CONSUMER WILLINGNESS-TO-PAY FOR CONCORD GRAPE JUICE TREATED BY HIGH-PRESSURE PROCESSING (HPP) AND PULSED ELECTRIC FIELD (PEF) METHODS

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ABSTRACT

The New York Concord grape industry, the second-largest Concord grape producing state in the country, makes enormous contributions to the labor market and has huge economic impacts in the state. However, change of consumers' preferences, decreasing consumption of carbohydrate-rich juice, and increasing supply of Concord grape, all have led to price declines of concord grape juice products. New processing technologies including High-pressured Processing and Pulsed Electric Field have been widely discussed to boost consumption of Concord grape juice. We conducted an online survey to investigate consumers' willingness to pay designing a discrete choice model experiment. Mixed logit models and Latent-class logit models are used to estimate consumers' willingness to pay toward different attributes including processing technology for the productions of Concord grape juice. We found that consumers tend to pay more for High-pressure processed juice. Among these novel technologies, high-pressure processed juice with Pulsed Electric Field receives the highest willingness-to-pay. This study provides useful suggestions for concord grape juice farmers and juice processors adopting novel processing technologies.

BIOGRAPHICAL SKETCH

Anna Hu received her B.S. degree in Math and Business at Northeastern University in 2018. She continued her graduate study at the Dyson School of Applied Economics and Management of Cornell University from 2019 to 2021. Her research interests are in the fields of the agricultural economy, consumer demand, statistics, and finance. In addition, she applied her multidisciplinary study experiences to her internships at Pathfinder International, Ernst & Young, and China International Capital Corporation Limited.

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CHAPTER 1 INTRODUCTION

Consumption of vegetables and fruits containing antioxidants, especially phenolic compounds, has potential health benefits in humans (Lamport et al. *2016*). For instance, consumption of grapes rich in polyphenolic compounds provide positive health effects by preventing several diseases, including atherosclerosis and coronary disease (Capanoglu et al. 2013). With growing concerns of food safety and nutrients in recent years, consumers have increased spending on healthy food. (Bureau of Labor Statistics, 2020) As a result, the juice market expects continuous growth along with increasing demands of healthy food. (Statista, 2021) Contrary to the growing trend of juice market revenue, Concord grape juice consumption is declining as consumer preferences diverge from carbohydrate-rich drinks. (Statista, 2021)

In response to the rising health awareness of consumers, the food industry has responded by producing healthier food products, including fruit, with minimal processing to preserve more nutritional and sensory characteristics of food products. Fruit production is usually subjected to processing to extend shelf life and maintain original flavor and nutritional properties (Rodrigo et al. 2019). Specifically, thermal processing, a traditional pasteurization technique in fruit juice preservation, has been applied in most fruit juice production processes. During thermal processing, microorganisms are effectively removed by high temperature (Aaby et al. 2018). However, high temperature compromises nutritional and sensory qualities of fruit juice, which leads to consumers' dissatisfaction (Rattanathanalerk et al. 2005).

In order to process juice products with minimal effects on their nutrients, non-thermal processing technologies, including high-pressure processing and pulsed electric field, were introduced to preserve liquid food. These advanced processing technologies help to optimize bacterial inactivation, avoid nutrients loss, and improve processing efficiency (Chen et al. 2013).

High-pressure Processing (HPP) is a non-thermal processing technique which exposes the fruit to high hydrostatic pressure up to 1000 MPa (Lado et al. 2002). It effectively kills microorganisms and barely affects the sensory and nutritional qualities of fruits (Yi et al. 2021). Pulsed Electric Field (PEF), one of the non-thermal alternative technologies, processes fruit by delivering pulses of high-intensity electric field within millisecond range (Lado et al. 2002). Compared to the traditional thermal processing method, it effectively extends the shelf-life, retains more nutritional properties, and preserves sensory characteristics of fruit juice (Salehi et al. 2020).

Currently there are studies investigating consumer willingness to pay for non-thermal processed orange, strawberry, tomato, and pomegranate juice (Chen et al. 2016; Aaby et al. 2018; Zhu et al. 2018; Romano et al. 2015). However, there is no study examining consumer willingness to pay for Concord grape juice treated by High-pressure processing and Pulsed Electric Field. To fill this literature gap, a consumer experiment was designed by collecting data from 726 respondents through Qualtrics™. Results suggest that consumers are willing to pay higher prices for novel processing technologies and health attributes of Concord Grape juice.

The remaining of the thesis is organized as follows: Chapter 2 discusses previous studies on the health benefits of HPP and PEF and consumers' willingness to pay towards these two technologies. Chapter 3 explains the design of the discrete choice survey. The methodology of the discrete choice model and description of data are discussed in chapter 4. Chapter 5 reports the analyzed results. Finally, Chapter 6 concludes and summarizes the study.

CHAPTER 2 LITERATURE REVIEW

This chapter first examines the impacts of health attributes of fruit and vegetable products on consumers purchasing decisions and willingness to pay. It then investigates the relationship between processing methods and the health benefits of juice products. Finally, consumer willingness to pay studies on processing technologies are discussed.

With rising awareness of health benefits and nutrients levels of food products, relevant attributes leading to consumers' purchase were largely investigated in the literature. Both internal and external characteristics of the product influence consumers' purchase decisions. External attributes include size, grade, cultivars, and reputation (Carew 2000; Quagrainie et al. 2003; Tronstad et al. 1992). Internal attributes include factors related to food quality, including sensory characteristics and nutrients of food products (Brennan and Kuri 2002; Kajikawa 1998; McCluskey et al. 2007; Miller et al. 2004).

