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An Outline of the Issue or Problem: The cider industry in Washington is undergoing a major expansion due to rediscovery among consumers for this alcoholic beverage. To make a premium cider, cideries desire apple cultivars with high tannin, high acid, and/or high sugar content. Few apple cultivars have all the desirable characteristics for cider, so cider makers often blend multiple varieties to achieve a desired flavor profile. One of the key issues faced by commercial cideries is the limited availability of cider apple varieties needed for making premium cider. There were an estimated 204 acres of cider apples grown in Washington in 2010 and 256 acres in 2011 (NABC, informal survey, 2013), compared to 149,500 bearing acres of dessert apples produced in the state, on average during the same period (NASS, 2014).

Historical data have been collected by tree fruit associations and U.S. Department of Agriculture regarding traditional apple production (e.g., apple varieties, price received, volume of production, bearing acres, etc.) at the state and national levels. Data on volume of cider production are recorded by the U.S. Department of Treasury-Alcohol and Tobacco Tax and Trade Bureau (TTB). However, data regarding the scale of both cider apple production and cideries are deficient. Lack of this knowledge is an important issue because, without this type of data, it is not possible to adequately assess the economic impact of this emerging and growing industry.

Furthermore since cider apple varieties are only used for cider making, growers need reliable information on specific varieties that cideries would purchase. On the other hand, the styles of cider preferred by consumers can affect the cider maker's varietal choice. The intrinsic attributes of cider (e.g., flavor, aroma, appearance, body) can affect consumer preferences. Since these attributes are linked with the juice qualities of cider apple varieties, consumer preference appears to be a key driver in the selection of cider apple varieties as much as the cider style. At present, there is a knowledge gap about cider characteristics that affect consumer preferences.

Goals and Objectives: The long-term goal of this research agenda is to identify factors that could contribute to the growth of the cider industry in the United States, and thus increase the economic viability of specialty crop farmers (apple growers), and those who add value to these specialty crops (cider makers). As a step towards achieving this long-term goal, the overall aim of the proposed research is to provide market information related to cider production that will help both apple growers and cider makers in Washington maintain or augment their income.

Objective 1 - A report showing the scale of cider apple and hard cider production in Washington State.

We surveyed cider maker members of the Northwest Cider Association (NWCA), and have a total of 9 responses from 29 members located in Washington State, a response rate of 31%. The results of the survey indicate that cider makers prefer cider apple varieties and are willing to pay a premium over dessert apple varieties, however when cider apple varieties are limited the makers are willing to substitute dessert apple in cider making.

At the time of the survey, we identified 6 NWCA members from Washington who are cider apple growers. We received 6 responses to the cider apple growers survey, thus this was a 100% response rate. Additional responses were obtained from 4 cider apple growers in Skagit and Whatcom Counties in northwest Washington through face-to-face interviews conducted by a Western Washington University undergraduate student, as part of her research project. The student utilized the questionnaire that we distributed to the NWCA members. The area of cider apples grown by respondents was between less than 1 and up to 2 acres, and most individual varieties were grown in less than 1 acre areas. A majority of apple growers use their own apples to make cider and the remainder sell their cider apples to other cider makers.

Objective 2 - A report showing different cider apple varieties grown in Washington and the specific varieties that form the flavor profile of cider styles preferred by consumers.

This sensory evaluation was undertaken in February 2015 and data analysis has been completed. The chemical analysis was completed in March and a report was been prepared. One benefit from undertaking these analyses has been the interaction and response from the cider industry. The industry personnel we talked with and from whom we purchased cider are very interested in the outcomes of the evaluation, from both a technical perspective and from a consumer perspective. Specifically, the industry is interested in learning about consumer's preference and willingness to pay for craft cider.

Objective 3 - General templates for the industry assessment survey, sensory experiment, chemical analysis, and consumer survey that can be used to extend the project's overall aim to other regions in the U.S.

After the development of the two survey instruments for cider makers and cider apple producers, the sensory evaluation survey, and the chemical analysis of finished bottled ciders, several factors have been identified that may require further development. The first is the low response rate to the cider maker survey, which may be due to the low number of full-time cider makers in the NWCA, as part-time cider makers may not have the time or inclination to complete the survey. In the sensory evaluation survey several issues arose, one was the length of the survey, which we intend to reduce in future sensory evaluations. However, the pilot survey instruments themselves appear to work well, and may be adapted for use in a future national SCRI research project proposal of the cider industry in which the investigators in this project are involved.

The protocol for the chemical analysis of finished bottled ciders will be reviewed by national experts and revised as needed for future studies both in Washington and nationally.

Contribution of Project Partners: Our research featured collaborators from diverse interests within the College of Agricultural, Human, and Natural Resource Sciences at Washington State University:

Ms. Suzette Galinato (Research Associate, IMPACT Center, School of Economic Sciences) and Dr. Carol Miles (Professor and Extension Specialist, Department of Horticulture) contributed in the development and dissemination of the survey questionnaires to cider producers and cider apple growers, and in the analysis of data collected. They also worked with Dr. Jill McCluskey (Professor, School of Economic Sciences) and Dr. Carolyn Ross (Associate Professor, School of Food Science) in the development of the survey questionnaire used in the sensory evaluation of ciders. Dr. Ross also manages the sensory evaluation laboratory where Objective 2 was accomplished. The accomplishment of the three project objectives was a team effort.

No other public or private agencies were direct partners in this project.

Results, Conclusions, and Lessons Learned:

The project results can be categorized into two parts – industry related and research related. The industry related results show that the cider industry in Washington is still relatively small compared to either the brewing industry or the dessert apple industry. However, the industry is well-organized with an industry-focused organization, the Northwest Cider Association, overseeing and aiding industry research and development. One lesson that was identified in the research was that due to the small size of the industry, and that there are few full-time cider makers and cider apple growers, the response rate to the surveys was low, and that a different tool or approach needs to be taken to measure true industry size. The project did utilize the services of the NWCA to email the survey to cider makers and growers, and we believe that this aided with the response rate.

From the surveys in Objective 1, we found that cider makers are planning to increase production in Washington by 20% to 400% per year in the next 5 years. Results showed that the limited supply of specialty cider apple varieties was a significant obstacle to cider producers maintaining or expanding their business in Washington; this problem will only increase as cider makers expand production. While cider makers prefer cider apple varieties, most use/substitute dessert apples due to the inadequate supply of cider apples. The greatest demand is for bittersweet and/or bittersharp cider apples – these types account for the top 3 varieties desired by cider producers and the top 5 varieties grown by cider apple growers. Respondents indicated they were willing to pay a higher price for desirable varieties. A willingness to pay of $0.35-$0.59/lb for some cider apple varieties indicates these cider apple varieties may be more profitable for apple growers than some dessert apples. For example, the fresh returns net of warehouse cost for the 2013-14 marketing season for some dessert apples were: Red Delicious $0.25/lb, Golden Delicious $0.30/lb, Granny Smith $0.37/lb, and Gala $0.44/lb.

While our survey did not capture a significant acreage of cider apples produced in Washington, data from a previous survey indicated that cider apple bearing acreage was 256 acres in 2011. This acreage was very small relative to the total bearing acreage of dessert apples in the state, which was about 149,500 acres on average in 2010-2011; however, the cider apple acreage increased by about 25% between 2010 and 2011. Cider apple production is expected to continue to increase in the next 5 years based on the growers' planned expansion and the cider makers' increased demand for cider apples. Cider apple growers should consider

planting bittersweet and bittersharp varieties, however the yield and specific management issues for each variety is currently unknown and so profitability is also unknown. Also, a willingness to pay of $0.35-$0.59/lb by cider makers puts cider apples at premium over some dessert apples, which is an important consideration in evaluating whether or not production of cider apples can be a viable part of a grower's production system.

For Objective 2, we conducted a blind tasting sensory evaluation experiment and a chemical analysis of four craft hard apple ciders from the Pacific Northwest of the USA. Using the sensory and demographic data collected during the experiment, we estimated the consumer willingness-to-pay (WTP), using a contingent valuation model. Overall liking, taste, and aroma, from the sensory evaluation, as well as age of the sampler and if the sampler was a cider drinker, contributed positively to the WTP. In contrast, if the subject was a beer drinker this reduced their WTP. From the chemical analysis we found that tannin level had a positive effect on WTP, but an increased level of sweetness, as part of a ratio of specific gravity to acid, decreased consumer WTP.

Cider makers were also interested in the outcomes of the aforementioned sensory evaluation and how consumers valued cider and what they were willing to pay for craft cider. An interesting outcome of discussions with cider makers at various events was the interpretation of craft cider and what factors influence the typing of ciders by makers. These discussions will be useful when developing new research projects focusing on the cider industry, sensory evaluation, and cider classifications.

The two keys to the success of this project were the resources of the NWCA, and the links that two of the project researchers had developed with the organization before the project was started, and the availability of the Sensory Evaluation Unit at Washington State University. These two aspects enabled the research to begin on time, but also finish earlier than expected as the researchers did not have to identify these resources after initiating the project.

Evaluation: The objectives of the project were to provide a more accurate measure of the size of the cider industry in Washington State, and to determine the value consumers place on cider and cider characteristics. A survey was sent to cider makers and cider apple growers in the state, the results compiled and a report written, this report was sent to the NWCA, and was submitted for publication through Washington State University Extension. The value of cider to consumers was measured through a sensory evaluation analysis and survey, and a peer-reviewed publication was submitted and published in the Journal of Wine Economics (with several citations since publication).

Other than the peer-reviewed publication and the industry report, other outreach and outputs emanated from the project. Researchers in the project have presented at industry-related events, such as Beeronomics 2015 Cider Symposium and CiderCon 2016, and horticulturally-related events, such as the Washington State Tree Fruit Association Annual meeting and the American Society of Horticultural Science Annual Meeting.

Current or Future Benefits/Recommendations for Future Research: The development of various protocols and survey instruments during the project was also useful. These tools are being used by

other researchers and industry bodies who are attempting to undertake further sensory evaluation studies of ciders and to more fully understand the structure of the national cider industry.

Given that the project was a pilot study, several potential areas of future research are evident. The first is to further research consumer preferences for the characteristics of various ciders and also to identify if there are regional preferences for different styles or tastes of ciders. The second is to more fully understand the process cider makers use to define their own ciders, and the definition of "craft" ciders and the pricing mechanisms used by cider makers. The final area is in the development of a cider style guide, similar to that of Riesling producers, with the objective to provide cider consumers a "standard" by which they can compare ciders across regions and producers to ensure consumers are identifying the style of cider they prefer.

Project Beneficiaries: As noted earlier the interactions with the NWCA and the national cider association, US Association of Cider Makers (USACM) have led to the USACM utilizing the survey instruments developed in a national survey of cider makers and cider apple growers. Other beneficiaries include cider makers who have further information regarding consumer preferences for cider styles, and the NWCA in knowing the size of the industry in Washington, and also some of the issues that are facing cider makers and or cider apple growers as they attempt to expand production or orchard size to cater to the rapidly expanding demand for craft hard ciders.

Additional Information: Include publications, presentations, websites and other materials or information generated by the project. Provide as attachments or Internet links.

Peer-reviewed publication: Tozer, P.R, S.P. Galinato, C.F. Ross, C.A. Miles, and J. McCluskey. 2015. Sensory Analysis and Willingness to Pay for Craft Apple Cider. Journal of Wine Economics, 10(3): 314-328.

Extension publication: S.P. Galinato, P.R. Tozer, and C.A. Miles. 2016. Hard Cider and Cider Apple Production in Washington State. Washington State University Extension Publication (Status: Submitted and Under Review).

Paper presentation: Tozer, P.R, S.P. Galinato, C.F. Ross, C.A. Miles, and J. McCluskey. (2015). Sensory Analysis and Willingness to Pay for Craft Apple Cider. Presentation to Beeronomics 2015, Seattle, WA, 9 September 2015.

Paper presentation: Galinato, S.G. and P.R Tozer. (2015). Assessment of the Cider Market in Washington State: A Pilot Study. Presentation to Beeronomics 2015, Seattle, WA, 9 September 2015.

Poster presentation: Galinato, S.P., P.R. Tozer, C.A. Miles, and G. Coffey. Assessment of the Cider Industry in Washington State: Cider Apple Production and Cider Making. Poster Presentation, Washington State Tree Fruit Association Annual Meeting, Yakima, WA, 8 December 2015.

Poster presentation: Galinato, S.P., P.R. Tozer, C.A. Miles, and G. Coffey. Assessment of the Cider Industry in Washington State: Cider Apple Production and Cider Making. Poster Presentation, CiderCon 2016, Portland OR, February 2-5, 2016.

Presentation: Ross, C. Sensory analysis of craft ciders: What do consumers perceive in apple ciders? CiderCon 2016, Portland OR, February 2-5, 2016.

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Sensory Analysis and Willingness to Pay for Craft Cider*

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Abstract

We conducted a blind tasting sensory evaluation experiment and a chemical analysis of four craft hard apple ciders from the Pacific Northwest of the USA. Using the sensory and demographic data collected during the experiment, we estimated the consumer willingness-to-pay (WTP), using a contingent valuation model. Overall liking, taste, and aroma, from the sensory evaluation, as well as age of the sampler and if the sampler was a cider drinker, contributed positively to the WTP. In contrast, if the subject was a beer drinker this reduced their WTP. From the chemical analysis we found that tannin level had a positive effect on WTP, but an increased level of sweetness, as part of a ratio of specific gravity to acid, decreased consumer WTP. (JEL Classifications: C91, D12, L66, Q13)

Keywords: U.S. cider industry, sensory evaluation, willingness to pay, blind taste testing.

I. Introduction

Cider is an ancient drink with references back to at least Roman times (Watson, 2013), and is currently enjoying a revival in the USA. Sales and production of cider have shown significant increases from 2007 to 2014. Production of bottled cider, on which taxes were paid, was approximately 6 million gallons in 2007, and

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by 2014 this had risen to over 53 million gallons (ATTTB, various years). Much of the growth in the cider industry has been in the bulk product segment of the market. This segment includes brands such as Angry Orchard, Woodchuck, and Strongbow, currently accounting for 90% of cider sales (Keri, 2015). The remaining 10% of cider sales is spread across approximately 400 cideries, many producing small quantities of "craft" cider.

Given the small but growing nature of the current industry, consumer knowledge of cider and their preferences for sensory characteristics, including taste, is limited. Another factor that is challenging to consumers is the sheer number of ciders available in the market place, either from retail outlets or online markets. As with all beverages, consumers vary in their preferences and it may be difficult for them to decide upon a cider. It would be useful for cider makers to understand which cider characteristics drive consumer preference, and using this information, cider makers could decide what style or taste profile to produce. As noted by several authors there are as many ciders as there are cider makers (Jolicoeur, 2013; Watson, 2013). Given that there are no well-defined standards to categorize cider styles, such as there are for wines, consumers are faced with a difficult task of making a cider purchase based on inconsistent information on the product label.

Cider, like wine, has many intrinsic characteristics that contribute to the taste profile including bitterness, astringency, sweetness, and acidity (Jolicoeur, 2013). These characteristics manifest themselves to the consumer through the taste, aroma, "body", dryness, or bitterness of the cider. Wine and cider are both "experience" goods, in that the consumer cannot gain any utility from the product until it is consumed (e.g., Ashton, 2014). Because of this, if a consumer has a bad sensory experience with a product, their repeat purchase of the product, either the same brand or the same product, may be affected by this experience (Grunert, 2002).

There are two common approaches to estimate consumer valuation for product characteristics: hedonic price analysis using market data and willingness to pay (WTP) estimation using either a stated preference technique or economic experiment. Hedonic price analysis has been used many times to estimate the market value of specific product characteristics. Examples of hedonic price analysis in the wine industry are numerous and include Cardebat and Figuet (2004), Lecocq and Visser (2006), and Oczkowski and Doucouliagos (2014). Also, Capehart (2015) utilized hedonic price analysis to study the pricing of characteristics of bottled water. However, the relationship between price and quality has been questioned by several researchers (Goldstein et al., 2008; Ashton, 2014). Rather than using revealed prices as a method of analysis, as in hedonic price analysis, WTP analysis asks consumers if they are willing to pay a specific price for a product with certain attributes, including sensory and or physical attributes that may enhance consumption or utility. Willingness-to-pay analysis has been utilized in estimating the value consumers place on certain sensory attributes in wine (Holmquist et al., 2011; Yang et al., 2009). As noted earlier, the cider industry is relatively small and diverse, and as

far as could be determined, no sensory evaluation of ciders and consumer preference valuation of cider sensory properties has been reported previously. Didier et al. (2012) showed that consumers differed in their preference for characteristics of cider, but did not value individual ciders or characteristics of these ciders.

Blind taste testing, as described in Ashton (2014) and Olkin et al. (2015) amongst others, is the preferred method to elicit consumer preferences that are not biased by extrinsic factors, such as labels, price or other marketing related materials. However, blind testing is still somewhat subjective as each tester brings to the test their own preferences and tastes, and their own physiological makeup, i.e., how their nose and tongue sense various attributes (Lawless and Heymann, 2010).

