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From Niche to Mainstream: US Consumer Trends and Preferences for Elderberry Products

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Abstract. **Elderberry (*Sambucus* spp.) is an emerging and popular specialty crop in North America and worldwide. Both the fruit and flowers are being increasingly consumed because of their proven health benefits, mostly in the form of dietary supplement products. We explored changes in consumer knowledge and purchasing preferences regarding elderberry products after comparing results of a survey conducted in 2022 with those of a previous study conducted in 2011. Findings based on responses from 1036 US residents revealed that 41.2% had previously consumed elderberry products. This marks a significant increase from the 6.9% reported in the 2011 survey. Elderberry-based vitamin supplements were the most consumed elderberry product reported in the survey. Approximately half of the respondents reported consuming this product, which is an approximately seven-fold increase from 7.0% reported in 2011. We noted a change in purchasing venues, with more than 50% of participants purchasing elderberry products from grocery stores in 2022 compared to 43% in 2011. An analysis of a discrete choice experiment revealed that, among selected product attributes, organic and pesticide-free production of elderberries were the most important attributes. Statistical results of the choice experiment suggested that consumers were willing to pay, on average, US$3.51 more per 12-ounce (355 mL) bottle of juice made from organic elderberries and an even higher premium of US$3.97 more per bottle of pesticide-free elderberry juice compared to that for juice made from conventionally grown elderberries. We also estimated that consumer products made with American-grown elderberries would garner a 13% price premium over elderberries grown in Europe. Elderberry products with carbon neutrality elicited a 13% premium per bottle of juice (approximately US$1.91 more per bottle) compared to that of those without disclosure of the carbon emission information. In summary, elderberry products labeled as pesticide-free, locally produced, and carbon-neutral are likely to offer the greatest market appeal to US consumers and would further contribute to the mainstreaming of elderberry products.**

The American elderberry (*Sambucus nigra* subsp. *canadensis*), which is botanically akin to the European elderberry (*Sambucus nigra* subsp. *nigra*), is a perennial deciduous shrub indigenous to the eastern and midwestern United States (Charlebois et al. 2010). It predominantly thrives in moist but well-drained habitats and flourishes in both full sun and partially shaded areas (Byers et al. 2022; US Department of Agriculture, Agricultural Research Service 2002). Over the past 20 years, American elderberry has emerged as an increasingly important specialty crop grown by hundreds of farmers across eastern North America (Charlebois et al. 2010) and is primarily marketed and consumed because of its health-benefiting attributes (Thomas et al. 2020).

Elderberries and elderflowers have many uses. North American indigenous communities have integrated various parts of the American elder bush into their traditional medicinal practices. For example, the ripe berries have been used to treat fevers, rheumatism, gastrointestinal issues, and diarrhea (Gafner et al. 2021). Elderberries and elderflowers are versatile ingredients in culinary and beverage applications that are commonly used in teas, juices, syrups, cordials, and a variety of alcoholic beverages, including wine, beers, and ciders (Mohebalian et al. 2012). Tart elderberries are frequently featured in food items such as jellies, jams, pies, and baked goods. Elderberries can also serve as natural colorants and dyes for foods and textiles. Rich in anthocyanins and phenolic compounds, elderberries have strong antioxidant properties and have been associated with various health benefits, including alleviating flu symptoms and improving brain health (Chuang et al. 2014; Curtis et al. 2024; Osman et al. 2023).

The global elderberry market is on a growth trajectory, with projections suggesting an increase of $389.8 million worldwide from 2023 to 2028, with a compound annual growth rate of 8.8% (Technavio 2024). Europe is the leading producer of European elderberry, and industry projections suggest that approximately 48% of growth in elderberry production will likely originate in Europe (Technavio 2024). Germany and Austria currently produce and export the majority of elderberry products consumed in the United States (Technavio 2024). The growth of the elderberry market was boosted by an 83% surge in product sales between 2018 and 2019 that was primarily driven by products targeting immune health and cold and flu remedies (Grebow and Krawiec 2020). Commercial elderberry cultivation is gaining momentum in the United States. The United States reported 790 acres dedicated to commercial elderberry production in 2017, and nearly half that acreage is in the state of Missouri (US Department of Agriculture, National Agricultural Statistics Service 2017). US elderberry cultivation reached a total 2627 acres in 2022, with approximately 607 acres in Missouri (US Department of Agriculture, National Agricultural Statistics Service 2022).

