

Re-Establishment of Native Fruit Species in New England in Support of Climate Smart Agriculture: *Assessing the Consumer Education Barriers for Market Entry*

By: Izze Clark, Mateo Rull-Garza, Jaime C. Piñero

Stockbridge School of Agriculture, University of Massachusetts Amherst

Abstract

Now is the time for elderberries to go big. Developing elderberry markets in New England may not only create a new health product and wine industry but, it has the potential to aid in climate smart agriculture practices. While the environment deteriorates and weather patterns shift, elderberry, or *Sambucus nigra* sbsp. *canadensis*, abides by the predicted variations in climate through shorter and later fruit development while promoting improved soil health through low soil disturbance and increases in biodiversity through extrafloral nectaries. Considering the predicted increase in demand, entering the elderberry industry as a forager, small grower, or wholesale producer shows potential. Here, we expand on this potential through comparative economic analysis and a consumer education assessment. Across 56 respondents surveyed from the general public, our study found a low baseline of general knowledge on elderberry products but a willingness to go out of the way to try said products. The establishment of two new elderberry research plots in the central Massachusetts area is expected to increase our understanding of elderberry ecology and production in support of climate change. Our production experiments going forward can support the establishment of an elderberry market in New England.

1 Introduction

With increases in global human population, production, and consumption, the impact of Carbon Dioxide (CO₂) on the environment drastically alters the rhythm of seasons and increases the chances of extreme weather events (Earthjustice, 2023). The effect of climate change on our current agricultural systems is detrimental as food growers face increasing losses from invasive pest species, treatment-resistant diseases, as well as frost and drought episodes (Yinhong et al., 2009). In recent productivity reports, up to 70% of crop losses have been attributed to climate change, including rising temperatures, volatile patterns of rainfall, and more freeze-thaw periods across the year (Cole, 2022). For example, hay farmers saw 75% yield loss in 2016 due to drought across New Hampshire, Connecticut, Massachusetts, and Vermont (Cole, 2022). Not only are climate factors contributing to crop loss, but conventional pest control methods, including the spray of broad-spectrum pesticides can lead to serious environmental concerns. Among these, decreased soil quality, contaminated water sources, elimination of biodiversity, development of resistance, and the emergence of opportunistic pests (Pesticide Action

Network, 2023). Further, certain pesticides are known to cause adverse health effects to animal life (including humans) exposed to the chemicals (Damalas, 2016). As human societies rely more and more on technology for communication, work, transportation, we become increasingly disconnected from the natural world around us. Engagement with food production systems is a chance to bridge that disconnect and remediate the environment we have exploited for centuries; increasing awareness of where food comes from, how it is cared for, and what inputs go into producing one single apple, for instance, can bring a new perspective to consumers and get them thinking about what is actually going into their bodies.

Human societies, however, have not always been so disconnected from their food sources (Cole, 2022). In fact, studying and restoring practices developed by aboriginal cultures (such as alley cropping and polycultures) can promote resilient ecosystems and climate smart agriculture (Cole, 2022). The Three Sisters planting model system is an example of increasing biodiversity through companion cropping (Kruse-Peeples, 2016). The three sister crops consist of corn, beans, and squash, which work synergistically to promote mutual success: The corn provides a natural trellis for the beans to climb. The beans are known nitrogen fixers which increase the quality of the soil through the hosting of rhizobia bacteria on their roots, essential for converting toxic forms of nitrogen into plant-available forms and making nitrogen accessible for other plants that do not have these modified roots (Basden, 2021). Nitrogen is an essential plant nutrient which can not be utilized by the plant in toxic forms (Killpack, 2021). Thus, the beans allow for nitrogen fixation to increase available nutrients for all three plant species (Kruse-Peeples, 2016). Squash leaves improve the moisture content in the soil and shade out weeds that might compete for these nutrients (Kruse-Peeples, 2016). These seemingly forgotten practices can be brought back as a way to promote symbiotic relationships that have been neglected in modern agroecosystems.

As extreme climate change events become more prevalent, conventional agricultural systems, and especially monocultures, face catastrophic losses (Cole, 2022). Frost episodes, such as the one on May 18th, 2023, impacted New England apple and peach growers to the point where millions of dollars worth of crops were lost (Vermont Public, 2023). Temperatures dropped below freezing during the early hours of the morning during the early fruit development stage. Sobieski's River Valley Farm, a blueberry farm in Whately, MA, reported 75-80% loss on their 10,000 blueberry bushes from one freeze event at a crucial flowering time (Sobieski River Valley Farm, 2023). Many other peach and apple growers in MA have reported near-total losses (Personal Correspondence). Not only does this mean a deficit in crop production and food security, but an economic hit for growers without safety nets, especially those with small or homogenous productions.



