand, 2010). Aronias are multi-stemmed, deciduous shrubs in the rose family, with white flowers and red, purple, or black berries depending on the species (Brand, 2010). Black chokeberry is a valuable food source for wildlife and is supposed to be the best shrub species for land mine restoration (Kuntz, US Forest Service, pers. comm.).

Aronia berries grown for commercial fruit production and human consumption are *A. mitschurinii*, an intergeneric hybrid between *A. melanocarpa* and *Sorbus aucuparia* (Leonard et al., 2013). Although several cultivars are on the market, e.g. Viking', Nero', and 'Galicjanka', the first is most planted. Moreover, these cultivars are nearly identical when compared with genetic methods (Brand et al., 2017; Smolik et al., 2011).

Commercial production of aronia berry is highest in the Mid-West (Iowa, Wisconsin, Illinois, Missouri), and Northeast US but has been expanding westward to Oregon (Strik, 2003). From information generated in northern areas, aronia berry is adapted to a wide range of soils, tolerating even poorly drained and excessively drained soils; nor does it require overly fertile soils (Ristvey and Mathew, 2011). Based on reports from the literature, aronia berry has few major pest problems (Ristvey and Mathew, 2011) and is amenable to mechanical harvesting. In northern U.S. regions growers can expect to harvest three pounds of fruit per plant in the third year and up to 15 pounds per plant after the crop is 5 years old (Ristvey and Mathew, 2011).

Aronia berries have risen from being a novelty item at farmers markets into a multimillion-dollar U.S. industry (Beck, 2014). In 2023 the global market size was US$ 356.9 million, and it is anticipated to expand to US$ 498.7 million by 2033 (Straits Research, 2023). The current market price of aronia berry can reach $7.50/lb (Zion Market Research). The University of Wisconsin-Madison Center for Integrated Systems (Secher, 2008) assessed 13 unusual fruits with sustainability potential. Aronia was selected as the crop with the greatest promise, surpassing currants, gooseberries, and elderberries. The reasons cited include its low input requirements, high adaptability, strong insect pest resistance, high nutraceutical content, quick time to first yield, ease of cultivation, and high potential for machine harvesting.

Limited knowledge exists on aronia berry culture in the Southeast U.S., even though it is often marketed in regional nurseries as a native shrub with edible berries. No information exists on any commercial aronia berry cultivars grown in Georgia. Small farms typically seek a niche product with multiple appeal; such farms are standard for montane regions of the state. Considering the facts that cranberries are not adapted to grow in Georgia, blueberry markets are stable, and Extension fields stakeholders' inquiries, we considered it timely to investigate the potential of developing Aronia berry as a new specialty crop for the state.

Our overarching goal is to study feasibility of commercial production of aronia berry in Georgia. Several objectives were of interest in this project: 1) conduct a climate-controlled test on young plants to determine chilling hour requirement; 2) establish two replicated sites in different geographic locations in North Georgia to evaluate best establishment practices, assess yield, fruit, and plant health; and 3) set up an educational site at a public location for the purposes of Extension outreach demonstration.

Here, we provide a high-level summary of progress from past studies and on-going trials as well as extension projects conducted in the state of Georgia and discuss our short- and long-term goals.

Materials and Methods

Chilling hour study. To explore chilling hour requirements for aronia berry we subjected dormant *Aronia* 'Viking' 2-year-old liners to 37^0F for 0, 204, 408, 612, or 816 hours (Pennisi et al., 2021). Plants were kept in a controlled environment, first in a cold chamber, followed by a warm greenhouse. Ten replicates per temperature treatment were placed in a completely randomized design. Plants were evaluated weekly for the following parameters: number of leaves, developing buds (bud break), flowers, and fruits over a five-month period. The data were analyzed using generalized linear mixed model in SAS 9.4® (SAS Institute Inc., Cary, NC). Chill hours, days and chill hour days interaction were considered as fixed effect and replication were considered as the random effect. Normality of residuals was checked before interpreting the results. Mean separation was done using lsmeans in

SAS, and adjustments were done using Tukey-Kramer method, and statistical significance was determined at the $P \leq 0.05$ level.