The existing literature regarding the market for elderberry products is limited, with most studies dating from 2011 to 2013. From the perspective of the producer, Cernusca et al. (2011, 2012) conducted two studies based on interviews with key stakeholders in the US elderberry industry to examine market participants, supply and demand dynamics, future trends, and market limitations. In a separate study, Cernusca and Gold (2013) identified barriers and opportunities for producers and processors across the US elderberry industry.

From the consumer perspective, several studies have explored awareness and preferences. Mohebalian et al. (2012) distributed a survey in 2011 and found that one-third of US consumers were familiar with elderberries. Subsequent research by Mohebalian et al. (2013) compared consumer preferences for elderberry jelly with blackberry and grape alternatives, and the results suggested that consumers were 27% and 20% less likely to choose elderberry jelly than to choose blackberry jelly and grape jelly, respectively.

Mohebalian et al. (2013) also examined the impact of other product attributes on consumer purchasing decisions regarding elderberry products and found that factors such as price, region of origin (locally produced, produced in the United States, and imported), and the presence of a health claim label all significantly influenced consumer preferences.

The primary goal of this study was to gauge trends in US consumption and purchasing preferences for elderberry products since 2011. Specifically, based on a survey of US residents, we aimed to accomplish the following: assess the current state of the elderberry consumer market; examine changes in consumer preferences since 2011; quantify how selected product attributes structured in a discrete choice experiment (price, elderberry production practices, origin of elderberries, and the presence of a carbon-neutral claim) influence purchasing preferences for elderberry juice; and determine consumers' willingness-to-pay (WTP) price premiums for selected elderberry juice attributes.

Methods

Questionnaire design

This study used an online survey to gather US consumers' knowledge of and preferences for elderberry and its value-added products. The survey comprised four sections. First, we inquired about consumers' familiarity with elderberries, past purchasing behaviors, and consumption frequency. Questions regarding the types of elderberry products sampled or purchased as well as their sources of acquisition were included. The second section gauged consumers' attitudes and perceptions toward elderberry-based food purchases. Using a 5-point Likert scale, participants were queried about the relative importance of various product attributes, including nutrition, taste, price, ingredients, packaging, brand, environmental benefits, and region of origin (local, US-produced, and imported). Questions in these two sections were adapted from Mohebalian (2011).

A third section presented a discrete choice experiment (DCE) to elicit consumer preferences for selected attributes of a bottle of elderberry juice. The DCE entails the modeling of choice behavior in consumer preferences research. Among others, Mohebalian et al. (2013) and Cai et al. (2019) have applied a DCE to specialty crop products. A DCE is grounded in random utility theory (McFadden 1974), whereby it is assumed that consumers, as rational agents, can construct the expected utility derived from selecting a particular product and choose the one that yields the greater net utility considering price and other relevant attributes. Consumers' utility is unobservable, but their choices are; therefore, the latent utility behind choices can de decomposed between a deterministic component and a stochastic term. The deterministic component is represented by the attribute-specific characteristics that explain choices (Louviere et al. 2000). In our study, the product of choice in the DCE was a 12-ounce (355 mL) glass bottle of elderberry juice because of its prevalence in consumption patterns (Mohebalian et al. 2013). Other product attributes imputed to the DCE design were price, elderberry production practices, origin of elderberries, and the presence of a carbon-neutral claim (Table 1). Price levels were informed by prevailing market prices. For instance, River Hills Harvest (Hartsburg, MO, USA) marketed a comparable product at approximately $15 in 2020. River Hills Harvest is a major elderberry juice producer in the United States that sells elderberry products online and through distributors at both regional and national levels to more than 500 retail stores in the United States (River Hills Harvest 2024).

