

Exploring the Sensory Characteristics of Virginia Ciders through Descriptive, Consumer, and Chemical Methods

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Presentation Outline



Background



Study 1:
Descriptive
Analysis



Study 2: Consumer
Study



Study 3: Chemical
Analysis



Conclusion



Questions

Background & History of Cider

Cider is the fermented, alcoholic beverage made from the juice of apples.

By the 18th century:

- Cider was the national drink in the US¹

In the 20th century cider production and consumption declined due to: ^{1,2}

- Industrial Revolution
- Prohibition
- Popularity of Beer



Virginia Cider Industry

Virginia Ciders

- 6th largest apple producer in the country¹
- Apples are the 16th top commodity for the state
- 32 known cider producers in Virginia
- Over 200 apple varieties grown throughout the state³



Why is this important?

- The diversity of cider making practices and the range of apples used to create cider led to a need to creating a distinct sensory profile for Virginia ciders.
- Descriptors for beer and wine are currently being used for cider¹
- A standardized, descriptive language would aid in understanding what cider characteristics and styles drive consumer preference¹



Research Questions



QUESTION 1: WHAT SENSORY DESCRIPTORS ARE ASSOCIATED WITH VIRGINIA CIDERS?



QUESTION 2: WHAT ARE THE DRIVERS OF CONSUMER PREFERENCE AMONG VIRGINIA CIDERS?



QUESTION 3: IS THERE A RELATIONSHIP BETWEEN CHEMICAL AND SENSORY DATA FOR VIRGINIA CIDERS?

Study 1: Descriptive Analysis



Descriptive Analysis

Training Sessions¹

- Exposed to all samples
- Create a descriptive terminology



Consistency¹

- During the final training, the panelists will rate the intensities of each attribute on a scale.



Evaluation Sessions¹

- Panelists will rate all samples in replicate for each descriptor on the 15-point scale.

Methods: Descriptive Analysis

24 Samples

- Representing 16 VA Cideries

6 Panelists

- 8 Training Sessions
- 8 Evaluation Sessions

48 Descriptors

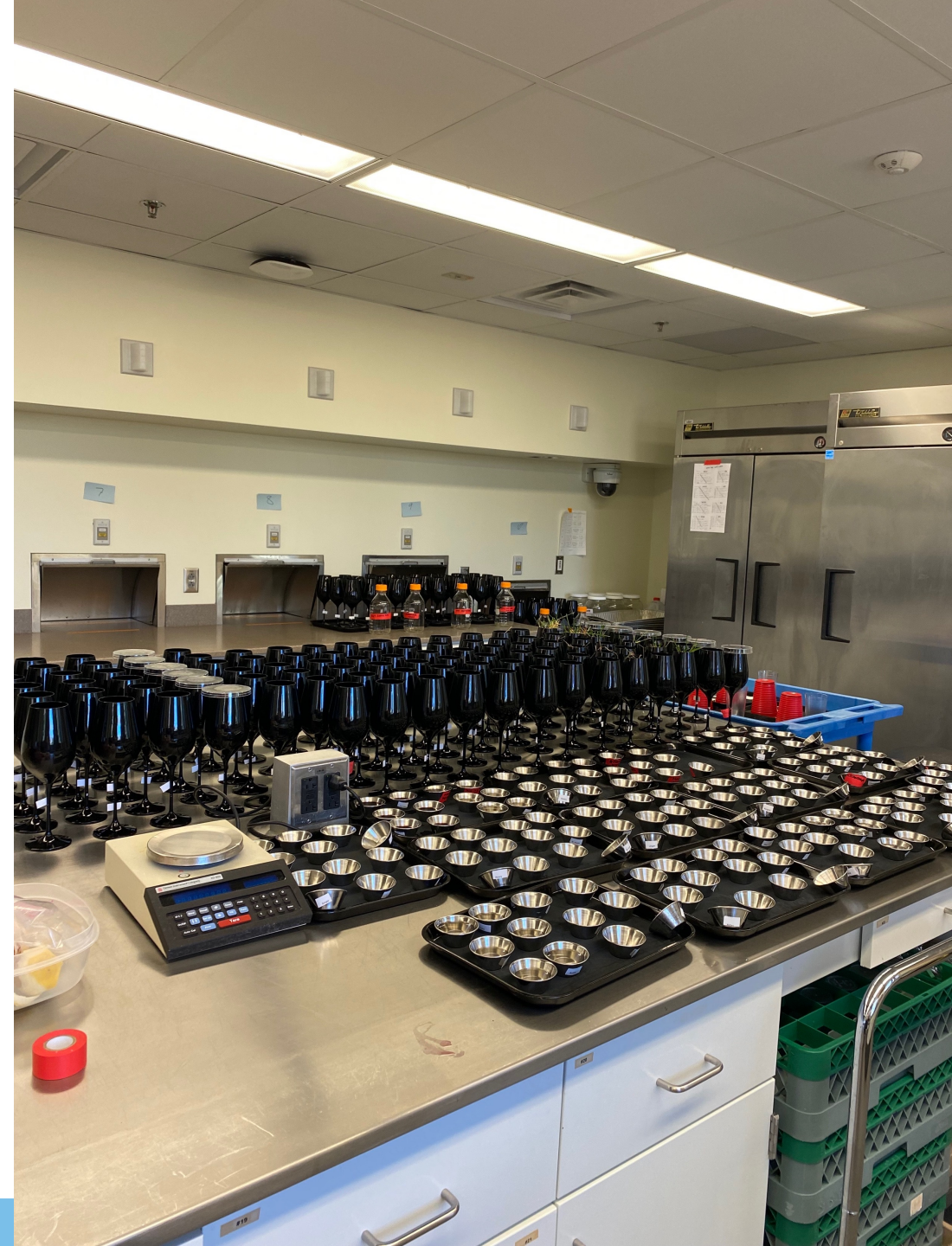
- 33 Aroma/Flavor
- 3 Taste
- 12 Mouthfeel

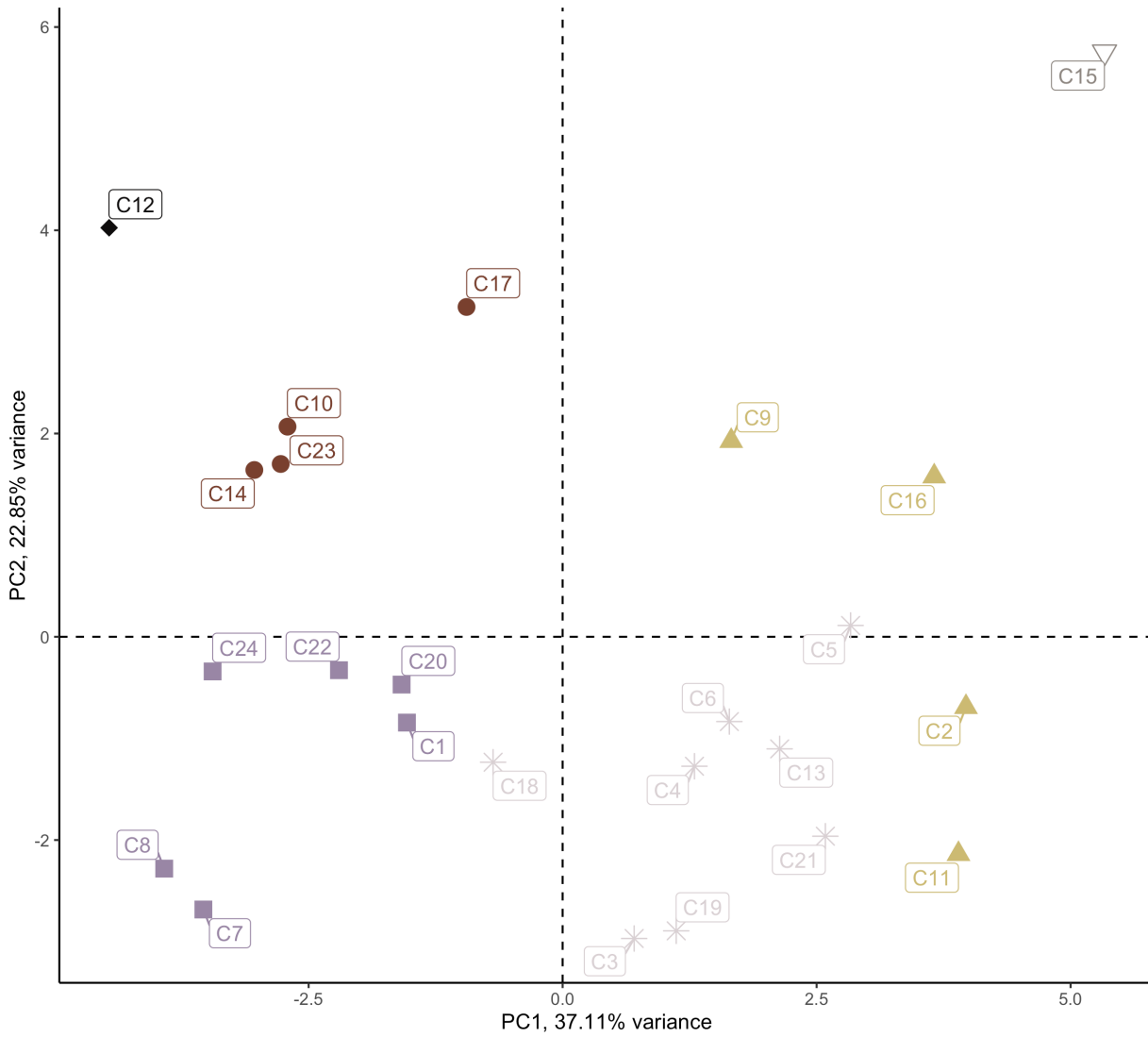
Data Analysis: MANOVA, ANOVA, PCA, HCA



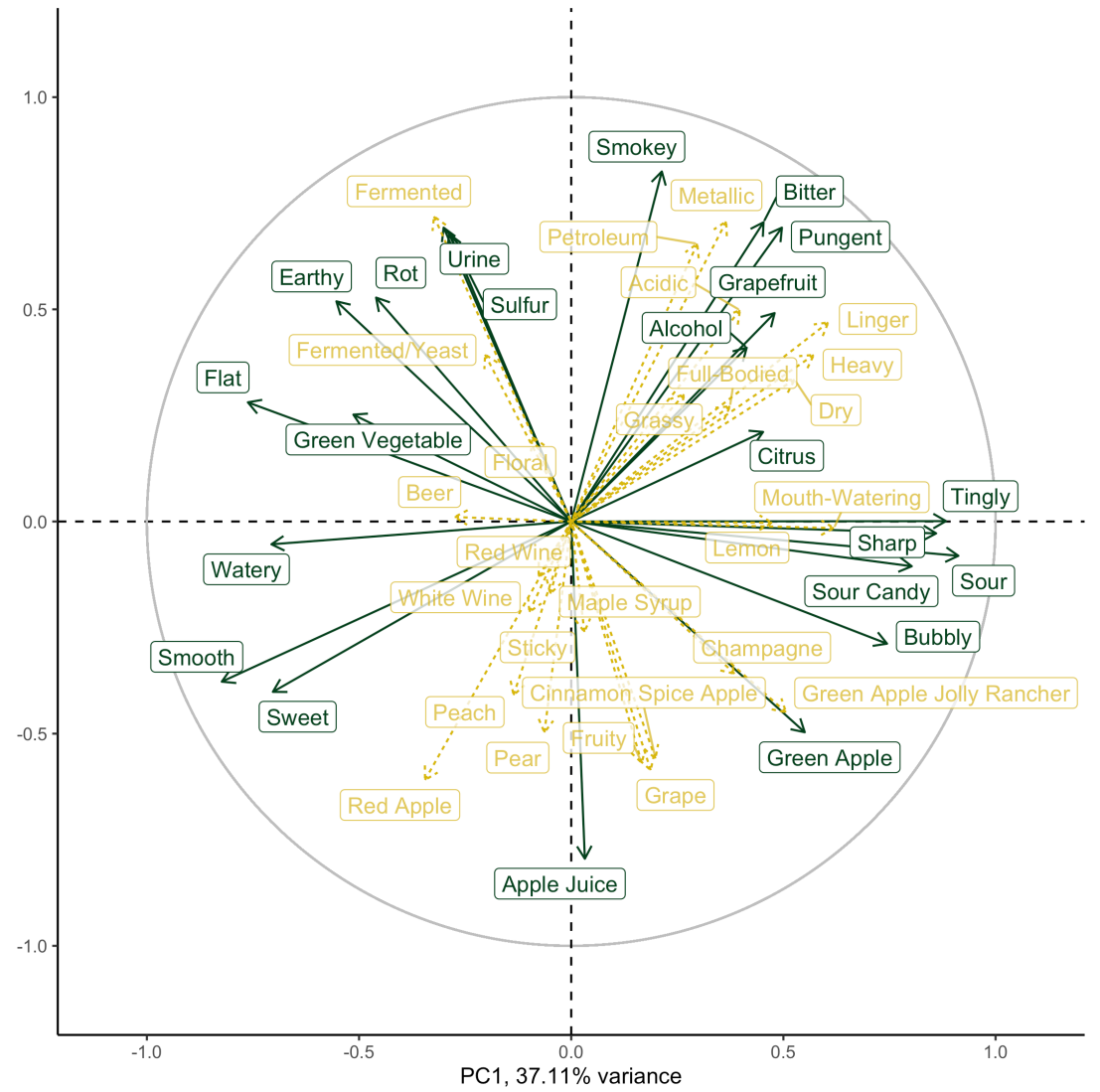
Methods: Descriptive Analysis

- In evaluation sessions, ciders were evaluated in duplicate
- For evaluation sessions each cider placed in the fridge the day before the session and was opened 10 minutes prior to the first panelists arriving.
- Protocol adapted from Hood White and Heymann (2015)
- The ciders were then poured into 1L bottles and placed back in the fridge.
- References were given weekly during these sessions (4 times total)