Field studies. A replicated planting of aronia berry plants was established at the University of Georgia Mountain Research and Education Center (GMREC) in Blairsville, GA (USDA Zone 7a, Blue Ridge region) in 2021 (Figure 1). In 2023, a replicated planting was established at Mercier Orchards (commercial operation) in Blue Ridge, GA (USDA Zone 7a, Blue Ridge region), and a demonstration planting at Hardman Farm Historic Site in White County (USDA Zone 7a, Blue Ridge region) (Figure 1). At all three locations, and following standard field preparation, *Aronia* 'Viking' plants in 1-gal (GMREC, 10 replicates) or quart containers (Mercier Orchards, 154 replicates) were planted in a single row on a 4-foot spacing (GMREC and Hardman Farm, 12 replicates) or multiple rows on 8-10 feet spacing (Mercier Orchards).

At the GMREC and Mercier sites, irrigation was provided at planting by hand watering. Plants were mulched and fertilized with 25 grams of N at planting (Osmocote 20-20-20), and each year since in the spring. At Hardman Farm Historic Site, plants were not irrigated at planting, they were mulched but not fertilized.

The planting at Mercier Orchards is an on-farm research project involving three fertilization levels: 0, 6, 12, or 18g N/plant [Nature Safe All-Season Fertilizer (10-2-8)] applied in May 2024.

Figure 1. *Aronia* 'Viking' plantings at GMREC, Blairsville (right, July 2021), Mercier Orchards (middle, November 2023), and Hardman Farm (right, May 2023).

Data. Plant measurements (height and two widths), bloom phenology, total yield, and fruit quality are reported from the GMREC site in 2022, 2023, and 2024. From the Mercier Orchards site, plant measurements data are reported from 2024. Growth index (GI) was calculated according to the formula H + [(W1 + W2)/2)/2]. After harvesting, berries were weighed and stored in a freezer at 0^0F until further processing. Total Soluble Solids (TSS) were measured using a hand-held refractometer and expressed as °Brix, and Total Titratable Acidity (TTA) was assessed with an automatic titrator (Mettler Toledo Easy Pro). Both tests were performed in the laboratory following standard protocols and frozen berries. Data from the field studies are presented as averages only without further statistical testing.

The presence of pests and disease incidence was noted through visual observations, but no systematic data were taken. The presence of beneficial insects such as pollinators and natural enemies were also noted.

Results

Chilling hour study. Bud break was significantly affected by chill hours (Table 1 and Figure 2). We observed earlier bud break and leaf emergence on plants subjected to 816 chilling hours, compared to 204 chilling hours. Even when placed under warm greenhouse conditions, plants that received the lowest chilling hours were considerably slower to leaf out, as much as a month later than those that received 816 hours. Only 40 and 50 % of plants that received the lower chilling treatments broke dormancy a month after moved to a warm greenhouse. By week 19 after the cold treatments, plants subjected to 0, 204, 408, 612, or 816 hours had developed 1.88, 1.74, 2.83, 4.00, or 4.69 bud breaks, respectively (Figure 2). Although flowers and fruits had developed earlier on plants that had received higher chilling hours, by the end of week 19-20, there were no differences among treatments.

Table 1. Statistical analysis results for bud break in *Aronia* 'Viking'. Treatment (tmt): chilling hours (0, 204, 408, 612, 816); Week (wk): Feb 17 – Jun 28, 2021.

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
tmt	4	25	6.59	0.0009
wk	6	150	36.86	<.0001
tmt*wk	24	150	4.22	<.0001