Previous studies demonstrated that internal factors are key determinants of consumer preferences and purchasing decisions (Zhang et al. 2010). Among all internal attributes, health-related factors are often influence consumers' willingness to pay. Food products with fresher flavors are more likely to gain price premiums (Goodman et al. 2002; Lawless et al. 2012). According to Chen et al. (2016), juice products with health benefits, more nutrients, and more juice content can be sold at higher prices. Earlier studies found that apples with appropriate Brix and acid levels, adequate firmness, flavor, juice, and size boost consumers' willingness to pay (Chen et al. 2016; Kajikawa 1998.). McCluskey et al. (2017) points out that consumers expectations for food quality are increasing and conclude that repeating purchasing behaviors of consumers ultimately depend on the sensory properties of apples (McCluskey 2007). Despite large amounts of studies investigating the relationship between internal sensory characteristics of food products

and consumers' willingness to pay, few investigates the relationship between health attributes, such as artificial ingredients level as well as juice concentration, and consumers' willingness to pay. In this study, the influence of health attributes on consumers' willingness to pay is evaluated.

Food processing is a critical factor impacting product quality, nutrients level, and shelf life of food products. Thermal processing, a conventional processing technology aiming to eliminate pathogenic microorganisms in food products, process fruits under high temperature environment and negatively impacts antioxidant capacity, color, and nutrients (Patras et al. *2009;* Liu et al. 2012). Given the increasing popularity of healthier and natural taste foods, many studies examine the advantages of non-thermal processing technologies for fruits and vegetable products over traditional thermal processing. High-pressure processing (HPP), for example, treats fruits with a high hydrostatic pressure for a few minutes (Lado et al. 2002). It achieves microorganism inactivation and protein denaturation without deteriorating nutritional properties and organoleptic quality of the food (Li et al. 2020). Furthermore, HPP treatment was found to improve quality and microbiological stability in cupped strawberries (Gao et al. 2016). HPP also presents an advantage in extending the shelf life of fruit juice with minimal effects on other internal attributes (Yi et al. 2020).

Pulsed Electric Field (PEF), a competing technology, demonstrates similar potential as HPP in the preservation of nutritional properties and product quality. PEF succeeds in microbial and enzyme inactivation, shelf-life extension without compromising the nutritional and sensory characteristics of food products. PEF processed juice can retain more vitamins, ascorbic acid, carotenoid, anthocyanins, lycopene, and organoleptic attributes than thermal processed juice. It effectively lowers the non-enzymatic browning of fruit and vegetable products (Salehi 2020). Combining these two non-thermal processing methods (HPP and PEF) overcomes the limitations

of individual techniques and improves the effectiveness of microbial inactivation. In addition, from an environment perspective, food manufacturers and society can benefit from HPP and PEF since they use less energy than the traditional process (Olsen 2010; Chen 2013). Recent literature examined the impacts of of HPP and PEF on fruits products, including watermelon juice, tomato carrot puree, strawberry, Djulis, pea starch, Aronia berry juice, apple juice, and pineapple juice (Liu 2012; Patras 2009; Yildiz 2020; Sun et al. 2019; Leite et al. 2017; Yi et al. 2021; Zhu et al. 2009; Chakraborty 2016). However, to our knowledge, no studies have researched the advantages of HPP, or PEF treated Concord grape juice. The potential of HPP and PEF treatments on Concord grape juice remains unclear. Even though non-thermal processing technologies present absolute health and environmental advantages over conventional thermal treatment, it is important to understand consumers' attitudes toward novel techniques prior to scaling up these novel technologies for large-scale production (Olsen 2010).

Price premiums offered by consumers is the most direct way to measure acceptance of new technologies. Previous studies evaluated consumers' attitudes and willingness to pay for PEF and HPP-treated food products including chilled ready meals, seafood salad, fresh salsa, juice, and baby food (Sorenson and Henchion 2011; Zhu et al. 2018; Hicks et al. 2009). Most studies found that consumers recognize and appreciate the benefits of novel processing technologies and exhibit positive attitudes to PEF and HPP-treated products. Butz et al. (2003) conducted a survey in Europe to investigate consumers attitudes toward High-pressure food processing and found that 67% of participants from France and Germany accepted HPP methods without extensive information before survey (Butz et al. 2003). Puiyeelee (2015) found that 90% of Chinese consumers accept PEF or/and PEF treated food with a 10% price premium and perceive them as value-added products. Whereas PEF and HPP methods are relatively new to the market and have

not been broadly adopted in commercialized production, the expected naturalness, improved taste, and nutritional value related to the non-thermal processed products potentially sway consumers' purchasing decision from the traditional processed products (Lee et al. 2015). However, consumers' willingness to pay for HPP or /and PEF processed Concord grape juice have not been addressed by previous studies. This study fills this gap in the literature by conducting a discrete choice experiment to estimate consumers' willingness to pay for HPP and PEF-treated grape juice with the presence of nutritional benefits related to these technologies.

CHAPTER 3 SURVEY INSTRUMENT

A discrete choice model was embedded in the survey to evaluate consumers' willingness to pay for Concord grape juice processed by two non-thermal pasteurization treatments for US consumers over 18 years old. This 7 - 10 min online survey was designed and applied through the Qualtrics™ online platform. We successfully collected data from 727 respondents by including conditional questions and one attention check question. Respondents who either failed the attention check question, never purchased juice products, or answered the questions with less than half of the median time were excluded from our study. The survey consists of five parts, including questions of participants' socio-demographic information, purchasing, and buying habits of juice products, the focal choice experiments, and willingness to pay for non-thermal processing technology.