The elderberry production practice attribute had three levels. Current research indicated that consumers prefer organic and pesticide-free production and are willing to pay a premium for such products. For example, Cai et al. (2019) conducted a survey among North American pawpaw (*Asimina triloba*) consumers using a choice experiment method. They discovered that consumers showed a preference for organic and pesticide-free pawpaws over those produced using conventional methods. Similarly, Batte et al. (2007) surveyed 199 consumers at an Ohio grocery store and found that consumers were willing to pay a higher price for organic and pesticide-free products than for products produced using conventional methods. These findings emphasize the increasing importance of providing organic and pesticide-free options, along with correlated labeling, to obtain price premiums for such products. Therefore, production practices for elderberries used in the juice were categorized as conventional, pesticide-free, or organically certified, and their definitions provided to respondents were adapted from Cai et al. (2019).

Conventional. The production practice for elderberries may involve the use of chemical fertilizers and synthetic pesticides to maximize the yield and quality of elderberries.

Pesticide-free. Elderberries are grown without the use of synthetic pest and weed control methods.

Organically certified. Elderberries are grown using no synthetic fertilizers or pesticides and have been certified by a certification agency.

The origin of elderberries included two levels: American-grown elderberries and European-grown elderberries. Regarding the presence of a carbon-neutral claim, it was incorporated as a binary attribute. This claim denoted that elderberry juice's carbon emissions during production, sorting, packing, and transportation have been offset by purchasing carbon credits (Birkenberg et al. 2021). The carbon-neutral claim informs buyers of the greenhouse gas emissions generated throughout the lifecycle stages of a commodity or service encompassing production, distribution, and utilization (Taufique et al. 2022). The primary objective of carbon labeling is to actively involve consumers in endeavors aimed at mitigating climate change. Consumer behavioral research has suggested a growing emphasis on environmental sustainability in purchasing decisions (Potter et al. 2021). Consumers are also becoming increasingly knowledgeable and discerning about sustainability claims (Tripathi and Sharma 2023), suggesting a potential increase in the influence of carbon-neutral labeling on consumer preferences in the future. Numerous studies have investigated the impact of carbon labels on consumer behavior in the retail sector, with evidence indicating a positive effect on consumer choices of products with lower carbon footprints. For instance, Birkenberg et al. (2021) surveyed German consumers regarding the impact of carbon-neutral labels on their preferences and purchases of specialty coffee. Their findings revealed that German consumers were willing to pay a price premium for coffee labeled as carbon-neutral. However, Grunert et al. (2014) reported different results, indicating that the influence of sustainability labels (e.g., carbon footprint, Fair Trade) on consumer preferences in Europe was limited for various reasons, such as the lack of credibility of the labels or uncertainty about who is responsible for certification.

Table 1. Attributes and levels of elderberry juice used in the discrete choice experiment design.

Attributes	Levels
Price	US$12, US$15, and US$18
Elderberry production practices	Organic, pesticide-free, and conventional methods
Origin of elderberries	American-grown and European-grown
Carbon-neutral claim	With a claim and without a claim

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A fractional factorial design was used for the generation of product profiles in the DCE. The factorial design was constructed using SAS software (Kuhfeld 2010), with a design efficiency of 93% and a minimal design error of 0.94. With eight product profiles available for pairwise selection, the survey questions presented participants with four distinct choices, with the opt-out product serving as a status quo option (Louviere et al. 2000). Participants were presented with sets of DCE denoting product profiles and a no-choice (or opt-out option) to simulate a real-world shopping experience. Before presenting the DCE scenario, we presented a "cheap talk" script and provided an explanation of the concept of hypothetical bias to mitigate potential bias (Ladenburg and Olsen 2014). Hypothetical bias is characterized as the discrepancy between respondents' stated preferences in hypothetical scenarios and their actual behavior in real-life situations (Cai and Aguilar 2013). This often arises because of individuals' proclivity to express certain preferences when choice outcomes lack tangible consequences. We asked respondents to respond to the survey questions carefully as if they were truly purchasing items for household consumption. Short opt-out reminder statements were included alongside each product pairing to help mitigate hypothetical bias (Ladenburg and Olsen 2014). Participants were instructed to imagine that they were shopping for a 12-ounce (355 mL) glass bottle of elderberry juice at a grocery store, and there were several options of elderberry juice products from which to choose. Then, respondents were presented with diagrams depicting two juice bottles as hypothetical products available in stores. Respondents were asked to select the product that they would be most likely to purchase; otherwise they selected the "neither" option. An illustrative DCE question is presented in Fig. 1.

