Final Report

October 31, 2023

Project Title: *Sensory Directed Research on Artisanal Cheese to Benefit the Local, Regional, and National Dairy Industry*

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Summary:

Surface-ripened cheeses, including bloomy and washed rind cheeses, are a rapidly growing sector of the United States specialty cheese market due to their distinctive flavor qualities. These value-added dairy products provide unique opportunities to support the local rural economies of small American dairy farmers. The goal of this project was to implement a range of sensory and innovative consumer testing methods to define the aroma and flavor characteristics of artisan cheese to optimize sales and consumption in the future, and to identify variables which positively and negatively influence the sensory quality of artisan cheese. Two groups of University of Vermont (UVM) trained sensory panels received focused Descriptive Sensory Analysis (DSA) training on cheese aroma and flavor at the beginning of this program. In addition, we developed a strategic plan, protocols, and methods to collect specific data to correlate with objective DSA results on cheese samples produced at these sites to understand which variables, such as microbial profile, have positive or negative effects on artisan cheese aroma and flavor. In addition, a sensory training program for collaborating cheesemakers was initiated in the fall of 2021 and continued in 2022. Also in 2022, we conducted a monthly cheese evaluation program using our DSA panel, conducted a pilot test in March to prepare for study's full test in August 2022, and completed the full test in August 2022. In addition, we conducted special consumer research training at Jasper Hill Farm (JHF) in the Product Attribute Elicitation Method (PEM). We also conducted the Sensory Directed Chemical Analysis (SCDA) program for artisan cheese at Tufts University with the help of UVM Sensory. Finally, we completed the sampling of cheese from both JHF and Spring Brook Farm (SBF) for the August test, executed the various analytical tests, and analyzed the data. In the fourth quarter of 2022, we completed the monthly sampling and analysis program of cheese samples from JSF, and the bi-monthly sampling and analysis program of cheese samples from SBF. This report summarizes and provides final details for all aspects of this study.

Project Goals:

1. Our first goal was to use innovative sensory and consumer testing methods to understand short- and long-term changes in consumer behavior during the COVID-19 pandemic. Specifically, our focus was on understanding consumer purchasing and consumption of dairy products including artisan cheeses.

2. Our second goal was to use the trained sensory analysis panel at the University of Vermont Extension (UVM Extension) to objectively benchmark the aroma and flavor of artisan cheeses currently available to consumers and to translate their expressed needs for aroma and flavor into actionable product targets.
3. Our third goal was to collect critical data at the participating farms and creameries to correlate with consumer and sensory results to better understand the factors that drive higher quality, as defined by the end user, to significantly increase consumer purchases and consumption. These data included factors at the farm level such as dairy cow diet, on-farm sensory characteristics, and milk handling procedures, as well as factors at the cheesemaking level including microbial community identity and diversity.
4. Our fourth goal was to successfully transfer all learnings in this study to participating farmers and artisan cheesemakers to inform key decisions on future production to help sustain market success and viability.

Final Project Report:

We have completed the four key task areas outlined to meet the goals of this project. These key task areas were:

- Task 1: Objective Descriptive Sensory Analysis (DSA - The Human Instrument)
- Task 2: Consumer/End User Insights
- Task 3: The Core Research Experiment
- Task 4: Education and Outreach

Task 1: Objective Descriptive Sensory Analysis (DSA - The Human Instrument)

Arthur D. Little, Inc. (ADL) developed the Flavor Profile Method (FPM) of Sensory Analysis in the early 1940's. It was the first objective descriptive sensory analysis method in the world to measure both the qualitative and quantitative properties of food products. In 1978, ADL modified FPM to create a more efficient sensory method called Profile Attribute Analysis (PAA). PAA allows for more samples to be evaluated by a trained panel, with more robust analysis of data. These sensory methods are described in more detail in Appendix III.