Part 1. Demographics

The survey begins with questions that explore respondents' demographic characteristics. This part asks respondents to provide information about their gender, ages, ethnicity, region of residence, educational background, and household income. Respondents selected matching information from a drop-down list in each question. The age question was designed to exclude respondents lower than 18 years old to ensure the quality of the survey. Other socio-demographic questions were used to identify the characteristics of consumers. Descriptive statistics of the demographic characteristics are shown in Table 1. The levels of each category are consistent with the most recent U.S. Census (United States Census Bureau, 2019).

Table 1: Demographic characteristics and levels

Demographic characteristic	**Levels**
Gender	Male
	Female
Age(years)	21-24
	25-34
	35-44
	45-54
	55-64
	65+
Income ($ U.S. 2017)	0-24,999
	25,000-49,999
	50,000-74,999
	75,000-99,999
	100,000+
Education	Less than High School
	High School graduate
	Some college, no degree
	Associate's degree or Bachelor's degree
	Graduate or professional degree
Region	Northeast
	Midwest
	South
	West

Part 2. Juice Purchasing Habits

Questions following demographic part aim to understand respondents' purchasing habits for juice products. In this part, we asked respondents questions about their/their household's purchasing frequency of juice products, whether the respondent is the household's primary shopper, the types of retail outlets where they purchase fruit juice, and factors affecting the purchasing decision. The question of buying frequency provides answer range from *Never* to *More than weekly*. Respondents who selected *Never* were skipped from other questions of this block. We provided six main types of offline grocery stores and online shopping selections for the stores of purchasing question. We provided a write-in option if the respondent's choice is not listed.

The final question in this section asked respondents about the top three factors affecting their fruit juice purchasing decisions. These factors include price, brand, taste, localness, organic

ingredients, sugar content, style, packaging, nutritional information, shelf life, and highlighted information to call attention.

Part 3. Choice Experiment

As the main part of the survey, the choice experiment part starts with introducing the experiment. Two hypothetical 10oz grape juice products with varying attributes were given in each of the nine questions included in the experiment. Respondents were asked to choose the juice they preferred from three given options, namely *Juice A*, *Juice B*, and *None of them*. On the following stage of the survey, we reminded respondents to treat the hypothetical situation as a real one to ensure the quality of the answers. The definitions of the three processing technologies (i.e., thermal processing, HPP and PEF) were provided before the participants were given the choice set. To help participants easily understand the differences of the juice, we referred juice treated by high-pressure processing (HPP) as *Cold-pressed juice* and juice treated by high-pressure processing (HPP) with pulsed electric fields pre-treatment (PEF) as *Cold-pressed Plus Juice*. Using these substitute terms for processing technologies aims to minimize inaccurate answers due to the confusion about processing technology terms. The definition of each term is provided below with highlighted information.

- ***Thermally processed juice****: grapes are pressed and then heated at a high temperature for pasteurization. This is a traditional way to produce juice.*
- ***Cold-pressed juice:*** *grape is cold-pressed then pasteurized using a non-thermal high-pressure process.*

  Cold-pressed: ***minimal processing, more nutrients, and fresh fruit flavor.***

- ***Cold-pressed Plus juice:*** *before pressing, grape was pre-treated by Pulsed Electric Fields,* ***a novel technology*** *to change the skin permeability. This results in higher amounts of nutrients leaching into juice. The juice is then pasteurized using high-pressure process.*

  Cold-pressed plus: ***novel technology, minimal processing, more nutrients, fresh fruit flavor, higher antioxidant level than thermally processed and Cold-pressed juice.***

Following information on processing technologies, we added an attention check question before giving respondents the actual choice questions to examine respondents' understanding of each processing technology. Each of the nine questions in this block provides two hypothetical juice choices, Juice A and Juice B, with four different attribute levels, as shown in Table 2. Four attributes are included in our survey including processing technologies, concentrate level, artificial ingredients, and price. There are three levels for the processing technology attribute including *Thermally processed*, *Cold-processed* and *Cold-pressed Plus*. *Cold-pressed* refers to juice treated by high-pressure processing. *Cold-pressed Plus* refers to juice treated by high-pressure processing with pretreatment of Electric Pulsed Field. These two terms are used for respondents' convenience. The concentrate and artificial ingredients attribute have one level for each which are *not from concentrate* and *no artificial flavors, colors or preservatives*. There are three levels for *price* attribute including $3/ six-pack, $5/six-pack, and $7/six-pack. And the choice questions are shown in the format of Figure 1 to respondents. Respondents were asked to choose the one they would like to purchase in real life based on the combinations of each attribute. The third option also is provided if the respondent chooses to purchase neither Juice A nor Juice B. The definitions of the processing technologies in the experiment were provided once again in each choice set. To avoid potential order effects, the order of the choice questions was randomized when administrating the survey. That is, the order of the choice questions was presented differently for different participants.

Table 2 Attributes and Attributes Level Used in the Choice Experiment

Attributes	**Attribute's level**
Processing Technologies	Thermally pressed
	Cold-pressed
	Cold-pressed Plus
Concentrate	Not from concentrate
Artificial ingredients	No artificial flavors, colors, or preservatives
Price	$3/six-pack
	$5/six-pack
	$7/six-pack

Figure 1. Example Choice Alternative in the Choice Experiment

Cold-pressed Plus juice: novel technology, minimal processing, more nutrients, fresh fruit flavor, higher antioxidant level than Thermally processed and Cold-pressed juice.