The final section of the questionnaire collected respondents' demographic information. Participants were asked about their age, residential location (whether they resided in an urban area with a population of at least 50,000), marital status, educational attainment, annual household income, gender, and age.

Fig. 1. An example of a discrete choice experiment question.

Data collection and analyses

The survey was pretested by a group of 17 US consumers in Oct 2022 before final deployment, with their feedback used to improve the clarity of the survey instrument. Data collection was conducted using the Qualtrics online survey platform in Nov 2022. Participants were recruited through Qualtrics Research Services (Provo, UT, USA), which maintains a diverse pool of more than 4 million respondents and provides e-gift cards or contracts with various companies to compensate participants through rewards programs such as retail outlet shopping points, airline miles, and other incentives (Douglas et al. 2023). Initial invitations, accompanied by brief instructions regarding accessing the questionnaire, were sent to individuals in the United States who were 18 years of age or older. Daily reminder emails containing a link to the questionnaire were dispatched until the predetermined quota of 1000 responses was achieved. Ultimately, 1036 complete surveys were collected online. The response rate could not be calculated and reported because of our data collection method. We relied on comparisons of our samples with the US census to examine the representativeness of our sample to the larger population.

We computed descriptive statistics for variables denoting consumption frequency, perceptions toward elderberries and their value-added products, as well as demographic characteristics. Statistical differences in past consumption of elderberry products across various demographic groups were tested using *t* tests. To analyze consumers' preferences for specific DCE attributes (price, origin of elderberries, elderberry production practices, and the presence of a carbon-neutral claim), we used a mixed logit model. A mixed logit regression accommodates variation in model coefficients across consumers, thereby addressing potential heterogeneity in preferences (Train 2003). The dependent variable corresponded with respondents' choices among the three elderberry juice options, whereas the independent variables captured the following attribute levels: price (US$15, US$18, and US$20); elderberry production practices (conventional, pesticide-free, organically certified); origin of elderberries (American-grown and European-grown elderberries); and the presence or absence of a carbon-neutral claim. The mixed logit model assumed homogeneity among respondents with respect to the impact of price on purchase preferences and treated the price coefficient as fixed across the sample with zero standard deviation. This fixed price coefficient facilitated the calculation of consumers' WTP price premiums. Conversely, coefficients for origin of elderberries, elderberry production practices, carbon-neutral claim attributes, and the alternative-specific constant were assumed to vary across respondents. Estimation of model coefficients required the selection of the following base-level attribute variables other than price: elderberry juice produced using conventional methods; elderberries sourced from Europe; and the absence of a carbon-neutral claim. Coefficients and odds ratios in the regression were estimated relative to these base levels. An odds ratio corresponds the ratio of the odds of an elderberry juice being chosen over the odds of not being chosen (Ambo et al. 2020).

We also estimated the relative importance of each attribute to reported choices in the DCE using Eq. [1], which was consistent with the methodologies outlined by Harrison et al. (2002), Mohebalian et al. (2013), and Cai et al. (2019). In the equation, Range_q represents the coefficient differences for attribute q. Attributes with higher relative importance percentages were deemed more influential for shaping consumers' purchasing decisions for elderberry juice.

$$(\text{Relative Importance})_q = \text{range}_q * 100 / \sum_{q=1}^{4} \text{range}_q \; q = 1, 2, 3, \text{ and } 4 \quad [1]$$

We estimated consumers' WTP premiums for three specific attributes of elderberry juice. These corresponded to premiums for organic and pesticide-free elderberry production methods over conventionally produced juice; juice made using American-grown elderberries over European-grown elderberries;

and the inclusion of a carbon-neutral claim over no claim. The concept of WTP captures the monetary value consumers are willing to pay to offset the utility change resulting from alterations in product attributes compared with the base level (Louviere et al. 2000). To calculate the WTP premiums for each attribute, we divided the respective coefficient of the attribute level by the price coefficient derived from our mixed logit model. All data analyses were performed using Stata18 (StataCorp 2023).