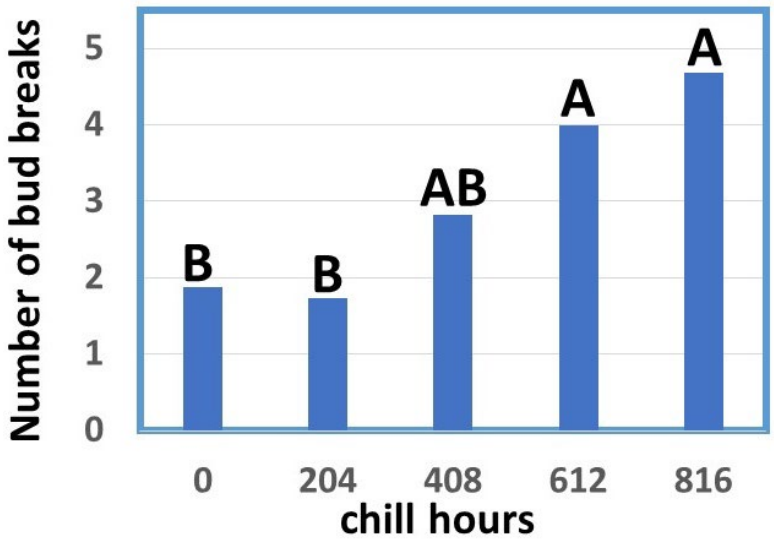

Figure 2. Bud break means for Aronia 'Viking' as affected by increasing chilling hours (data from June 28th, 2021). Means with different letters are significantly different at the $p<.05$ level.

Field studies. Plant survival was 100%, 97%, 100% at GMREC, Mercier Orchards, and Hardman Farm, respectively (data not shown). We could only take plant measurements (height and two widths), bloom phenology, total yield, and fruit quality (TSS and TTA) at GMREC as we quickly learned that young aronia plants need protection from deer browsing. At the GMREC plants are fenced; at Mercier Orchards, a fence was installed in 2024 after intense browsing happened at both locations (Figure 3).

Figure 3. Electrical fencing at Mercier Orchards (left), and individual plant cages at Hardman Farm (right).

Demonstration site. The planting at Hardman Farm State Historic Site has helped to provide additional information as a comparison to the two sites of study. These plants lacked deer protection in their first year of establishment resulting in stunted growth in the first season. Individual wire baskets were placed to add protection. Furthermore, a balanced 10-10-10 fertilizer application topped with mulch was added mid-summer in 2024. Field days for the public are scheduled to take place in early summer of 2025.

Aronia 'Viking' bloomed in May, starting the second week and reaching peak bloom by end of May, with berries maturing from mid-July to mid-August (Figure 4).

Figure 4. Bloom in *Aronia* 'Viking' plantings at GMREC, Blairsville, GA (left, May 2023, middle, May 2024); fruit, (right, August 2024).

At the GMREC site, plants increased 22% in size between 2022 and 2024 (Table 2). Berry production increased from 0.41 lb to 4.5 lb over the same period. Total soluble solids were higher in 2022 (29 °Brix) compared to 2023 (24.3 °Brix) (Leyton Naranjo et al., 2024) while Total Titratable Acidity was 0.95 in 2022, and 1.04 in 2023.

Table 2. Growth Index (GI), yield, Total Soluble Solids (TSS) and Total Titratable Acidity (TTA) of *Aronia* 'Viking' grown at the GMREC in Blairsville, GA for three years. Values are means of 10 replicates.

Parameter	Year		
	2022	2023	2024
GI	271	295	345
Yield (lb)	0.41	1.54	4.5
TSS (°Brix)	29	24.3	-
TTA	0.95	1.04	-

*Missing values are for tests still pending for 2024.

At the Mercier Orchards site, plants also grew well and responded positively to an increase in fertilizer rate (Figure 5). As previously mentioned, due to deer browsing, blooms were not present in 2024.