Two groups of panelists were trained in FPM and PAA using a standard approach developed by ADL. The primary instructor was Roy Desrochers, the Sensory Practice Leader in the UVM Extension Northwest Crops and Soils Program (NWCSP), who spent the first 20 years of his career at ADL and has over 40 years of experience training DSA panelists for food and beverage companies around the world. In addition, Mr. Desrochers conducted numerous sensory orientation sessions to prepare the trained panel at UVM Extension to evaluate both milk and cheese samples. All sensory training was completed prior to sampling beginning in 2022.

In January 2022, we began collecting and evaluating milk and cheese samples from JHF as part of a monthly testing effort. The overall objective of the monthly testing task was to generate data on a small set of artisan cheese and production milk samples on a monthly basis to better understand variations in artisan cheese sensory quality from batch-to-batch, month-to-month, and season-to-season. We completed this effort at the end of 2022 as follows:

Alpha Tolman, Bayley Hazen Blue, and Harbison cheese samples were collected from JHF the last week of each month, beginning in January 2022 until the first week of December 2022. JHF also submitted samples of the milk that was used to produce these cheeses every month from January to July of 2022. In addition, we assessed two cheese samples, Reading and Ashbrook, from SBF beginning in March of 2022. These samples were submitted for DSA every other month through December 2022. All monthly samples were assessed by the DSA panel using a milk specific PAA scoresheet for JHF milk samples (Appendix I), and a cheese specific PAA scoresheet for both the JHF and SBF cheese samples (Appendix II).

The DSA panel evaluated each monthly milk and cheese sample twice. These samples were coded to allow for blind analysis and presented to the DSA panel in random order. Individual PAA scores for each sensory attribute listed on the PAA milk and cheese response ballots were averaged for each panel and submitted for analysis.

The preliminary data analysis indicated differences in cheese sensory quality across sampling months. This finding was generated using Principle Components Analysis (PCA) of the cheese data, which yielded three primary dimensions that described differences in the sensory quality of the samples: richness, cleanness, and cheese type (Table 1).

Table 1: Principle Components Analysis Results

Sensory Attribute	Abbreviation	PCA1	PCA2	PCA3
Total Intensity of Aroma	TIA	0.07	-0.14	0.08
Balance	BAL	-0.10	0.18	-0.10
Fullness	FULL	0.20	0.09	0.03
Total Intensity of Flavor	TIF	0.11	-0.09	0.04
Fatty Acid Sour - Butyric	FASBU	-0.24	0.01	0.41
Fatty Acid Sour - Sweaty	FASSW	0.32	-0.05	-0.60
Savory	SAV	0.29	0.14	0.20
Sulfidy/Vegetable	SUL	0.42	0.11	0.34
Ammonia	NH4	0.17	-0.26	0.14
Barny	BAR	0.19	-0.24	0.04
Musty/earthy	MUS	0.26	0.08	-0.31
Oxidized/Mature	OXID	0.03	0.02	-0.25
Green	GRN	0.45	0.16	0.26
Sweet	SW	-0.11	-0.02	0.06

Sour	SO	-0.06	-0.23	0.03
Salty	SA	0.17	-0.05	-0.06
Umami	UM	0.35	0.07	0.05
Mouthfeel	MF	0.00	-0.22	0.17
Others	OT	0.11	-0.75	0.00
Aftertaste	AT	0.02	-0.26	0.00

The three PCA's (sensory dimensions) are used to visualize sensory differences by calculating a sensory index score using the weighting factors generated by the PCA for each attribute and the average DSA panel value for that corresponding sensory attribute. We simplify this illustration of data results by adding descriptive labels, and defined endpoints, for each index (Figure 1).

Figure 1: PCA Identified Sensory Summary Indices

	Lower scores are:	Higher scores are:
PCA 1 "Richness"	Less Green Less Sulfidy Less Umami Less Isovaleric Less Musty More Butyric Thinner	More Green More Sulfidy More Umami More Isovaleric More Musty Less Butyric Richer

	Lower scores are:	Higher scores are:
PCA 2 "Cleanness"	More Others More Aftertaste More Ammonia More Barny More Sour More Mouthfeel	Less Others Less Aftertaste Less Ammonia Less Barny Less Sour Less Mouthfeel