Results and Discussion

Demographics

Table 2 presents demographic characteristics of our sample (1036 respondents) and the 2020 US census data (US Census Bureau 2020). Responses were almost evenly distributed between genders, with 49.5% of surveys completed by female respondents. The age distribution closely mirrors the 2020 census data except the older than 74 years group. This might be attributable to lower access to computers and familiarity with online survey panels. Our sample had a higher representation of individuals with associate degrees compared with that reported by the US census data, suggesting that our sample might underrepresent other education level categories. In terms of income distribution, our sample had a higher percentage of respondents earning less than US$35,000 annually per household and a lower percentage of respondents earning more than US$100,000 annually per household. Our sample had a larger proportion of people who reside in nonurban areas (less than 50,000 people) compared with that reported by the 2020 US census data. Approximately 76% of the respondents reported that they did most of the grocery shopping for their household. These small differences somewhat limited our ability to make direct inferences to the US population in general; hence, we limited our results and implications to respondents within our sample.

Table 2. Summary of demographic information for survey respondents.

Variables	Our sample (%)	2020 US Census (%)
Gender		
Female	49.5	50.9
Male	50.5	49.1
Age		
Younger than 25 years	13.2	12.0
25–34	15.6	17.3
35–44	20.4	16.9
45–54	16.6	15.5
55–64	17.0	16.1
65–74	13.4	13.0
Older than 74	3.8	9.2
Living in an urban area of at least 50,000 people		
Urban	37.3	67.0
Nonurban	62.7	33.0
Education		
Associate degree	12.6	7.8
Bachelor's degree	22.0	20.6
Graduate degree/ Professional studies	13.6	12.4
High School	26.5	27.2
Some college, no degree	23.9	21.5
Other	1.4	10.5
Income (US$)		
Less than $24,999	21.5	15.8
$25,000–$34,999	13.9	7.5
$35,000–$49,999	14.6	10.3
$50,000–$74,999	19.6	15.6
$75,000–$99,999	12.6	12.1
More than $100,000	17.9	38.7
Marital status		
Married	40.9	48.0
Divorced	15.4	10.5
Never married	34.9	34.3
Others	8.8	0.1

Elderberry consumption and purchasing outlets

Approximately three-quarters of our respondents (75.3%) indicated that they had heard about elderberries before completing the survey, and approximately two-thirds (62.2%) had heard about elderberries before the COVID-19 pandemic. To provide some interpretation of elderberry consumption trends over time, elderberry consumption between 2011 (Mohebalian et al. 2013) and 2022 (this study) was compared (Table 3). The results indicated that the percentage of respondents who had consumed elderberry products increased nearly six-fold between 2011 (6.9%) and 2022 (41.2%).

Among consumed elderberry products, elderberry-based vitamin supplements (products that are made of elderberry extract derived from the berries of the elderberry plant and have essential vitamins added) were the most frequently purchased, with almost half of the respondents reporting their consumption. This is a very large increase compared with 7.0% of respondents who indicated doing so in 2011, as reported by Mohebalian et al. (2013). The health benefits associated with elderberry products may play a significant role in driving large consumption increases in the US market. As noted in Mohebalian et al. (2013), elderberry juice with a health claim highlighting its antioxidant-rich ingredients and immune system support experienced greater consumer preference. This suggests that consumers are influenced by elderberry's health benefits when making decisions about elderberry product purchases.

Among elderberry products reportedly consumed, elderberry juice was ranked second in our sample, whereas it was ranked first in 2011. Again, greater awareness of possible health benefits of consuming elderberry products might explain this temporal change. Carbonated elderberry drink consumption decreased substantially from 33.3% in 2011 to 8.0% in 2022. In terms of purchasing outlets, "grocery stores" were still the most frequent location where consumers purchased elderberry products. Health food stores were ranked the second most frequent place to purchase elderberry products in 2022, whereas in 2011, farmers markets were ranked second.

In terms of elderberry product consumption frequency, among those who indicated they had consumed elderberry products before, almost 40% indicated they consumed elderberry products more than 10 times per year (Fig. 2).