Image 1. Three Sisters Planting. Illustration of the three sisters planting with pole beans growing up a corn stalk above squash plants used to shade the ground.

At present, each season brings forward weather uncertainties beyond human control that our cropping systems are not prepared to withstand. Based on these changing conditions, growers need to be proactive in their efforts to sustain their farms in the short and long term. How can we mitigate the effects of climate change while fostering a biodiverse system that will support environmental and financial sustainability in reliable and efficient ways? Our study aims to address these climate adversities with the installation of native plant species to remediate the uniformity of the current crop markets, promote biodiversity, and provide insight to the budding elderberry market through remediative growing. *Sambucus canadensis*, or elderberry, is an excellent candidate for these efforts based on its inherent and resilient qualities that have stood the test of time for centuries.

1.1 Principles of Climate Smart Agriculture

Essentially, climate smart agriculture supports the human and environmental ecosystem through the traditional practices observed by indigenous people and other stewards of the land. The modern aim of these efforts is to regenerate our living systems and their “health, vitality and evolutionary capability” (Cole, 2022). Backed by previous research, climate smart practices consist of the three main umbrella categories of crop management, soil management, and the integration of trees and livestock.



Image 2. Main concepts to climate smart agriculture. Three large practices of tree and livestock integration, soil management and crop management are described above.

Integration of Trees and Livestock

Silviculture integrates trees into livestock operations through the control of baseline forest health, the establishment and makeup of a forest to achieve the desires of wildlife, landowners and timber requirements (U.S Forest Service) while managed grazing

incorporates livestock into the model which improves organic matter through a low labor alternative to spreading manure.

Permaculture. Improving biodiversity via permacultural and agroforestry practices are among the few small-scale integrations that model historical polyculture practices. Permaculture refers to the conscious design and maintenance of agricultural productions that emulate the diversity, stability, and resilience of natural ecosystems (Mollison, Bill). Elderberries are a popular permaculture plant because they serve many purposes. For example, elderberries encourage the presence of beneficial insects, parasitoids, and pollinators (Rose, 2006). With an emphasis on biodiversity, permaculture is being adopted by small-scale growers and owners of homesteads. As it is not meant for wholesale production, these practices instill a connection with the food being grown and the people tending to it. Permaculture started in the 1970’s as

the concept of “permanent agriculture” systems that highlight the interconnectedness of natural ecosystems and how each part of the multi-layered system mitigate the need for external inputs through the synergistic relationship between different crops and microclimates (Bambrey, 2006). Attempting to align the natural energy circles through common sense application and design fortify the growing area with biodiversity.

On the other hand, *agroforestry* is the century-old intentional integration of trees and shrubs into crop and animal farming systems to encourage environmental, economic, and social benefits (USDA, 2019). Much like permaculture, agroforestry is not a new idea.

Alley Cropping is defined as the planting of rows of trees and/or shrubs to create alleys within which agricultural or horticultural crops are produced for landscape or crop use. The trees may include valuable hardwood veneer or lumber species, nut or other specialty crop trees/shrubs, or desirable softwood species for wood fiber production (USDA, 2017). While this may not be viable for crop production conditions with the increase in shade, propagation methods can benefit from this with wholesale plants being grown in the spaces between.

Soil Management. Soil health is important for food production because it is the foundation of productive, sustainable agriculture. Reducing disturbance provides structurally-sound soils that maintain optimal pore space, carbon content, and the microbial diversity that plants need to thrive (Cole, 2022). For example, protecting the soil surface by increasing the organic matter through cover cropping incorporates plant material (and its nutrients) back into the topsoil. These practices ensure strong soil health to support a wide variety of crop production systems (Cole, 2022). Post-Harvest Plant Material Incorporations, Alternation of Amendments, and No-Till/Reduced Tillage are all examples of soil remediation techniques.

Crop Management. Sustainable crop production includes methods of raising vegetables, fruits, grains, and other food and fiber crops in ecological ways that focus on soil health and biodiversity. Maintaining living roots while increasing plant biodiversity are key factors in regenerative agriculture practices, which create more available carbon sources to soil organisms (Cole, 2022). In turn, increasing the diversity of the soil microbiome improves soil health, crop resiliency and enhances yield over time (Cole, 2022). Moreover, continual root and plant growth also stabilizes organic matter content as well as sequesters carbon from the atmosphere (Cole, 2022).