	Lower scores are:	Higher scores are:
PCA 3 "Cheese Type"	More Isovaleric Less Butyric Less Sulfidy More Musty Less Savory	Less Isovaleric More Butyric More Sulfidy Less Musty More Savory

These indices are consistent with PCA results on much larger sets of data generated in previous studies that typically indicate a "*Cleanness*" or "*Quality*" sensory dimension and a "*Richness*" or "*Identity*" sensory dimension. ADL developed a "*Quality*" Index to be used in this situation using PCA weighting factors from these larger studies, provided it correlates with a PCA sensory dimension generated by the smaller study. In this case, it correlates with the "*Cleanness*" sensory dimension. The details for the cheese "*Quality*" Index can be found in Figure 2, Table 2, and Figure 3.

Figure 2: Flavor Leadership Criteria – "*Quality*" Index

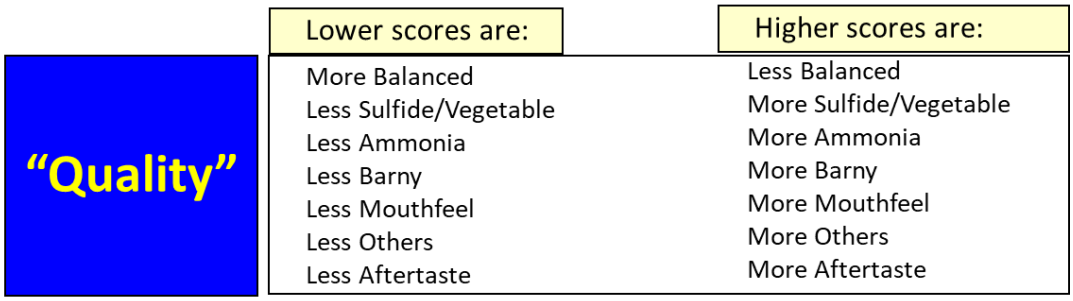
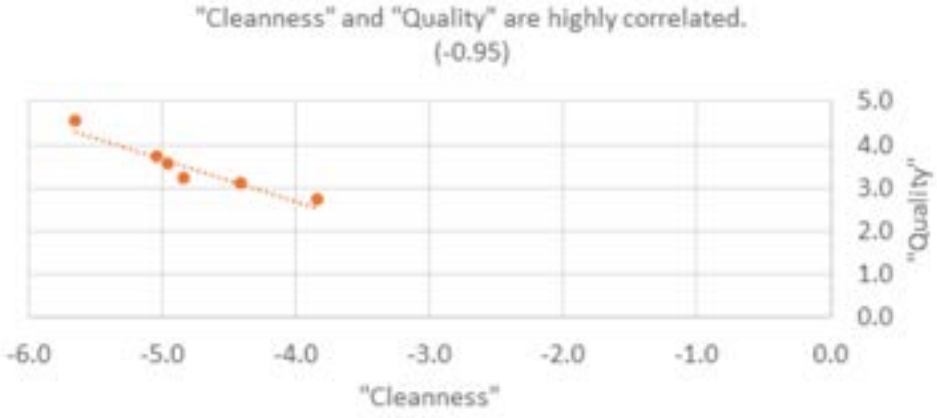


Table 2. Flavor Leadership Criteria - "*Quality*" Index PCA Weighting Factors

Sensory Attribute	Weighting
Balance	-0.35
Sulfide/vegetable	0.20
Ammonia	0.20
Barny	0.20
Mouthfeel	0.30
Others	0.30
Aftertaste	0.30