In this research, we used an untrained consumer panel for blind tasting of four commercially available craft ciders from the U.S. Pacific Northwest region to estimate consumer preferences for particular characteristics of ciders, and how consumers rank and price these characteristics. A secondary part of the analysis using analytical methods was to measure how well the cider characteristics – tannin, residual sugar, acidity, and acid levels – of the four ciders explain consumer WTP in comparison to how well the consumers' responses to sensory questions explain their WTP. In the context of the current research, subjects were provided with a definition of craft cider. The definition was not complete, but included terms such as orchard or farm-based, small-scale independent producers, and cider made with local cider apple juice, containing natural colors, flavors and aromas.

The results from this research can be useful to craft cider makers to aid them in understanding the levels of cider characteristics that consumers prefer and value. Secondly, the use of analytical measurements for cider valuation through a WTP framework has not been empirically tested, and we will assess whether this approach is valid in some research scenarios.

II. Model

A double-bounded (DB) dichotomous choice contingent valuation (CV) model was utilized to estimate the WTP for cider attributes (Hanemann et al., 1991). In the DB model, participants are presented with a set of sequential "price bids" with the price increasing or decreasing depending on the response to previous bids. This sequence of bids places upper and or lower bounds on the true WTP for a particular consumer. The bounds partition the WTP into four intervals based on the response to bids. To initiate the process, a participant is offered an initial bid price, B_0, if the reaction to this initial bid is negative (no), the participant is offered a second discounted bid, B_D, if the response to the second bid is also no (no, no), then the respondent's WTP is bounded by the interval (0, B_D). If the second lower bid is accepted (no, yes), then the WTP has a lower bound of B_D and an upper bound of B_0, i.e., $B_D \leq \text{WTP} < B_0$. A positive response to the initial bid (yes), B_0, leads to a second higher bid, B_H, if the participant rejects this second higher bid (yes, no), the WTP for that

respondent is bounded by B_0 and B_H. Accepting B_H (yes, yes) indicates the participant's WTP is bounded below by B_H. Formally, the partitioned space for WTP for individual i is given as:

$$Y_i = \begin{cases} 1 \, if \; WTP_i < B_D \\ 2 \, if \; B_D \leq WTP_i < B_0 \\ 3 \, if \; B_0 \leq WTP_i < B_H \\ 4 \, if \; WTP_i \geq B_H \end{cases} \tag{1}$$

Now Y_i, the bid function for each individual is a function of the ultimate or last bid for the consumer (B_i) and a vector of explanatory variables (z_i) including socio-demographics – age, gender, education, cider and other alcoholic drink consumption, and other factors, as well as attributes of the product, such as sweetness, bitterness, or dryness. The WTP bid function for an individual, i, based on sensory evaluation is as follows:

$$WTP_i = \alpha - \rho B_i + \lambda' z_i + \varepsilon_i \tag{2}$$

where α, ρ, and λ are parameters to be estimated and ε_i is an error term with mean 0 and variance σ^2 of a cumulative logistic distribution. The bid function for the objective evaluation is similar except that the vector z_i is replaced by a vector of objective measurements (ζ_i) rather than the sensory evaluation and demographic information.

The DB dichotomous choice CV model used in this research is well-documented in Hanemann et al. (1991) and Lopez-Feldman (2012), and the analysis used in this research does not deviate from the standard model in those publications. The WTP model was estimated using the "doubleb" macro in STATA (Lopez-Feldman, 2012). The "doubleb" macro is designed for CV dichotomous questions with follow-up or double bounded questions as in this research. The "doubleb" method has been used in research to elicit the WTP of nuclear power in China (Sun and Zhu, 2014) and smart-home function in Europe (Rihar et al., 2015). Different to previous methods of determining WTP, the "doubleb" model directly estimates the marginal values for each variable then estimates the WTP from these mean values (Lopez-Feldman, 2012). The mean WTP is calculated as $-(\hat{\alpha} + \bar{z}\hat{\lambda})/\hat{\rho}$ as shown in Grimsrud et al. (2004).

III. Data and Experimental Method

A. Sensory Evaluation

Sensory evaluation data were collected from an experiment conducted at the Washington State University School of Food Science Sensory Evaluation Laboratory in February 2015. An untrained panel of 109 subjects was recruited with a small non-monetary compensation; each subject tasted four commercially available "craft" ciders in a blind taste test for a total of 436 tastings. All participants were over 21 years of age and signed an informed consent form as required by the

Table 1
Definitions and Summary Statistics of the Demographic Variables from Sensory Panel Survey (n = 109)

Variable	*Description*	*Frequency (%)*
Gender	Male	37.61
	Female	62.39
Age	21–25	40.37
	26–30	21.10
	31–40	17.43
	41–50	5.50
	51–60	8.26
	>60	7.34
Student	Yes	43.12
	No	56.88
Income	<$19,999	38.53
	$20,000–$29,999	14.68
	$30,000–$39,999	9.17
	$40,000–$49,999	13.76
	$50,000–$59,999	6.42
	$60,000–$69,999	2.75
	$70,000–$79,999	6.42
	$80,000–$89,999	2.75
	$90,000–$99,999	0.92
	$100,000–$149,999	1.83
	>$150,000	0.92
	Prefer not to answer	1.83
Race	1 if white	83.49
	0 otherwise	16.51
Married	1 if married	42.20
	0 otherwise	57.80
Education	1 - some high school	0.00
	2 - high school graduate	2.75
	3 - some college	20.18
	4 - bachelor's degree	34.86
	5 - advanced degree	42.20

institutional review board's approval for human subject experimental protocol. Due to the lack of standards in regards to labeling of ciders, four ciders were selected based on recommendations from independent cider industry experts and the researchers. The trial design was such that there were two ciders considered "dry" and two "semi-sweet".

At the beginning of the sensory evaluation panel, samplers were asked a series of demographic questions covering gender, age, income, race, marital status, education, drinking habits, and preferences for cider, beer and wine. Table 1 summarizes the demographic characteristics of the sample. Females made up a large proportion of the sample (62.4%), which is not a "true" representation of the population in general, but

Table 2
Cider Consumption and Preferences (n = 73)

Variable	*Description*	*Scaled values/Frequencies (%)*
Frequency	*How often do you drink craft cider*	
	1 – every day	0.00
	2 – a few times a week	5.48
	3 - once a week	8.22
	4 – once or twice a month	45.21
	5 - occasionally	41.10
Home	*The frequency of cider consumption at home*	
	Most often	45.21
	More often	41.10
	Less often	8.22
	Least often	5.48
Pay (per bottle)	*Actual amount paid for cider*	
	Less than or about $10	39.73
	Between $10 – $12	42.47
	Between $12 – $13.50	9.59
	Between $13.50 – $15	2.74
	Above $15	5.48
Style	*Cider style preference*	
	Sweet	17
	Dry	17
	Semi-Sweet/Semi-Dry	42
	No Preference	3
	Don't know	2
	(Total numbers are higher than number of observations as multiple styles were allowed).	
Selection	*The most important factor when buying cider*	
	Taste/flavor	82.19
	Brand	9.59
	Price	8.22

may be a reflection of the cider drinking population. The average age of the sample group was 32, and median age was approximately 28 years old, which may be an indication of the college setting for the study; however, only 43% of the sample were students. Income ranged from less than $20,000 to greater than $151,000, but a large proportion of the panel earned incomes less than $30,000. No mean income was reported as subjects were asked to designate an income range, rather than a specific value. This was done to reduce potential under-reporting of income. Most of the sample panel identified as Caucasian, less than half were married, and a majority held at least a bachelor's degree.

Cider drinking preferences are summarized in Table 2. Of the 109 subjects, 73 indicated they had previously consumed craft cider, 92 drank wine, and 82 drank beer. A majority of the sample that drank cider did not drink it more frequently than once or twice per month, and preferred to drink cider at home. Most samplers who

indicated they were cider drinkers identified their cider preference in the semi-sweet/semi-dry range which may be an indication of the lack of standard styles of cider or consumers not knowing how to clearly define cider preferences. Subjects' responses showed that the actual price paid for craft cider was typically less than $12 per 750 mL bottle equivalent, and that taste or flavor rather than price determined their purchase decision.

Prior to the trial, the sample ciders were purchased directly from each cider maker in glass bottles (either 500 mL or 750 mL bottles) with one of two types of stoppers, champagne-style corks or standard steel beer bottle crown caps. Cost for each cider was $10, $19, $15, and $10.50 per 750 mL bottle equivalent, for Cider 1, 2, 3, and 4, respectively. The cider was kept refrigerated prior to serving and only one bottle of each cider was open at any one time during the sampling phase. During the sampling phase, all ciders were kept in ice-baths to maintain serving temperature at approximately 5 °C. Each sampler received all four cider samples, with cider samples presented in a random serving order, one sample at a time. Each sample consisted of 25 mL of cider served in an International Standards Organization/Institut National des Appellations d'Origine (ISO/INAO) tulip-shaped wine tasting glasses (250 mL) covered with a petri dish. Each sample was coded with a unique three-digit code. Subjects were instructed to cleanse their palates between samples with a bite of cracker and deionized filtered water and wait at least 45 seconds between samples.

After each cider sample was evaluated, samplers were asked to score the appropriate sensory attribute for the sample on a 9-point scale. The categorical dislike/like scale was anchored by extremely dislike (1) and extremely like (9) with a midpoint of neither like nor dislike (5). The sensory attributes scored were, in order: 1) appearance; 2) aroma; 3) sweetness; 4) bitterness; and 5) flavor or taste. A final question in the sensory evaluation was for the sampler to rate how well they disliked/liked the sample overall.

The final step in the individual cider sensory evaluation was to ask each sampler how much they would be willing to pay to purchase a 750 mL bottle of the cider just evaluated. Each sampler was offered an initial bid of $13.50 per bottle. The value of $13.50 was the average price for a 750 mL bottle equivalent of craft cider available for purchase on-line in the Pacific Northwest, using the Northwest Cider Association's (NWCA) website for cider makers in the region (NWCA, 2015). If the sampler rejected the initial bid, a lower price of $12.50 was offered. Similarly, if the sampler accepted the initial bid, they were offered a higher bid of $14.50.

B. Chemical Analysis of Cider

Chemical analysis of one bottle of each of the four ciders was undertaken using protocols developed for evaluation of apple juice and cider (Miles and King, 2014; Miles et al., 2015). A single bottle of each cider was analyzed at the Washington State University Northwestern Washington Research and Extension Center in Mount

Table 3
Chemical Analysis of the Four Sample Ciders

Cider	*Specific Gravity (SG)*	*pH*	*Titratable Acid (g malic acidlliter, TA)*	*Tannin %*	*SG to TA Ratio (S2A)*
Cider 1	1.003	3.66	6.2	0.04	0.1618
Cider 2	1.009	3.99	4.5	0.11	0.2242
Cider 3	1.004	3.71	5.6	0.10	0.1793
Cider 4	1.012	3.47	6.1	0.07	0.1659

Vernon, WA. Values for cider pH, specific gravity (SG), titratable acid (TA), and percent tannins were collected and presented in Table 3. The specific gravity to acid ratio (SP2A) was included post evaluation as a means of capturing the "balance" of sugar to acid as is undertaken in the International Riesling Foundation's taste profile protocol (IRF, 2008). Specific gravity is used as a measure of sugar content as it is the simplest measure of sugar content that is not confounded by other factors such as a refractometer measurement error (Jolicoeur, 2013).

IV. Results and Discussion

A. Sensory Evaluation

The mean sensory attribute scores for each cider, and over all ciders, are presented in Table 4. Scores for sensory attributes across all ciders were, in general in the neutral (5) to slightly liking or positive range of 6 or 7. Cider 2 tended to be scored in the neutral to slightly negative range for each individual attribute, and based on the comments of samplers, this cider may have possessed off-flavors. From Table 4, we can see that Cider 4 was ranked highest based on the mean overall liking score (7.04), followed by Ciders 1 (5.56), 3 (5.51) and 2 (4.77). A paired t-test for each cider pair using the overall scores showed that Cider 4 had a statistically higher score than the other three ciders. Cider 2's overall liking score was significantly lower than Ciders 1 and 3, and there was no significant difference in the overall liking for Ciders 1 and 3.

After the final sample cider was tested, each sampler that had responded "no" to the question – "Whether they drink craft cider" – was asked if their experience with the ciders tested had changed their drink preference, and if they would now consider cider a potential alternative drink. Of the 36 samplers who responded "no", 20 (or 55%) indicated that they would now consider craft cider as an alternative to beer or wine. A further seven (13%) said that after sampling, they would not change their drink preference, three (5%) indicated that they would not consider cider as an alternative to beer or wine, and four (7%) samplers indicated they would drink less cider (2 samplers had invalid responses to the question and were not included in the analysis).

Table 4
Summary Statistics for Sensory Attributes for Each Cider Sample

Sensory Attribute	*Mean*	*Std. Dev.*
Scale: 1 = Extremely dislike attribute, 9 = Extremely like attribute.		
Cider 1 (n = 109)		
Appearance	6.39	1.55
Aroma	6.32	1.57
Sweetness	5.60	1.89
Bitterness	5.27	1.98
Taste	5.54	1.95
Overall	5.55	1.86
Cider 2 (n = 109)		
Appearance	7.27	1.07
Aroma	4.10	1.88
Sweetness	5.45	1.78
Bitterness	5.10	2.03
Taste	4.83	2.01
Overall	4.77	2.03
Cider 3 (n = 109)		
Appearance	7.24	1.29
Aroma	6.33	1.58
Sweetness	5.46	1.80
Bitterness	5.33	1.90
Taste	5.49	1.90
Overall	5.51	1.91
Cider 4 (n = 109)		
Appearance	6.70	1.49
Aroma	6.24	1.65
Sweetness	6.91	1.52
Bitterness	6.45	1.73
Taste	7.06	1.52
Overall	7.09	1.51
All samples (n = 436)		
Appearance	6.90	1.41
Aroma	5.75	1.92
Sweetness	5.85	1.85
Bitterness	5.54	1.98
Taste	5.73	2.02
Overall	5.73	2.02

B. Response to Bids

The participants' responses to higher WTP bidding process was as expected; as the bid price increased, the number of bids rejected increased, i.e., as price increased, respondents increasingly said that they would not buy the cider at the

Table 5
Willingness to pay Models Based on Sensory Evaluations

	Model 1	*Model 2*	*Model 3*	*Model 4*
Gender	−0.0555			−0.0531
Age	0.0312*[1]	0.0308*	−0.0065***	−0.0063***
age^2	−0.0007**	−0.0004**		
Cider Drinker (Y/N)	0.1519**	0.1481**	0.1730***	0.1770***
Beer Drinker (Y/N)	−0.1344*	−0.1456**	−0.1309*	−0.1202*
Overall Score	0.0908*	0.0864*	0.0855	0.0897*
Taste Score	0.2052***	0.2098***	0.2110***	0.2068***
Aroma Score	0.0493*	0.0497***	0.0449**	0.0444**
Constant	10.3865***	10.3813***	11.0294***	11.038***
Log of the Likelihood function	−319.4005	−319.7793	−322.2602	−321.9192
Mean willingness to pay	12.8169***	12.8169***	12.8175***	12.8174***
Standard error of mean willingness to pay	0.0330	0.0331	0.0333	0.0332

[1] ***, **, * significantly different from zero at $P < 0.01$, 0.05, and 0.10, respectively.

increased price. At the initial bid of $13.50, 349 of 436 bids were rejected. Of the 349 rejected bids, 51 of these respondents accepted the follow-up lower bid at $12.50 leaving a further 298 bids with WTP below $12.50 per bottle. Forty three of the 87 respondents who accepted the initial bids rejected the follow-up higher price of $14.50, with 44 remaining bids with a WTP exceeding $14.50 per bottle.

The responses to bids, particularly the number of bids rejected at the lower end of the bid range could indicate several factors. The straightforward interpretation is that the bids offered were simply too high in relation to the value consumers place on craft cider in the region. However, we suspect that consumers may be comparing the bid to the prices of mass produced ciders being offered at a grocery store. Thus, the samplers may have a reference price in mind for cider, based on prices for non-craft ciders which are typically less than $3.00 per 750 mL equivalent. As consumers are increasingly exposed to craft ciders, they can develop a taste for the product and increase their WTP. A factor could be how consumers define craft cider, in that some consumers may define craft cider, as a cider that is not produced by a major cider maker, such as Angry Orchard, Woodchuck or one of the large European makers such as Strongbow, and others may define craft cider as small lot, farm made or “artisanal” ciders. Depending on the definition of cider by the consumer, prices will differ, as some relatively large regional producers have prices in the range of $5 to $10 per 750 mL equivalent, whereas the smaller cider makers charge between $12 and $19 per 750 mL equivalent (NWCA, 2015). The latter range was used as the basis for bid development in the research reported here as this reflects the price range of ciders included in this study.