Thermally processed juice: grapes are pressed and then heated at a high temperature for pasteurization. This is a traditional way to produce juice.

Juice A	**Juice B**
Cold-pressed Plus	Thermally processed Not from concentrate No artificial flavors, colors or preservatives
$5/six-pack	$3/six-pack

If these were your only options, which would you choose?

	Juice A	Juice B	None of them
I would choose	○	○	○

Part 4. Health Preferences

We examined the health awareness of respondents and their willingness to pay for the novel processing technologies in Part 4, which is included in the exit survey. First, respondents were

asked to rank their preference for the five most popular juice types including apple juice, orange juice, cranberry juice, grape juice, and pineapple juice. Based on the consumption frequencies within three months and a write-in box is also provided if they decided to add another juice type. Next, we asked whether consumers were interested in purchasing a new kind of juice. Subsequently, we examined consumers' health awareness of juice products with questions related to functional juice products which contains components bringing health benefits. Respondents were asked to provide information about their purchase frequency of functional juice in this section. This component of the survey asked about the frequency of reading health claims of food products ranging from *Never* to *Always at purchasing*. We also asked respondents to evaluate their physical health and mental health condition with options ranging from *Strongly disagree* to *Strongly agree* to measure their health consciousness level. Finally, the survey included two questions designed to study consumers' willingness to pay for novel technology. One question asked the participants the maximum price of a 10oz bottle of cold-pressed plus juice that they can accept and consider purchasing, ranging from $0.00 to $6.00. Another question asked the respondents to provide a price they would not consider purchasing a 10oz bottle of Cold-pressed Plus juice, range from $0.00 to $10.00.

CHAPTER 4 EMPIRICAL METHODOLOGY

This study explores consumers' willingness to pay for novel processing technologies treated grape juice by applying a discrete choice model and a latent class model. In the choice experiment, we provided a mutually exclusive, exhaustive, and finite choice set to fit the criteria of the discrete choice model (Train 2009). Respondents can only choose one from the three listed options, including *Juice A*, *Juice B*, and *None of them*. *None of them* includes all options except for *Juice A* and *Juice B* (i.e., the outside option) and the choice set is exhaustive. Applying random utility theory to the discrete choice experiment, we assumed that respondents derive utility from attributes of the juice product rather than the product itself (Zheng et al 2016.) Consumers are assumed to choose the alternatives with maximum utility. The utility is derived by including a decision maker, labeled as *n*, and alternatives, labeled as *j*. The utility function contains two parts, including the observed utility, V_{nj}, and another unobserved part, $\mathcal{E}_{nj}$ (Train 2009). It is specified as:

(1) $$U_{nj} = V_{nj} + \mathcal{E}_{nj}$$

Since V_{nj} and $\mathcal{E}_{nj}$ capture the observed and unobserved utility component respectively, V_{nj} is treated as a deterministic component and $\mathcal{E}_{nj}$ is treated as a random component of the utility function. We present the probability that respondent *n* chooses among *j* alternatives as:

(2) $$P_{nj} = Prob(V_{nj} + \mathcal{E}_{nj} > V_{ni} + \mathcal{E}_{ni} \ \forall j \neq i)$$

It is more likely for consumers to choose the alternative with higher utility. The function above presents the probability of decision maker *n* choosing alternative *j*. In this study, selecting the option *Juice A* in one choice question indicates that attributes included in *Juice A* bring the highest utility among all alternatives. The probability of respondent *n* choosing juice *j* in a closed form are specified as:

(3) $$P_{nj} = \frac{e^{V_{nj}}}{\sum_i e^{V_{ni}}}$$

For estimation, we employ a mixed logit model to capture the heterogeneity preferences of respondents that are unrelated to observable characteristics. The mixed logit model is a flexible model to evaluate random utility by releasing restrictions of standard logit model. It allows random taste variations, unrestricted substitution patterns, and correlation in unobserved factors over time (Train, 2009). In our study, explanatory variables including all attributes of alternatives which are *Thermally processed, Cold-pressed plus*, *Whether or not from concentrate*, *Artificial ingredients*, and *Price*. Thermal processing and cold-press plus are included in the analysis whereas the cold-press technology served as a reference variable (i.e., included in the intercept). The utility derived by individual *n* from choosing alternative *j* at choice occasion *t* shown as:

(4) $U_{njt} = \beta_{n1} Thermal\ processed_{njt} + \beta_{n2} Cold\ pressed\ plus_{njt} + \beta_{n3} Concentrate_{njt} + \beta_{n4} Artificial_{njt} + \beta_{n5} Price_{\ njt}$

The probability decision maker *n* chooses alternative *j* at scenario *t* evaluated at β_n shown as:

(5) $$P_{njt} = \int \left(\frac{e^{\beta' x_{njt}}}{\sum_j e^{\beta' x_{nit}}} \right) f(\beta) d\beta$$

Logit probability depending on parameters β is given by:

(6) $$L_{njt}(\beta_j) = \left(\frac{e^{\beta_i x_{njt}}}{\sum_j e^{\beta_i x_{nit}}} \right) f(\beta) d\beta$$

To better identify consumers' preferences accounting for heterogeneity, we applied a latent class model in addition to the mixed logit model described above. Schwarz's Bayesian information criterion (BIC), a default criterion for latent class model is used to determine the number of classes. Each class in the population has distinct choice behaviors and different preferences. The share of

classes m in the whole population is shown as S_m. And the choice probability is specified as (Train, 2009):

(7) $$P_{njt} = \sum_{m=1}^{M} S_m \left(\frac{e^{\beta_m x_{njt}}}{\sum_j e^{\beta_m x_{nit}}}\right)$$

CHAPTER 5 DATA DESCRIPTION & RESULTS

Summary statistic of respondents' socio-demographic characteristics

In total, 727 completed responses were used in this study. Information of respondent socio-demographic characteristics was obtained. We verified that the socio-demographic characteristics of our respondents were comparable with related data from the most recent U.S. Census (United States Census Bureau, 2019), as shown in Table 3. In general, the demographic characteristics of our sample are consistent with those of the U.S. population, with a few exceptions.