Figure 3. "*Cleanness*" Index vs. "*Quality*" Index

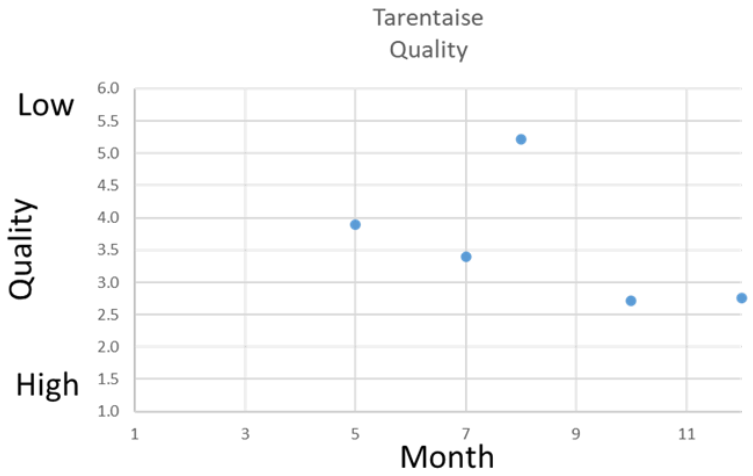


The cheese types that were tested monthly in this study can be compared using the sensory "*Quality*" Index (Appendix IV). It is important to note that a 0.5-unit difference on a summary index score such as "*Quality*" has been shown to be meaningful through numerous global sensory and consumer research studies. A difference of this size indicates that the average consumer would not only notice but may alter their

consumption behavior as a result. The monthly cheese test results are summarized as follows:

- The Reading, Ashbrook, and Alpha Tolman cheeses had consistent sensory quality over the testing period
- The Tarentaise and Harbison cheeses were less consistent in sensory quality from month to month
- Tarentaise had the most variation in sensory quality among the cheese types, especially in August 2022 during the core test period (Figure 4).

Figure 4: Quality Ratings for Monthly Tarentaise Evaluations



Detecting and defining these monthly variations will allow us an opportunity to correlate with other data generated in this study to understand drivers of sensory quality.

Task 2: Consumer/End User Insights

A critical piece of this study was the generation of primary consumer research data to correlate against all variables that were being tested. The overall objective for consumer insights was to:

- Explore which sensory characteristics of artisan cheese have the greatest impact on consumer acceptance and in which direction.
- Generate consumer sensory attribute level data to correlate to other data generated in this study including objective descriptive sensory analysis data, microbiology, fatty acid analysis data, chemistry, and cheese making process variables.
- Generate information on how artisan cheese consumers describe cheese sensory experiences and preferences for use in future marketing messaging.

The consumer tests in this study were not designed to explore flavor segments within the cheese market, but rather the overall consumer acceptance criteria. It was also not our intention to develop complete consumer response data on the brands included in this

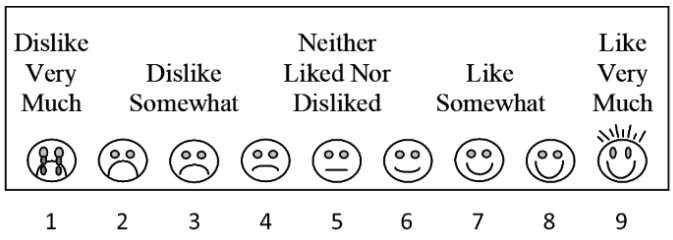
study. The cheese samples were selected for the range of sensory characteristics they represented to allow us to identify possible drivers of aroma and flavor.

We conducted multiple consumer research tests:

- UVM Field Day in Alburgh, Vermont (October 2021) – Hedonic - Overall Liking
- Innovative Test (PEM - May 2022) in Alburgh and Rutland, Vermont
- Burlington, Vermont (June 2023) Hedonic - Overall Liking

The first consumer test we conducted was at the UVM Extension NWCSP field day in October 2021. This was a traditional hedonic test using a standard nine-point degrees of liking ballot (Figure 5).

Figure 5: Hedonic Nine-Point Degrees of Liking Scale



Fifty-five participants representing a range of sex, age, and artisan cheese usage provided data. Each participant rated a set of six cheese samples that included:

- Alpha Tolman
- Whitney
- Harbison
- Tarentaise
- Ashbrook
- Reading

The samples were coded and assessed blind. For each sample, participants were asked to provide a rating using the nine-point liking scale and to provide descriptive words supporting their rating (Figure 5). The average scores indicated a range in overall liking (OL) ratings (Table 3). Alpha Tolman was liked the most with an average overall liking value of 7.0, and Harbison was liked the least with an average overall liking score of 5.3, which is just above neutral (Table 3).