During our analysis, we observed significant differences in past consumption of elderberry products across various demographic groups. Specifically, respondents with an annual household income less than US$74,999 had a statistically significantly lower preference ($P < 0.001$) for consuming elderberry products compared with those with incomes exceeding US$74,999. Additionally, respondents with a high school education or some college education showed a significantly higher elderberry consumption preference ($P < 0.001$) compared with those with at least a college degree. These findings underscore the influence of socioeconomic factors and educational attainment on elderberry product consumption behaviors among respondents.

Consumer perceptions

Among respondents, 82.8% indicated that "taste" was either a "very important" or "extremely important" influence on their food-purchasing decisions. "Price" was ranked the second most influential factor because 66.9% of the respondents indicated "very important" or "extremely important." Additionally, 63.6% of the respondents indicated nutrition was either "very important" or "extremely important" to their purchases. In terms of environmental benefits and region

Table 3. Comparison of elderberry product consumption and purchasing outlets between 2011 and 2022.

Year	2011[i]	2022
Sampled or purchased elderberry products	6.9%	41.2%
Products that were most frequently purchased		
Elderberry-based vitamin supplements	7.0%	49.9%
Juice	45.2%	35.1%
Wine	39.0%	23.4%
Jelly	22.3%	22.3%
Carbonated elderberry drink	33.3%	8.0%
Purchasing outlets		
Grocery stores	43.1%	51.3%
Farmers markets	34.4%	27.6%
Health food stores	29.9%	35.4%
Restaurants	17.4%	12.9%
Events/conferences	7.7%	7.5%

[i] Numbers were calculated based on survey data collected in 2011 (Mohebalian et al. 2013).

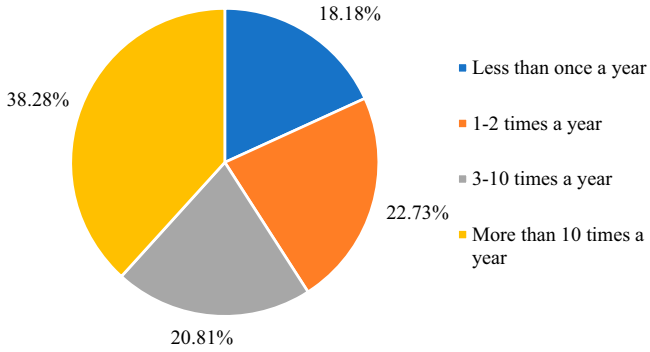

Fig. 2. Elderberry product consumption frequency among US respondents who had consumed elderberry products before (n = 418).

of origin, 36.8% and 34.2% indicated they were "very important" and "extremely important," respectively. Brand and packaging were the least important factors that affected consumer purchases because only 22.8% and 20.0% of the respondents indicated that they were either "very important" or "extremely important" to their decisions.

Mixed logit regression of discrete product choices

The results of the mixed logit model used to analyze DCE responses are presented in Table 4. This model was found to be statistically significant ($P < 0.001$) for the likelihood ratio test. Variability in coefficients across individuals was found in our models as denoted by the standard deviations that were statistically significant for all random parameters ($P < 0.001$).

The regression found that all variables were statistically significant, with $P < 0.001$. Price had a negative coefficient, indicating that, with all other attributes at the same level, an increase in price will reduce the likelihood of consumers choosing elderberry juice. The results indicated that a US$1 increase in the price of a 12-ounce (355 mL) bottle of elderberry juice would lead to a 30% lower likelihood of it being chosen.

Coefficients of variables including organic, pesticide-free, American-grown elderberry, and the presence of a carbon-neutral claim were all positive and statistically significant. This indicated that an elderberry juice product with of any these attributes resulted in an increased probability of it being chosen over one with base-level attributes (i.e., elderberries produced using conventional method, European-grown elderberries, and without a carbon-neutral claim). Consumers in our study preferred organic or pesticide-free elderberry juice over juice made from fruit grown using conventional horticultural methods. Based on the odds ratio, consumers were 2.38-times more likely to purchase organic elderberry juice and 2.96-times more likely to purchase pesticide-free elderberry juice than to purchase juice made using conventional production methods. This finding is consistent with existing literature regarding consumer behavior toward food choices (Cai et al. 2019; Gracia and de Magistris 2007; Hughner et al. 2007; Zanoli and Naspetti 2002). The preference for organic and pesticide-free elderberry juice over products produced using conventional methods may stem from increasing consumer awareness and demand for transparent production practices. This preference is likely driven by a combination of factors, including health consciousness, environmental sustainability, and ethical considerations (Bonti-Ankomah and Yiridoe 2006). Consumers tend to perceive organic and pesticide-free foods as preferred options for their quality, safety, nutritional value, and for being better for the environment (Mohebalian et al. 2013). These findings underscore the multifaceted nature of consumer preferences and the importance of considering various factors that influence food choices. It is worth mentioning that although mixed logit coefficients had different values, there was no statistically significant difference in preferences between organic and pesticide-free juice.