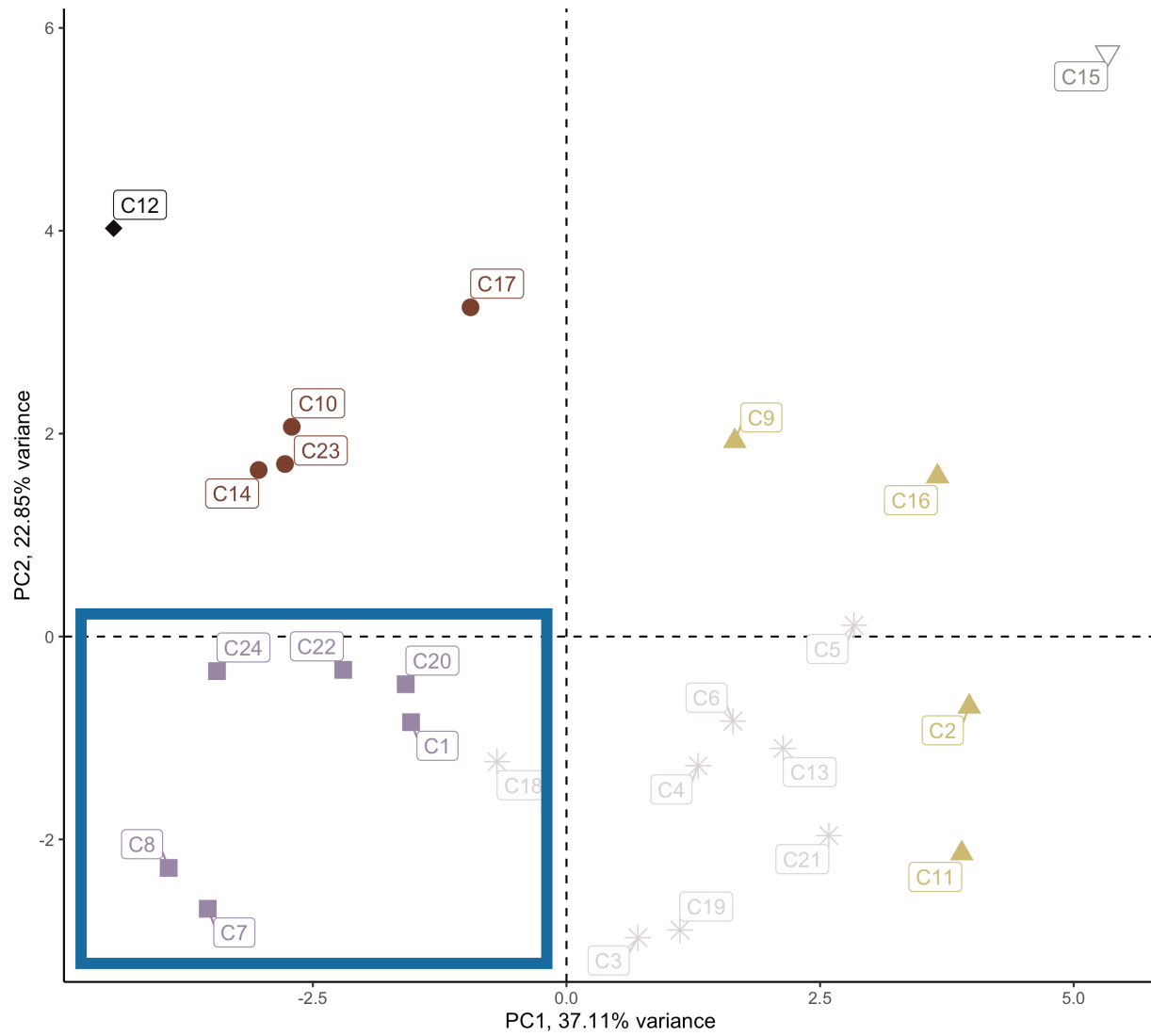




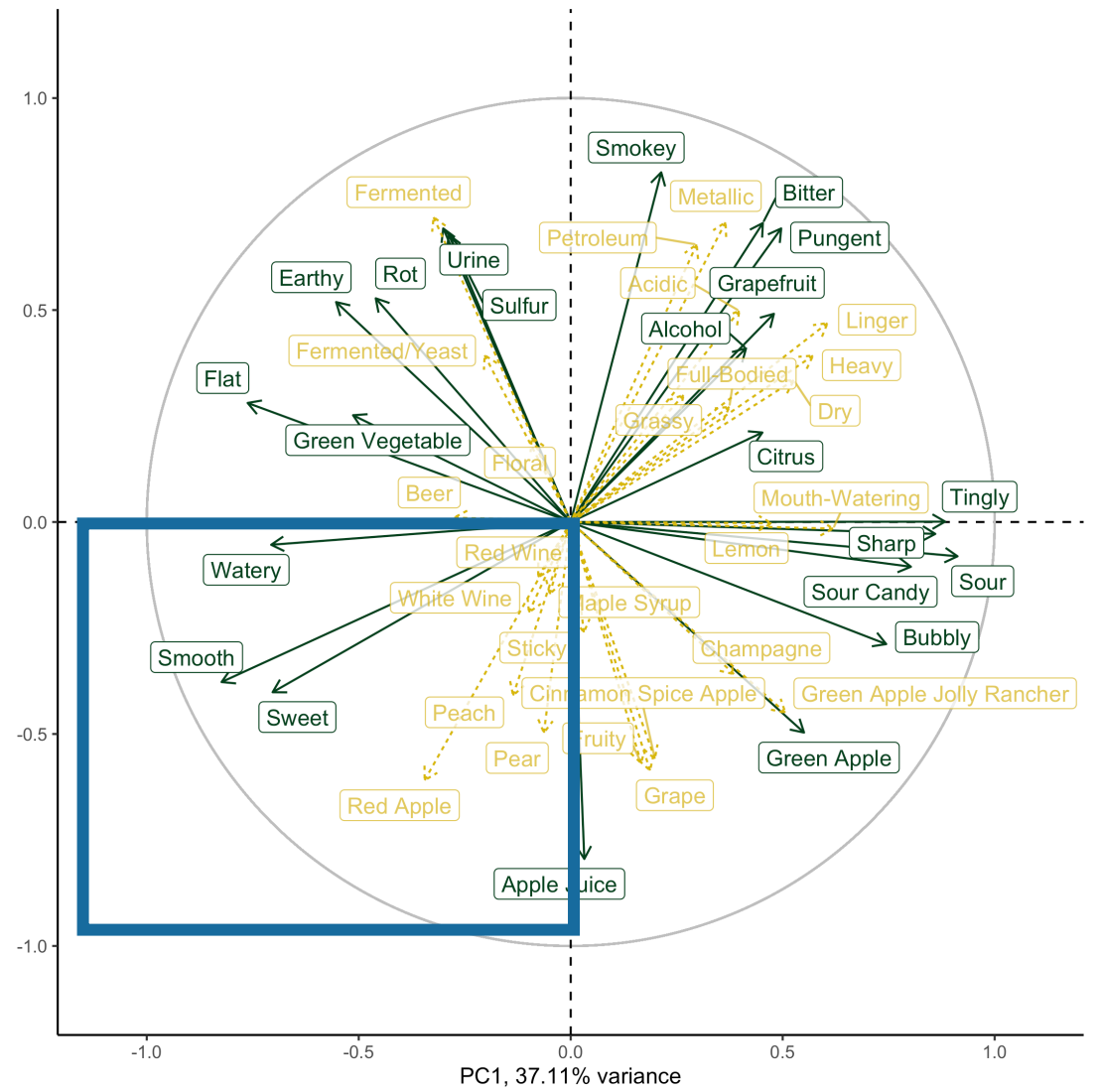
cluster from HCA: ■ 1 ● 2 ▲ 3 ◆ 4 * 5 ▽ 6



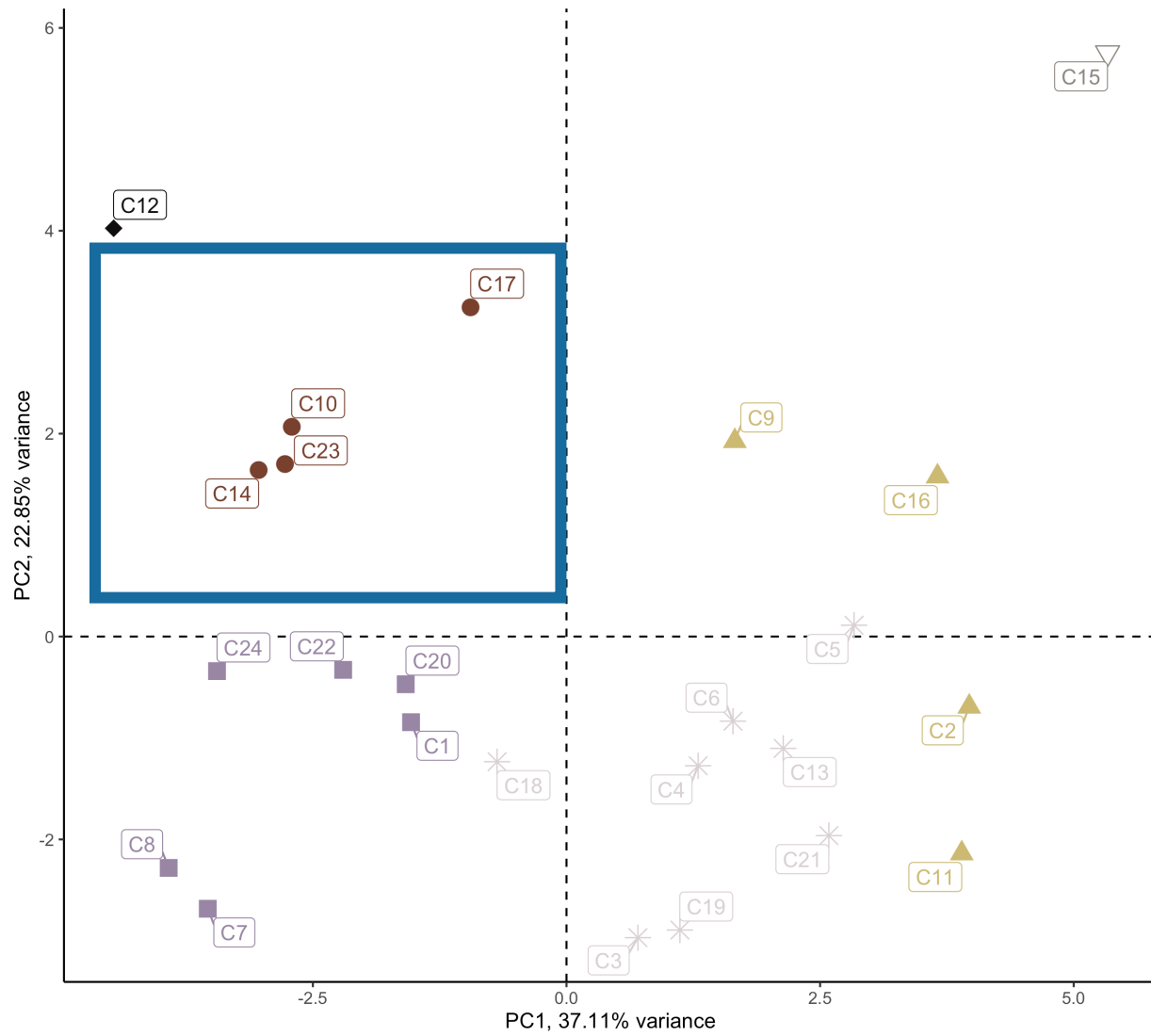
descriptor role: ← significant ↔ supplementary



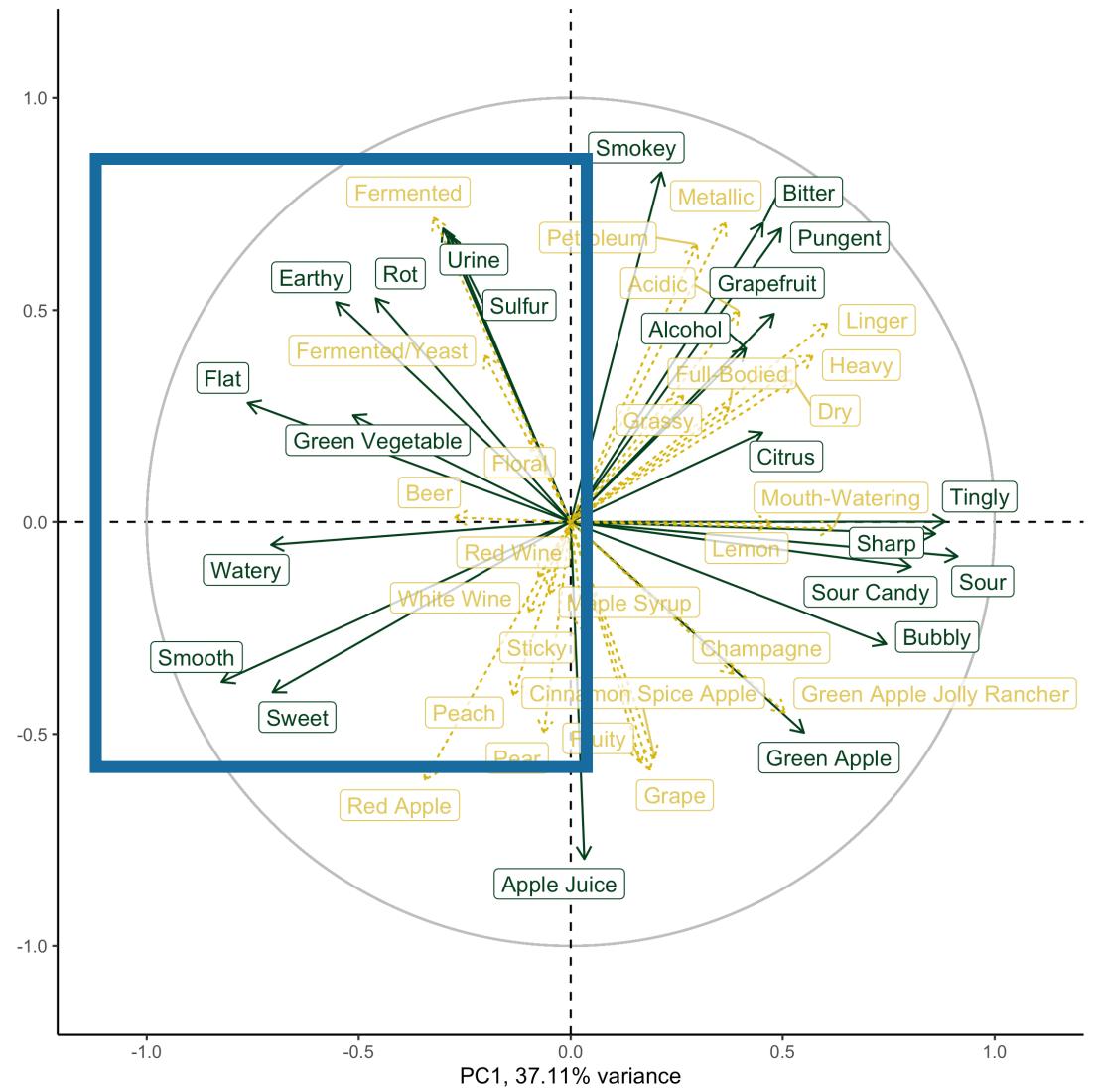
cluster from HCA: ■ 1 ● 2 ▲ 3 ◆ 4 ✱ 5 ▽ 6