Table 3: Average Consumer Overall Liking Ratings – Field Day

Producer	Cheese	OL
JHF	Alpha Tolman	7.0
SBF	Tarentaise	6.5
SBF	Ashbrook	6.3

SBF	Reading	6.0
JHF	Whitney	5.8
JHF	Harbison	5.3

This range in average consumer overall liking is critical to the success of the overall study. We established that the cheese samples varied in sensory quality and need a big enough range in consumer overall liking to have confidence in the correlations between these overall liking scores, and the DSA measurements on the same cheese types. These correlations will give insight into what sensory attributes drive cheese user satisfaction.

The graphs in Appendix V show the distribution of overall liking scores for each cheese tested. Some of the cheeses were more consistently liked, such as Alpha Tolman, while some were more polarizing, such as Harbison (Figures 6 and 7).

Figure 6: Consumer Overall Liking Distribution for Alpha Tolman

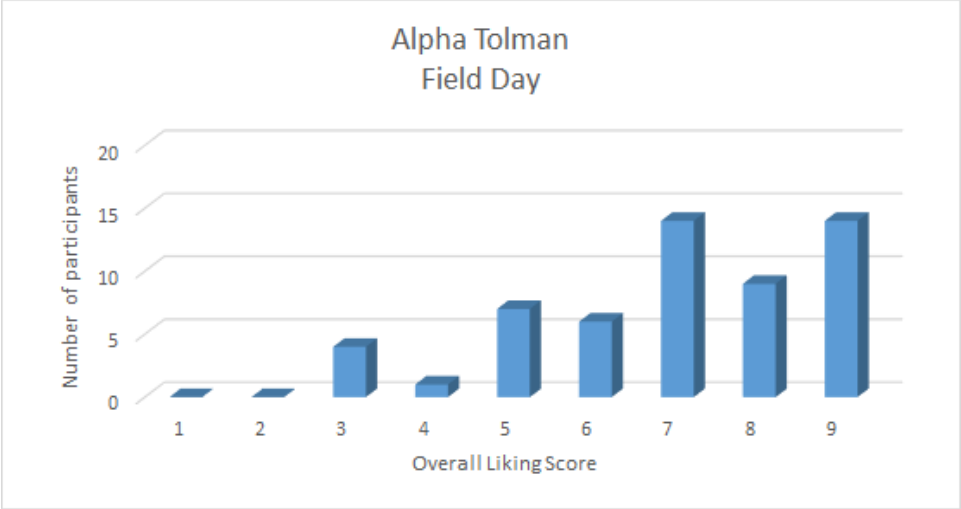
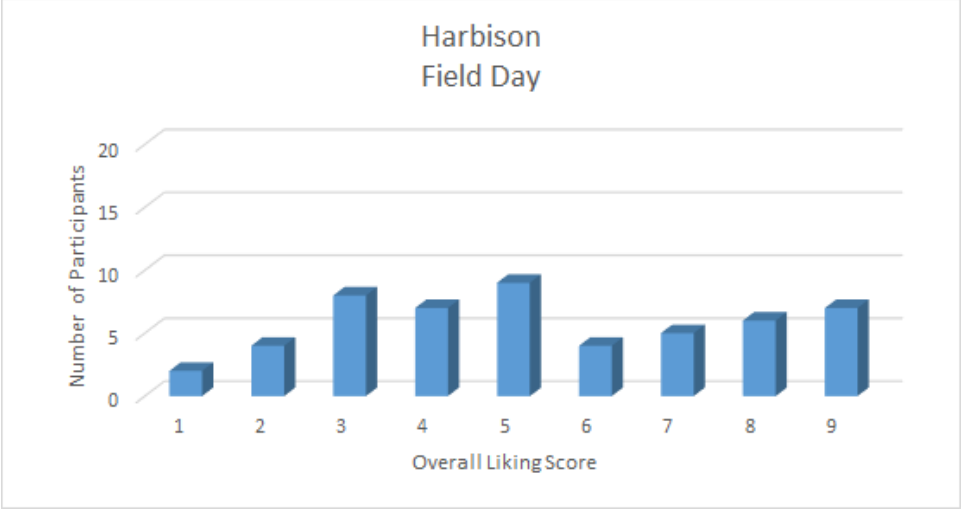