C. Impact of Demographic and Sensory Variables on Willingness to Pay

The estimated parameters of models based on equation 2 are presented in Table 5. Four models are presented in this table, with differences in the number of demographic variables, particularly gender, age, and the square of age (age^2). Age and income were positively correlated at over 70%; and for this reason, to reduce the impact of multicollinearity on model parameters, income is not included in the final model. But the implication from this correlation is that we would expect WTP to increase with income, if we assume cider is a normal good. In two of the four models, we include both age and age^2 to allow for nonlinear effects of age. One might expect for age to have a positive effect and age^2 to have a negative effect, which is consistent with the signs of the parameters in the first two models. However, when age^2 is included, age is not statistically significant. The age effect on mean WTP increases until a turning point is reached at 34.4 years of age. This indicates that younger drinkers are willing to pay more for cider, but WTP diminishes and then declines as the age of the drinker reaches the maximum point. If cider is a relatively new product to the taster, the older taster may be more set in his/her ways. In the models that do not include the age^2 variable, the variable age has a negative coefficient, indicating that as age increases, mean WTP decreases. This is consistent with theory that old habits are hard to change and experienced consumers are less open to new tastes. Model 1 shows that gender does not affect mean WTP, which is interesting given that females composed a substantial majority of the sensory panel. Other demographic variables, such as marital status and education level were not statistically significant in preliminary analyses and were therefore not included in the final models. Also, given that there is no statistical difference between models 1 and 2, model 2 was used for comparative testing due to consistency with economic theory and statistical significance of all variables.

Drinking habits included in the final mean WTP model were the binary variables, BeerYN and CiderYN, which indicate whether the respondent did or did not drink beer and or cider. If the respondent was a cider drinker mean WTP increased by \$0.15 per bottle, and if the respondent answered yes to drinking beer there was a discount of \$0.15 per bottle in WTP.

Three sensory attributes were included in the model – overall liking, taste/flavor, and aroma; other sensory variables such as sweetness, bitterness, or appearance did not significantly affect mean WTP, and were thus excluded. All attributes contributed positively to WTP, with taste increasing WTP by \$0.21 per bottle per unit of increase in taste score, aroma increased mean WTP by \$0.05 per bottle per unit, and overall liking added \$0.09 per bottle per unit.

Based on the demographic and sensory variables included in the model, the estimated mean WTP was \$12.82 per 750 mL bottle. This value falls below the average price of cider in the region as noted earlier and was in the lower end of the bid range. Individual cider WTP models were also estimated, and the mean WTP for each was \$12.76, \$12.41, \$12.72 and \$13.33 for Ciders 1, 2, 3, and 4, respectively. The mean

Table 6
Mean Willingness to Pay (WTP) for Individual Ciders Compared to Price Actually Paid for 750 mL Equivalent Bottle

Sensory Evaluation WTP				
Cider	1	2	3	4
WTP ($/bottle)	12.76	12.41	12.72	13.33
s.e. WTP	0.0544	0.0886	0.0707	0.0555
Price Paid ($/bottle)	10.00	18.00	15.00	10.50
Difference in mean WTP and price paid[1]	2.76**	−5.59**	−2.28**	2.83**
Difference in mean WTP of individual cider[2]	a	b	a	c

[1] **significantly different from actual price paid at $P < 0.05$, except for ciders 2 and 3 that differ at $P < 0.1$.

[2]Columns with different letters indicate that the individual cider WTP differs significantly at $P < 0.01$.

Table 7
Willingness to Pay Models Based on Chemical Analysis

	Model 1	*Model 2*
Specific gravity to acid ratio	−14.4352***	−9.8627***
Tannin (%)	5.0880**	
Constant	15.0360***	14.6072***
Log of the Likelihood function	−463.9095	− 465.4632
Mean willingness to pay	12.8043***	12.8043***
Std error of mean willingness to pay	0.0422	0.0425

[1] ***, ** significantly different from zero at $P < 0.01$, and 0.05, respectively.

WTP rankings are identical to those for the overall liking scale; and similar to the overall liking scores, pairwise t-tests of the mean WTP showed that with the exception of the mean WTP to pay for Ciders 1 and 3, there were statistically significant differences in mean WTP between all ciders. Cider 4's mean WTP was significantly higher than for the other ciders and the mean WTP for Cider 2 was significantly lower than for the other ciders, perhaps due to off-flavors as noted above.

Estimated mean WTP for each cider, compared to the price paid was significantly different for three of the four ciders (Table 6). The actual price paid for Cider 1 was not different to the WTP; however the mean WTP for Ciders 2 and 3 was significantly less than the price paid ($P < 0.001$), but the mean WTP for Cider 4 was $1.84 higher than the price paid ($P < 0.001$).

D. Willingness-to-pay Model with Objective Measurement

Two models were estimated to assess the explanatory power of analytical measurements in estimating WTP and compare the results to the estimation with sensory analysis variables. Table 7 summarizes the two estimated models. Variables included in these models were tannin percentage and SP2A; cider pH and SG were not

included as they did not significantly affect mean WTP; and TA was not included as it was highly correlated to SP2A. Models 1 and 2 differ significantly at $P < 0.05$, and therefore model 1 was selected as the basis for the final WTP analysis using analytical measurements. The negative SP2A coefficient indicated that as the sweetness of a cider increases, assuming TA level was held constant, WTP declines. The SP2A ratio is also a measure of "dryness" of a cider, and a larger value indicates a cider that has a lower level of "dryness" (Watson, 2013). The mean WTP estimated using objective measurements was $12.80 per 750 mL bottle equivalent, which does not differ significantly from the mean WTP based on sensory evaluation.

Measures of goodness of fit for the models are compared using the fully correctly classified cases (FCCC) method (Kanninen and Khawaja, 1995). This measure calculates the percentages of respondents that the models correctly classified into the appropriate group based on responses to the first and second bids (yes/yes, yes/no, no/yes, and no/no). A higher value of percentage of correct prediction indicates better model fit, and one should note that pure chance results in 25% correct predictions, since there are four categories. The correct predictions in our models are 46.3% for the sensory analysis model and 26.3% for the analytical version of the model. The FCCC percentage value for the sensory analysis model compares favorably to other studies. For example, Kanninen and Khawaja (1995) in studying WTP for water supply reliability correctly predicted the WTP categories for 35% of observations. The WTP from the analytical model shows the limited variation within the model due to a small number of variables affecting the mean WTP.

V. Conclusions

The objectives in this research were to identify the characteristics of craft cider that consumers prefer and value, and to develop a framework for objective analysis of cider and the determination of consumer WTP utilizing this framework. Variables that affect the WTP for cider include age, whether the sampler is a cider or beer drinker, and the sensory attributes of overall liking, taste/flavor, and aroma. From the objective analysis of the sample ciders it is estimated that WTP is affected by tannin percentage, and the ratio of specific gravity to titratable acid of the ciders.

A finding that should be of particular interest to industry is that one of the key factors determining WTP is overall liking of the cider, flavor and aroma, while sweetness and bitterness do not affect WTP. This may indicate that drinkers are willing to pay for a product that provides a complete package of sensory experience, rather than individual components of the sensory experience. However, the lack of WTP for sweetness or bitterness may be due to several reasons. Firstly, it may be that consumer tastes are heterogeneous, so that if a subject prefers sweet, then they are WTP for sweet; but in the overall estimation, the sweet effect may be cancelled out by subjects who like dry. On the other hand given that the panel was untrained, subjects may not have the sensory "skill" to identify the sensory differences between sweetness

and bitterness in the ciders presented. Also as noted, a majority of samplers who had not previously consumed craft apple cider, indicated they would now consider craft cider as an alternative alcoholic drink to beer and wine. This could indicate to the craft industry that to increase consumption of craft cider, cider makers need to raise awareness of their product to the non-craft cider drinking population.

As this research is one of the first to attempt to derive consumer preferences for craft cider characteristics the opportunities for further research are numerous. Further comparison of the objective and subjective measurement of cider characteristics could aid industry in determining if cheaper objective evaluations could be a proxy for subjective testing, which is relatively more expensive to undertake. In this study, we used only four ciders and the objective evaluation was based on one sample from each of these four ciders, thus replicating the objective measurements with different bottles of the same cider could also aid in identifying the consistency within a product, as consistency of experience is important to consumers (Grunert, 2002). This type of testing could also determine if characteristics, such as the off-flavors identified in one of the test ciders carried through into a whole batch, thus reducing the consumer experience. Any reduction in the consumer experience, either from an individual cider or from cider in general, could slow the growth in the industry to the detriment of all cider makers and cider apple growers.

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WASHINGTON STATE UNIVERSITY

Hard Cider Apple Grower Survey

Dear Hard Cider Apple Growers,

This survey focuses on apples, including dessert and specialty cider apple varieties, which are used to produce hard cider. The survey is part of a research project at Washington State University with a goal of identifying factors that could contribute to the growth, sustainability and viability of the cider industry in the Pacific Northwest and in the United States. This research project is being funded by the U.S. Department of Agriculture-Agricultural Marketing Service.

Please take time to fill out the survey. The information you provide is vital to a better understanding of the scale of the industry, supply of and demand for hard cider apple varieties, as well as the challenges encountered in hard cider apple production. Furthermore, your feedback will help inform our research and outreach activities that are geared to aid the hard cider industry grow and remain profitable and sustainable.

Your responses will be kept confidential. Data from the survey will be aggregated thus the responses will not be attributed to any individual. There are 14 questions in the survey. Please complete the survey by March 9. If you have any difficulty accessing the survey or if you have questions about the survey or project, feel free to contact Peter Tozer (peter_tozer@wsu.edu).

We value your feedback and sincerely appreciate your participation.

Sincerely,
Peter Tozer, Suzette Galinato, and Carol Miles

WASHINGTON STATE UNIVERSITY

Hard Cider Apple Grower Survey

* 1. In what county is your orchard located?

2. What are the top five dessert and/or specialty cider apple varieties you currently grow that are used to produce hard cider? Please indicate their respective bearing acres and average yield per acre. *If the variety is not listed in the drop-down choices, please list below in "Other".*

	Variety Grown	Bearing acres	Yield per acre
Variety 1			
Variety 2			
Variety 3			
Variety 4			
Variety 5			

Other (please specify the variety, bearing acres and yield per acre):

3. What is the selling price (average or expected) of hard cider apples by variety?*If the variety is not listed in the drop-down choices, please list below in "Other".*

	Variety Grown	Price received ($/lb)
Variety 1		
Variety 2		
Variety 3		
Variety 4		
Variety 5		

Other (please specify the variety and price):

4. Of the hard cider apples produced, please estimate theproportion (%) that went to the following users.
(Only numbers may be entered in the fields below. The sum must equal 100%.)

Used to produce own cider (%)	
Other cider producers (%)	
Wholesalers (%)	
Other (%)	

5. Are hard cider apples a profitable crop for you to grow?

- ◯ Yes
- ◯ No

6. Are you planning to expand hard cider apple production in the next five years?

- ◯ Yes
- ◯ No

If "Yes", how many additional acres of each variety?

7. Are there other hard cider apple varieties that you would like to grow but are not currently growing?

- ◯ Yes
- ◯ No

If "Yes", what varieties?

8. How much of an obstacle are the following in starting/maintaining/expanding hard cider apple production?

	Not an obstacle	Minor obstacle	Medium obstacle	Major obstacle
Lack of market information (e.g., price paid per variety, demand for specific hard cider apple varieties)	○	○	○	○
Lack of workers or farm labor	○	○	○	○
Prices paid for inputs	○	○	○	○
Prices received for hard cider apples	○	○	○	○
Obtaining cider apple trees from nursery	○	○	○	○

Other obstacles (please specify)

9. Where do you get your cider apple trees (name and location of nursery)?

10. How many months or years in advance of planting do you have to arrange with the nursery for grafted cider apple trees?

11. Why do you grow hard cider apples? Please select all that apply.

- ☐ Crop diversification
- ☐ Profitability
- ☐ Niche market
- ☐ Other (please specify)

12. What other tree or vine fruits do you grow? Please select all that apply.

- [ ] Fresh apples
- [ ] Sweet cherries
- [ ] Pears
- [ ] Grapes
- [ ] Other (please specify)

13. What is the total area of your farm in tree and/or vine fruits (acres)?

14. Please write below any comments about hard cider apple production related to your experience or in general.

Thank you for your participation.
A report presenting the key results of the survey will be sent to the Northwest Cider Association.

WASHINGTON STATE UNIVERSITY

Cider producer survey

Dear Cider Producers,

In October 2014, through the Northwest Cider Association, we sent the same survey and we are trying to gather more responses. Thank you very much to those who have completed the survey. To date, we received 8 responses and in this regard, we would like to request the participation of other association members.

The survey is part of a research project at Washington State University with a goal of identifying factors that could contribute to the growth, sustainability and viability of the cider industry in the Pacific Northwest and in the United States. This research project is being funded by the U.S. Department of Agriculture-Agricultural Marketing Service.

Please take time to fill out the survey. The information you provide is vital to a better understanding of the scale of the industry, cider styles available, current marketing activities, as well as the needs for specialty cider apple varieties and other challenges encountered in cider production. Furthermore, your feedback will help inform our research and outreach activities that are geared to aid the hard cider industry grow and remain profitable and sustainable.

There are 15 questions in the survey. Individual responses will be held completely confidential; and only aggregated responses for the industry will be reported. If you have already completed this survey once before, please do not complete it again. If you have not yet completed the survey, please complete and submit the survey by January 30, 2015. In case you have any difficulty accessing the survey or questions about the survey or project, feel free to contact Peter Tozer (peter_tozer@wsu.edu).

Thank you for your time and consideration.

Sincerely,
Peter Tozer, Suzette Galinato, and Carol Miles

WASHINGTON STATE UNIVERSITY

Cider producer survey

* 1. In what city is your cidery located?

2. If you grow your own cider apples, please indicate the top five varieties that you grow and their respective bearing acres and average yield per acre. *If the variety is not listed in the dropdown choices, please list below in "Other".*

	Variety Grown	Bearing acres	Yield per acre
Variety 1			
Variety 2			
Variety 3			
Variety 4			
Variety 5			

Other (please specify the variety, bearing acres and yield per acre):

3. If you obtain cider apples from outside sources, please indicate the main cider apple varieties purchased and their respective source (location of the farm), form (fruit or juice), and price paid. *If a particular variety comes from multiple sources, please indicate the source where majority of that variety is acquired. Please list in "Other" any outsourced variety not listed in the dropdown choices.*

	Variety Outsourced	Source	Form (Fruit or Juice)	Price paid ($/lb if fruit, $/gallon if juice)
Variety 1				
Variety 2				
Variety 3				
Variety 4				
Variety 5				

Other (please specify the variety, source, form and price):

4. What are the cider apple varieties that you prefer to use***but*** are not currently using or able to buy? Please also indicate if you are looking for fruit (i.e., apples to press) or for juice, and the price you would be willing to pay for each variety. *If your desired variety is not listed in the dropdown choices, please list below in "Other".*

	Desired Variety	Form (Fruit or Juice)	Willingness to Pay ($/lb if fruit, $/gallon if juice)
Variety 1			
Variety 2			
Variety 3			
Variety 4			
Variety 5			

Other (please specify the variety, form and price you are willing to pay)

5. What percentage of the apples used in your cidery are specialty cider apples in comparison with dessert apples? *(Only numbers may be entered in the fields below.)*

Cider apple varieties (%)	
Dessert apple varieties (%)	

6. What are the cider styles that you sold? Please select all that apply.
(The definition of each style is from the 2008 Beer Judge Certification Program Style Guidelines for Beer, Mead and Cider.)