A combination of regenerative agricultural practices improve soil and water quality, reduce on-farm fuel consumption, encourage beneficial wildlife, and reduce weed and plant pest pressures (American Farmland Trust, 2022). How does elderberry fit into a regenerative, climate smart agricultural system?

1.2 Elderberry Background

Sambucus nigra sbsp. *canadensis* is a native small fruit native to eastern and central North America with documentation ranging from Nova Scotia (Canada) to southern Florida (Small et al. 2004). It is a multi-stemmed deciduous shrub that produces intense clusters of small white flowers that develop into rich black berries in the later summer months (Charlebois, 2007). A fully-grown individual plant can reach up to three meters in height for wild types (Charlebois,

2007) but domesticated varieties (such as the ones used in our study), have been dwarfed for research cultivation and large-scale growth. The leaves are pinnately compound with five to eleven leaflets per branch, making them a very densely foliated shrub (Charlebois, 2007). Elderberry flowers bloom in early June with clusters of fruit ripening over the following two months (Charlebois, 2007). Single clusters have been known to contain as many as 2000 berries and, as the weight of the fruit increases, the cymes (i.e. Flower clusters with a textural stem which develop primarily followed by the other lateral stems) bend which can inherently protect the crop from feasting birds (Charlebois, 2007). The fruit is rich in polyphenols, flavonoids, anthocyanins, and vitamins, all of which are beneficial to human health (Sidor et al., 2015). For centuries, it has been a staple medicinal crop and most recently adopted into European markets for its antioxidant qualities (Cernusca et al., 2012). It is known by aboriginal cultures for its use in treating fevers as well as rheumatism (Charlebois, 2007). Elderberry's antioxidant capacity measured via the Oxygen Radical absorbance Capacity (a.k.a. ORAC method), surpasses that of blueberry, cranberry, mulberry, raspberry, as well as strawberry (Charlebois, 2007).

The flowers can also be dried and steeped into tea in late spring while the berries ripen through August and can be harvested in September for most varieties (Wilson, 2016). The berries, once heated and processed, can be made into jams, jellies, tinctures, juices, and more. Health shots are among the more niche products that result from elderberry production with difficulty in marketing without approval from the Food and Drug Administration (FDA; Hoover, 2021).

Two elderberry varieties, Bob Gordon and York were selected for establishment in New England, specifically at the University of Massachusetts Amherst Cold Spring Orchard Research Facility (CSO) in Belchertown, Massachusetts (MA), the UMass Agricultural Learning Center (ALC) in Amherst, MA, and Plum Brook Farm in Amherst, MA. Bob Gordon is a cultivar originally developed by the University of Missouri Extension: purchased from Buehler Organics. It is known for its large berry yield which outcompetes other varieties by three-fold (Wilson et al., 2016). Clusters of flowers develop into hanging fruit which adds further defense from feasting birds. This cultivar is also sought out by winemakers for the higher brix content (*i.e.* a measure of dissolved solids in a solution, where one degree brix is equivalent to 1 gram of dissolved sucrose in 100 grams of a solution). These plants are drought tolerant, and a highly praised cultivar from the Midwest (Wilson et. al., 2016). York is a later maturing variety with similar productivity to the Bob Gordon cultivar. With distinctly larger berries, this is a smaller growing type that has been known to reach maturity at 1.25 to 1.5 meters (Wilson et. al., 2016).

When it comes to incorporation of elderberry in the context of regenerative agriculture, it can be planted in particularly wetland areas, accompany shade tolerant ground cover crops, or even attract predatory insects through the use of their unique extrafloral nectaries. Incorporation is not only dependent on the environmental needs but also what the general public demands for food products. As a niche fruit, there are many factors that play into the success of crop sales such as consumer knowledge.

1.3 Marketing Challenges

Despite an expansive market of European elderberry in North America (Charlebois, 2007), there is a potentially vast untapped market for the native species. The American varieties of

elderberry (only recently sub-classified) are comparable in yield potential to the European species (Charlebois, 2007). In 2012, an audience of elderberry foragers, wholesale and small scale growers, and homestead owners were surveyed for needs assessments (Cernusca et al., 2012). The results indicated that 54% of the 74 surveyors claimed that they saw an increase in demand for elderberry over the last 5 years (Cernusca et al., 2012). Looking forward to the next five years, 59% also predicted an increased demand.