Table 3. Demographics of the U.S population versus the demographic of the samples

Demographic characteristic	% U.S. Population	% Sample
Gender		
Male	49.03%	51.44%
Female	50.97%	48.56%
Age		
18-20	3.7%	7.7%
21-24	17.8%	7.02%
25-34	14.0%	24.48%
35-44	12.6%	27.24%
45-54	12.6%	10.87%
55-64	12.8%	9.77%
65+	16.4%	12.93%
Income ($)		
0-24,999	17.8%	23.38%
25,000-49,999	20.0%	23.80%
50,000-74,999	16.5%	16.64%
75,000-99,999	12.3%	11.69%
100,000+	34.1%	24.48%
Education		
Less than High School	14.8%	4.95%
High School graduate	27.0%	22.70%
Some college, no degree	26.5%	24.62%
Associate's degree or Bachelor's degree	20.2%	27.51%
Graduate or professional degree	11.4%	20.22%
Region		
Northeast	17.1%	19.39%
Midwest	20.8%	20.77%
South	23.9%	38.10%
West	38.3%	21.60%

The gender composition in our survey is slightly different from that of the U.S. population. Though our sample has more male respondents than female respondents, the proportion is only 2% different when compared to the gender composition of the U.S. population. Compared with the data from the U.S. Census, percentages of age groups 18-20, 25-34, and 35-44 in our sample are higher than the counterparts in the U.S. population, indicating younger people are overrepresented in our sample. Since the survey was distributed online through Qualtrics™, which is accessible via smartphones or computers, we expect higher rate of response among young people. The sample consists of slightly more respondents with income ranges of $0-24,999, $25,000-49,999, and $50,000-74,999 and slightly less respondents in the $75,000-99,999 and $100,000+ income groups. Since most of our participants gathered at the young age groups, it is reasonable that the median income is relatively lower in our survey than in the U.S. Census. In respect to educational levels, our respondents exhibit higher education level than the U.S. population, with 4.95% of respondents without a high school degree compared to 14.8% in the census. About 22.70% of our survey participants graduated with high school degree and 24.62% went to college without a degree. Meanwhile, 27.0% of the U.S. population obtained high school degree and 26.5% attained some college but without degree. Individuals with associate's degrees and bachelor's degrees occupy 27.51% and 20.33% in our sample population, respectively, which are greater than the U.S. population. Similarly, the percentage of participants who gained graduate or professional degrees accounts for 20.22% of the sample, which is higher than that of the whole U.S. population. Percentages of participants from Northeast and Midwest is consistent with the those of the population. There are more percentage of participants from South in the survey than the census and less percentage from West.

Results of the Mixed Logit Model

The coefficients of attributes in the mixed logit model are shown in Table 4. In the model, there are a total of 19,629 observations with -4852.4 of log-likelihood ratio test statistics. Variables were included in this model including price, processing technologies (*Cold-press Plus* and *Thermally processed*), *Not from Concentrate*, and *No artificial flavor, colors, or preservatives*.

Table 4. Estimation Results of Mixed Logit Model

	Mean		**Standard Deviation**	
Variable	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Price	-0.266***	0.027		
Cold-pressed Plus	4.292***	0.154	1.637***	0.102
Thermally Processed	-0.840***	0.112	1.324***	0.095
Not from Concentrate	0.024	0.124	1.362	0.078
No artificial flavor, colors, or preservatives	4.437***	0.140	0.998	0.104

Note: *, **, and *** denote significance at the α = 0.1, 0.05 and 0.01 levels, respectively.

All variables except for *not from concentrate* are statistically significant at the 1 percent level (P-value <0.01). The coefficient of *Price* is treated as fixed, and the coefficients of all other variables were considered random. Not surprising, the coefficient of *Price* is negative and significant, indicating that people prefer juice with lower price. The higher the price is, the less likely consumers are willing to purchase the product. The coefficient of *Thermally Processed* is also negative and significant, indicating that consumers prefer the Cold-pressed juice (served as the reference variable in this model) over the thermal processed juice. In addition, the coefficient of *Cold-pressed Plus* is positive indicating that participants prefer Cold-pressed Plus juice over Cold pressed juice. In addition, results suggest that consumers prefer juice without artificial ingredients reflected by a positive estimated coefficient of 16.701.