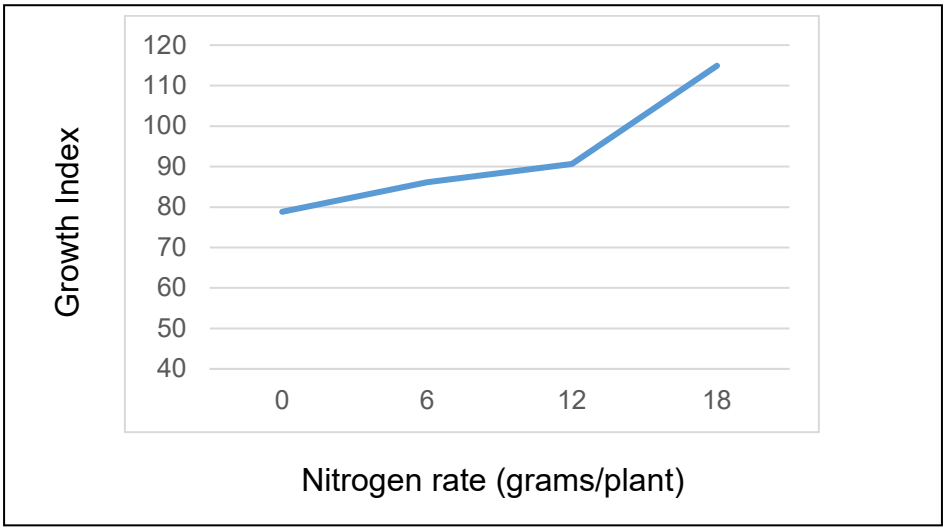

Figure 5. Effect of fertilizer rate on growth Index (GI) of Aronia 'Viking' grown at Mercier Orchards in Blue Ridge, GA. Values are means of 148 replicates. Data are from July 2024.

No major pest or disease issues were encountered. Some foliar damage by Japanese beetle was observed and aphid presence was detected. However, neither pest appeared to significantly impact the plants (Figure 6).

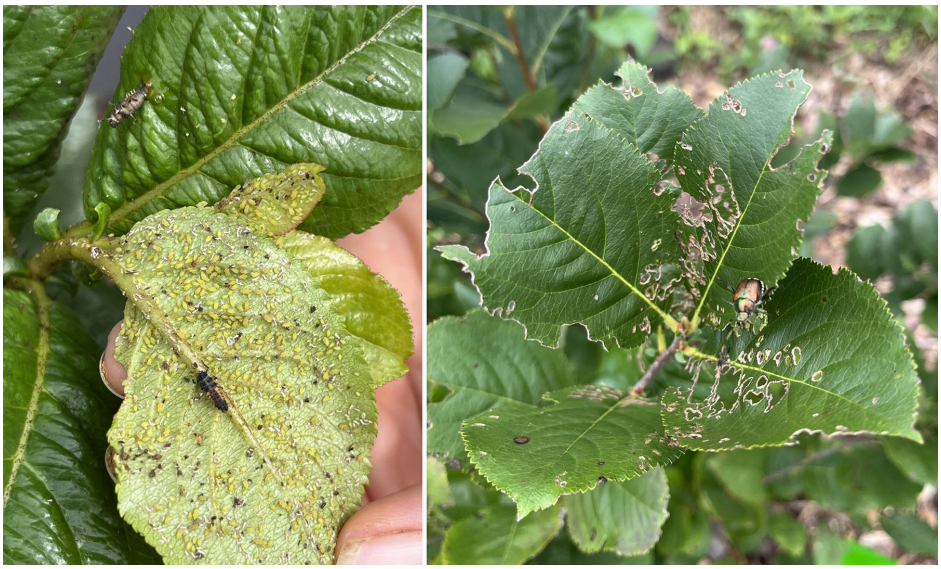

Figure 6. Aphids on *Aronia* 'Viking' foliage (left); lady beetle larva is also present predating on the aphid prey, also parasitism is evident (brown aphid mummies. Japanese beetle and foliar damage (right).

Extension activities. We participated in the NAFEX SE Regional Excursions in October 2023 and did a walking tour of the aronia berry research site. We also shared research findings at the GMREC Field Day in July 2024; the event was attended by 120 stakeholders (Figure 7). Aronia tasting was also offered.

Figure 7. UGA Extension specialist discusses aronia berry project to stakeholders in north Georgia (left). Juice and jam made from Georgia-grown berries also were offered for tasting (right).

Discussion

Chill hours. According to historical data from UGA's weather stations across the state, north Georgia on average receives approximately 2000 number of chilling hours (defined as temperatures below 45˚F) compared to that of middle Georgia with approximately 1300 number of hours (www.georgiaweathernet.net). Even though the chilling hour study conducted in controlled environment did not show significant differences in number of leaves, flowers or fruits after 5 months, field data indicate that fruit set is lower in southern locales (Leyton Naranjo et al., 2023). This suggests that areas in north Georgia may observe higher fruit yields due to higher chill hours. Mahoney et al. (2023) determined the optimal chilling requirements for *A. mitschurinii* 'Viking' to be greater than 900 hours using the single temperature model under field conditions and confirmed the results under a fixed temperature cold room. In the same paper they reported that southern wild genotypes of *A. melanocarpa* (black aronia berry) from southern regions in the United States required chilling accumulation of 600 hours (single temperature model), compared with genotypes from northern regions that required more than 900 hours. With all genotypes and in all their experiments, the rate of budbreak and shoot growth was positively correlated with increasing amounts of chilling.