- [ ] Common cider - *A common cider is made from culinary/table apples, with wild or crab apples often used for acidity/tannin balance.*
- [ ] English cider - *This includes the English "West Country" plus ciders inspired by that style. These ciders are made with bittersweet and bitter-sharp apple varieties cultivated specifically for cider making.*
- [ ] French cider - *This includes Normandy styles plus ciders inspired by those styles, as well as ciders made by various techniques to achieve the French flavor profile. These ciders are made with bittersweet and bittersharp apple varieties cultivated specifically for cider making. Traditional French procedures use small amounts of salt and calcium compounds (calcium chloride, calcium carbonate) to aid the process of pectin coagulation.*
- [ ] New England cider - *This is a cider made with characteristic New England apples for relatively high acidity, with adjuncts to raise alcohol levels*.
- [ ] Fruit cider - *This is a cider with other fruits or fruit-juices added, for example, berry. Note that a "cider" made from a combination of apple and pear juice would be entered in this category since it is neither cider nor perry.*
- [ ] Applewine - *The term for this category is traditional but possibly misleading: it is simply a cider with substantial added sugar to achieve higher alcohol than a common cider.*
- [ ] Other specialty cider - *This is an open-ended category for cider with other adjuncts such that it does not fit any of the categories above. This includes the use of spices and/or other sweeteners. A cider with added honey may be entered here if the cider character remains dominant.*

7. For the cider styles you sold, please indicate the approximate retail price of each style.*(Only numbers may be entered in the fields below.)*

Common cider ($/bottle)	
English cider ($/bottle)	
French cider ($/bottle)	
New England cider ($/bottle)	
Fruit cider ($/bottle)	
Applewine ($/bottle)	
Other specialty cider ($/bottle)	

8. What is the approximate cost of producing cider, in general? Please include the cost of ingredients, packaging and production labor, but not overhead. *(Only numbers may be entered in the fields below.)*

Cost per barrel ($)

Cost per bottle ($)

9. What selling methods/channels do you utilize to market your cider? Please select all that apply.

- [ ] Retail/Tasting Room/Online Purchase/Mail Order directly to the consumer
- [ ] Wholesale directly to accounts
- [ ] Sales directly to distributor
- [ ] Sales to a broker who sells to a distributor
- [ ] Other (please specify)

10. How much of your cider was sold through each channel? Please estimate the percentage of product sold through various channels. *(Only numbers may be entered in the fields below.)*

Retail/Tasting Room/Online Purchase/Mail Order (%)

Wholesale (%)

Sales to distributor (%)

Sales to broker (%)

Other (%)

11. What is the approximate annual volume of cider produced in the past five years?*(Only numbers may be entered in the fields below.)*

2013 (gallons/year)

2012 (gallons/year)

2011 (gallons/year)

2010 (gallons/year)

2009 (gallons/year)

12. Do you have plans for expansion in the next five years?

- ◯ Yes
- ◯ No

If "Yes", what is your target relative to your current production (e.g., X% more)?

13. What type of business agreement do you have with apple producers? Please check all that apply.

- ☐ Verbal commitment
- ☐ Formal/written contract
- ☐ Call around until you find what you want
- ☐ Other (please specify)

14. How much of an obstacle are the following in starting/maintaining/expanding cider production?

	Not an obstacle	Minor obstacle	Medium obstacle	Major obstacle
Lack of information (e.g., market research, demand for specific cider apple varieties)	◯	◯	◯	◯
Availability of desired cider apple varieties	◯	◯	◯	◯
Cost of desired cider apple varieties	◯	◯	◯	◯

Other obstacles (please specify)

15. As part of the research project, we are also going to survey cider apple growers about the varieties they produce and production-related concerns. If you purchase field-run cider apples from (other) growers, we would be appreciate it if you can provide their name and contact information.

Thank you for your participation.
A report presenting the key results of the survey will be sent to the Northwest Cider Association.

Sensory analysis of craft ciders: What do consumers perceive in apple ciders?

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Washington State University

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Sensory Analysis and Willingness to Pay for Craft Cider*

Peter R. Tozer [a], Suzette P. Galinato [b], Carolyn F. Ross [c], Carol A. Miles [d] and Jill J. McCluskey [e]

Abstract

We conducted a blind tasting sensory evaluation experiment and a chemical analysis of four craft hard apple ciders from the Pacific Northwest of the USA. Using the sensory and demographic data collected during the experiment, we estimated the consumer willingness-to-pay (WTP), using a contingent valuation model. Overall liking, taste, and aroma, from the sensory evaluation, as well as age of the sampler and if the sampler was a cider drinker, contributed positively to the WTP. In contrast, if the subject was a beer drinker this reduced their WTP. From the chemical analysis we found that tannin level had a positive effect on WTP, but an increased level of sweetness, as part of a ratio of specific gravity to acid, decreased consumer WTP. (JEL Classifications: C91, D12, L66, Q13)

Keywords: U.S. cider industry, sensory evaluation, willingness to pay, blind taste testing.

I. Introduction

Cider is an ancient drink with references back to at least Roman times (Watson, 2013), and is currently enjoying a revival in the USA. Sales and production of cider have shown significant increases from 2007 to 2014. Production of bottled cider, on which taxes were paid, was approximately 6 million gallons in 2007, and

*Research funded by the USDA-AMS - Federal-State Marketing Improvement Program (FSMIP). Project entitled *Assessment of the Cider Market: Pilot Study in Washington State* (GRANT 11680819). The authors are also grateful to an anonymous referee and comments provided by the editor, Karl Storchmann.

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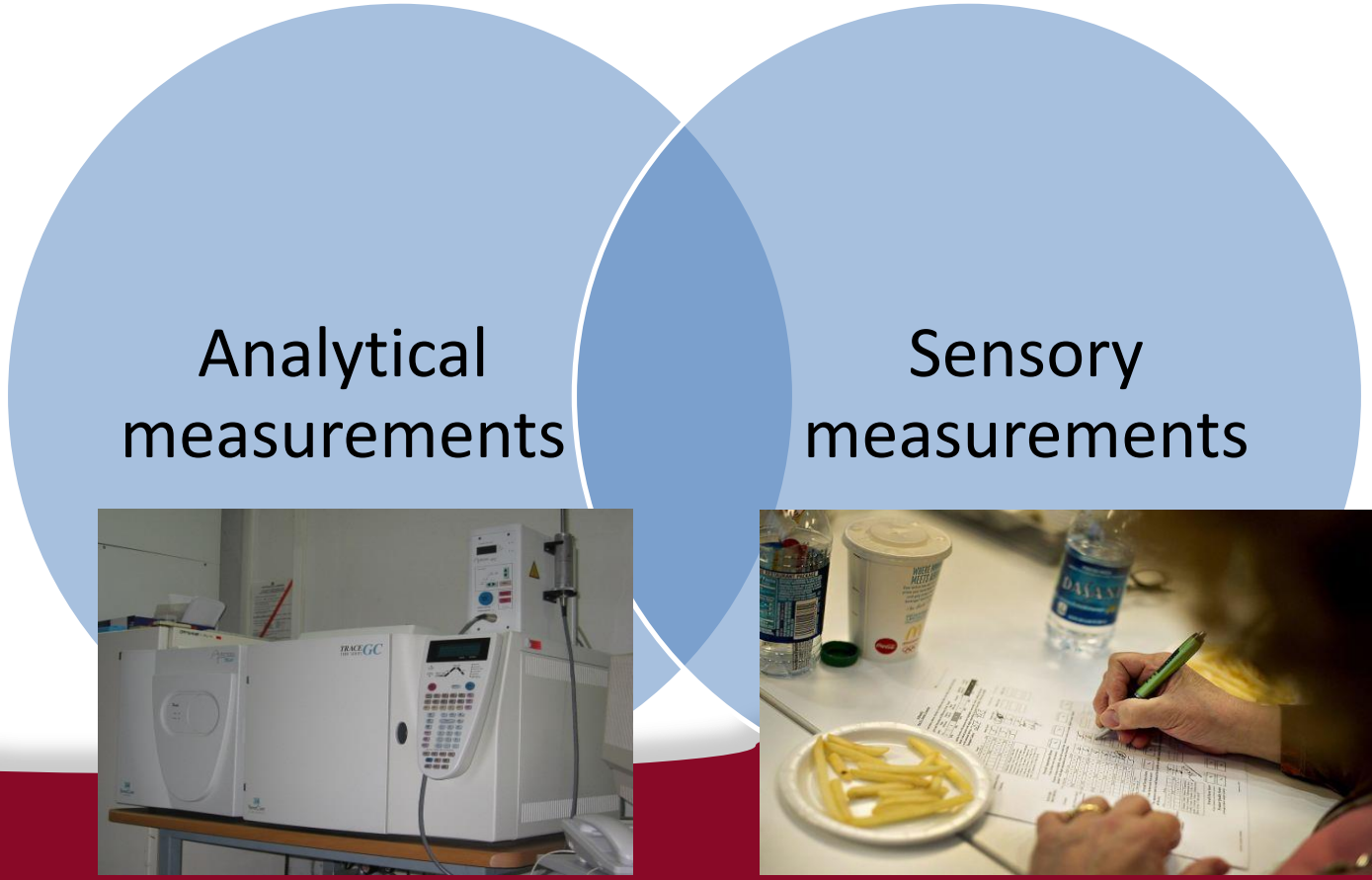
Introduction

- Apple cider has been around for a long time
- Increasing sales of cider including the “bulk” product segment (ie. Angry Orchard, Woodchuck)
- AND craft cider (includes ~400 cideries)
- Different ways to evaluate ciders

Cider profiling

- Food and beverage profiling
  - Analytical chemistry – chemical and physical properties
  - Sensory evaluation – uses human subjects

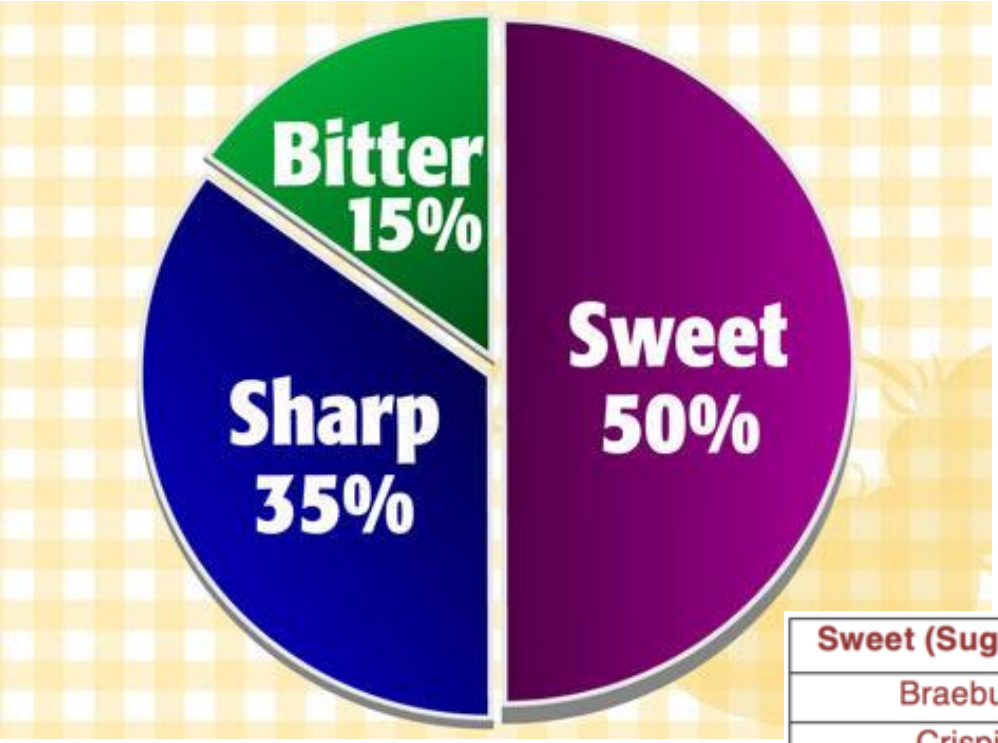


Cider Chemical Profiling

- Ethanol
- pH
- TA
- Tannin
- Sugar
- Good information… aromas, overall taste profiles

Sensory Evaluation?

- Scientific discipline used to evoke, measure, analyze and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, touch, taste and hearing



Ciders…mix of apples, mix of attributes

Sweet (Sugar) 50%	Tart/Sharp (Acidic) 30-35%	Bitter (Tannins): 20-15%
Braeburn	Granny Smith	Baldwin
Crispin	Gravenstein	Cortland
Fuji	Liberty	Dolgo Crabapple
Gala	McIntosh	Empire
Golden Delicious	Northern Spy	Esopus Spitzenburg
Honey Crisp	Pink Lady	Foxwhelp
Jonagold	Winesap	Newtown Pippin
Macoun		Porter's Perfection
Red Delicious		
Rome		

Sensory properties of cider

Attribute	Specifics
Appearance	color (clear, yellow, golden, copper, red), clarity (clear, cloudy)
Aroma	apple, ethanol, grassy, caramel, earthy, woody, tropical fruit, berry, citrus, floral, nutty, spicy, straw, yeasty, chemical
Taste	sweet, sour, bitter, salty
Flavor	apple, berry, butterscotch, citrus, fruit, earthy, grassy, honey, nutty, pear, spicy, straw, woody, yeasty
Mouthfeel	astringent, carbonated, creamy, metallic, chalky, ethanol
Aftertaste	duration, intensity, characteristics
Overall	Balance

Agroscope Flavour Wheel for Apple Juice and Cider

Cider Wheel

What Influences Sensory Evaluations?

- Physiological factors influencing evaluations
  - Adaptation: Change in sensitivity as result of continued exposure to that stimulus
  - Enhancement: Mix>A + B
  - Suppression: Mix<A + B

What Influences Sensory Evaluations?

- Psychological factors influencing evaluations
  - Expectation error

    Information may trigger preconceived ideas
  - Stimulus error

    Irrelevant criteria influence the panelist
  - Halo effect

    Rating of one attribute tends to influence other attributes

What Influences Sensory Evaluations?

- Psychological factors influencing evaluations
  - Mutual suggestion: Influence by other panelists – more difficult tastings, great influence of others
  - Physical facilities

Other considerations…

- Sample preparation
  - How should you present the sample?
    - Serving temperature, Serving glass
  - Quantity of sample, Number of samples
  - Reference samples
  - Coding, order of presentation
  - Rinsing
  - Information about the sample

Influence of Cider Matrix

- How does cider composition influence the sensory experience?
- Little research done in this area
  - Learn using a wine and beer model
  - Not ideal because these are different compositionally
- What matrix components should we consider?
  - Ethanol, acids, sugars, polyphenolic compounds, CO_2 (carbonation)

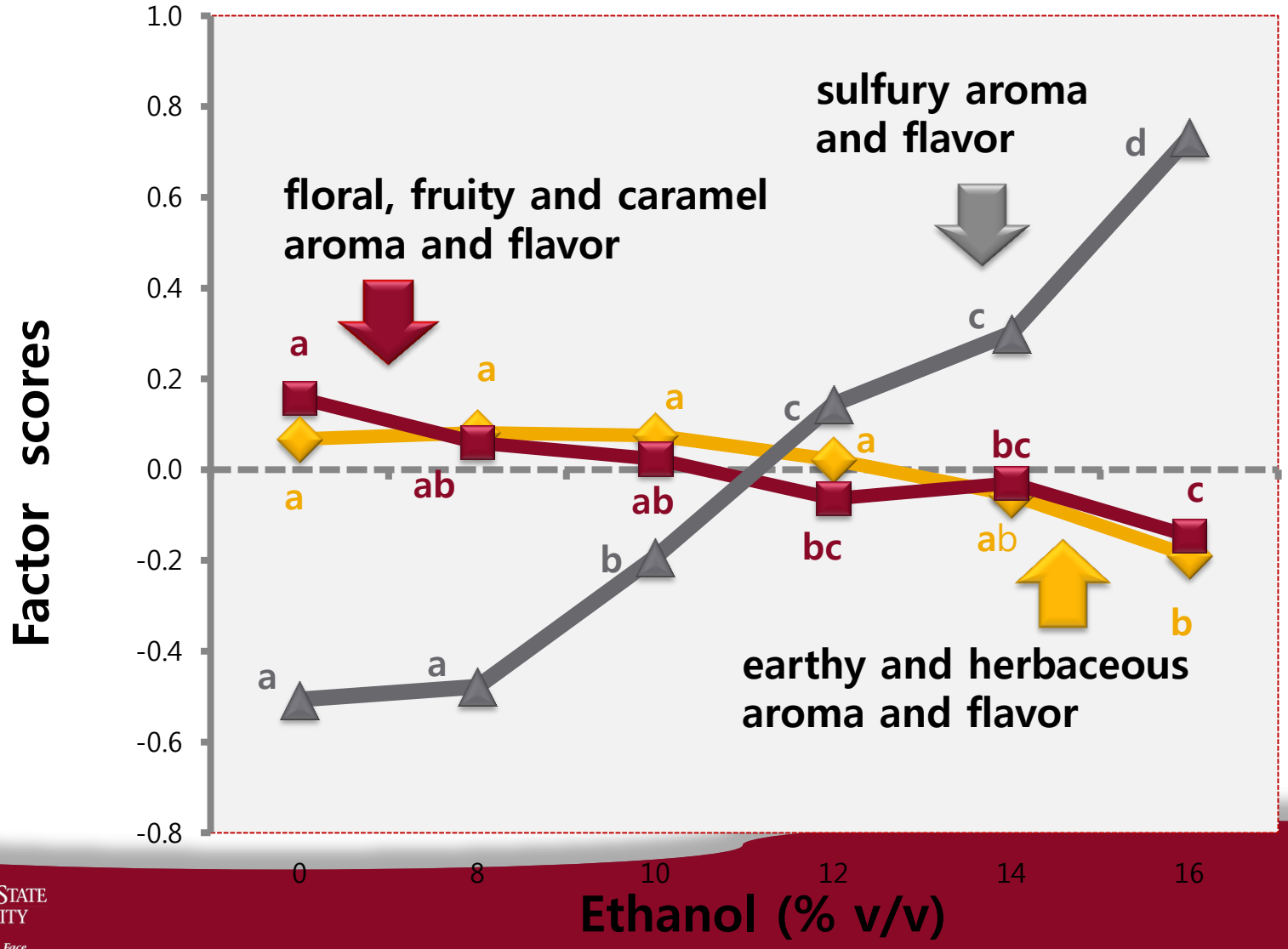
Influence of Ethanol

- Impact of ethanol on wine perception
  - As ethanol concentration increases:
    - Enhanced heat, roughness and bitterness
    - Reduced perceived astringency
    - Slightly enhanced sweetness
    - Slightly suppressed decrease in perceived sourness