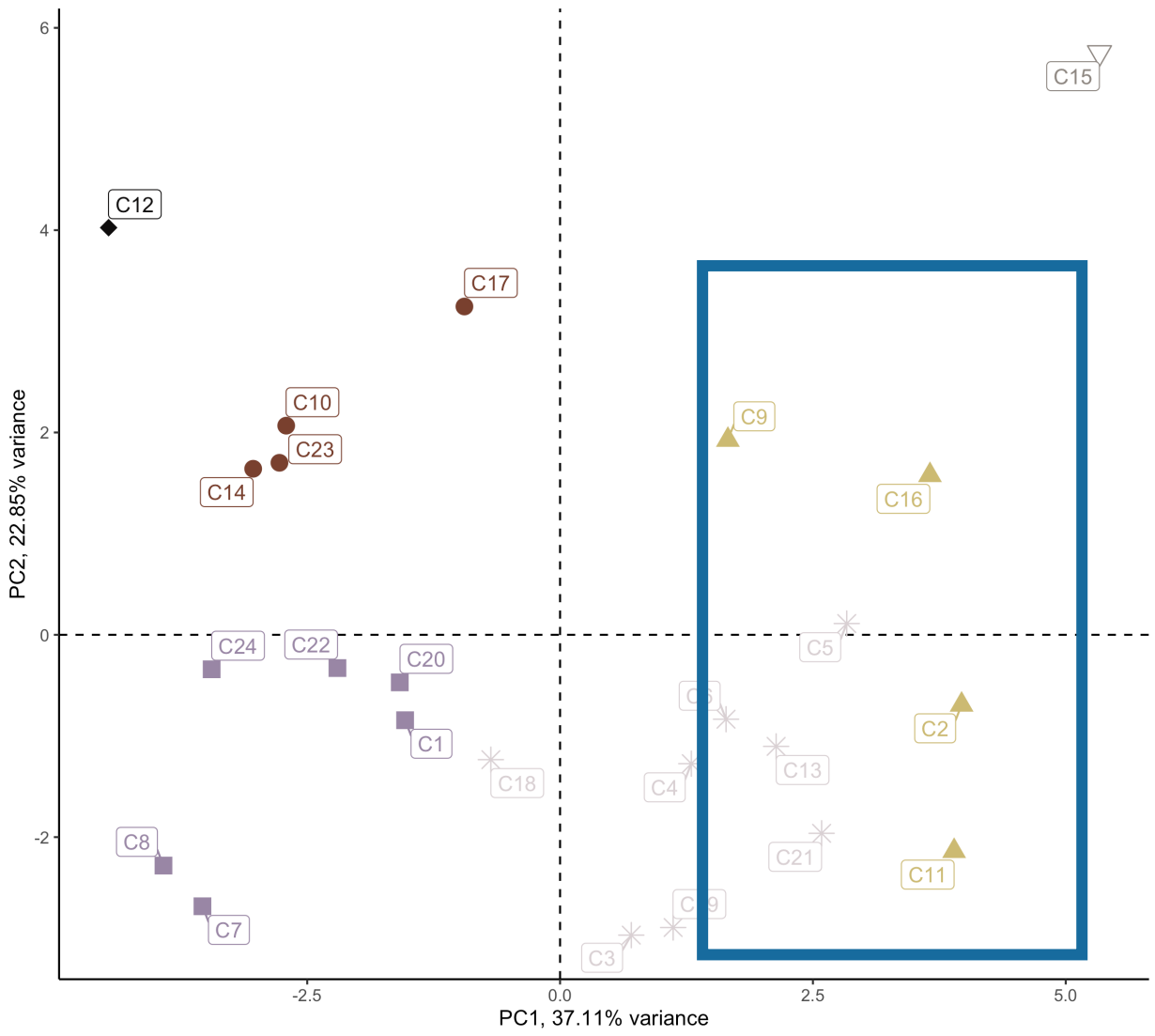
descriptor role: ← significant - - - supplementary



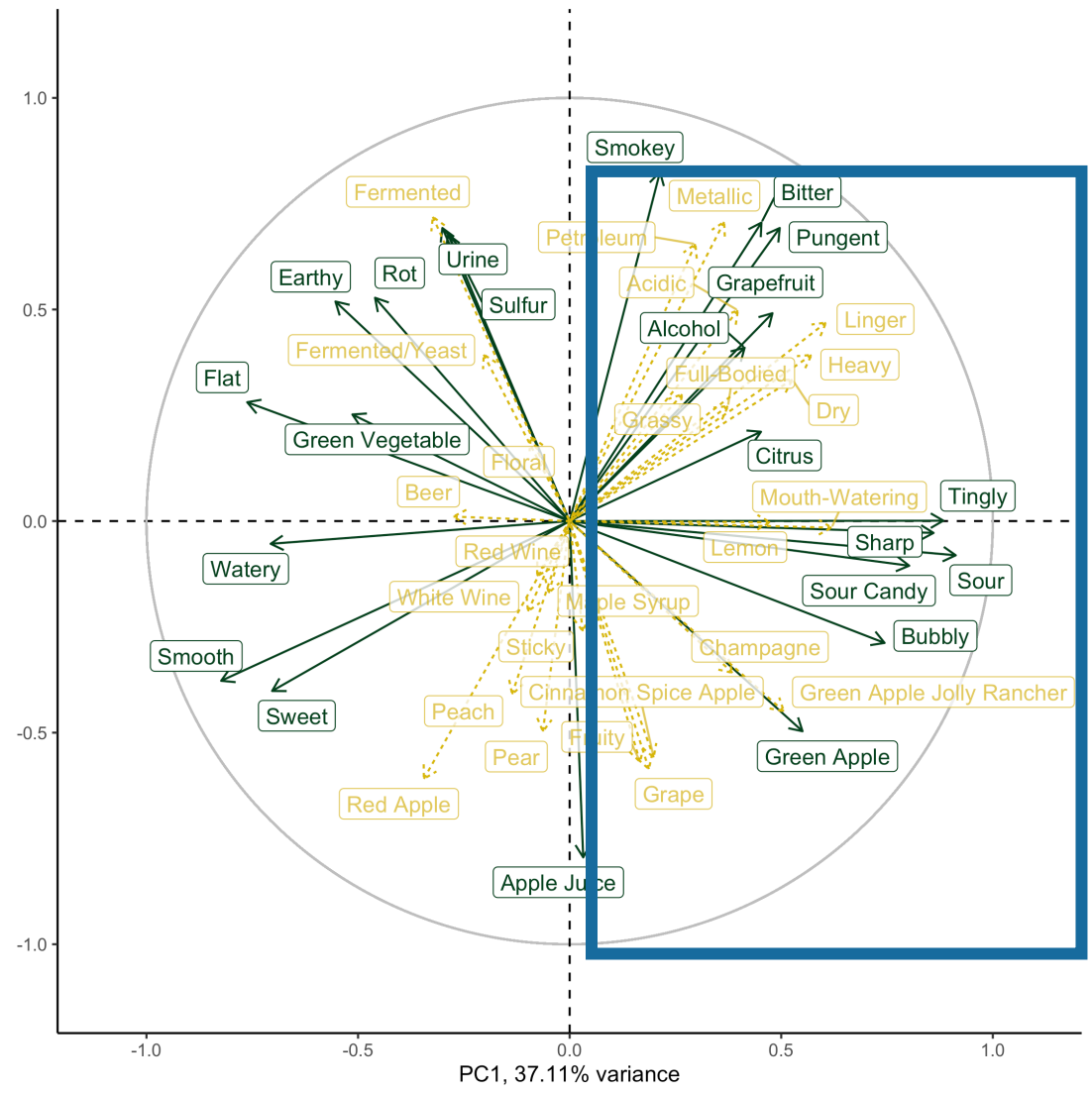
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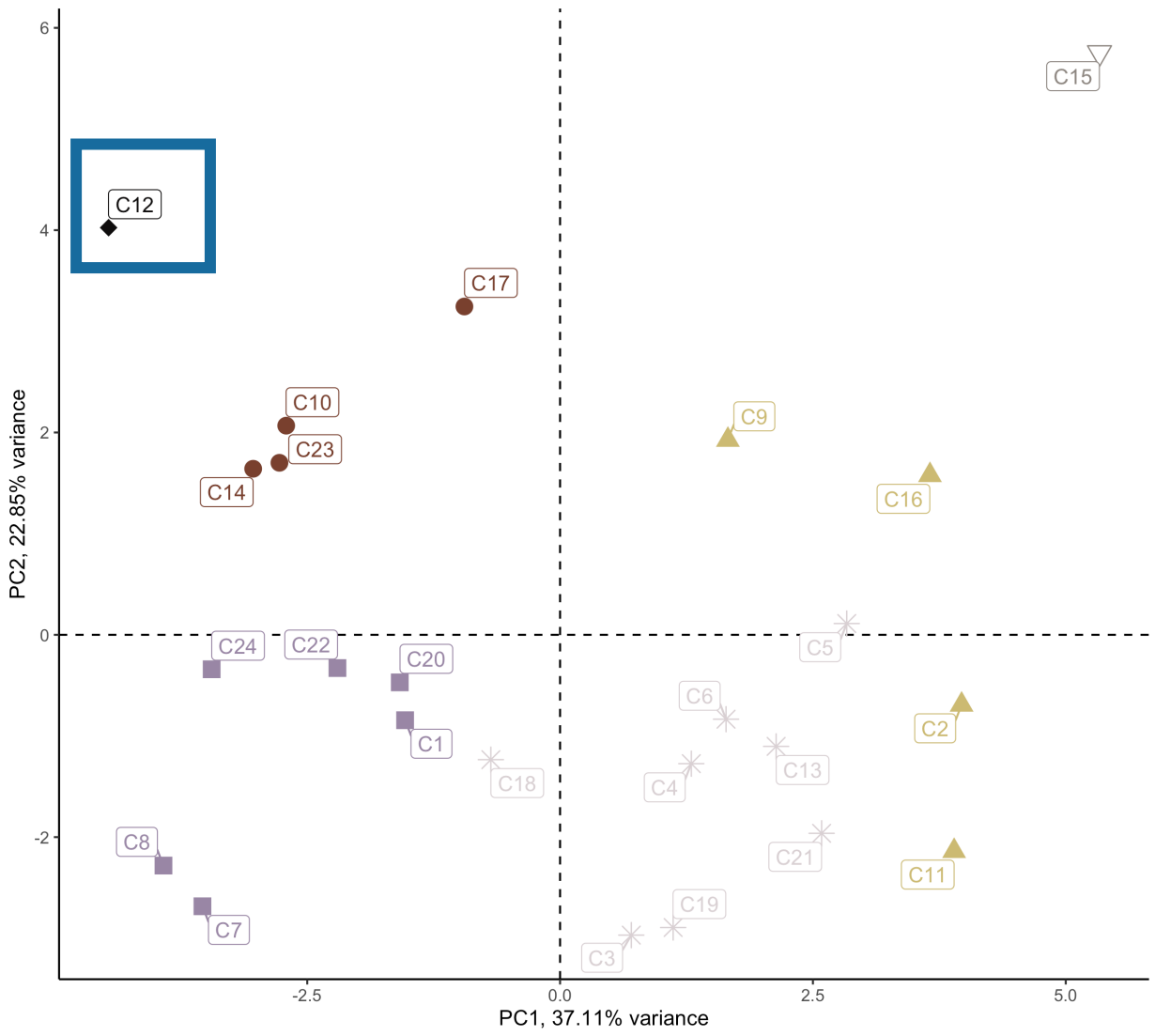
descriptor role: ← significant ↯ supplementary