As part of a larger project, we established field plots in southern parts of the state. We found that *Aronia* 'Viking' plants can grow in southern locales in Georgia, i.e. Griffin (USDA Zone 8a, Piedmont region) and even Macon (USDA Zone 8b) (Leyton Naranjo et al., 2023). Plant size does not appear to be different in Griffin compared to Blairsville (data not shown). However, fruit in sufficient quantity and quality for commercial production appears to develop only in north Georgia (Leyton Naranjo et al., 2023). These findings along with the chill hour study agree with Mahoney et al. (2023) report.

Plant establishment, fruit production and quality. Beyond irrigation during the 2-3-week initial period and standard level of fertilizer at planting, aronia did not require supplemental irrigation to produce fruit. However, to protect young plantings, deer fence is critical. Based on plant performance, our trials, and reports from the literature (Scott and Skirvin, 2007), *Aronia* has few major pest problems.

At Mercier Orchards, Aronia ‘Viking’ responded with increased growth to higher fertilization. However, research indicates that higher rates do not positively affect fruit quality; maximum production of anthocyanins per plant was obtained with a fertilizer rate of 50 kg N/ha (20.24 kg N/A), although a higher rate resulted in increased yields and larger plants (Niklas, 2000). Therefore, at Mercier Orchards the rates we implemented are aligned with recommendations from Maryland (Ristvey and Mathew, 2011) not to exceed 30 kg N per hectare (27 lb per acre).

In terms of fruit quality, fruit produced in northern areas reported TSS values of 13.6-14.5°Brix and 0.9 - 1.08 TTA (Lentz et al., 2023), while research from Montana reports higher TSS values, 17.4 - 23.7 °Brix (Montana State University Ag Research, 2024). We obtained TTA values of 0.95 in 2022, and 1.04 in 2023, and TSS of 29 °Brix (2022) and 24.3 °Brix (2023) (Leyton Naranjo et al., 2024), from juice made from frozen berries harvested at GMREC. These higher TSS values could be explained by the fact that we used frozen berries, as it has been reported that berry chemistry can be significantly affected by the condition of berry at sampling, i.e. refrigerated vs. frozen, especially with respect to titratable acidity (King et al., 2022). Although the same study (King et al., 2022), reported that TSS (°Brix) was not affected by cold storage (refrigeration or freezing). From these data we could draw initial inference that Georgia-grown aronia berry ‘Viking’ is at the very least comparable to northern-grown aronia berries, yet it may have different fruit flavor due to its higher sugar content. Fruit flavor is complex and encompasses a combination of factors such as aroma, texture, and sugar/acid ratios (Causse et al., 2011); more data are needed to elucidate the Georgia-grown aronia berry ‘Viking’ fruit profile.

We will continue taking data in future years from the GMREC Blairsville; as the plants are most mature and have not been affected by deer, the bushes will reach full size and yield quicker than plants at the other two locations.

Extension activities. Our Extension activities have been effective, and we have gathered numerous ideas for future programs, such as incorporating hands-on activities including propagation and food processing techniques.

Practical considerations. We are optimistic that aronia berry may develop into a good crop for north Georgia: a crop with low inputs and high returns would be of high interest to producers. Plants establish very well, with no supplemental irrigation and only limited water at planting. At the GMREC we applied standard fertilizer rates at onset, and the plants grew fast in three years, reaching comparable yields to northern grown aronia berries. Compared to blueberry (a commonly produced berry in North Georgia), aronia does not have a frost-damage risk, because it blooms in May, well after the last frost date. The small fruit clusters are like blueberries and take a long time to pick (approx. 1 hr/bush), therefore labor is a consideration in an overall business model if large acreage is considered. Aronia berry is amenable to mechanical harvesting (Scott and Skirvin, 2007), harvesting, processing, and packaging, so a blueberry production system could be easily adapted for aronia berries. Furthermore, aronia berry could provide revenue during a sales window in August, which currently no small fruit crop fills. This new alternative crop has the potential to generate good profits for producers and allow market diversification, which in turn would support economic viability of the farm enterprise.