Influence of Ethanol

- Impact of ethanol on aroma and flavor
  - At low concentrations, ethanol decreased aroma detection threshold
  - Masking effect on other volatile aromas at high concentrations
  - Affects solubility, volatility and binding properties with protein
  - Lower ethanol concentration resulted in higher intensity of fruity and floral aromas

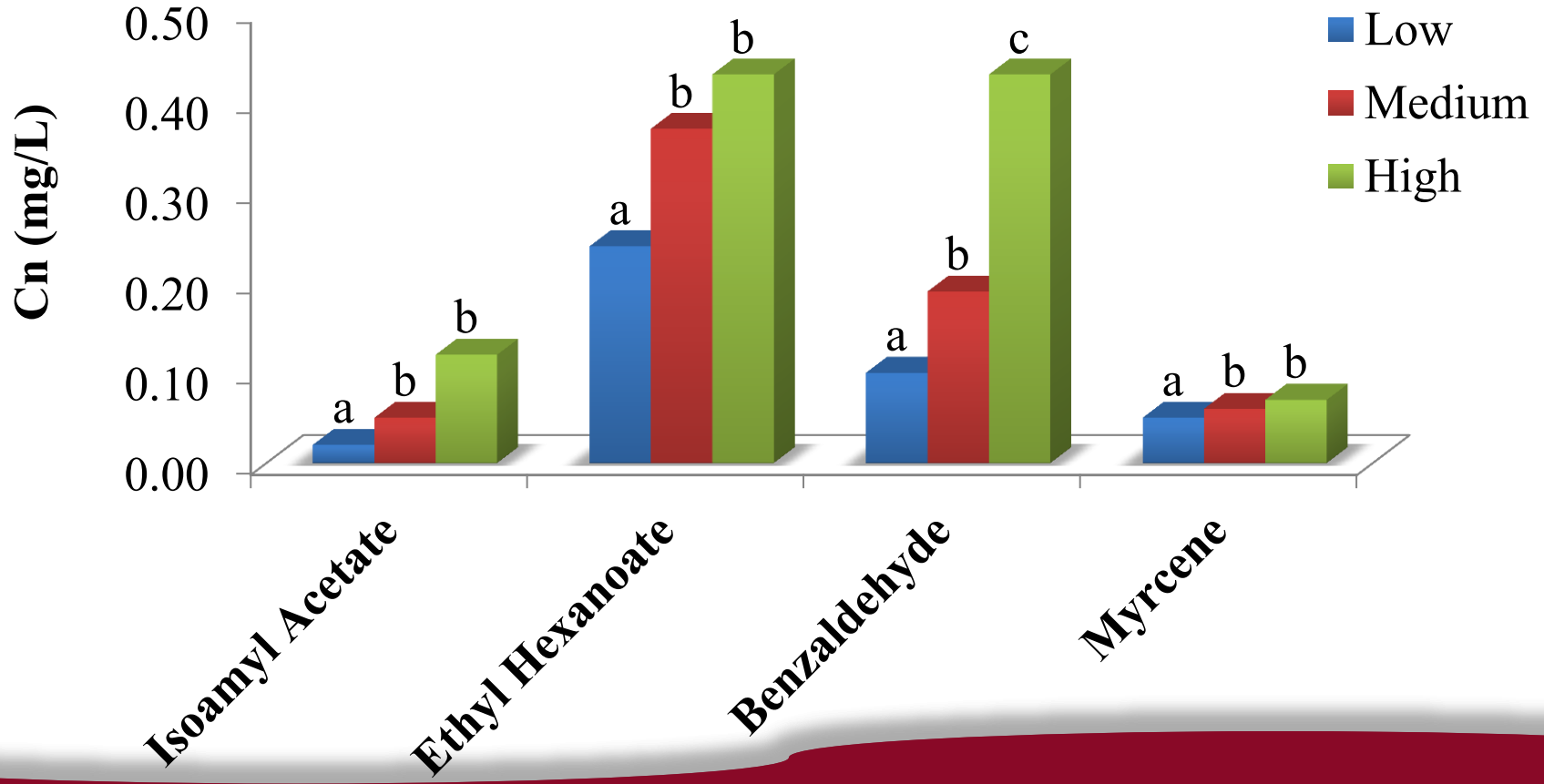
Influence of ethanol on sensory attributes of model wine red wines



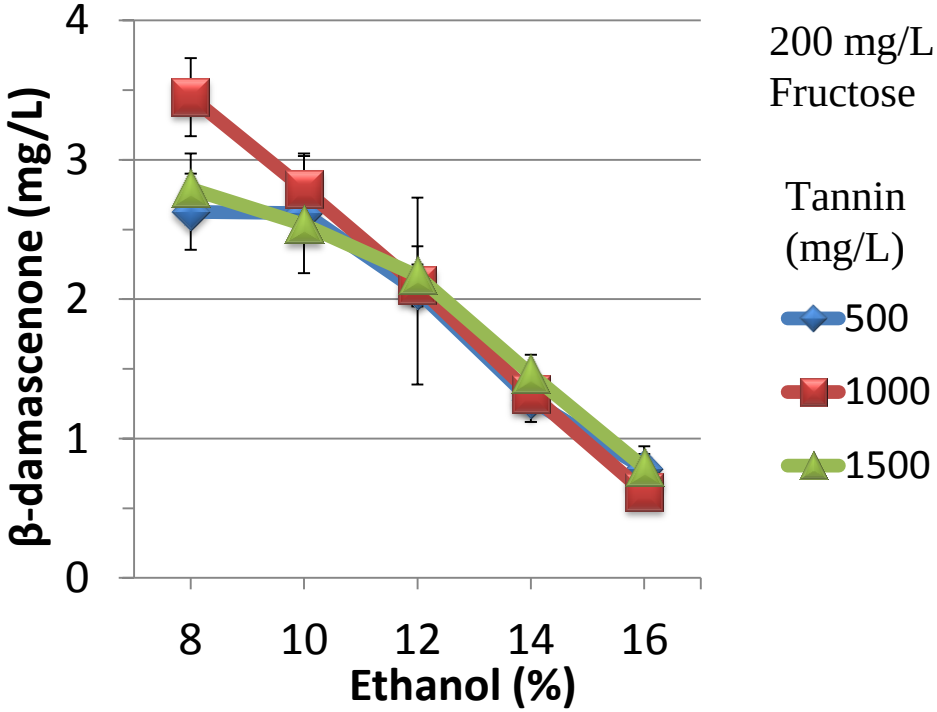
Other matrix influences…

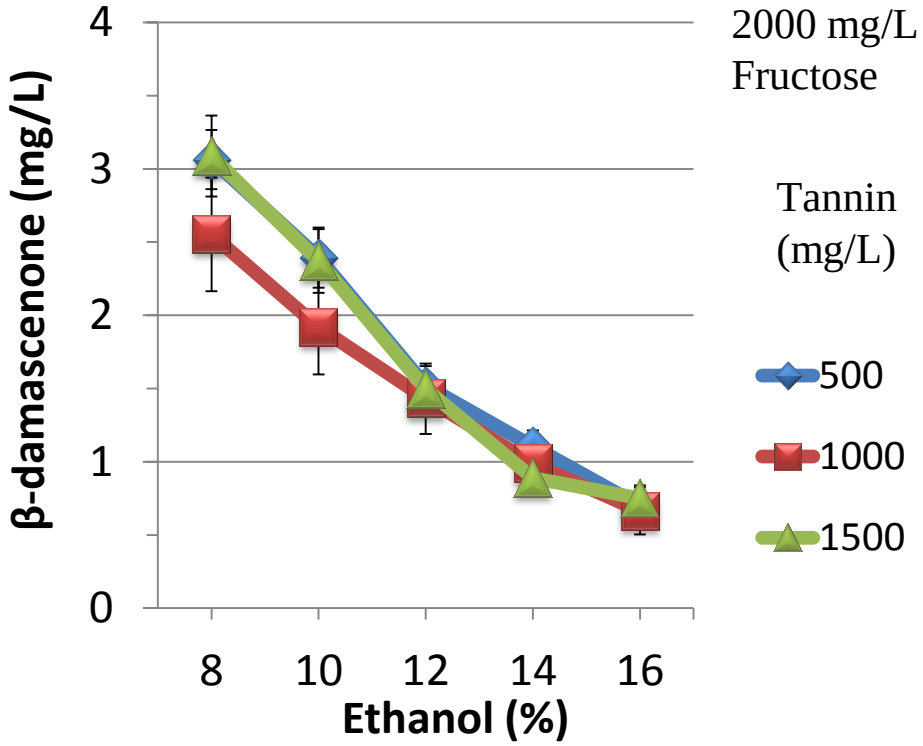
- Interaction effects of major grape and wine matrix components on aroma attributes
  - In wine…. matrix-volatile interactions: ethanol>glucose>glycerol>catechin
- Studies in beer
  - Influence of carbohydrate concentration of volatile perception using a model beer
  - Increase in aroma intensity with increasing levels of non-volatiles

Concentration of Compounds at Different Carbohydrate Concentrations in Beer



Headspace recovery of B-damascenone as a function of ethanol, tannin and fructose concentrations in model wines

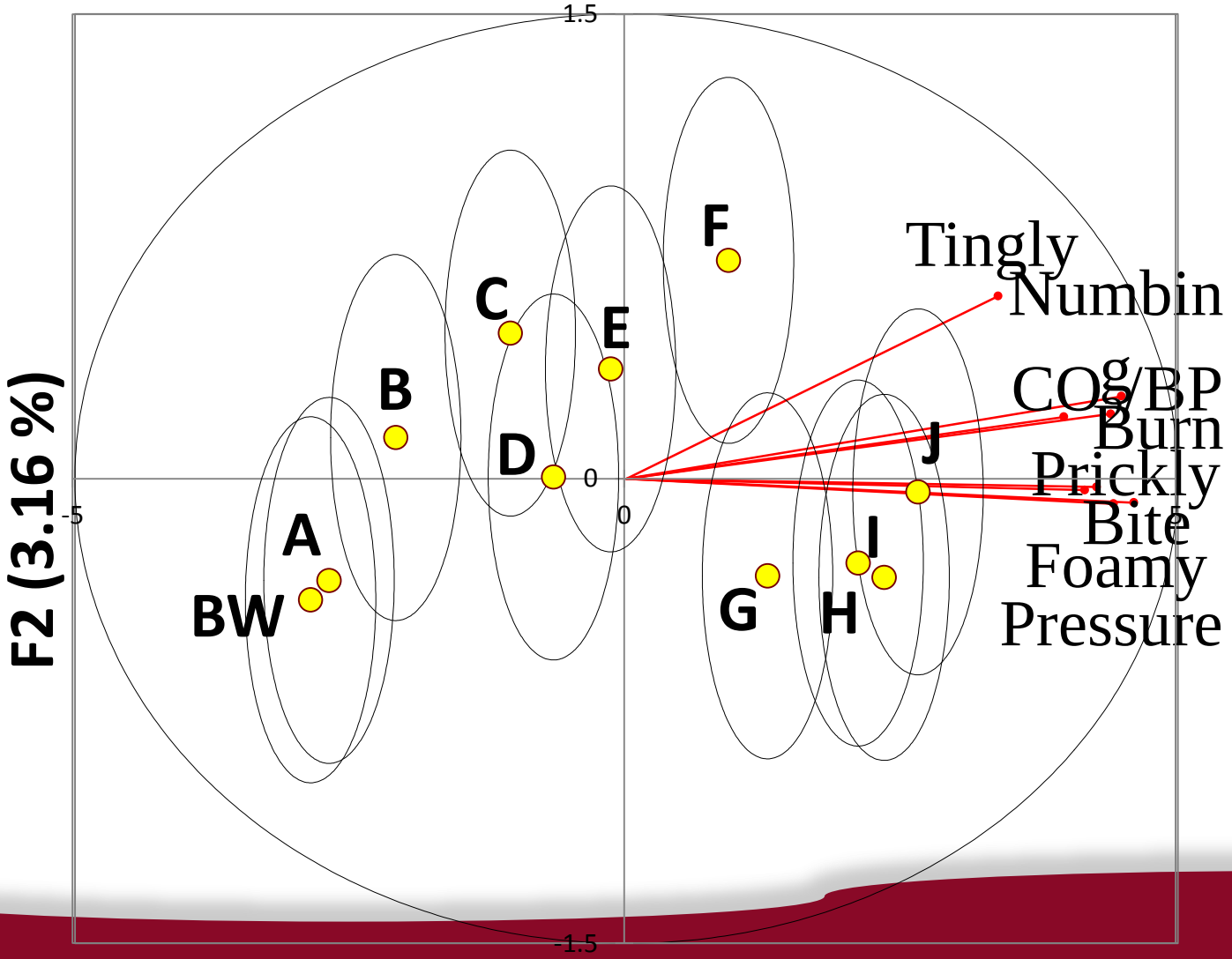




Influence of Carbonation

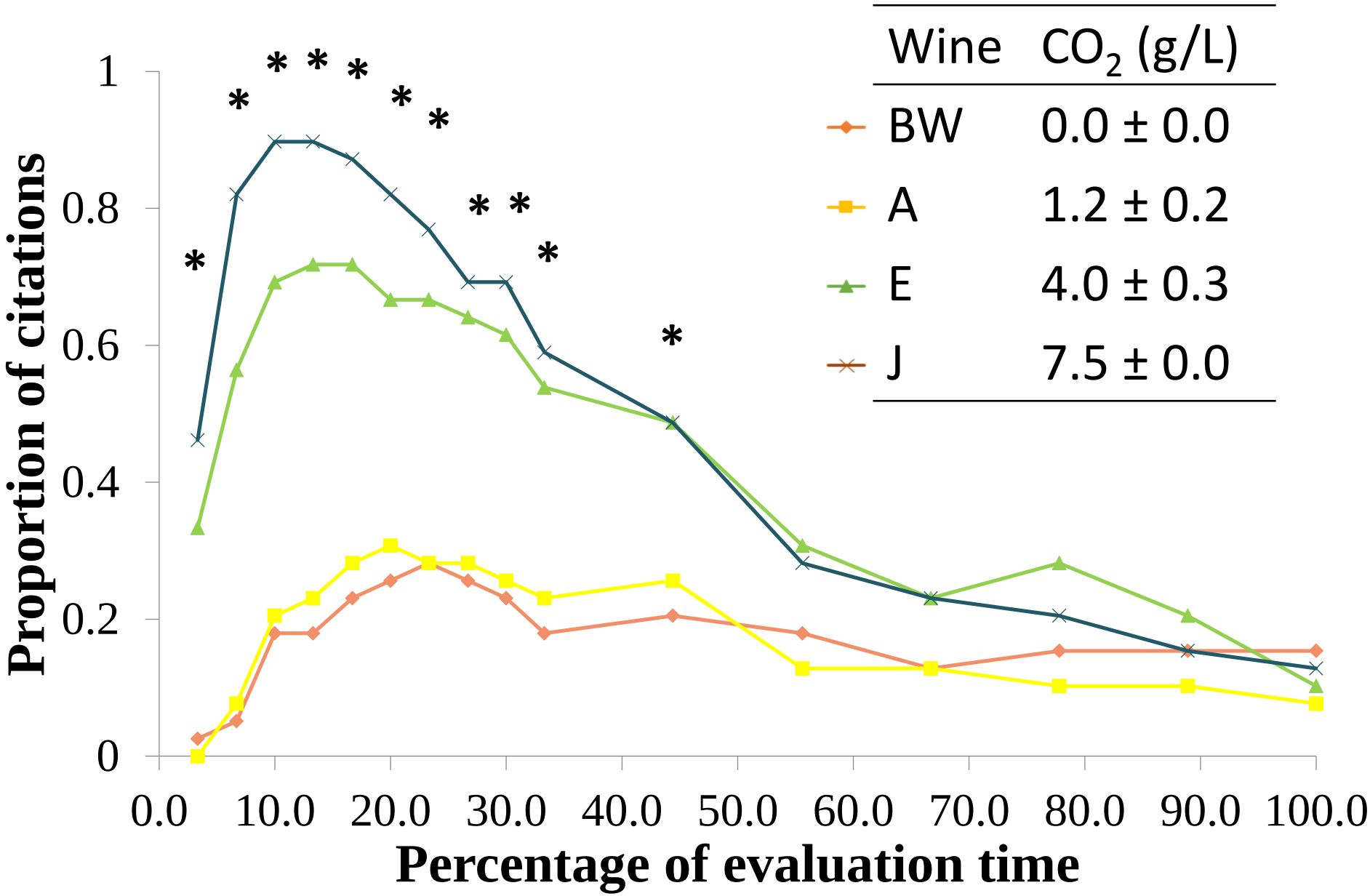
- Defined as the tingling imparted by the presence of carbon dioxide
- Levels in apple cider:
  - ~2 volumes of CO2 (~3.9 g/L)
- Research in dairy beverages, soda pop and sparkling wine