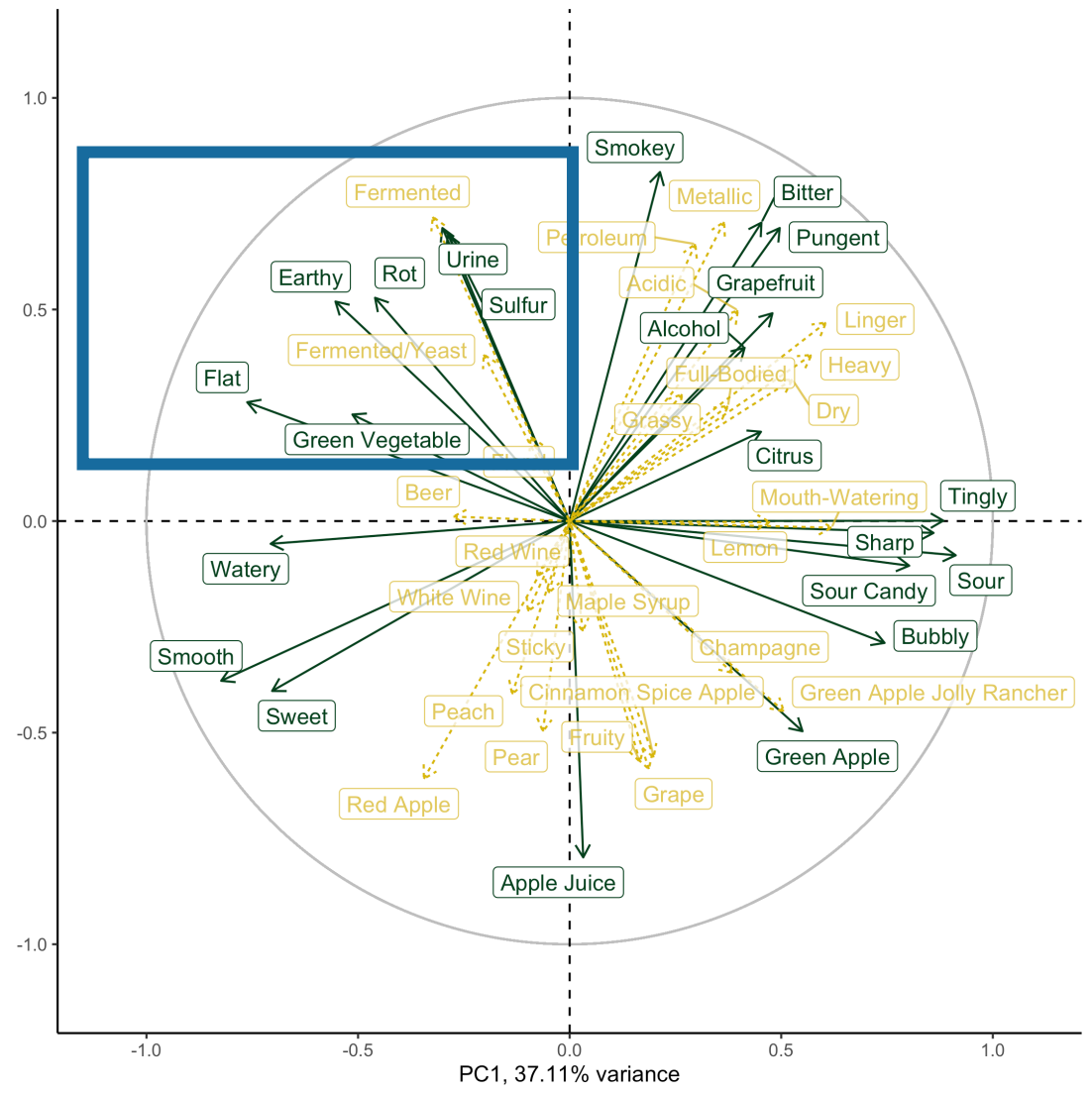
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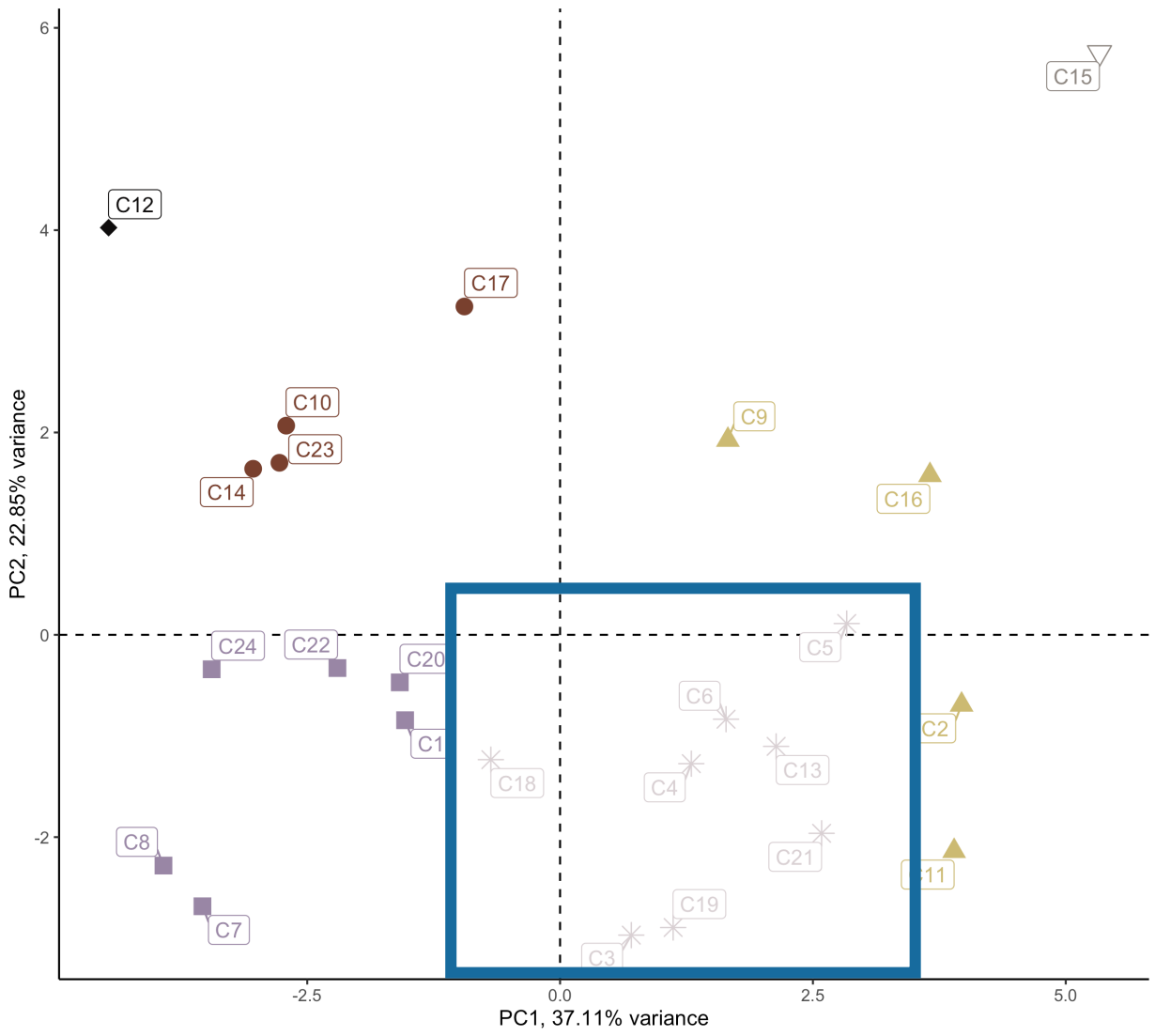
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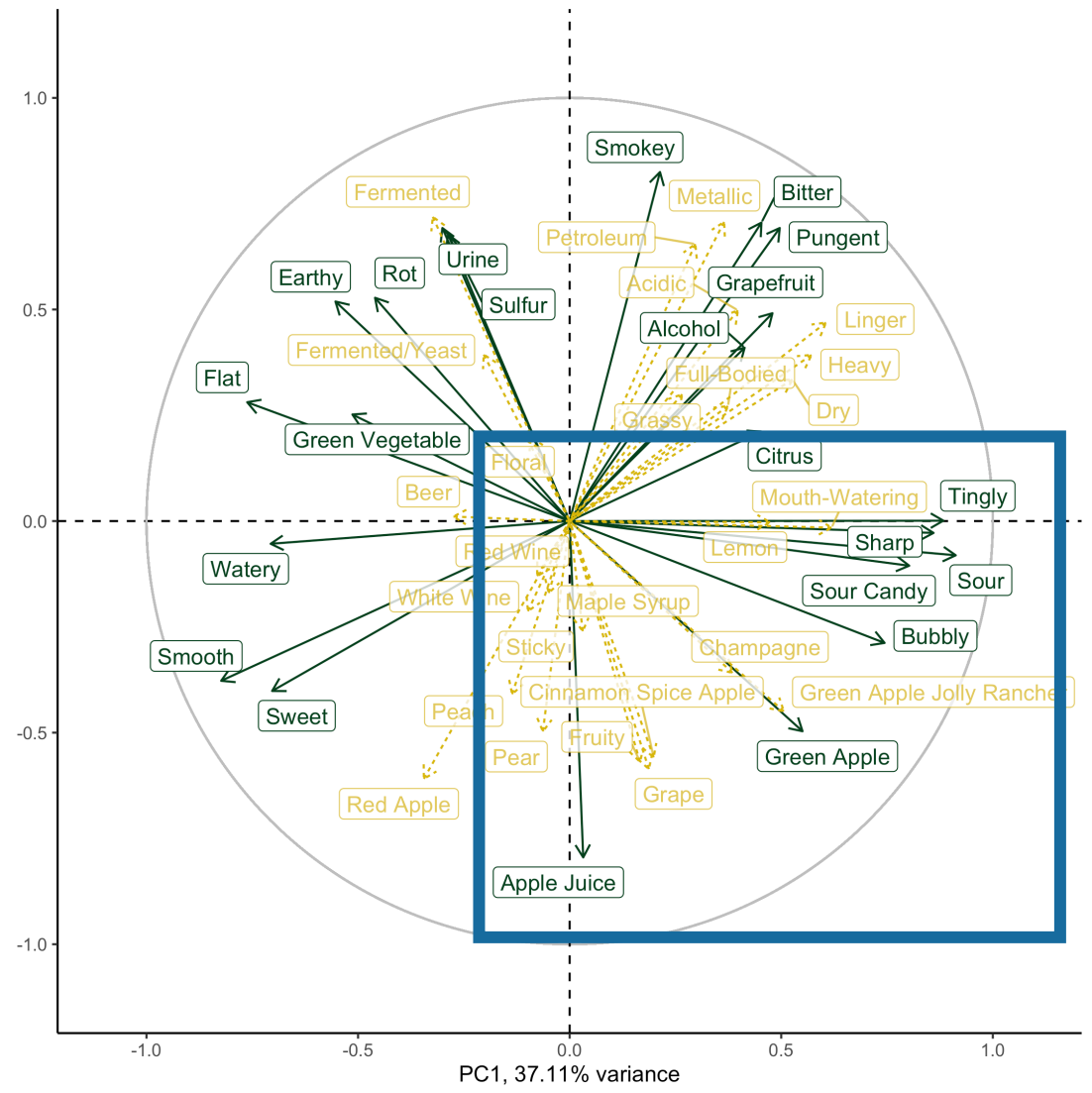
cluster from HCA: ■ 1 ● 2 ▲ 3 ◆ 4 * 5 ▽ 6



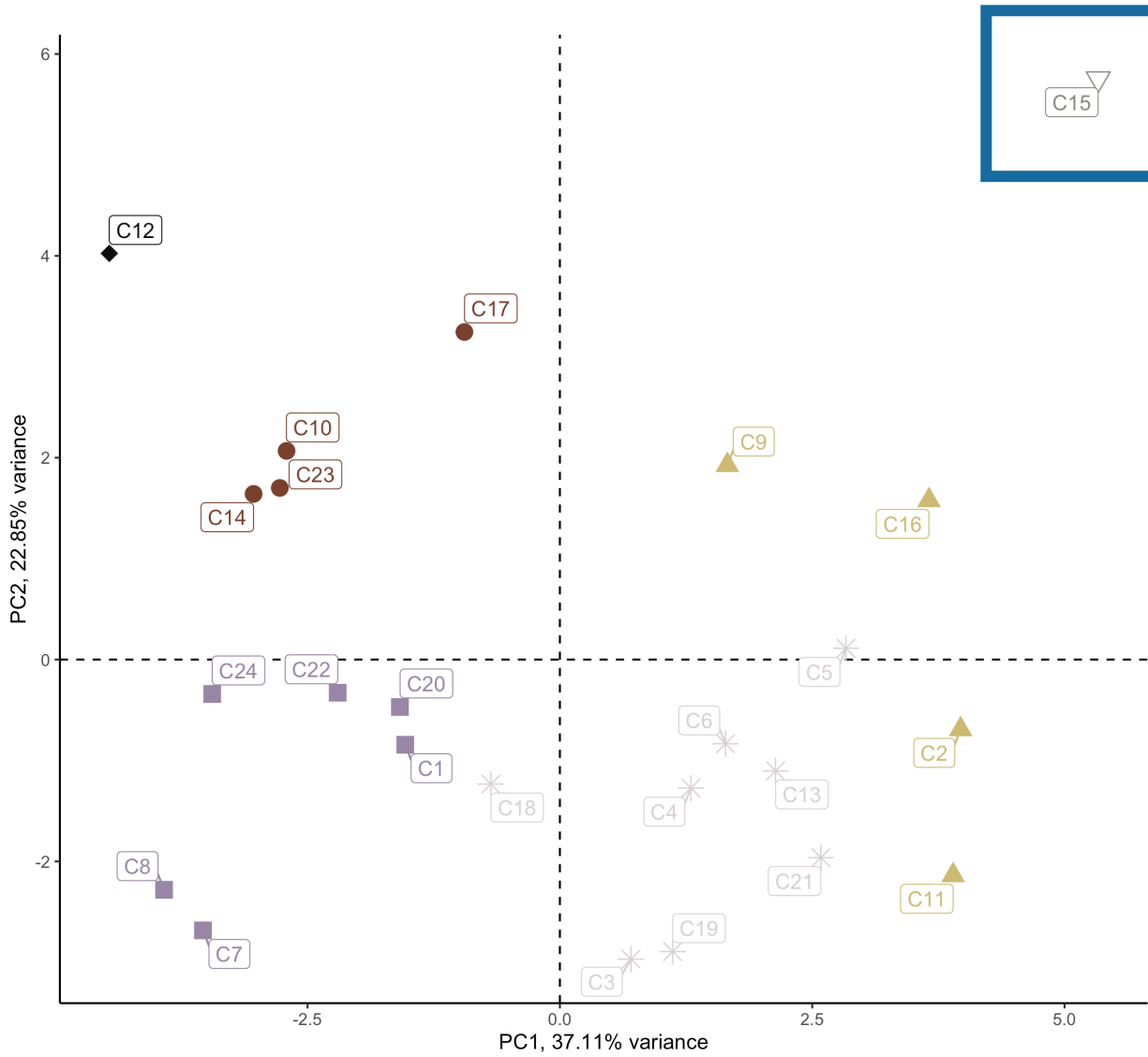
descriptor role: ← significant ↯ supplementary