Regarding origin, the odds ratio for American-grown elderberries indicated that a product with this feature and with all other attribute levels unchanged would be 99.7% more likely to be chosen than juice made from European elderberries. The preference of American elderberries may be attributable to the perceived freshness and support for local economies (Smith et al. 2021). Plausibly, consumers may perceive American-sourced ingredients as having higher quality and safety standards. This finding is consistent with those of previous studies. For instance, Mohebalian et al. (2012) found that juice made from local or US-grown fruit significantly attracted more consumer preferences compared with juices that used imported ingredients. Peterson and Li (2011) surveyed US households with young children using a choice experiment method and found that consumers of baby food preferred domestically grown ingredients in processed food products.

Elderberry juice products with labels claiming carbon-neutrality were more appealing (94.1% more likely to purchase) than those without such claim. In general, consumers have a relatively strong demand for carbon labels, although they may feel confused and have a lack of understanding about their implications (Gadema and Oglethorpe 2011). Our findings are consistent with those of several previous research studies (Birkenberg et al. 2021; Brunner et al. 2018; Potter et al. 2021). For example, Duan et al. (2023) highlighted the potential impact of carbon-neutral labeling on consumer perceptions, indicating a strong willingness to purchase carbon-labeled products. This finding is also supported by research that used the revealed preference method. Vanclay et al. (2011) analyzed sales differences over a 3-month period by labeling products with their carbon emissions and categorizing them as having above-average or below-average carbon footprints. Their results demonstrated that, on average, grocery products with below-average carbon emission levels experienced a 4% increase in sales after labeling. They further suggested that carbon labeling has the potential to stimulate reductions in carbon emissions. These studies collectively suggest the significance of carbon labeling for influencing consumer behavior and promoting environmental sustainability efforts and underscore the potential economic benefits for producers and processors to adopt carbon-conscious methods. The alternative-specific constant or the status quo option significantly affected consumer preferences for elderberry juice consumption (P = 0.001) and had a negative influence.

Table 4. Results of mixed logistic regressions to stated choices for selection of elderberry juices from choice experiment (n = 12,417).

Variable	Coefficient	Standard error	P value	Odds ratio	95% Confidence interval
Price	−0.346	0.031	<0.001	0.707	[−0.407, −0.285]
Elderberry production: organic	1.216	0.192	<0.001	3.375	[0.839, 1.593]
Elderberry production: pesticide-free	1.375	0.135	<0.001	3.957	[1.112, 1.639]
Elderberry origin: American	0.692	0.080	<0.001	1.997	[0.534, 0.849]
Claim: carbon-neutral	0.663	0.157	<0.001	1.941	[0.355, 0.971]
Alternative-specific constant	−1.351	0.395	0.001	0.259	[−2.125, −0.577]
*SD*s of random parameters					
Organic	−1.955	0.283	<0.001	N/A	[−2.509, −1.399]
Pesticide-free	1.690	0.202	<0.001	N/A	[1.294, 2.085]
American	−0.948	0.137	<0.001	N/A	[−1.216, −0.680]
Carbon-neutral	−0.959	0.340	<0.001	N/A	[−1.625, −0.293]
Alternative-specific Constant	8.166	0.661	0.005	N/A	[6.871, 9.461]
Model statistics					
Log-likelihood at convergence	−3219.67				
Prob > χ^2	<0.001				

Base levels used for each of the following attributes: elderberry production, conventional; elderberry origin, Europe; claim, without a carbon-neutral claim.