Based on the results shown in table 4, we infer that consumer prefer Cold-pressed Plus the most and thermally processed the least. Since the p-value of *Not from concentrate* variable is greater than 5 percent and statistically insignificant, we cannot conclude that the relationship

between this variable and consumers' preferences for the case of Concord grape juice. Based on results from the mixed logit model, consumers' willingness to pay for each attribute is discussed in Table 5. Willingness to pay for specific attributes is calculated by dividing the coefficients of variable (other than price) divided by the coefficient of price. The traditional thermally processing is the least favored among three processing methods. Since Cold-pressed attribute is treated as the base for processing technology variables, the negative willingness to pay for thermally processing indicates that consumers are willing to pay $3.16 less for thermally processed six-pack 10oz juice than for the six-pack 10oz Cold-pressed juice. And consumers are willing to pay an additional $16.15 for six-pack juice treated by HPP with pretreatment of PEF over thermally treated juice. $0.092 for juice not from concentrate, and $16.701 for juice without artificial ingredients, *ceteris paribus*. The high willingness to pay for *Cold-pressed Plus* indicates that consumers care both processing technology and health attributes including *Not from concentrate* and *No artificial flavor, colors or preservatives*. Similarly for the high willingness to pay for *No artificial flavor, colors, or preservatives.* Thus, consumers show strong interests in novel processing technologies and health factors and are willing to pay a very high price premium toward these factors.

Table 5. Willingness-to-pay for Concord grape juice from mixed Logit Model

Attributes	**Mean (dollars/six-pack)**	**95 percent Confidence Interval**
Cold-Pressed Plus	16.158	(13.680,18.636)
Thermally processed	-3.163	(-3.677, -2.650)
Not from Concentrate	0.092	(-0.8101, 0.994)
No artificial flavor, colors, or preservatives	16.701	(14.003,19.399)

Results of Latent Class Logit Model

The results from mixed logit model confirm consumer preferences toward certain attributes. As an extended analysis of mixed logit model, we applied a latent class logit model to our research to observe the characteristics of subgroups. Participants are categorized based on their characteristics. To determine the optimal number of consumer segments, we used Bayesian Information Criterion (BIC). With a relatively small value of BIC, the three-class model is identified as optimal with high accuracy. Information of each class is summarized in Table 6.

Table 6. Estimation Results of Latent Class Logit Model

Variable	**Class 1 Coef.**	**Std. Err.**	**Class 2 Coef.**	**Std. Err.**	**Class 3 Coef.**	**Std. Err.**
Price	-0.697***	0.056	0.050	0.042	0.072	0.093
Cold-Pressed Plus	5.136***	0.266	2.393***	0.285	6.066***	0.762
Thermally Processed	-0.838***	0.196	0.177	0.150	-1.650***	0.367
Not from Concentrate	0.087	0.195	0.092	0.167	-0.430	0.318
No artificial flavor, colors, or preservatives	5.005***	0.241	3.157***	0.268	5.153***	0.720
Class Share	36.4%		37.2%		26.4%	

*Note: *, **, and *** denote significance at the α = 0.1,0.05 and 0.01 levels, respectively.*

Class 1 represents 36.4% of the total participants. Participants within the group show strong response to price changes because the price coefficient is negative and statistically significant. The more expensive the product is, the less likely they would like to purchase the product. The coefficient of thermally processed is also negative and statistically significant. *Cold-Pressed Plus* and *No artificial flavor, colors, or preservatives* attributes positively correlate with consumer preference and are statistically significant. Consumers' attitude towards the *Not from concentrate* attribute remains unclear with a statistically insignificant coefficient. Participants in the first

segment are highly price-sensitive and show vital interests in health attributes and processing technologies.

Class 2 accounts for 37.2% of the whole sample. Only coefficients of *Cold-pressed Plus* and *No artificial flavors, colors, or preservatives* are statistically significant. Thus, we unable to draw conclusion from the other three attributes. Participants in Class 2 is not sensitive to price and processing technology. The results of Class 2 stand between Class 1 and Class 3.

Class 3 comprises 26.4% of total participants. Coefficients of *Price*, *Cold-Pressed Plus*, and *No artificial ingredients are positive*, and coefficients of *Thermally processed* and *Not from concentrate* are negative. Among all the coefficients, coefficients of *Cold-pressed plus*, *Thermally processed* and *No artificial ingredients* are significant and have robust values. Consumers in this segment much preferred the novel processing technology through the biggest positive coefficient of *Cold-pressed plus*. Also, they demonstrated the most substantial interest in the health contents of juice products.

Results of Socio-demographic Characteristics and Purchasing Habits of the Group

We examined differences in the consumers' socio-demographic characteristics and purchasing habits of each segment identified above through pairwise comparison and ANOVA tests. The P-value of ANOVA for each variable is statistically significant at one percent level. Results of the pairwise comparison are listed in Table 7.

Table 7. Results of pairwise comparisons of consumer demographic characteristics and purchasing habits for the consumer groups

	Class 1		**Class 2**		**Class 3**	
Variable	**Mean**	**Std.Err.**	**Mean**	**Std.Err.**	**Mean**	**Std.Err.**
gender	0.449	0.059	0.489	0.006	0.531	0.007
Income	2.616	0.017	2.996	0.017	3.156	0.021
Age	4.281	0.019	3.717	0.195	4.302	0.023
White	0.741	0.005	0.713	0.005	0.755	0.006