Due to a naive American market, addressing consumer education barriers within the growing elderberry industry may allow new entry level growers, foragers, and processors to establish a research-informed market. The threat of already established berries with similar properties is among one of the larger challenges to be overcome, especially in berry-producing regions such as New England. With comparisons to blueberry and cranberry, both of which are well known to the common grocery shopper, elderberry outperforms these fruits in a number of categories. However, the question remains: will the consumer know or care for this fact when faced with the choice between a well-known product or a novel one? With many avenues of sale such as tinctures, juices, health shots, and even jams, elderberry has many possibilities for growers to take advantage of for market entry but there are many barriers that come with such a niche industry.

Three types of barriers may impede elderberry marketing success:

- (1) *Financial Barriers*, which include the initial costs of purchasing plants for the intended scale of growth, harvest, pest management and processing;
- (2) *Operational Barriers* - meaning the costs associated with processing elderberries for consumption, as they can not be eaten raw. This is because they contain precursors to cyanide that at a large enough concentration could cause adverse health effects (BC Drug and Poison Information Center, 2012). To counteract this, the berries must be dried or heated to absolve the precursor elements (BC Drug and Poison Information Center, 2012). This entails a second component to production which includes investment in machinery.
- (3) *Informational Barriers* - Consumer and grower education is among the largest barrier to market success since actual production and marketing knowledge is learned through experience. The FDA also limits the market since producers are not allowed to advertise or promote the medicinal properties of elderberry unless clinical trials, carried out in the long term, are conducted and in support of claims (Cernusca et al., 2012).

1.4 Impact

Elderberry is a viable candidate for regenerative agriculture for many economic and environmental benefits that also coincide with health benefits. Combining the need for sustainable agriculture practices with the potential for a profitable North American market, elderberry could thrive in New England (assuming it can find its niche separate from the established berry industries) and has the adaptive skills to handle the extreme fluctuation and unpredictability of a changing climate. With a later and shorter growing season, these fruits can naturally avoid the threats of early spring frost episodes without modification or technical support (i.e. turbines, heaters, mist). Climate smart agricultural practices are projected to

increase in their effectiveness of CO2 emission mitigation with long term utilization among larger percentages of acreage (Cole, 2022).

Our study aims to also illustrate the importance of modifying long-standing agricultural practices to face modern day challenges with solutions that have been successfully implemented in comparable systems.

1.5 Gap in Knowledge

Without a well-established circular market in North America, we look to the European model for what success looks like in a small and niche fruit market. Using the Porter Model, growers and foragers were surveyed on their expectations for the industry in the coming years (Cernusca et al., 2012). However, that survey failed to address the lack of consumer feedback. How much does the average grocery shopper know about elderberry and its unique health benefits? Is this baseline knowledge enough to influence buying choices? How do we distinguish elderberry from its already established berry substitutes? These questions remain unanswered from the customer perspective but can be resolved with a consumer survey constructed in conjunction with this literature review. A qualitative and informative consumer survey will (1) give insight to the entry-level barriers that small scale growers face in specialty fruit growth, (2) allow for research-informed solutions, and (3) may encourage the success of an elderberry market in New England.

2 Materials and Methods

Consumer Attitudes Survey. To encourage the adoption of elderberries in Massachusetts Fruit Farms, we conducted a potential consumer survey. Questions were formulated to determine the consumer's level of knowledge about elderberry fruits, reluctance and/or willingness to consume elderberry products. Our demographic included consumers of all ages, ethnicity, individual income and education level. Data was analyzed and visually represented using Google Forms. The survey was implemented from mid July to early August and consisted of eleven questions.

3 Results

Among 56 responses gathered through a digital survey, 42.9% of respondents indicated familiarity with elderberry fruit products, 28.6% expressed some familiarity and 28.6% were not familiar with elderberry (Fig.1). When posed with a hypothetical scenario of "A new fruit juice has been introduced to market. Those who have tried it say it tastes a lot like cranberry juice and there are more health benefits to drinking the new juice. However, the price is somewhat higher. How likely are you to switch to the new juice noting the price difference?", 21.4% of respondents described their apt to buy as very likely where price does not serve as a large factor if there are substantial benefits. 44.6%

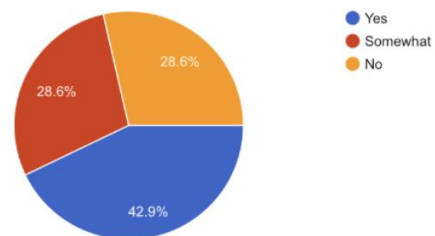


Figure 1. Familiarity with elderberry products (survey results, N = 56). The majority of respondents indicate familiarity, equal proportions indicate some and no familiarity with elderberry products.

indicated they were somewhat likely to purchase but not very often. 23.2% responded as not very likely to purchase where price is a big factor in their decision making. Alternative responses indicated importance in organic growth, an inclination to compare products, and willingness to buy but not due to health benefits.