Sparkling Wine Carbonation



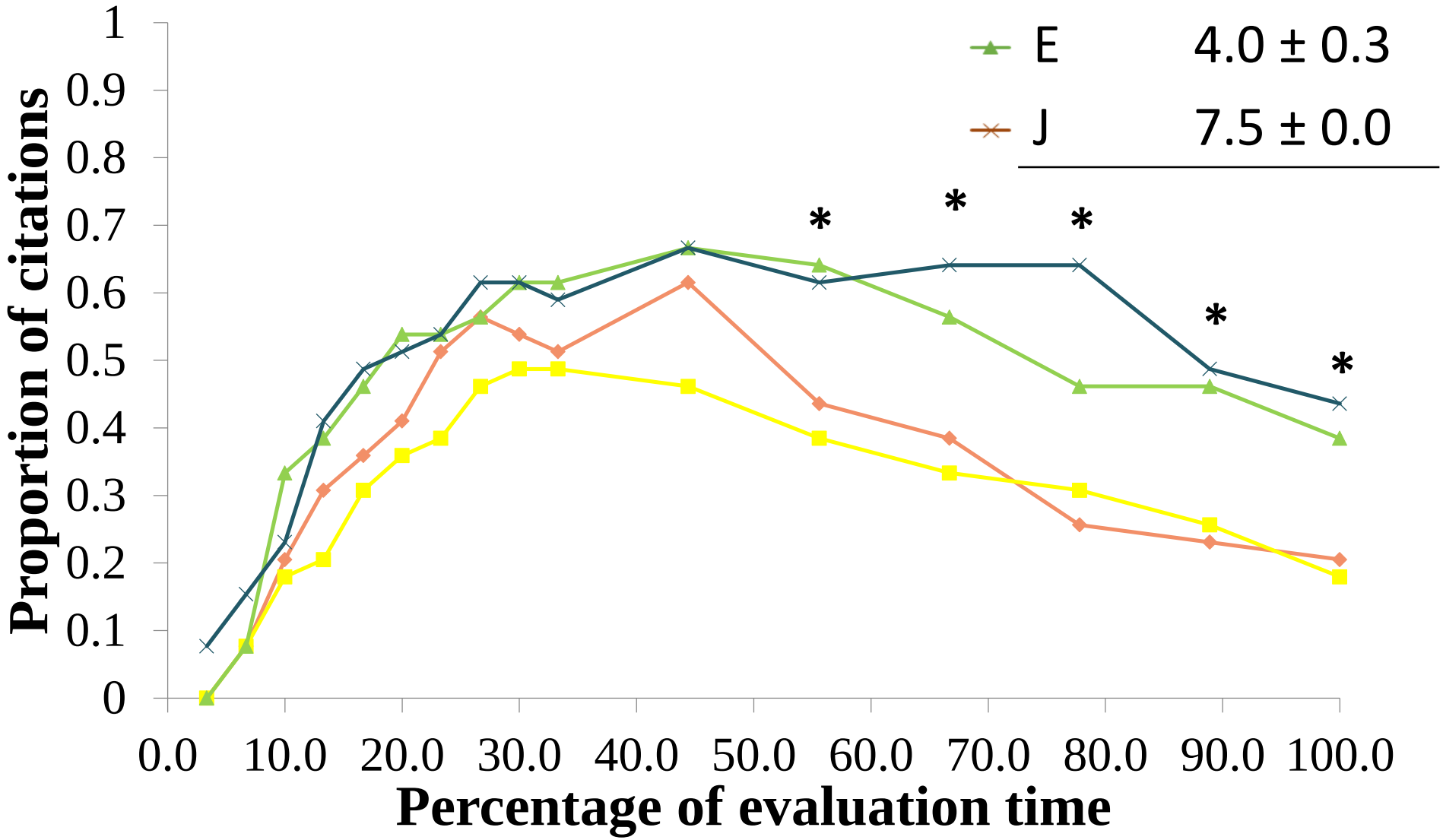
Wine	CO_2 (g/L)
BW	0.0 ± 0.0
A	1.2 ± 0.2
B	2.0 ± 0.4
C	2.8 ± 0.4
D	3.1 ± 0.1
E	4.0 ± 0.3
F	4.6 ± 0.3
G	4.9 ± 0.7
H	5.8 ± 0.0
I	6.7 ± 0.3
J	7.5 ± 0.0

Bite/Burn


Proportion of citations
1
0.8
0.6
0.4
0.2
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Percentage of evaluation time
Wine
CO2 (g/L)
BW
0.0 ± 0.0
A
1.2 ± 0.2
E
4.0 ± 0.3
J
7.5 ± 0.0

Tingly

Wine	CO_2 (g/L)
BW	0.0 ± 0.0
A	1.2 ± 0.2
E	4.0 ± 0.3
J	7.5 ± 0.0



Number of agreeing consumers

- Influences acceptance and mouthfeel perception

Final CO_2 (g/L)	Which wine is more carbonated?	Which wine has more mouthfeel of bite?	Which wine has more sourness in taste?	Which wine do you prefer overall?
0.0 ± 0.00 a	26	27	21	27
1.2 ± 0.21 b	26	27	24	25
2.0 ± 0.35 c	38**	38**	23	32*
4.0 ± 0.28 d	48**	44**	17	41**
5.8 ± 0.03 e	48**	46**	18	36**
7.5 ± 0.01 f	48**	45**	21	37**

Consumer testing

- Now… getting back to apple cider
  - Some understanding some of the influences of the composition of cider on perception
- Cider considered to be an experience good
  - Consumer cannot gain utility from the product until it is consumer
- Bad experience?
  - Repeat purchase will be influenced (the brand or the product itself)
- Provide additional information about the cider

Riesling Example

- Research showed that consumers wanted more information upon which to base decisions

- No well defined standards in ciders for consumers to use

Study objective

Overall objective: Determine consumer liking and willingness to purchase craft ciders

Consumer experience

Analytical evaluations

Ciders used in study

- 4 ciders were studied: 2 dry and 2 semi-dry
- Ciders purchased in 500 mL or 750 mL bottles
  - Cider 1: $10
  - Cider 2: $19
  - Cider 3: $15
  - Cider 4: $10.50
  - (all per 750 mL bottle equivalents)

How we evaluated consumer experience

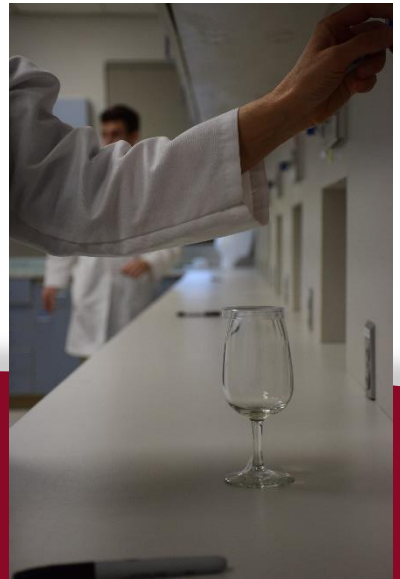
Consumer blind taste test

Evaluated liking of ciders (9-pt liking scale)

Evaluated willingness to purchase ciders

Consumer Panel

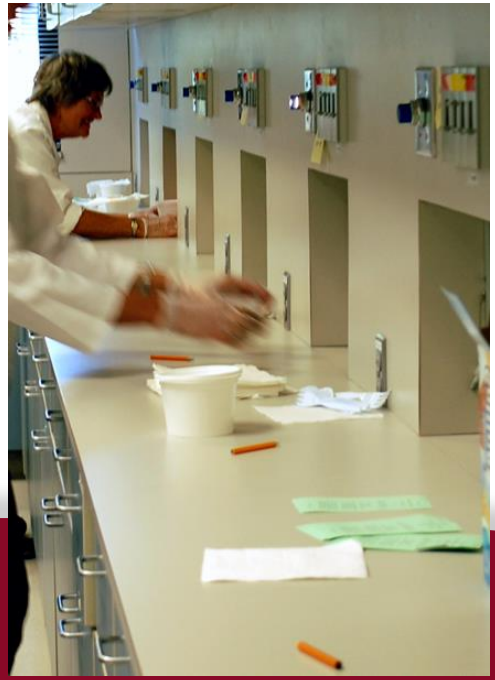
- Each consumer evaluated 4 samples
- Demographic information collected
- Serving size: 30 mL
- Serving temperature: ~7°C
- Presented in ISO tasting glass
- Provided with cuspidor, crackers, water



Consumer liking questions

- For each sample…
  - Pull off lid: immediately evaluated aroma acceptance
  - Then… acceptance of appearance, sweetness, sourness, bitterness, flavour
  - Overall acceptance

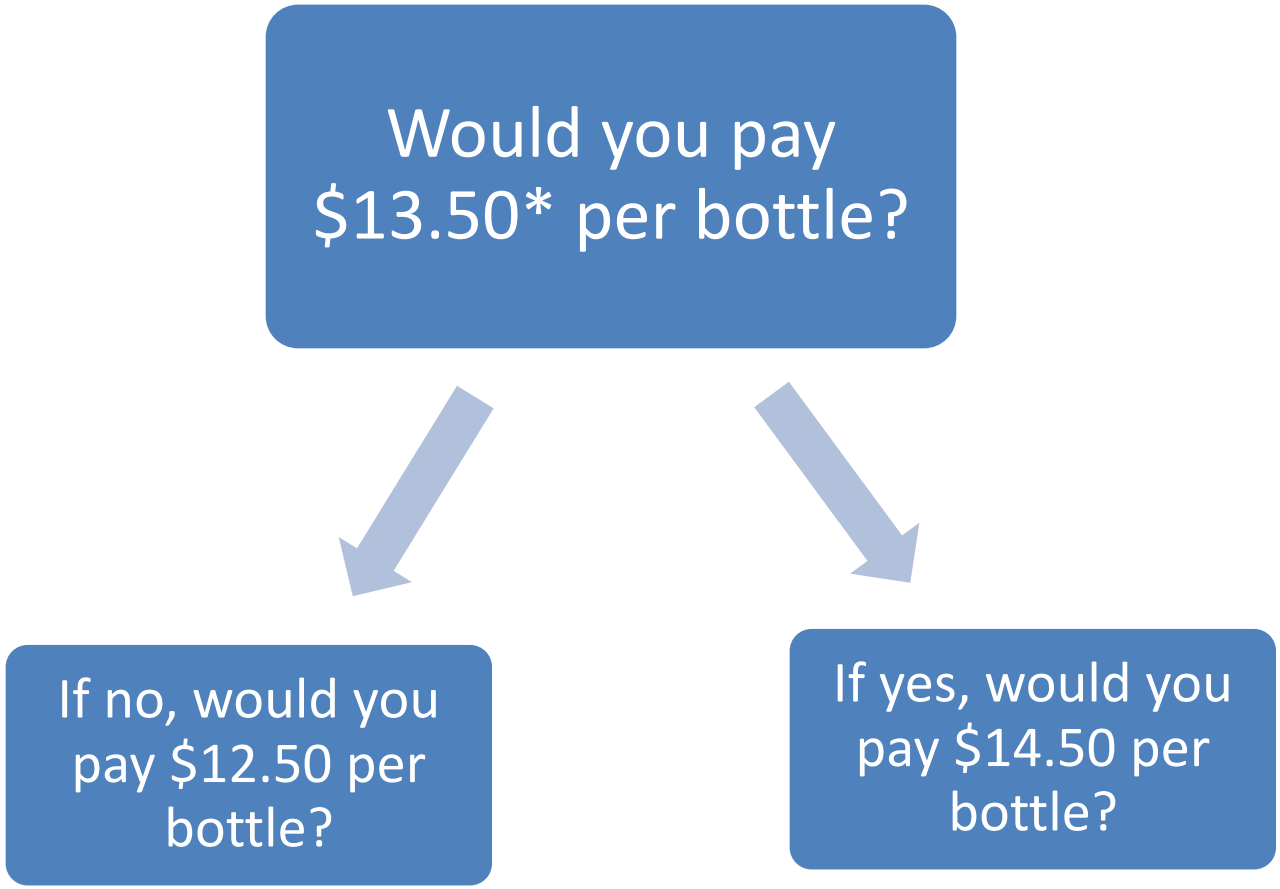
9-Point Hedonic Scale	
9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely



Willingness to purchase questions

- For each cider sample, after tasting, consumers were presented with a series of price bids
  - The price increasing or decreasing depending on the response to the previous bid
  - The sequence of bids places upper or lower bounds on the true WTP for a consumer

Willingness to purchase questions



*The $13.50 was the average price for a 750 mL bottle equivalent of craft cider available for purchase on-line in the Pacific Northwest using the NW Cider Association's website for cider makers in the region

Chemical analysis

- Standard cider chemistry measurements: pH, specific gravity (SG), titratable acidity (TA) and % tannin
- All chemical analyses performed at the WSU Northwest Washington Research and Extension Center (Mount Vernon)

- SG to TA ratio determined balance between sugar and acid)

Electronic Tongue

Membrane coated sensor array

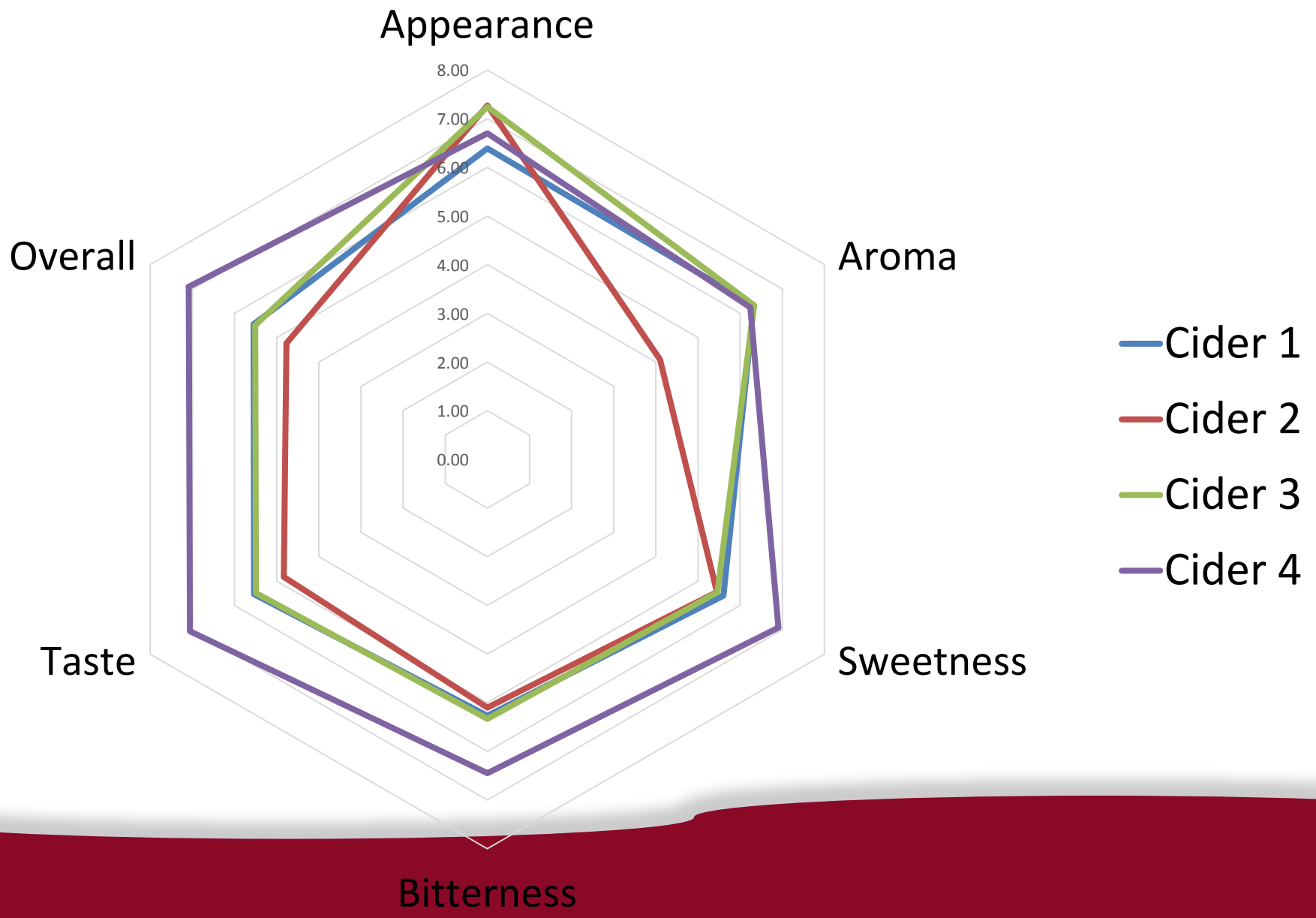
Results: Consumer demographics

- 109 consumers participated
- 62.4% female
- Mean age: 34 years
- Consumption patterns:
  - 67% had previously consumed craft cider
  - 84.4% drink wine
  - 75.2% drink beer
- What attributes did they look for in a cider?
  - Semi-sweet/semi-dry
- Average price paid: less than $12/750 mL bottle