Black	0.106	0.004	0.151	0.004	0.104	0.005
Purchasing frequency	4.034	0.134	4.522	0.013	4.443	0.156
Juice drinker	2.125	0.111	2.221	0.011	2.125	0.013
Purchasing at healthy stores	0.027	0.003	0.077	0.003	0.078	0.003
Purchasing at discount stores	0.141	0.004	0.099	0.004	0.130	0.005
Interest level of new juice	0.817	0.004	0.794	0.004	0.948	0.005
Purchasing functional juice	0.373	0.006	0.551	0.006	0.531	0.007
Purchasing CPP juice	3.833	0.117	4.040	0.115	4.411	0.014
Diet level	4.490	0.020	4.587	0.020	5.339	0.0233
Exercise level	4.099	0.022	4.783	0.021	4.917	0.036
Mental health	5.213	0.018	5.353	0.018	5.839	0.021
Consider to buy	3.141	0.017	3.891	0.016	3.977	0.019
Not consider to buy	4.722	0.029	6.363	0.029	6.407	0.034

The composition of gender among the three groups is similar across classes. Participants in Class 1 and 2 earn less income than those in Class 3. Class 1 has the lowest income among the three classes, which perhaps driving their strong sensitivity to price changes as shown in Table 6. No significant difference in age was observed between Class 1 and Class 3. Meanwhile the mean of age in Class 2 is relatively lower than in the other two classes. Regarding race, because black and white population account for the major proportion of our sample, we only compare these two races across classes. Results indicate no significant race differences between classes 1 and 3. However, Class 3 exhibits a higher proportion of white individuals in comparison to the other classes; and Class 2 has a higher proportion of black individuals relative to the other classes.

We also investigated juice purchasing and consuming habits of consumers by applying pairwise comparisons and ANOVA tests. All means are statistically significant, which is reflected p-values in general lower than 0.01. Results suggest no statistically significant differences in

purchasing juice at discount stores between Classes 1 and 3. Also, results indicate no differences between Class 2 and 3 in terms of the maximum purchasing price of grape juice treated by HPP and PEF methods, as well as and the behavior of purchasing juice products at healthy stores. Class 2 includes relatively more juice drinkers than the other two classes, but participants in Class 2 are reluctant to try new juice products. This may explain the results from the latent class model that Class 2 has the smallest coefficient for the *Cold-pressed Plus* variable. Class 1 participants are the least concerned with health attributes reflected by low exercise level and low sensitivity of diet. They are more likely to purchase products at discount stores such as Dollar Tree and Dollar General. The acceptable price range of the Cold-Pressed Plus grape juice price of Class 2 is the smallest among all classes. Participants in Class is more likely to purchase Cold-Pressed Plus Juice than other two groups. They have highest income level across the three class and present a high interest in new juice products with novel technology. Strong awareness of physical and mental health in Class 3 encourages them to pay a price premium for grape juice treated with novel processing technology.

Class 1 has the lowest income level, highest price sensitivity, and the least health consciousness level across all three classes. Class 1 individuals often purchase at discount stores, but they still are open to try juice processed with novel technologies. Class 3 with the highest income level and the lowest price sensitivity. They are mostly older, white people, showing strong awareness of physical and mental health and are very much interested in trying juice processed with novel technologies. Class 2 is not very typical and stands in between class 1 and class 3.

CHAPTER 6 DISCUSSION AND CONCLUSION

This study examined consumers' willingness to pay for Concord grape juice treated with High-pressure processing and Pulsed Electrical Field through an online Qualtrics™ survey. The primary goal was to investigate consumers' purchasing attitudes towards Concord grape juice treated with novel technologies, controlling for demographic characteristics, and purchasing habits. Because the main differences between novel processing technologies, HPP and PEF, and traditional thermal processing, are the amounts of nutrients and antioxidant level in the product. The study includes two attributes that consumers care and appear on product labels: *not from concentrate* and *no artificial ingredients*. Participant's willingness to pay for Concord grape juice for all attributes is assessed.

Survey participants show strong interest in Concord grape juice produced using novel processing technologies and health attributes in general. For juice treated by three methods, juice treated by HPP with pretreatment of PEF is preferred by consumers the most. Juice treated by thermally processing is favored least. Results provide strong evidence that adopting these two processing technologies can positively impact the probability of Concord grape juice purchasing. All respondents expressed concerns related to health factors of Concord grape juice: Juice without artificial ingredients and not from concentrate is preferred by consumers.

We applied a latent class model to extend the analysis and identify segments with distinct preferences. For example, price-sensitive consumers are more likely to purchase Concord grape juice at discount stores than at healthy stores. People with an average income are the main juice drinkers. They exhibit interest in consuming juice produced using novel technologies, but they are only willing to pay a moderate price premium for these technologies. Older consumers with high income pay more attention to their health as well as the healthy contents of juice products they

consume. They show strong interest in functional juice and new juice products and prefer to purchase them at healthy stores.

These results provide valuable insights for juice processing producers to better develop the product and have a better understanding whether commercialize production is feasible. It also provides insights to marketers regarding how to best position and pricing this novel juice if it is produced. Furthermore, the results provide policymakers a better understanding consumer demands for this novel technology, which in turn, could provide a new market channel for concord grape growers who have suffered a great loss over the past several years due to the decreasing demand of regular thermal processed grape juice.

This project partly contributes to The Mighty Concord Project funded by the Department of Agriculture and Markets of New York State. The project aims to find a solution for the imbalance between demand and supply of the local Concord grape markets. Based on our analysis, it is imperative for Concord grape farms and juice processing companies to acknowledge the increasing health awareness of consumers. The Concord grape juice industry would benefit from adopting novel processing technologies to maximize the health attributes in juice products. Because different consumer groups demonstrate varied demographic characteristics and purchasing habits, the industry could distribute Concord grape products treated by different processing methods to target stores to boost the quantity of demand. Since healthy stores such as Whole Foods and others have a large group of health-sensitive consumers, price premiums can be expected by distributing Concord grape juice treated by HPP and PEF to healthy stores.