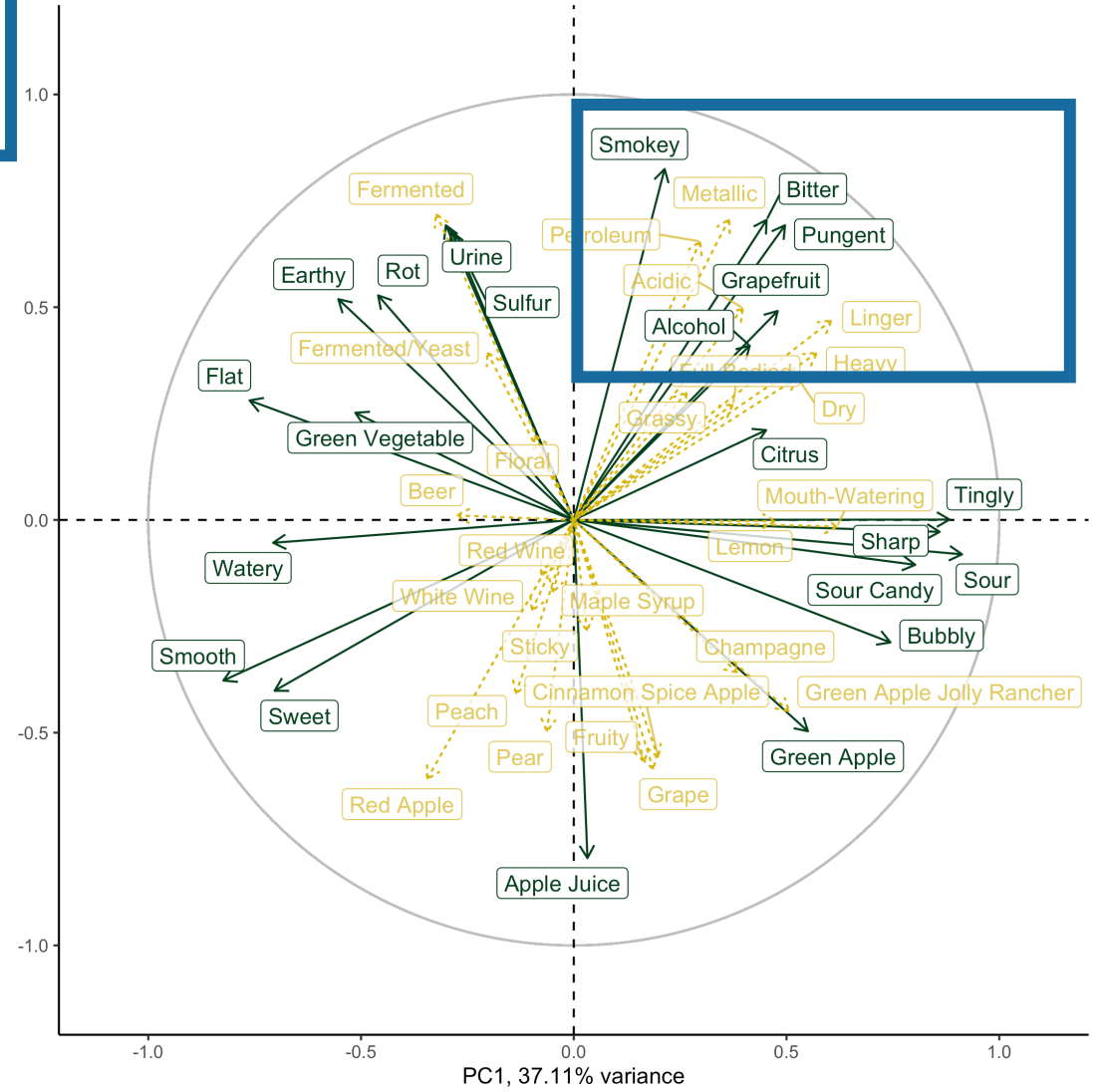
cluster from HCA: ■ 1 ● 2 ▲ 3 ◆ 4 ✱ 5 ▽ 6



descriptor role: ← significant - - - supplementary



cluster from HCA: ■ 1 ● 2 ▲ 3 ◆ 4 * 5 ▽ 6



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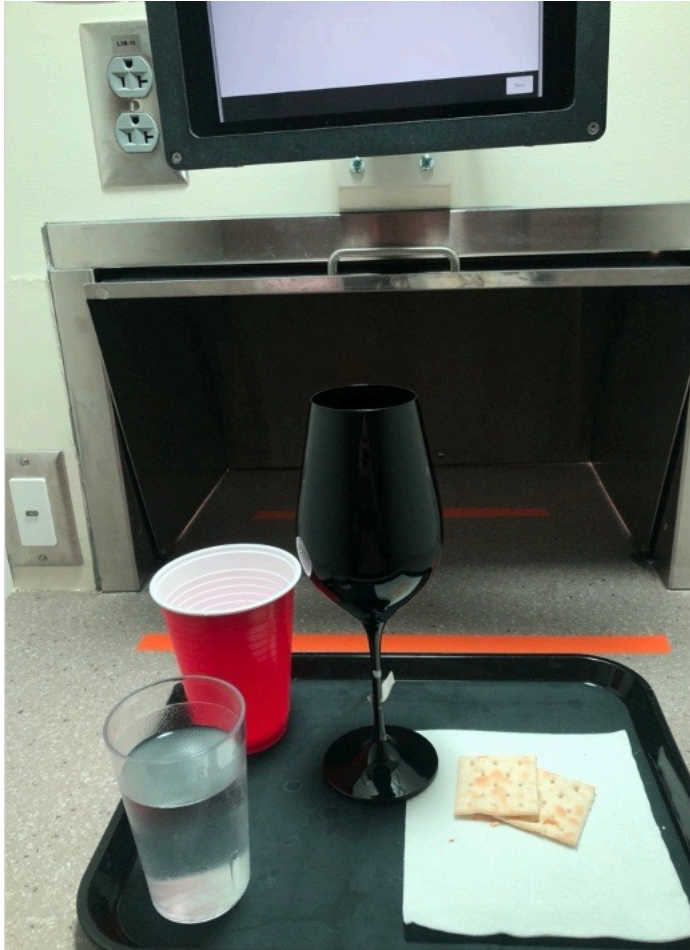


Study 2: Consumer Study

Methods: Consumer Study

- 8 Total Samples
- N = 67
- Demographic Data, Overall Liking, Purchasing Intent, Willingness to Pay
- Data Analysis
 - External Preference Mapping
 - Clustering around Latent Variables (CLV)
 - Partial Least Squares Regression (PLS)

Methods: Consumer Study



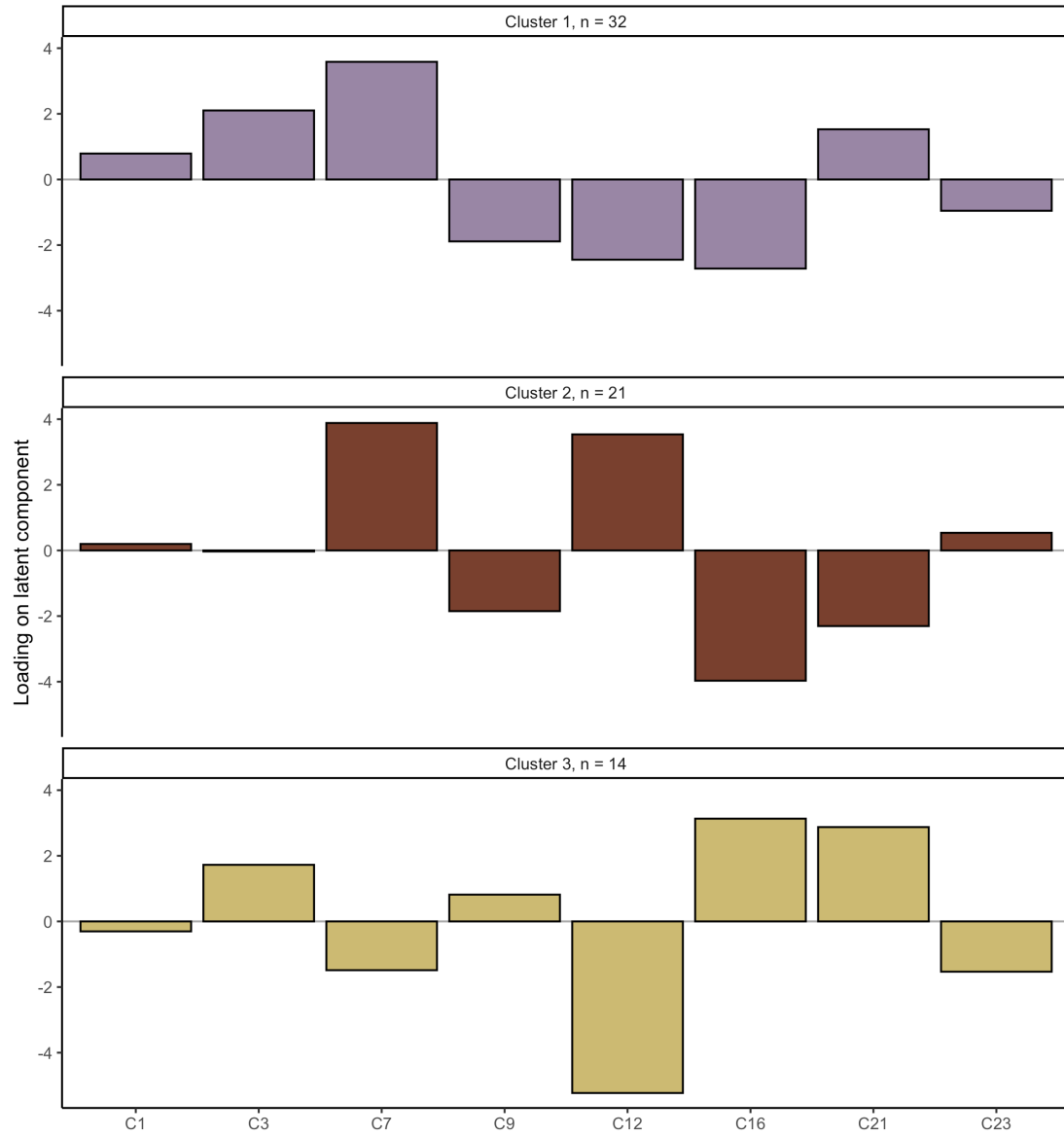
Demographic Questions:

- Gender Identity
- Age
- Education
- Income
- Cider Consumption Frequency

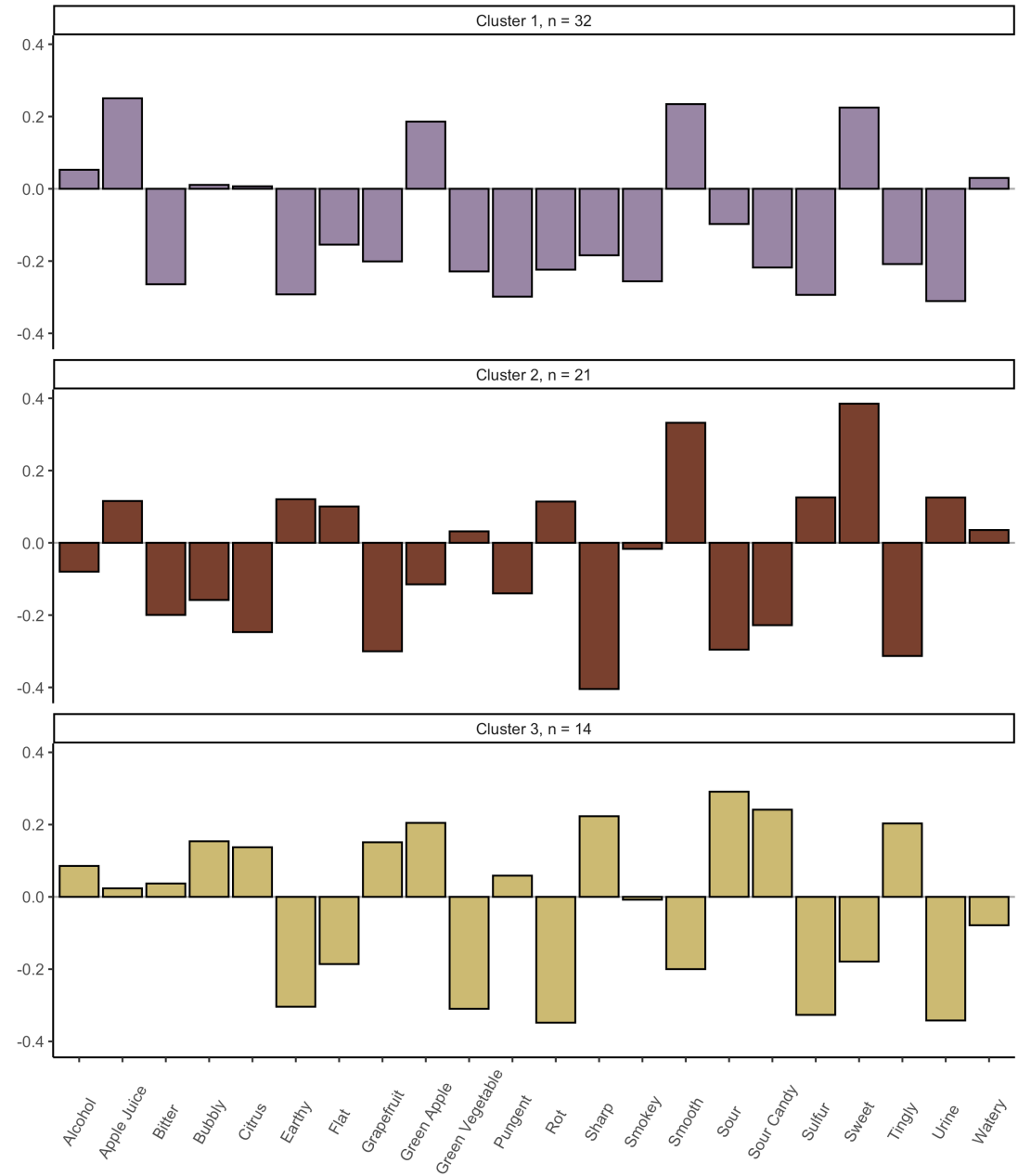
Sample Questions:

- Overall Liking
- Purchasing Intent
- Willingness to Pay

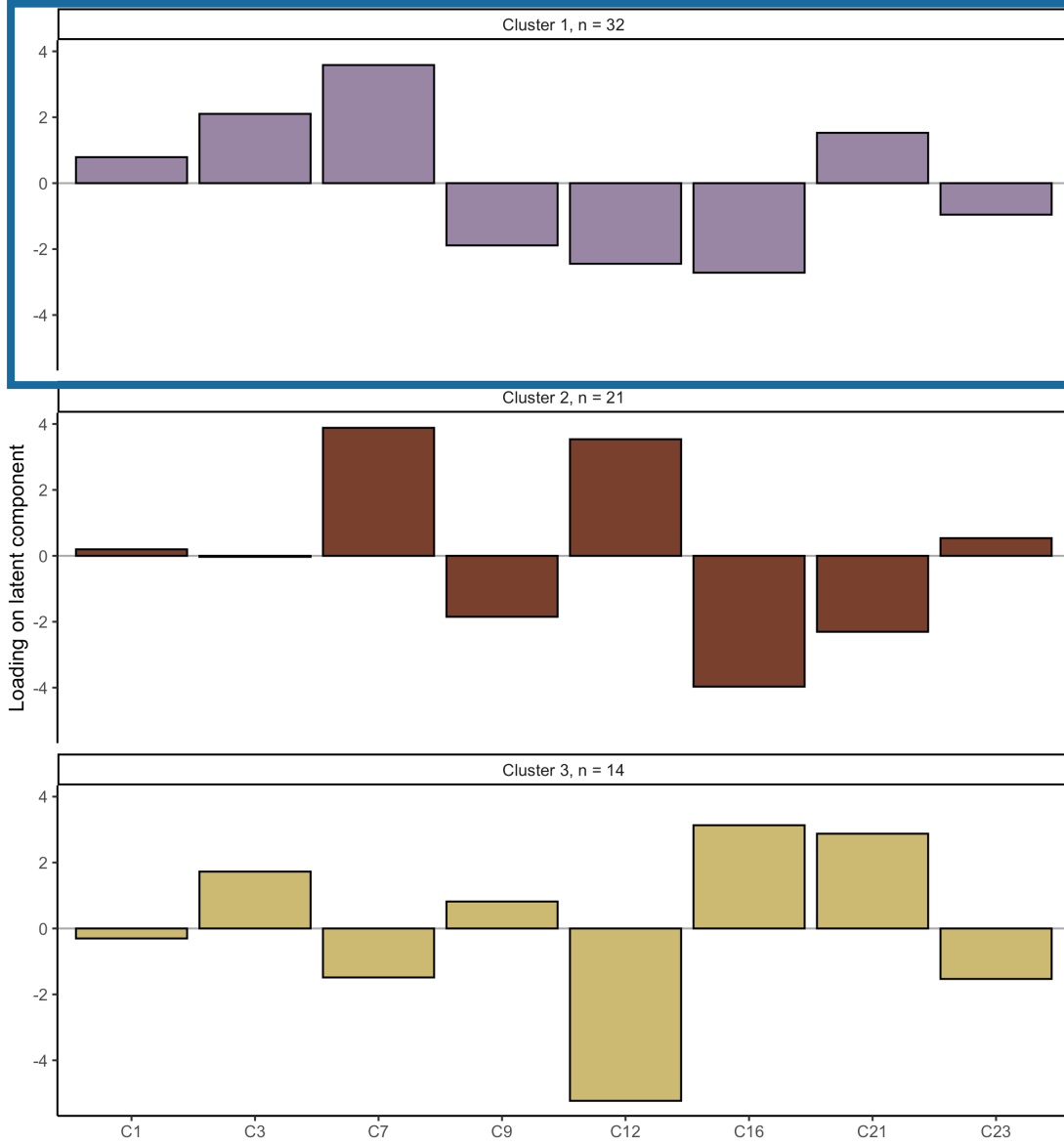
Loading of cider samples on latent variables describing consumer liking



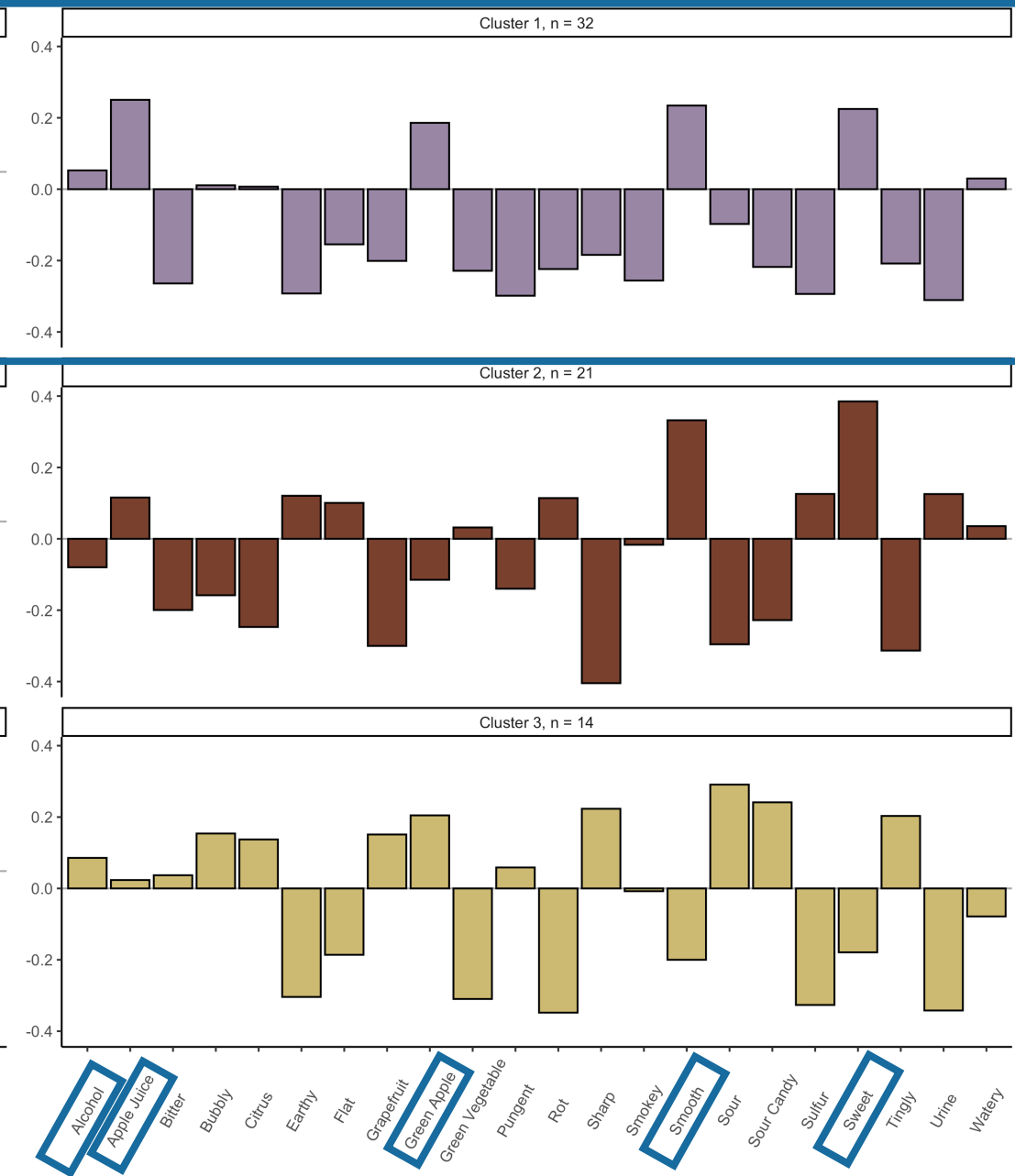
Loading of DA descriptors on latent variables describing consumer liking



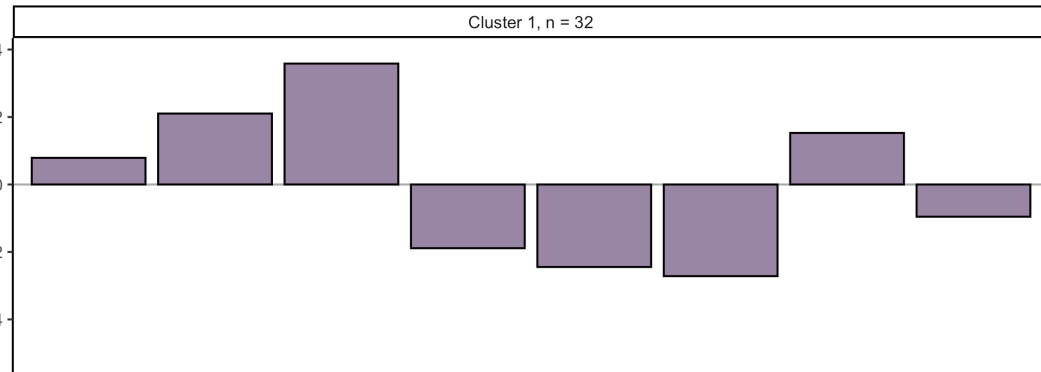
Loading of cider samples on latent variables describing consumer liking