Results: Chemical analysis of the ciders

	Specific Gravity (SG)	pH	TA (g malic acid/L)	Tannin %	SG to TA ratio
Cider 1	1.003	3.66	6.2	0.04	0.1618
Cider 2	1.009	3.99	4.5	0.11	0.2242
Cider 3	1.004	3.71	5.6	0.10	0.1793
Cider 4	1.012	3.47	6.1	0.07	0.1659

Results: Consumer acceptance of apple ciders



Consumer question

- After the final cider sample, each consumer who had responded “no” to “whether they drink craft cider” was asked if their experience with these ciders would change their drink preference and would they consider cider a potential alternative drink
  - 55% said they would consider craft cider as an alternative to beer or wine

Results: Willingness to Purchase

- As the price increased, consumers increasingly said they would not buy the cider
  - Bids offered were too high in relation to the value consumers place on ciders
  - Consumers may have been comparing the bids to the prices of mass produced ciders
    - Thus consumers may have had a reference price in mind (typically less than $3 per 750 mL)

Results: Other influences on WTP

- Age: Influence until turning point of 34.4 years
  - Younger drinkers were willing to pay more for cider but this declines above 34.4 years
- Drinking habits: if the consumer was a cider drinker, the mean WTP increased by $0.15 per bottle

Results: Influence of cider attributes on WTP

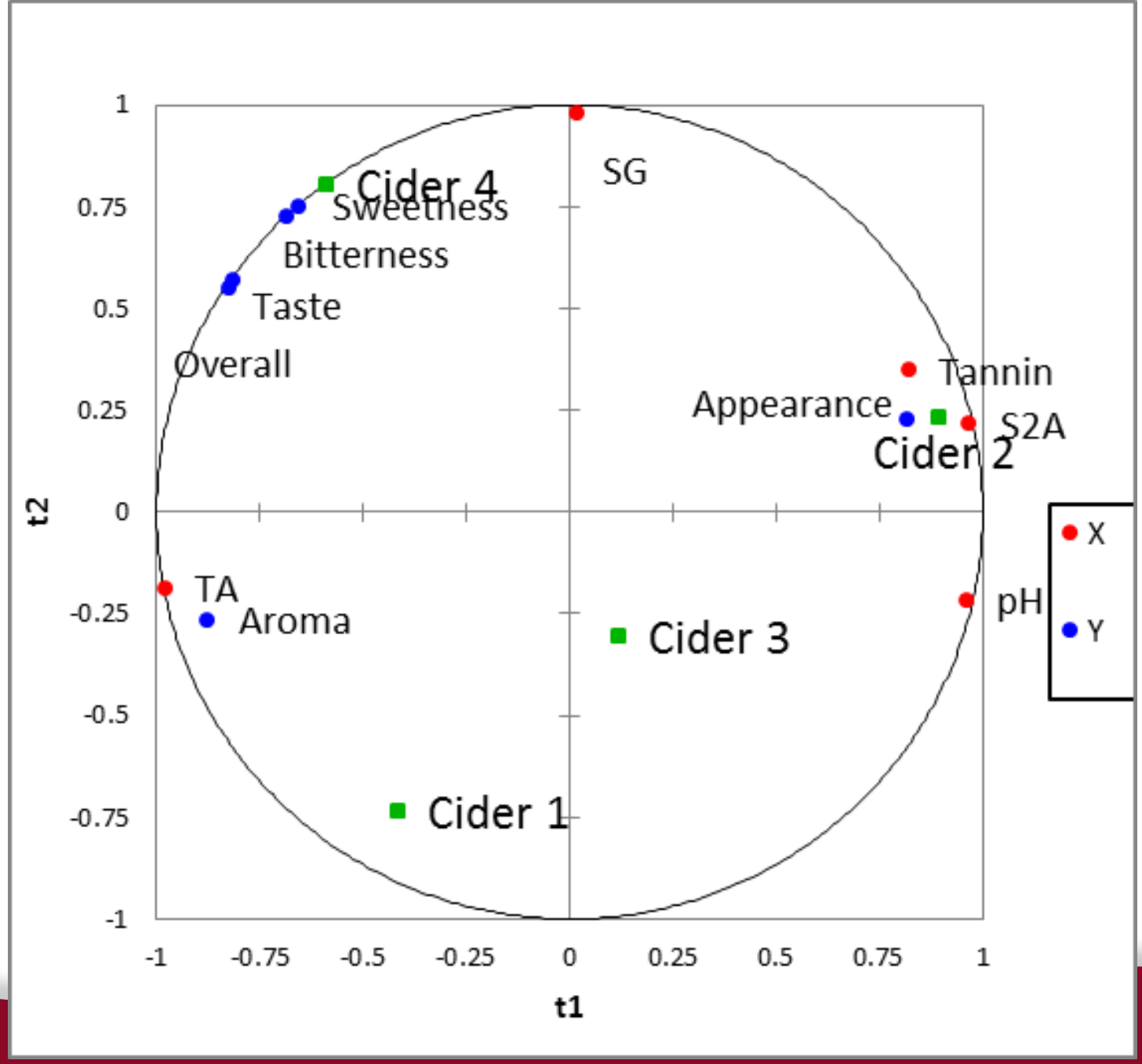
Taste liking	• Increased WTP by $0.21/bottle per unit increase in taste score
Aroma liking	• Increased WTP by $0.05/bottle per unit increase in aroma score
Overall liking	• Increased WTP by $0.09/bottle per unit increase in overall liking

Results: WTP of Ciders

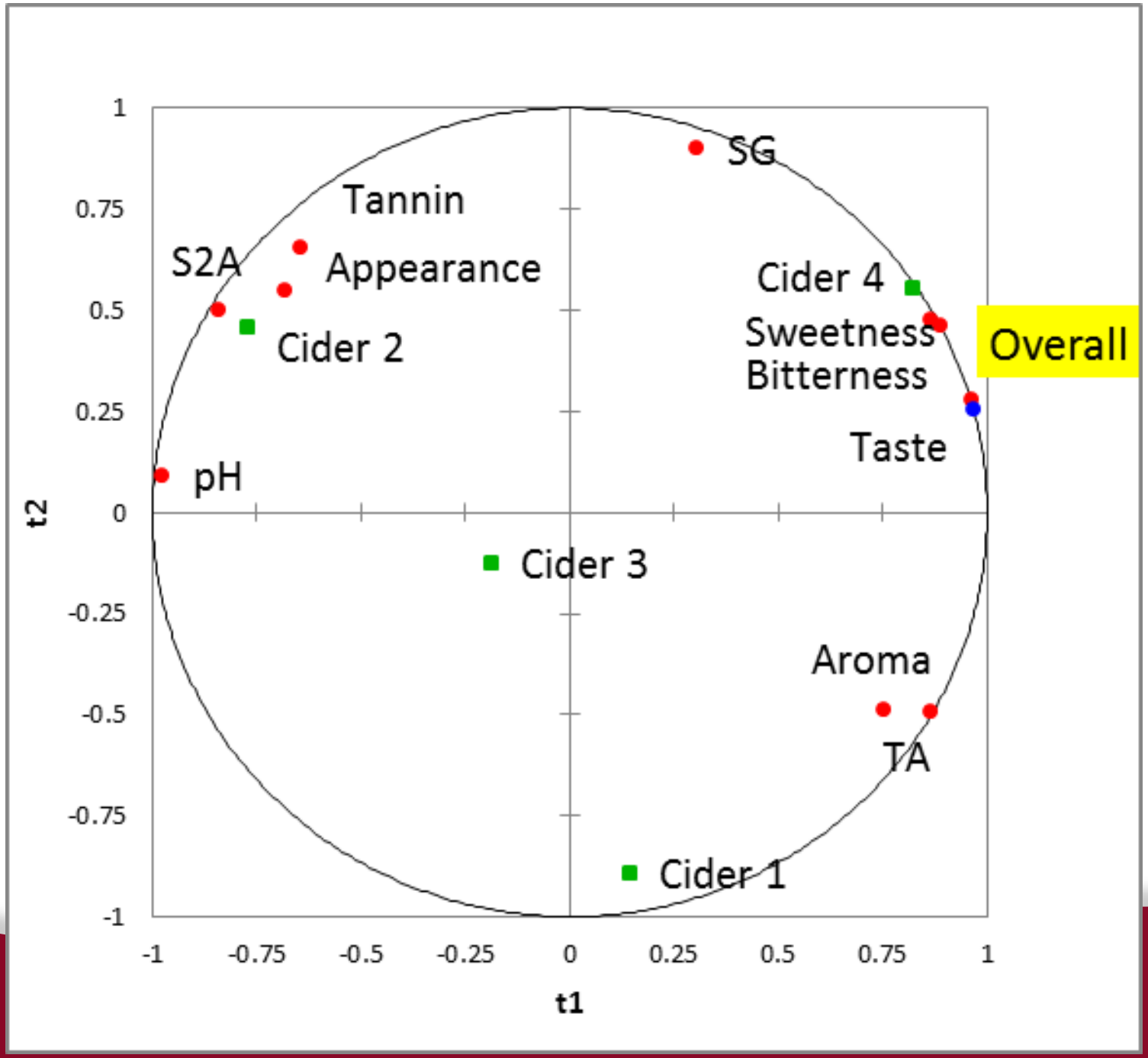
Cider	WTP ($) for 750 mL bottle	Overall Liking (9-pt scale)	Price (per 750 mL bottle)
1	$12.76[b]	5.55	$10 (ns from WTP)
2	$12.41[c]	4.77	$19 (*higher)
3	$12.72[b]	5.51	$15 (*higher)
4	$13.33[a]	7.09	$10.50 (*lower)

WTP and Analytical Measurements

- Tannin percentage and SP2A influenced WTP
  - Cider pH and SP were not significant
  - TA not included because high correlation to SP2A
  - SP2A: As sweetness increased (with TA held constant), the WTP declined
  - Tannin%: As tannin % increased, WTP increased



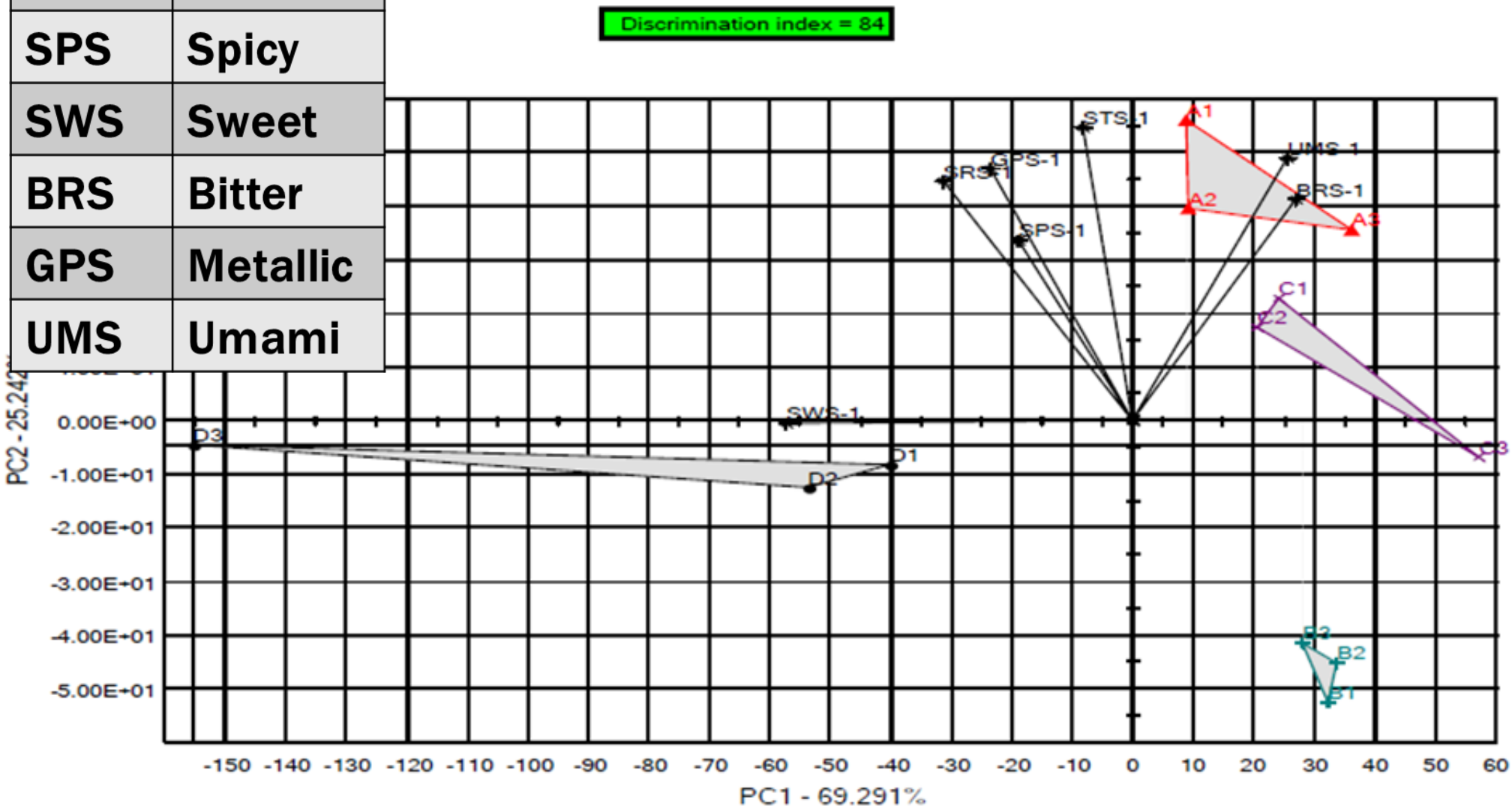
PLS with analytical and consumer data



PLS with analytical and consumer data

STS	Salty
SRS	Sour
SPS	Spicy
SWS	Sweet
BRS	Bitter
GPS	Metallic
UMS	Umami

E-tongue results



Conclusions

- What affects WTP of ciders by consumers?
  - Age
  - Sensory attributes of overall liking, taste/flavor liking and aroma liking
    - Sweetness and bitterness are less important
  - Chemical properties of tannin percentage and SG:TA of the ciders

Acknowledgements

- Peter Tozer, Suzette Galinato, Jill McCluskey
- Carol Miles
- Beata Vixie, Karen Weller
- USDA-AMS Federal State Marketing Improvement Program
- CiderCON 2016

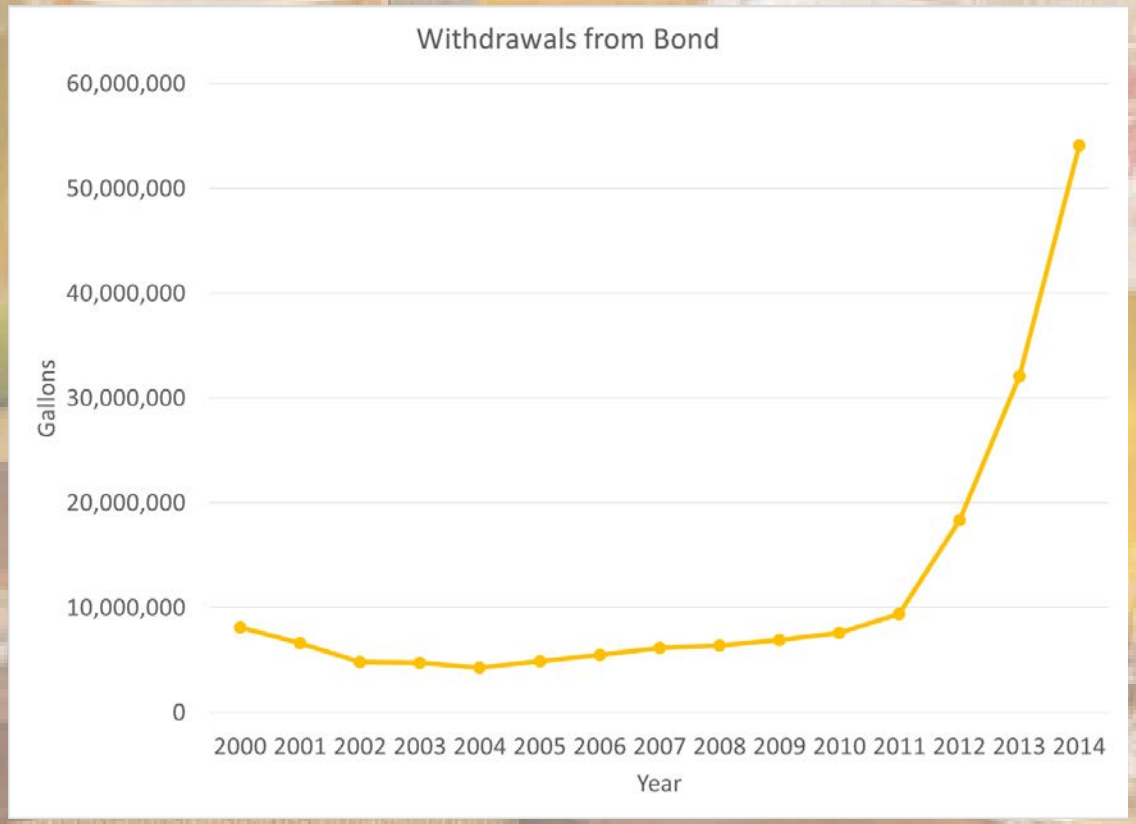
Cider Industry Overview and Cider Research