An analysis of the relative importance of price, production practice of elderberries, origin of elderberries, and the presence of a carbon-neutral claim showed that consumers most valued organic and pesticide-free production (45%), followed by the origin of ingredients (22%) and carbon-neutrality (22%), whereas price (11%) is the attribute that consumers value the least when making their elderberry juice purchasing decisions. Our assessments of relative importance were consistent with those of Hine et al. (2002), who conducted a survey among Colorado consumers and elucidated their inclinations toward locally and organically cultivated potatoes. Their research showed that the highest premium in pricing was attributed to locally sourced produce, closely followed by organically grown cultivars. The percentage estimates of price premiums derived from our study are much lower than those reported by a similar study by Cai et al. (2019). Their study demonstrated that consumers exhibited a WTP premium of 54% for organic over conventionally produced pawpaws, 42% for pesticide-free alternatives over conventionally grown pawpaws, and 66% for locally sourced pawpaws over those of unspecified origin. This disparity may imply that consumers' readiness to pay premium prices could diverge between fresh agricultural produce and value-added agricultural goods. It is important to acknowledge that differences in study populations and research regions could also contribute to disparities in findings. For example, the pawpaw study and our current study may have surveyed distinct groups of consumers (pawpaw conference attendees and association members vs. a nationally representative sample). Therefore, further research is needed to explore potential variations in WTP for fresh agricultural produce and value-added agricultural goods among different consumer groups and different regions.

Analyses of DCE data showed the presence of premiums associated with specific attributes of a 12-ounce (355 mL) elderberry juice bottle. Respondents were willing to pay premiums of US$3.51 (23%) more per bottle of elderberry juice that was organic rather than conventionally produced, $3.97 more per bottle (26% more) when the juice was pesticide-free rather than conventionally produced, and $2.00 more per bottle (13% more) when the juice was made from American-grown elderberries rather than European-grown elderberries. The WTP for carbon neutrality was $1.91 more per bottle, or 13% more, than that of bottles with no carbon information. Importantly, although the lower WTP price premiums for organic products appear marginally lower than that for pesticide-free alternatives, our results revealed no statistical difference in consumer preferences between organic and pesticide-free selections.

Conclusions

The niche market of elderberry products was first identified by Mohebalian et al. (2012), who recognized their potential appeal to health-conscious consumers. Since then, the elderberry market has experienced dramatic growth. By 2022, 41.2% of respondents reported prior consumption of elderberry products; this is a six-fold increase from 6.9% reported in 2011 (Mohebalian et al. 2013). This indicates a clear shift from a niche market to a broader consumer base in the United States.

Our results further indicate that more than half of the respondents purchased elderberry products from grocery stores (ranking first among purchase outlets), representing an 8.2% increase from 2011. This suggests that elderberry products have become widely available in mainstream retail outlets, thereby increasing their accessibility to a wider audience. Additionally, elderberry-based vitamin supplements have emerged as the most consumed elderberry product in the United States, accounting for almost half of the responses, compared with a mere 7.0% in the 2011 survey. This trend suggests that consumers are incorporating elderberry products into their daily health routines, thus reflecting its mainstream acceptance.

Using a mixed logit model, this study also examined the effects of price, elderberry production practices, origin of elderberries, and carbon-neutrality claims on consumer preferences for elderberry products and focused on elderberry juice as an example. Consistent with economic principles, the demand for elderberry juice demonstrates an inverse relationship with its price. Our DCE revealed the prevalence of WTP premiums for products labeled as organic ($3.51), pesticide-free ($3.97), domestically sourced ($2.00), and carbon-neutral ($1.91) over their corresponding base levels.

Product origin, particularly the American-grown status, had a significant influence on consumer decision-making when selecting elderberry juice. This was accompanied by preferences for organic and pesticide-free production methods. However, price sensitivity was relatively low, ranking as the least influential factor among the examined attributes. From a marketing standpoint, these findings emphasize the potential effectiveness of labeling strategies for elderberry juice. Products labeled as organic, pesticide-free, locally produced, or carbon-neutral are likely to strongly affect consumer purchasing preferences.

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