Amongst the most important factors when purchasing new food products, 26.8% of the respondents value price the most while 53.6% value the benefits. Other factors include importance in the source of the product (whether it is grown locally), its organic status, and its taste.

For willingness to try elderberry products (Fig. 2), 66.1% respondents indicated a complete willingness to try, 1.8% were not willing, 28.6% indicated that they have tried elderberry products and liked them, and 1.8% have tried these products and did not like them. When assessing the overall level of knowledge of elderberry health benefits (Fig. 3), the sample mean was 4.6 on a scale of 1 to 10 (1 being no existing knowledge and 10 being very knowledgeable) and the median was 4, indicating low to moderate pre-existing knowledge.

With the option for personal statements, one respondent replied saying that they currently have 50+ elderberry plants which they make juice, syrup, and honey out of. (See appendix for full set of survey questions).

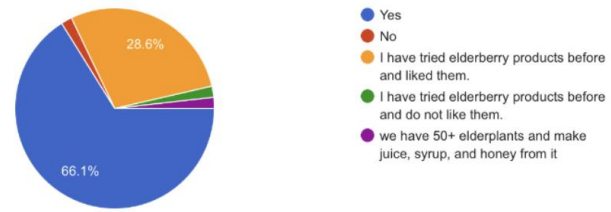


Figure 2. Description of respondents who have or have not tried elderberry products and their corresponding approval or disapproval (survey results, N = 56). More than half of the sample showed interest in trying elderberry products with over 25% describing themselves as having tried these products and liking them. One individual has more than 50 elderberry bushes which are used to make juices, syrup and honey.

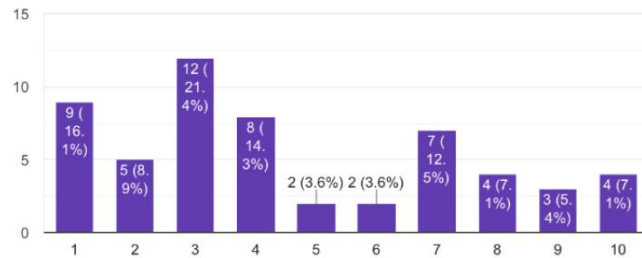


Figure 3. Distribution of prior knowledge of elderberry health benefits: 1 (no knowledge) to 10 (substantial knowledge) (survey results, N=56). Our distribution shows an average of 4.5 out of 10 with the median being 4. The concentration of responses are skewed to the right with the trend being on the lower end of the scale.

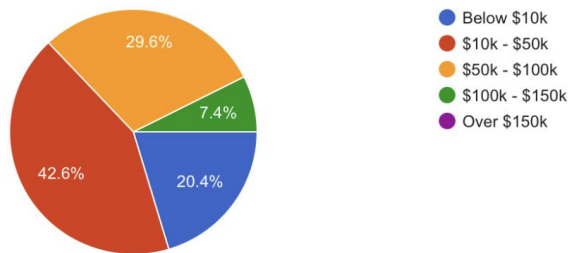


Figure 4. Individual income. Reported income lies mostly below the \$50,000 mark with 37% stating individual income is \$50k-\$150k.

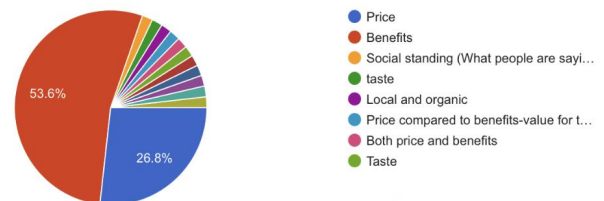


Figure 5. Most important factors when purchasing new fruit products. Over half of respondents indicate that benefits outweigh the price of an item at 53.6%. Price is the most important to 26.6% of the sample while a combination of both or another factor, such as organic status or taste is the deciding factor.

4 Discussion

4.1 Survey Data Analysis

Our results show a lack in consumer knowledge but a willingness to try introduced elderberry products regardless of their price. Our sample consisted of a range of individual incomes with a concentration of respondents indicating they make between \$10,000 and \$50,000 per year. The sampled population included students. That being said, our sample shows an interest in beneficial fruit products even with lower yearly income status.