Aronia berry attributes, such as “superfood,” “native plant,” and “locally grown,” will appeal to consumers. Being a less familiar fruit with a tart taste is an acknowledged marketing challenge, but perhaps more for the fresh fruit market rather than processed. Additionally, Aronia ‘Viking’ is not under patent; starter material can be easily generated in-house, both from seed and vegetative means (Figure 8).

Figure 8. *Aronia* berry ‘Viking’ seedlings (left) and cuttings (middle) from the plants grown in Blairsville; mature plant showing multiple suckering shoots which can be used in propagation (right).

Conclusions

Aronia 'Viking' shows promise as an alternative crop in north Georgia. By establishing multiple plantings in North Georgia, we hope to generate interest in aronia berry production and be able to deliver data-driven and timely answers to producers. Our on-going efforts have been successful in developing a novel, competitive, and valuable crop with potential for a range of value-added products for Georgia stakeholders.

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Literature Cited

Beck, M. 2014. Aronia berry gaining market foothold in U.S. *USA Today*. Accessed on September 01 2023. http://www.usatoday.com/story/money/business/2014/07/12/aronia-berry-gaining-market-foothold-in-us/12571761/

Brand, M. 2010. Aronia: native shrubs with untapped potential. *Arnoldia* January 2010: 15-25.

Brand, M.H., B.A. Connolly, L.H. Levine, J.T. Richards, S.M. Shine, and L.E. Spencer. 2017. Anthocyanins, total phenolics, ORAC and moisture content of wild and cultivated dark-fruited *Aronia* species. *Scientia Horticulturae* 224: 332-342.

Causse, M., R. Stevens, B.B. Amor, M. Faurobert, and S. Muños. 2011. Breeding for fruit quality in tomato, pp. 279–305. In: (M.A. Jenks and P.J. Bebeli, eds.), *Breeding Fruit Quality*. Wiley: New York, NY, USA.

Duffy V.B., S. Rawal, J. Park, M.H. Brand, M. Sharafi, and B.W. Bolling. 2016. Characterizing and improving the sensory and hedonic responses to polyphenol-rich aronia berry juice. *Appetite* 107: 116-125.

Hawkins, J., C. Hires, C. Baker, L. Keenan, and M. Bush. 2020. Daily supplementation with *Aronia melanocarpa* (chokeberry) reduces blood pressure and cholesterol: a meta-analysis of controlled clinical trials. *Journal of Dietary Supplements* 18(5): 517–530.

Hoke, O., B. Campbell, M. Brand, and T. Hau. 2017. Impact of information on northeastern U.S. consumer willingness to pay for aronia berries. *HortScience* 52(3): 395-400.

King, E.S., A. Noll, S. Glenn, *et al.* 2022. Refrigerated and frozen storage impact aronia berry quality. *Food Production, Processing, and Nutrition* 4: 3.

Kulling, S.E., and H.M. Rawl. 2008. Chokeberry (*Aronia melanocarpa*) – a review on the characteristic components and potential health effects. *Planta Medica* 74: 1625-1634.

Lentz, E.E., J.D. Lubell-Brand, and M.H. Brand. 2023. Renewal pruning alone or in combination with thinning pruning affects growth, fruit yield and fruit quality of aroniaberry. *HortScience* 58(9): 1023-1027.

Leonard, P. J., Brand, M. H., Connolly, B. A., and S. G. Obae. 2013. Investigation of the origin of *Aronia mitschurinii* using Amplified Fragment Length Polymorphism analysis. *HortScience* 48(5): 520-524.

Leyton Naranjo, L., B. Pennisi, and C. Robacker. In press. Sweet as a Georgia peach? horticultural performance of *Aronia* 'Viking' in Georgia (abstr). *HortScience*

Leyton Naranjo, L., C. Robacker, and B. Pennisi. 2023. Location matters: yield and fruit quality of aronia berry grown in Georgia (abstr). *HortScience* 58(9): S7.