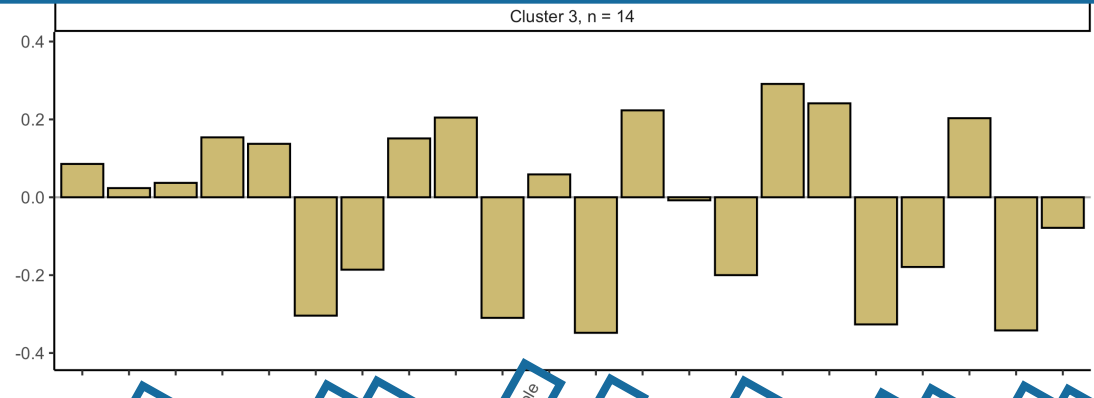
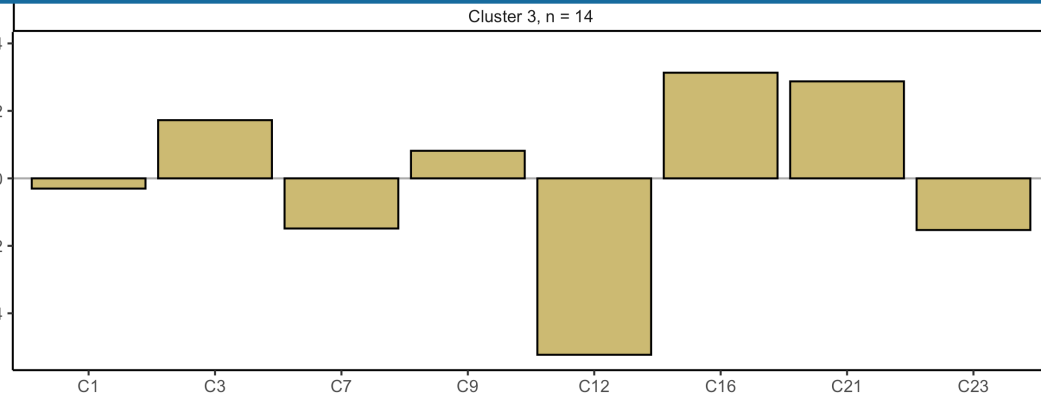
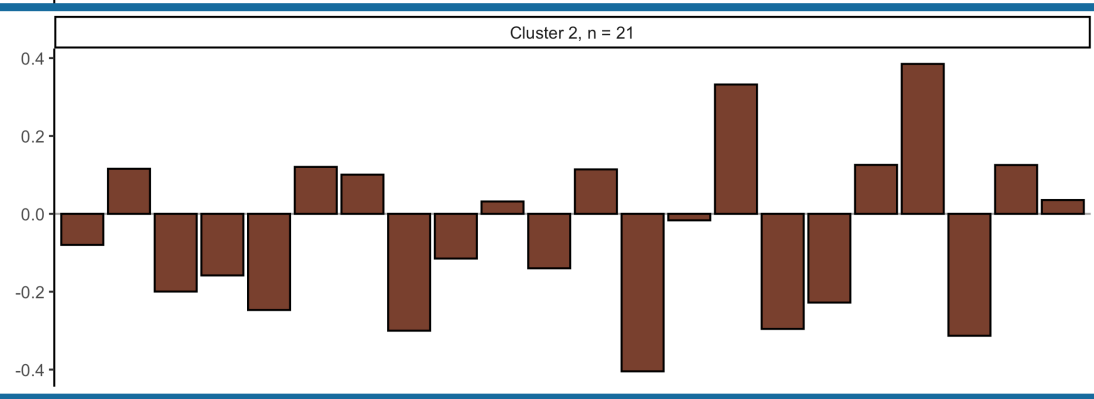
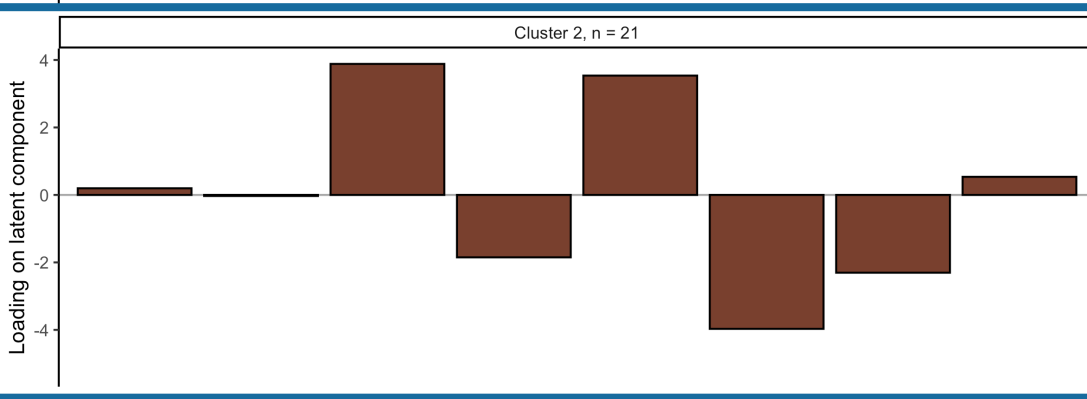
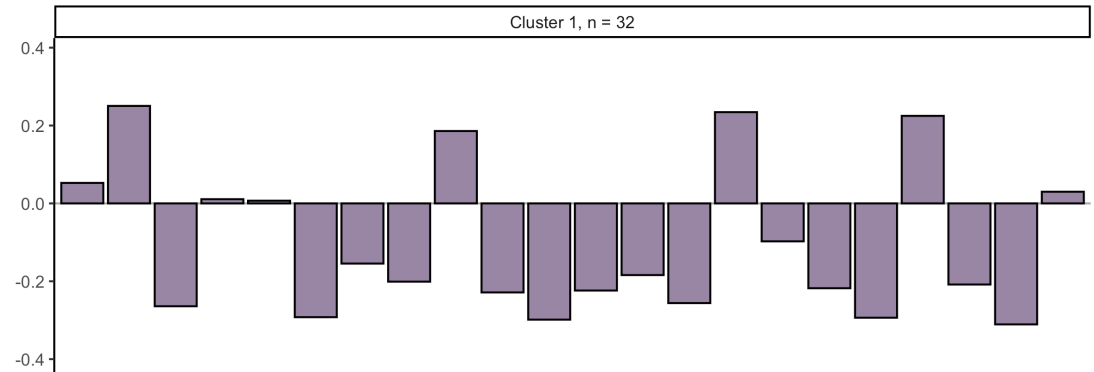
Loading of DA descriptors on latent variables describing consumer liking



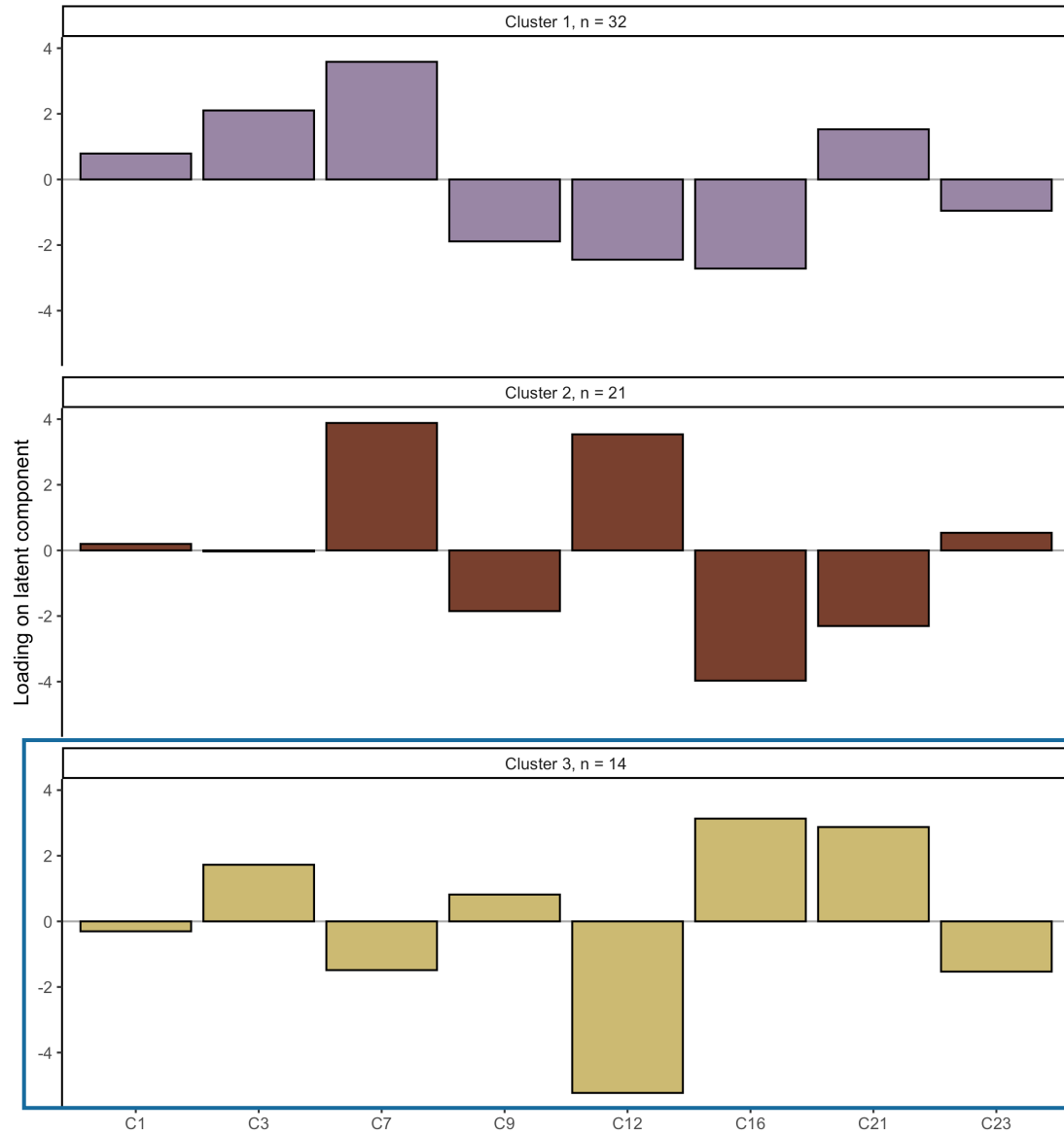
Loading of cider samples on latent variables describing consumer liking



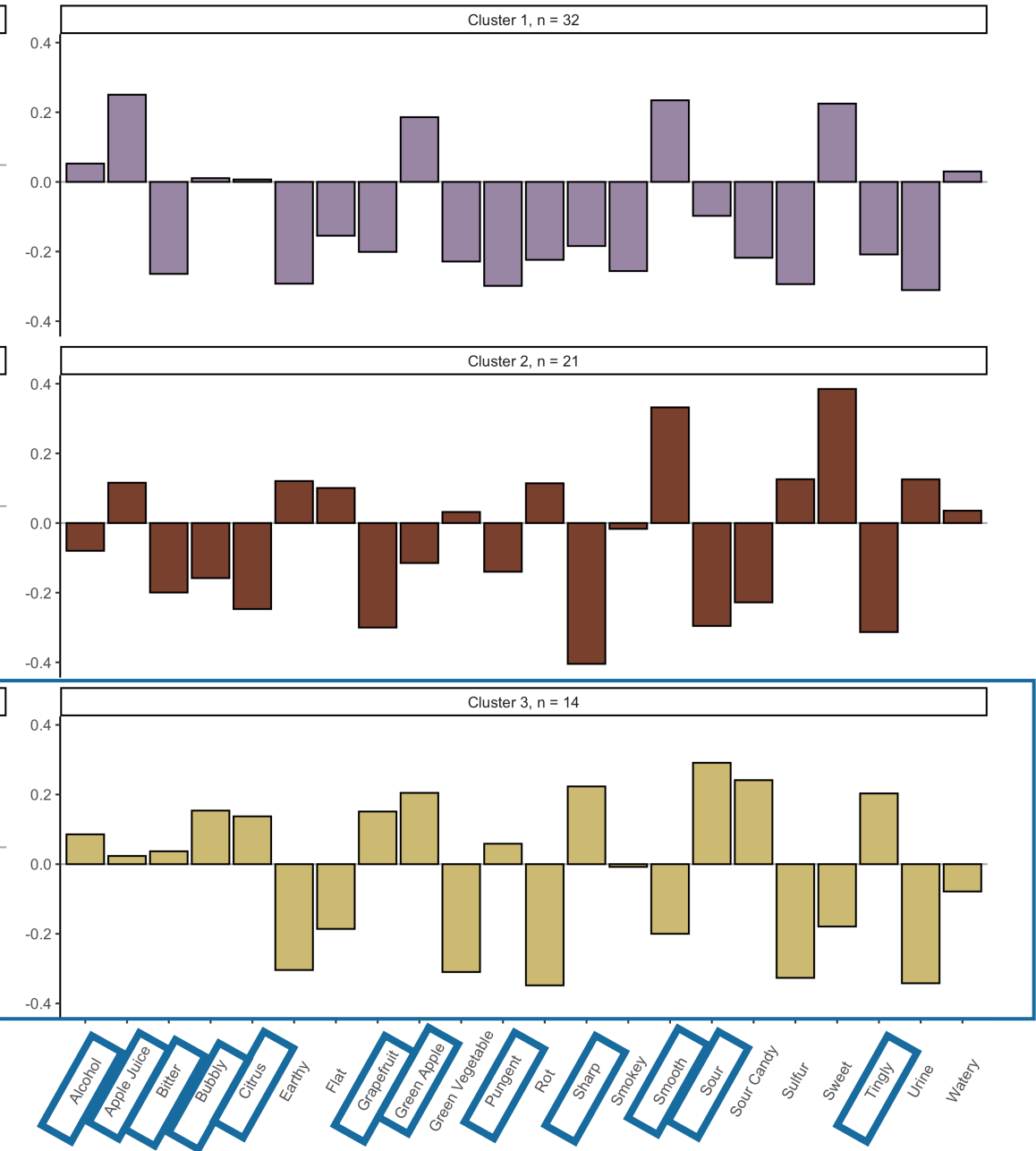
Loading of DA descriptors on latent variables describing consumer liking