Peter Tozer

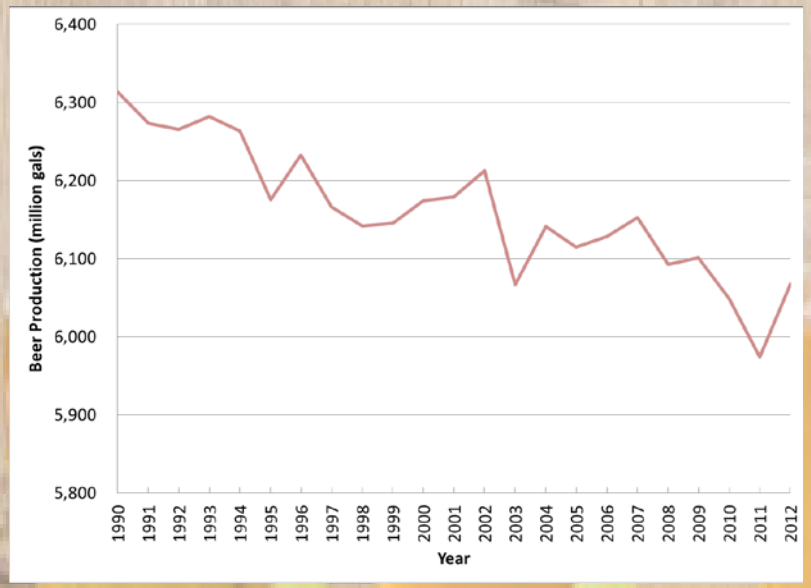
Washington State University

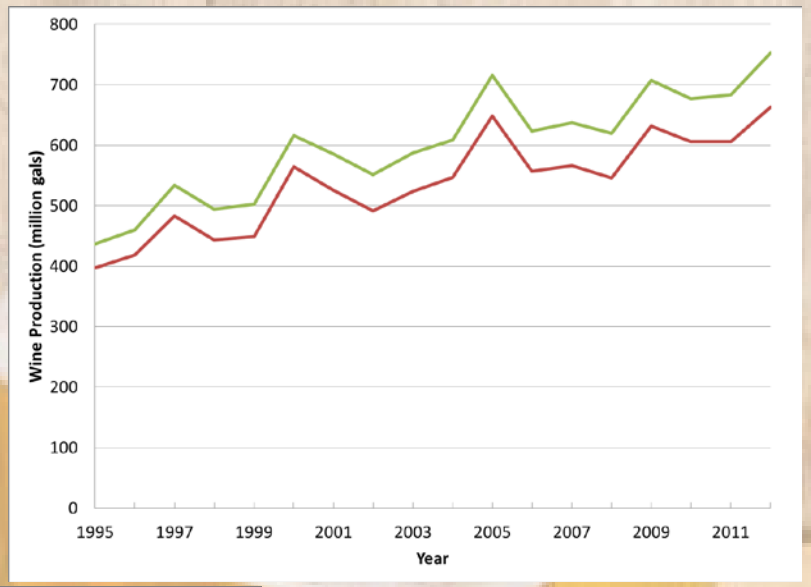
Cider Industry Overview

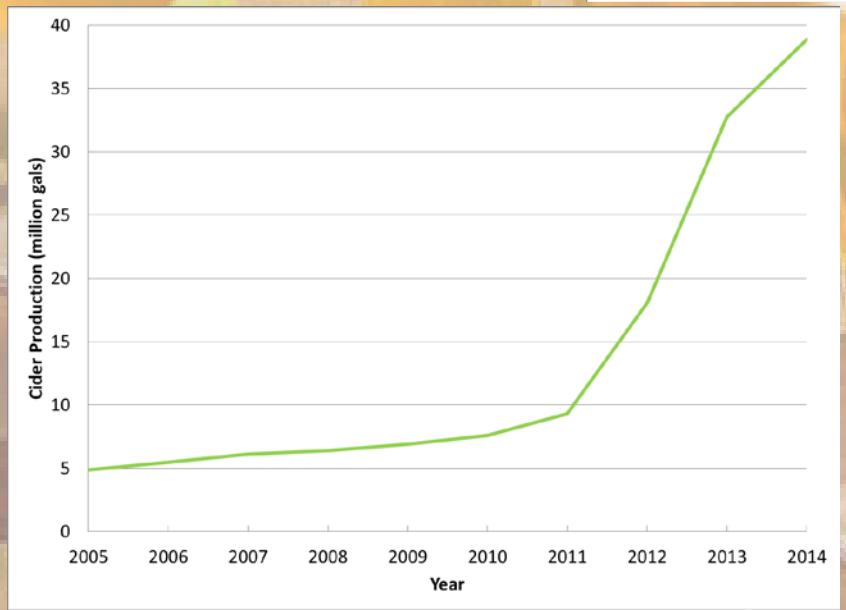
- Rapid growth in sales last 5 years or so, but still only just above 1% of beer market.



Cider Competition







Cider Characteristics

- Cider apples impart certain characteristics to the finished product
  - Bitterness
  - Sweetness
  - Astringency
  - Acidity
  - Flavor and aroma
- These apple characteristics give the finished product “body”, aroma, and dryness.

Cider Characteristics

- No well defined style of ciders – at discretion of cider maker
  - Dry
  - Semi-dry/semi-sweet
  - sweet
- Cider makers also use flavors other than apple
  - Fruits – cherry, grape, berries
  - Hops – dry hopped
  - Spices – cinnamon, jalapeno.

Research Objectives

- To estimate preferences for characteristics of cider.
- Estimate a willingness to pay (WTP) for these characteristics
- Analyze cider and estimate a WTP based on objective rather than subjective measurements.

Research Method

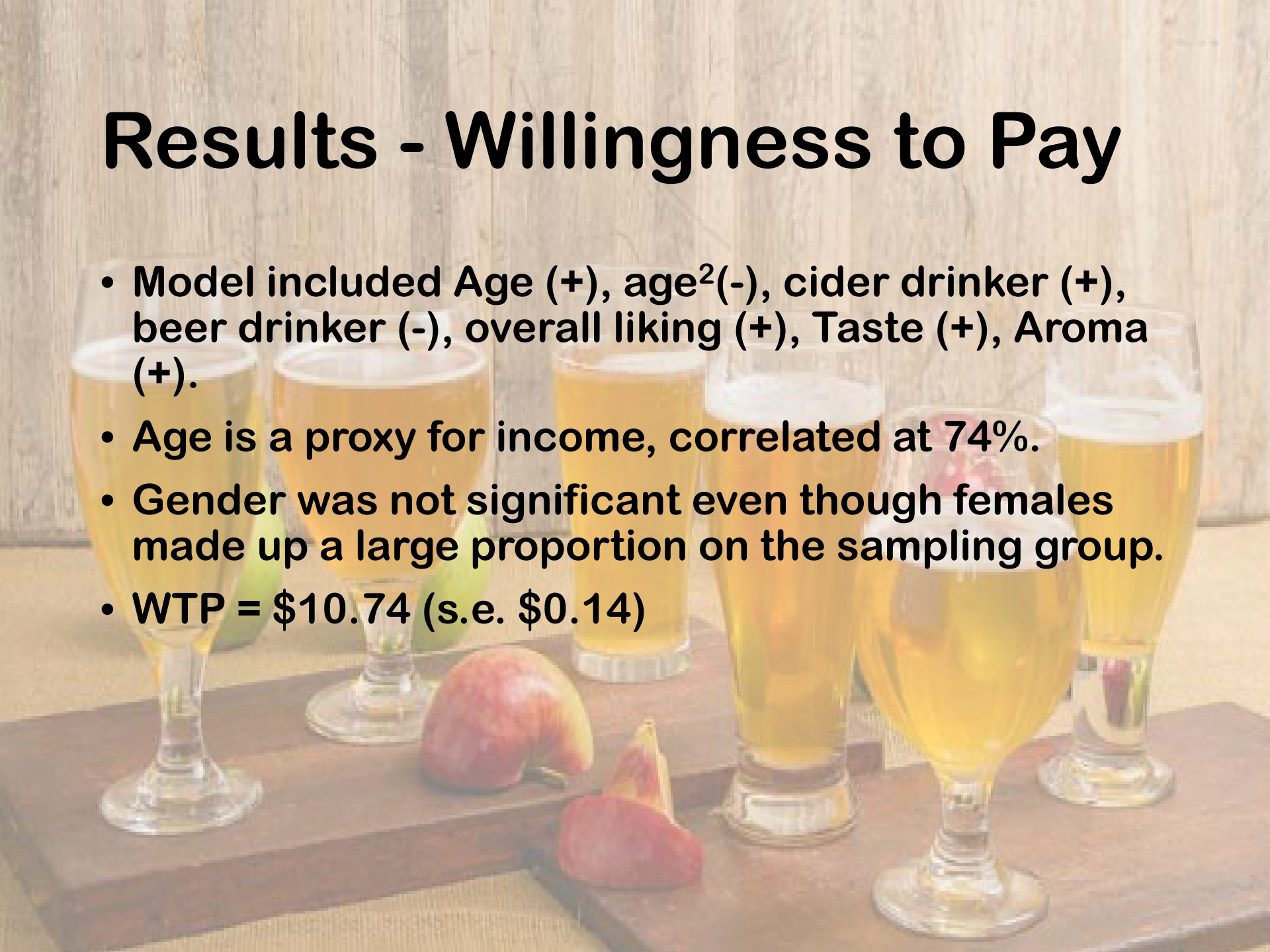
- Blind taste test - 4 ciders – untrained panel – 109 samplers.
- Demographic information
- Willingness to pay – initial bid $13.50 +/- $1, $1.50, $2.
- Chemical analysis of one bottle of each cider

Results

- Demographics
  - Cider drinking infrequent – 86% < 2x per month.
  - Cider drinking most often at home
  - Pay < $12 per 750 mL bottle equivalent
- Sensory Attributes (1-9 Scale)
  - Most average scores in the 5 - 6.5 range.
  - Cider 4 most preferred then 1, 3, and 2.
  - Cider 2 had some off-flavors and was least preferred

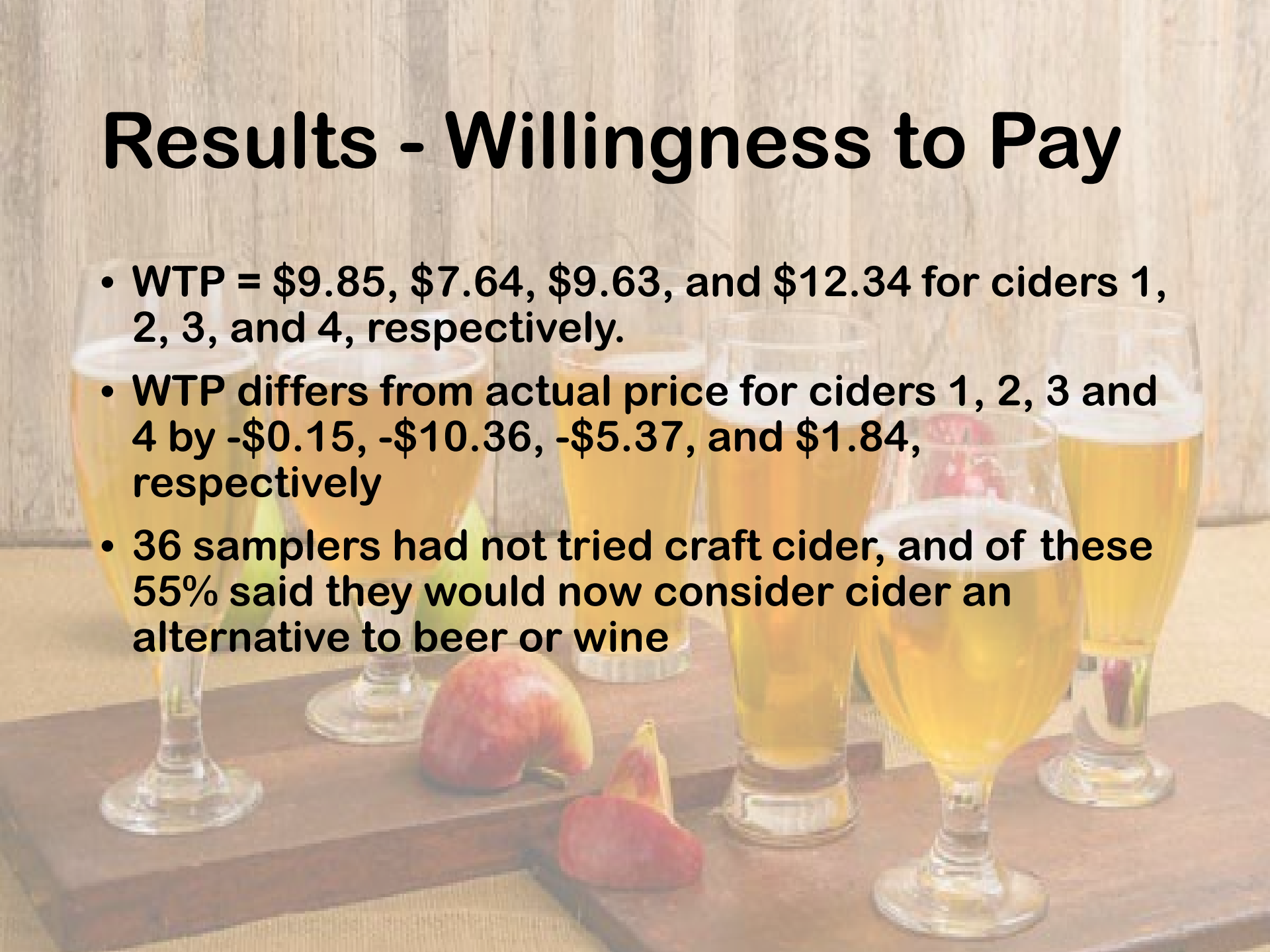
Results - Willingness to Pay

- Model included Age (+), age^2(-), cider drinker (+), beer drinker (-), overall liking (+), Taste (+), Aroma (+).
- Age is a proxy for income, correlated at 74%.
- Gender was not significant even though females made up a large proportion on the sampling group.
- WTP = $10.74 (s.e. $0.14)



Results - Willingness to Pay

- WTP = $9.85, $7.64, $9.63, and $12.34 for ciders 1, 2, 3, and 4, respectively.
- WTP differs from actual price for ciders 1, 2, 3 and 4 by -$0.15, -$10.36, -$5.37, and $1.84, respectively
- 36 samplers had not tried craft cider, and of these 55% said they would now consider cider an alternative to beer or wine



Results – Chemical Analysis

Cider	Specific Gravity (SG)	pH	Titratable Acid (g malic acid/ liter, TA)	Tannin %	SG to TA Ratio
Cider 1	1.003	3.66	6.2	0.04	0.1618
Cider 2	1.009	3.99	4.5	0.11	0.2242
Cider 3	1.004	3.71	5.6	0.10	0.1793
Cider 4	1.012	3.47	6.1	0.07	0.1659

Results - Willingness to Pay

- Model included tannin (+), specific gravity to acid ratio(-).
- Negative on sweetness to acid ratio indicates that as sweetness increases, relative to acid WTP declines – in other words drinkers prefer dry to sweet.
- WTP = $10.06 (s.e. = $0.20).
- WTP for individual ciders was $11.03, $10.64, $7.80, and $10.77 (c.f $9.85, $7.64, $9.63, and $12.34).

Production of Cider Apples

- Competition from dessert apples in the production systems

- Competition from dessert apples in the nursery system
  - WSU just released “Cosmic Crisp” 300,000 trees to be provided to “lucky” growers by 2017.
  - Not in nurseries yet or maybe just in.

Production of Cider Apples

- Revenue from cider apples somewhat competitive with dessert apples if yields are relatively high.
- Survey results indicate supply of desirable apples major factor to cider makers.

Conclusions

- Overall liking, aroma and flavor are key factors to willingness to pay.
  - Consumers prepared to pay for a complete sensory package, not components.
- Cider has the potential to increase market share if tasting experiences are provided.
- Research still has a way to go in objective and subjective measurement of desirable characteristics in cider and consumer preferences for these.