Due to the global Covid 19 pandemic, we are unable to conduct auction experiment by providing real products treated with different technologies for consumers to bid. The benefits of auction experiments are that they can closely imitate the real-world situation and monitor

consumers' preferences toward sensory characteristics of Concord grape juice. However, we used multiple methods such as attention checks and provided definition of each technology in choice questions to ensure the accuracy of our data. Considering most consumers are not acquainted with HPP and PEF processing technologies and their health advantages, advertisement and educational information on the two technologies are expected to boost consumer demand for Concord grape juice products. Results of this study suggest the industry should adopt HPP and PEF into Concord grape juice production. Further studies are necessary to better understand different consumer segments by including more attributes such as sensory characteristics through auction experiments.

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APPENDIX

Supplementary Material

Below is the first sample choice question in the survey.

Cold-pressed Plus juice: novel technology, minimal processing, more nutrients, fresh fruit flavor, higher antioxidant level than Thermally processed and Cold-pressed juice.

Thermally processed juice: grapes are pressed and then heated at a high temperature for pasteurization. This is a traditional way to produce juice.

Juice A	**Juice B**
Cold-pressed Plus	Thermally processed Not from concentrate No artificial flavors, colors or preservatives
$5/six-pack	$3/six-pack

If these were your only options, which would you choose?

	Juice A	Juice B	None of them
I would choose	○	○	○

Below are Socio-demographic Survey Questions

Q2 For federal government-related forms, you are identified as a

- Male
- Female

Q3 What is the highest level of education?

- Less than high school degree
- High school graduate (high school diploma or equivalent including GED)
- Some college but no degree
- Associate and/or Bachelor degree earned
- Graduate and/or Professional degree earned

Q4 Information about income is very important to this research. Would you please give your best guess? Please indicate the answer that includes your entire gross household income in previous year before taxes.

$0 to $24,999

Q5 In which state do you currently reside?

Alabama

Q6 Are you the primary shopper in the household?

- Yes
- No

Q7 Your age:

- 18-20
- 21-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

Q8 Choose one or more races to indicate what race you consider yourself to be:

- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Pacific Islander
- Other

Below are questions of consumer purchasing and consuming habits for juice products:

Q9

How often do you buy juice from a retail outlet for you and/or your household?

- Never
- Very rarely (less than once a month)
- Once a month
- Two or three times a month
- Weekly
- More than weekly

Condition: Never Is Selected. Skip To: End of Block.

Q10

Who typically drinks the juice you buy?

- Yourself
- Someone else (children, other family members, or partners)
- Both yourself and someone else

Q11

What kind of grocery store do you mostly go shopping over the past month?

- Wholesale clubs (e.g., Sam's club, Costco, and BJ's)
- Supercenters (e.g., Walmart, Target, and Kroger)
- Healthy food stores (e.g., Whole foods and the Fresh Market)
- Limited assortment stores (e.g., ALDI, Trade Joe's, and Save-a-lot)
- Drug stores (e.g., Walgreen and CVS)
- Dollar stores (e.g., Dollar General, Dollar Tree, and Family Dollar)
- Online grocery shopping
- Others, please specify

Q33

Please drag and drop to rank the juice you consume from the most to the least over the past three months

Orange juice	1
Cranberry juice	2
Apple juice	3
Grape juice	4
Pineapple juice	5
Others, please specify	6

Q3

Do you enjoy buying new kinds of juice that you have never tried before?

- Yes
- No

Q35

Have you ever purchased any functional juice (i.e., juice with detox function)

- Yes
- No

Q38

How often do you buy functional juice for you and/or your household?

- Very rarely (less than once a month)
- Once a month
- Two or three times a month
- Weekly

Page Break

Q17

How interested are you in buying the **Cold-pressed Plus** juice if priced within your budget?

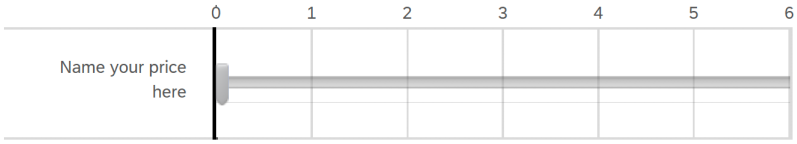
Cold-pressed Plus juice: novel technology, minimal processing, more nutrients, fresh fruit flavor, higher antioxidant level than Thermally processed and Cold-pressed juice.

- Extremely interested
- Very interested
- Moderately interested
- Slightly interested
- Not interested at all

Page Break

Q29

At what price would you think the **Cold-pressed Plus juice** (one 10oz bottle) is **getting expensive, but you still might consider it?**



Q15

How often do you read health claims when you purchase food products?

- Always at purchase
- Most of the time at purchase
- When have time
- When on diet
- First time of purchase
- Never

Page Break

Q56

Please evaluate the following statements

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I am conscious of my diet							
I maintain a regular exercise schedule							
I pay attention to my mental health							

Q32

At what price would you think the **Cold-pressed Plus juice** (one 10oz bottle) is **too expensive** to consider?

	0	1	2	3	4	5	6	7	8	9	10
Name your price here											

Page Break

Q14

Please choose the **top THREE factors** you would consider when buying juice?

- Price
- Brand
- Taste
- Localness
- Organic ingredients
- Sugar content
- Style (whether it is from concentrate)
- Packaging
- Nutritional information
- Shelf life/date of production
- Highlighted information to call attention (i.e., healthy claims)