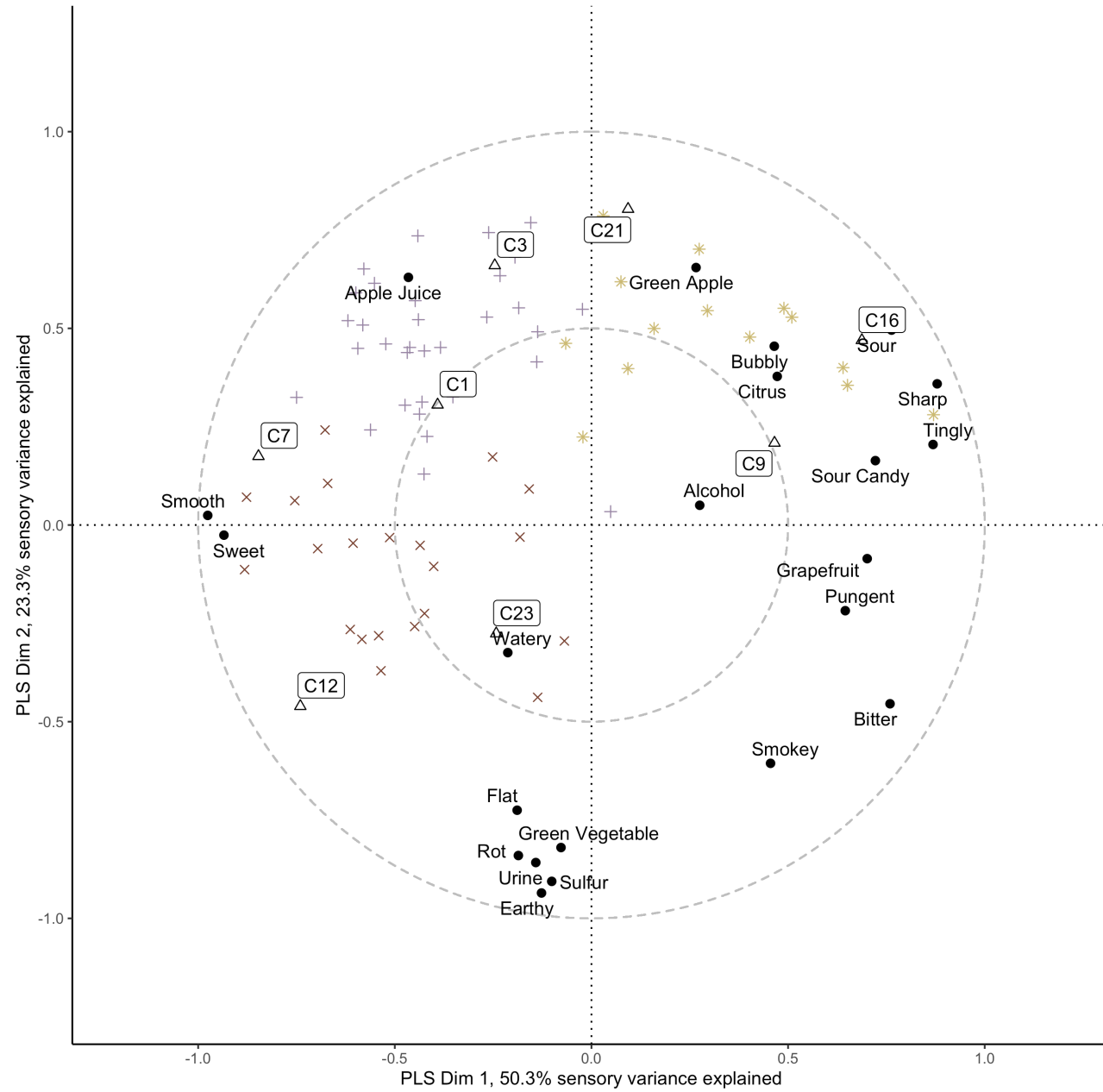


Loading of cider samples on latent variables describing consumer liking



Loading of DA descriptors on latent variables describing consumer liking





+ CLV cluster 1 × CLV cluster 2 * CLV cluster 3 ● descriptor △ product

Overall Liking

Cider	Cluster 1	Cluster 2	Cluster 3	Mean Overall Liking
C1	3.66 ± 2.22	3.95 ± 1.99	4.21 ± 1.85	3.87 ± 2.06
C12	2.78 ± 1.62	6.38 ± 1.77	2.64 ± 1.22	3.88 ± 2.32
C16	2.94 ± 1.90	4.19 ± 2.29	7.00 ± 0.96	4.18 ± 2.43
C21	6.12 ± 1.93	5.00 ± 1.05	6.21 ± 1.63	5.79 ± 1.85
C23	5.44 ± 1.83	5.62 ± 1.77	5.71 ± 1.73	5.55 ± 1.77
C3	5.47 ± 1.97	5.24 ± 2.51	6.21 ± 1.93	5.55 ± 2.14
C7	7.53 ± 1.24	7.14 ± 1.56	5.57 ± 2.17	7.00 ± 1.72
C9	4.41 ± 1.66	4.48 ± 1.94	5.29 ± 2.20	4.61 ± 1.87

Purchasing Intent

Cider	Cluster 1	Cluster 2	Cluster 3	Overall
C1	2.06 ±1.16	2.00 ± 0.89	1.93± 0.83	2.01±1.01
C12	1.59 ± 0.91	3.19 ± 0.93	1.36 ± 0.5	2.04 ±1.15
C16	1.59 ± 0.67	2.24 ± 1.37	3.57± 0.76	2.21±1.21
C21	3.19 ± 1.00	2.57 ± 1.16	3.14 ± 1.23	2.99 ±1.12
C23	3.03 ±0.97	2.81 ± 1.08	3.00 ± 1.11	2.96 ±1.02
C3	3.00 ±1.22	2.67± 1.15	3.21± 1.12	2.94 ±1.18
C7	4.00 ±1.05	3.86± 1.01	3.00± 1.3	3.75±1.15
C9	2.31 ± 0.82	2.14± 0.91	2.71± 1.2	2.34±0.95

Definitely will not buy

Probably will not buy

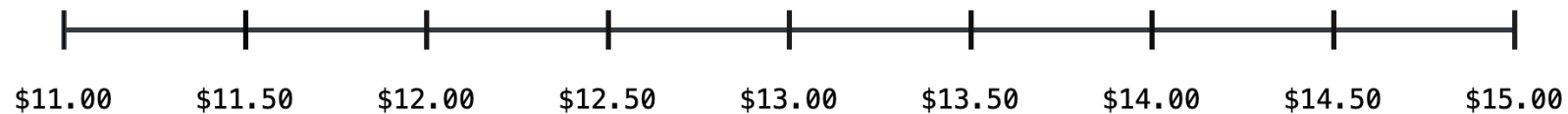
Might or might not buy

Probably will buy

Definitely will buy

Willingness to Pay

Cider	Cluster 1	Cluster 2	Cluster 3	Overall
C1	\$12.90 ± 1.33	\$12.30 ± 0.65	\$12.00 ± 0.67	\$12.50 ± 1.04
C12	\$11.80 ± 0.82	\$12.50 ± 1.01	N/A	\$12.30 ± 0.99
C16	\$11.60 ± 0.48	\$12.10 ± 0.67	\$12.30 ± 1.14	\$12.20 ± 0.95
C21	\$12.50 ± 0.96	\$12.80 ± 1.11	\$12.10 ± 0.92	\$12.50 ± 0.98
C23	\$12.60 ± 1.25	\$12.50 ± 0.85	\$12.20 ± 0.77	\$12.50 ± 1.06
C3	\$12.70 ± 1.26	\$12.80 ± 0.98	\$12.60 ± 1.29	\$12.70 ± 1.17
C7	\$12.80 ± 1.01	\$12.90 ± 1.26	\$12.30 ± 0.73	\$12.80 ± 1.07
C9	\$11.80 ± 0.72	\$12.20 ± 0.77	\$12.00 ± 0.45	\$12.00 ± 0.66





Study 3: Chemical Analysis

Chemical Analysis: Methods

pH → pH Ion Probe¹

Titrateable Acidity (TA) → Titration Method¹

CO₂ → Anton Paar²

Volatile Acidity (VA) → Cash Still Distillation & Titration Method^{1,3}

Alcohol → Anton Paar²

Total Residual Sugar (TRS) → Megaenzyme Glucose/Fructose Kit⁴

Malic Acid → Megaenzyme⁴

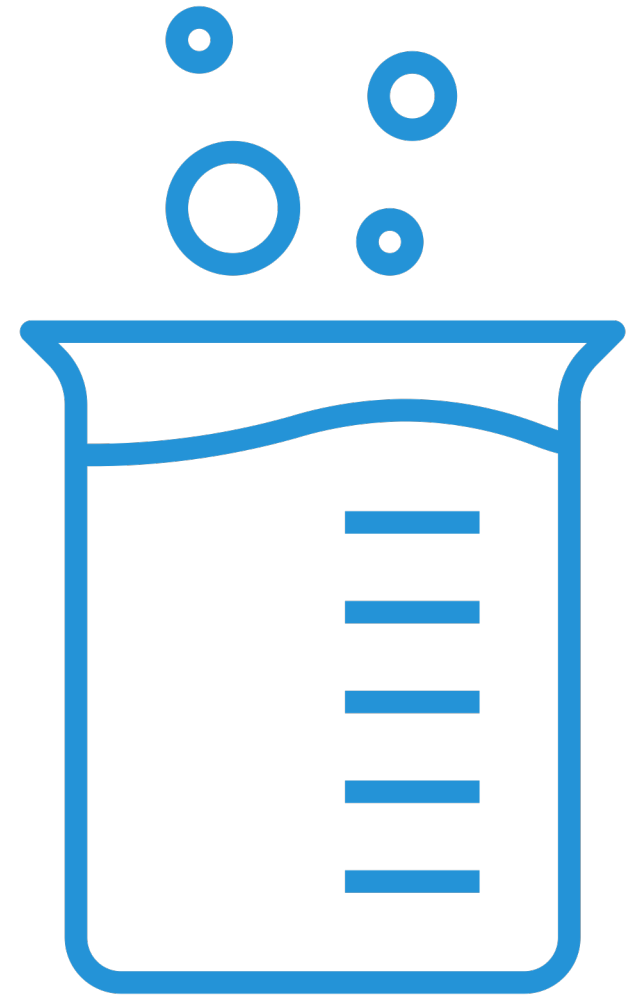
Total Polyphenols → Folin-Ciocalteu⁵

Total SO₂ → Aeration Oxidation³

Free SO₂ → Aeration Oxidation³

Results: Chemical Analysis

- C7, C8, C24 – RS
 - Highest mean sweetness intensity ratings
- C15 & C16 – VA
 - Associated with pungent, sharp, and sour attributes
- C11 and C9 – CO₂
 - Described using the sour and sour candy attributes²
- C5 – TA
 - Sour and sharp attributes¹



Conclusions

1

Virginia ciders have a distinct sensory profile and fall into six distinct groups

2

Three distinct clusters were identified with distinct product and sensory preferences

3

No unusual cider chemistry but the expected connections between chemical composition and the sensory profiles were made.

Acknowledgements

Dr. Jacob Lahne, Dr. Amanda C. Stewart, and Dr. Beth Chang

The Lahne Lab Group

ASBC

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DA Panel & Consumer study panelists

All Undergrads in the SEL

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Resources

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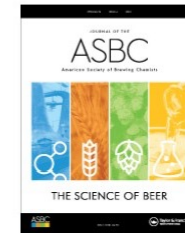
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Fishbones References
Troubleshooting in the Brewery





Appendices slides:

Conclusions

1

Virginia ciders have a distinct sensory profile and fall into six distinct groups

2

Three distinct clusters were identified with distinct product and sensory preferences

3

No unusual cider chemistry but the expected connections between chemical composition and the sensory profiles were made.

Cider	Packaging Format	Blend or Single Varietal	Apple Types	Location
C1	750mL Bottle	Blend	Albemarle Pippin, Gold Rush, Pink Lady, Virginia Gold, undesignated	North Garden
C2	750mL Bottle	Single	Virginia Hewes Crab	North Garden
C3	750mL Bottle	Blend	N/A	Monterey
C4	750mL Bottle	Single	Virginia Hewes Crab	Monterey
C5	750mL Bottle	Single	Virginia Hewes Crab	Richmond
C6	750mL Bottle	Single	Harrison	Richmond
C7	12 oz Bottle	Blend	N/A	Nellysford
C8	12 oz Bottle	Blend	N/A	Nellysford
C9	16 oz Can	N/A	N/A	Roseland
C10	12 oz Can	Blend	N/A	Richmond
C11	750 oz Bottle	Blend	Albemarle Pippin, Gold Rush	Keswick
C12	16 oz Can	Blend	Granny Smith, undesignated	Mineral

Cider	Package	Blend or Single Varietal	Apple Type	Location
C13	12 oz Can	Blend	N/A	Alexandria
C14	750 mL Bottle	Blend	N/A	Middleburg
C15	500 mL Bottle	Blend	N/A	Middleburg
C16	750 mL Bottle	Blend	Harrison, Ashmead's Kernel, Winesap, Golden Russet, Arkansas Black, Black Twig, Albemarle Pippin, Virginia Hewes Crab	Warm Springs
C17	750 mL Bottle	Single	Virginia Hewes Crab	Warm Springs
C18	750 mL Bottle	N/A	N/A	Abingdon
C19	750 mL Bottle	Blend	N/A	Abingdon
C20	12 oz Can	Blend	N/A	Leesburg
C21	16 oz Can	Blend	N/A	Winchester
C22	500 mL Bottle	Blend	N/A	Winchester
C23	750 mL Bottle	Blend	Gold Rush, Albemarle Pippin, Winesap	Charlottesville
C24	16 oz Can	Blend	Golden Delicious, Red Delicious and Granny Smith	Roseland

Demographic Parameter	Category	Group 1 (%)	Group 2 (%)	Group 3 (%)	Overall (%)
Gender	Male	28.1	47.6	35.7	35.8
	Female	68.8	52.4	57.1	61.2
	Non-Binary	3.12	0	7.14	2.99
	Prefer to Self-Describe	0	0	0	0
Age	21-30	78.1	71.4	64.3	73.1
	31-40	6.25	4.76	21.4	8.96
	41-50	0	0	0	0
	51-60	9.38	14.3	14.3	11.9
	60+	6.25	9.25	0	5.97
	Education	Some High School	0	0	0
	High School Graduate	0	0	7.14	1.49
	Some College	15.6	0	0	7.46
	Associate Degree	3.12	4.76	0	2.99
	Bachelor's Degree	56.2	42.9	57.1	52.2
	Master's Degree	18.8	42.9	21.4	26.9
	Doctorate	6.25	9.52	14.3	8.96
Cider Consumption Frequency	Everyday	0	0	0	0
	A Few Times a Week	6.25	4.76	0	4.48
	Once a Week	15.6	4.76	0	8.96
	Once or Twice a Month	18.8	38.1	64.3	34.3
	Occasionally	59.4	52.4	35.7	52.2
	Income	Less than \$25,000	40.6	42.9	28.6
	\$25,000 - \$49,000	25	19.0	14.3	20.9
	\$50,000 - \$75,000	9.38	9.52	35.7	14.9
	\$76,000 - \$99,999	3.12	0	7.14	2.99
	\$100,000 - 150,000	6.25	4.76	0	4.48
	Greater than \$150,000	9.38	9.52	14.3	10.4
	Prefer not to answer	6.25	14.3	0	7.46

Results: Chemical Analysis

- Malic Acid, Alcohol, Titratable Acidity
 - **higher** readings compared to previous studies ^{1,2}
- pH, Total Polyphenols, Volatile Acidity
 - **consistent** readings compared to previous studies^{1,2,3,4,5}
- Total Residual Sugars
 - **lower** readings compared to previous studies ^{1,2}