Based on this initial assessment, marketing niche fruit products, such as elderberry, could benefit from in-store fact sheets describing the benefits, the comparison between similar products, as well as education from local growers. While most respondents described their produce shopping from chain supermarkets, buying local is important to the sample, too. This could give an opportunity for small-scale growers to experiment with introducing elderberries to their product lineup. With a portion of the respondents (26.8%) indicating that price is somewhat important to buying a substitute product, future survey questions might include a price range scale to show how much the average consumer would be willing to pay for certain products of a higher value. With 56 respondents indicating an average existing knowledge on these products of 4 out of 10, this leads us to believe that there is a need for knowledge around the basics of black elder products.

4.2 Economic Considerations

Profit and input comparisons indicate significant profitability when compared to other fruits. With figures from U. Kentucky Extension and North Carolina State University Extension, elderberries on a fourth of an acre scale are 2.85 times more profitable than a full acre of tall spindle apples on a full acre (Table 1). Elderberry, however, requires cost for processing which include juicing, heating, and/or drying depending on the desired product (Ernst, 2023).

At year 5, elderberries bring in \$4,835 at ¼ of an acre with 200 plants while apples average \$2,324 at one full acre (U. Kentucky Extension & Good Fruit Grower). The substantial difference in potential profitability may be enough to encourage growers to include elderberry in their operations.

4.3 Pitfalls

Of the 150 cuttings purchased (both elderberry cultivars combined), come the day of intended planting, only 16 remained intact s. With predicted loss as a consequence of travel and medium adjustment, from bare root to soil, it is not uncommon for some cuttings not to take. Unfortunately, high temperatures and immense direct sunlight played a role in the failure of a

	Year 5 (Full Bearing)
Costs	
Fertilizer, mulch	65
Insect and disease control	90
Irrigation supplies/power	50
Harvest containers (reusable)	25
Machinery and miscellaneous costs	80
Hired labor: weeding, plot maintenance	165
Hired labor: harvest	310
Hired labor: pruning	80
Marketing costs	300
Total annual cash costs	1165
Gross income 1500 lbs. @ \$4 per lb.	6000
Cash inflow (outflow)	4835

Table 1. Cost and income breakdown of ¼ acre elderberry plot. Various key costs are illustrated with the income at \$4 per pound of raw fruit.

majority of the plants. We noticed even greater loss when the entire stock was overcome with spider mites. Spider mites are phytophagous, or plant eating, microscopic mites that resemble spiders through their physical characteristics and weblike silk (U. California IPM, 2023). They are often a serious greenhouse pest in dry and dusty conditions that pierce the plant cells and drain them of nutrients and water (U. California IPM, 2023). Detrimental for these young cuttings, only 17 survived. More elderberry cuttings will be purchased and transplanted to the experimental plots in the spring of 2024.

5 Conclusion

Elderberry provides multiple ecosystem services. Elderberry not only is beneficial to the environment by abiding to regenerative agriculture components but is also promising as a niche fruit industry shown through the consumer willingness to purchase new products based on hypothetical survey questions. Consumers expressed that price is a large deciding factor when it comes to purchasing new fruit products but, to some, benefits outweigh the cost. Future market research would benefit from assessing the fixed price the average consumer would be willing to pay per pound for regional pricing. Catering to a local market, consumers showing some to no knowledge of elderberry products, their taste, and positive health effects, would benefit from an in-person fact sheet partnered with the fruit.

As agriculturalists, it is our responsibility to work with the environment as a partner rather than an exploitative resource. Through the installation of these cultivars, the increased awareness of this valuable partnership and the future work to come, we can actively promote a healthier growing environment that is fit to support the demands of the population as well as the environment.

6 Acknowledgements

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Survey Questions Appendix

What is your age?

What is your gender?

Which category describes you? Please select all that apply.

What is your individual income?

Are you familiar with elderberry fruit products?

A new fruit juice has been introduced to market. Those who have tried it say it tastes a lot like cranberry juice and there are more health benefits to drinking the new juice. However, the price is somewhat higher. How likely are you to switch to the new juice noting the price difference?

What is the most important factor you have when purchasing new food products?

What is your level of knowledge on elderberry health benefits?

Have you gone out of your way to purchase and taste an uncommon fruit before? If so, what fruit and why?

Would you be open to trying elderberry products if you have not already?

Where do you acquire produce most frequently? (Select one or more)