Mahoney, J, D, A. G. Ristvey, and M.H. Brand. 2023. Chilling requirements to relieve bud dormancy in black-fruited *Aronia* taxonomic groups is related to ploidy and geographic origin. *HortScience* 58(9): 1028-1034.

Montana State University Ag Research. 2024. Western Agricultural Research Center. *Small Fruits: Aronia*. Accessed on September 01, 2024 https://agresearch.montana.edu/warc/research_current/berries/aronia.html

Niklas, J. 2000. The effect of fertilizer rate on vegetative growth, yield and fruit quality, with special respect to pigments, in black chokeberry (*Aronia melanocarpa*) cv. 'Viking'. *Sci. Hortic.* 83(2000):v127-137.

Pennisi, S., C. Robacker, and N. Joshee. 2021. Aronia 'Viking' responds favorably to chill hours. *HortScience* 56(9): S146.

Plocharski, W., J. Zbroszczyk, and W. Lenartowicz. 1989. Aronia fruit (*Aronia melanocarpa*, Elliot) as a natural source of anthocyanin colourants. 2. The stability of the color of aronia juices and extracts. *Fruit Science Reports* 16: 40-50.

Ren, Y., T. Frank, G. Meyer, J. Lei, J.R. Grebenc, R. Slaughter, Y.G. Gao, and A.D. Kinghorn. 2022. Potential benefits of black chokeberry (*Aronia melanocarpa*) fruits and their constituents in improving human health. *Molecules* 27(22): 7823.

Ristvey, A.G. and S.A. Mathew. 2011. Aronia: cultural and production consideration as an alternative crop. *Combined Proceeding of the International Plant Propagation Society* 61:463-468.

Scott, R.W. and R.M. Skirvin. 2007. Black chokeberry (*Aronia melanocarpa* Michx.): a semi-edible fruit with no pest. *Journal of the American Pomological Society* 61: 135–137.

Secher, D. 2008. *Fruit with Potential for Wisconsin Farms.* http://www.cias.wisc.edu/wpcontent/uploads/2008/07/carandale.pdf.

Shahin, L., S.S. Phaal, B.N. Vaidya, J.E. Brown, and N. Joshee. 2019. Aronia (chokeberry): an underutilized, highly nutraceutical plant. *Journal of Medically Active Plants* 8(4):46-63.

Sidor, A., and A. Gramza-Michałowska. 2019. Black chokeberry *Aronia melanocarpa* L. - a qualitative composition, phenolic profile and antioxidant potential. *Molecules* 24(20): 3710.

Smolik, M., I. Ochmian, and B. Smolik. 2011. RAPD and ISSR methods used for fingerprinting selected, closely related cultivars of *Aronia melanocarpa*. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 39(2):276-28

Straits Research. 2023. *Aronia Berries Market Size & Demand by 2031*. Report Code: SRFB54791DR. Accessed on September 01 2023 https://straitsresearch.com/report/aronia-berries-market#:~:text=Market%20Overview,period%20(2023%2D2031)

Strik, B. 2003. Performance of chokeberry (*Aronia melanocarpa*) in Oregon. *Acta Horticulturae* 626: 447-453.

Taheri, R., B.A. Connolly, M.H. Brand, and B.W. Bolling. 2013. Underutilized chokeberry (*Aronia melanocarpa, Aronia arbutifolia, Aronia prunifolia*) accessions are rich sources of anthocyanins, flavonoids, hydroxycinnamic acids, and proanthocyanidins. *Journal of Agricultural and Food Chem*istry 61:8581-8588.

USDA, ARS. 2010. *Germplasm Resources Information Network*. National Genetic Resources Program, Beltsville, MD 20705. Accessed on September 01, 2023, www.ars-grin.gov/

Wu, X., G.R. Beecher, J.M. Holden, D.B. Haytowitz, S.E. Gebhardt and R.L. Prior. 2006. Concentrations of anthocyanins in common foods in the United States and estimation of normal consumption. *Journal of Agricultural and Food Chem*istry 54(1): 4069–4075.

Zion Market Research. 2023. *Market Research Report: Aronia Berries Market Size, Share, Demand, Price, Trends 2030*. Report Code: ZMR-2174. Accessed on September 01, 2023. https://www.zionmarketresearch.com/report/aronia-berries-market