Figure 7: Consumer Overall Liking Distribution for Harbison



A range in the distribution of overall liking scores within a test group is indicative of possible flavor segmentation and additional work is needed to understand the size and nature of the cheese flavor segments. Flavor segments are smaller groups of consumers within a larger segment, such as artisan cheese, that like similar sensory attributes. For example, one group of cheeses users within the artisan cheese segment might like the sensory properties of Harbison, others may not.

We conducted a second hedonic test in Burlington, VT in June of 2023 using the same approach as described above. Fifty-five participants representing a range of sex, age, and artisan cheese usage provided data. Each participant rated a set of five cheese samples that included:

- Alpha Tolman
- Baley Hazen Blue
- Harbison
- Tarentaise
- Ashbrook

Following the first hedonic test, Baley Hazen Blue was added to expand the range of key cheese sensory attributes. The samples were coded and assessed blind. For each sample participants were asked to provide a rating using the nine-point liking scale and to provide descriptive words supporting their rating. Table 4 shows the average overall liking scores for the group.

Table 4: Average Consumer Overall Liking – Burlington 2023

Producer	Cheese	OL
JHF	Alpha Tolman	7.3
SBF	Tarentaise	7.1
JHF	Bayley Hazen Blue	6.9
SBF	Ashbrook	6.7
JHF	Harbison	5.3

Consistent with the first hedonic test at Field Day 2021, Alpha Tolman was liked the most with an average overall liking value of 7.3, and Harbison was liked the least with an average overall liking score of 5.3, which is just above neutral (Table 4).

Again, some of the cheeses were more consistently liked, such as Alpha Tolman, while some were more polarizing, such as Harbison and Baley Hazen Blue, indicating possible flavor segmentation (Figures 8, 9, and10).

Figure 8: Consumer Overall Liking Distribution for Alpha Tolman

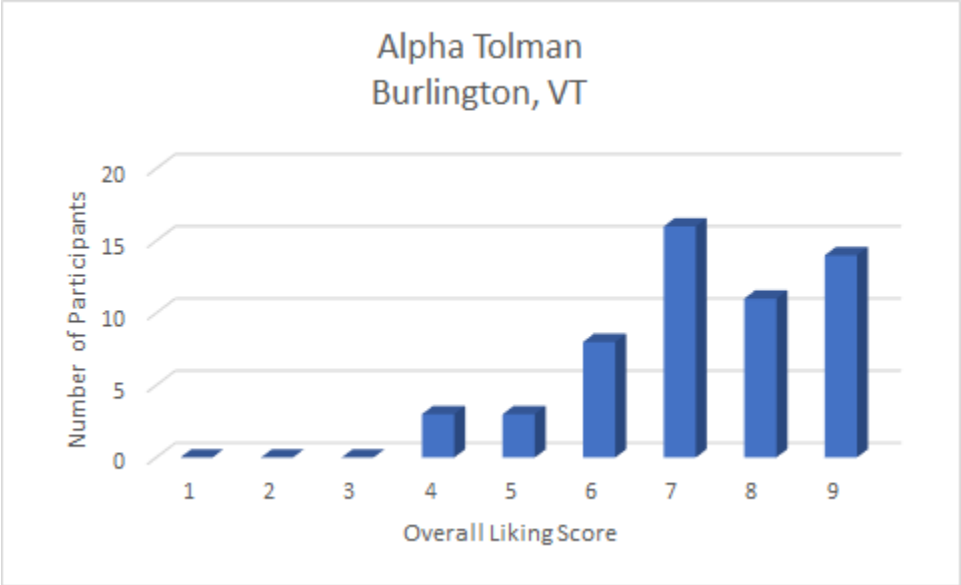


Figure 9: Consumer Overall Liking Distribution for Harbison

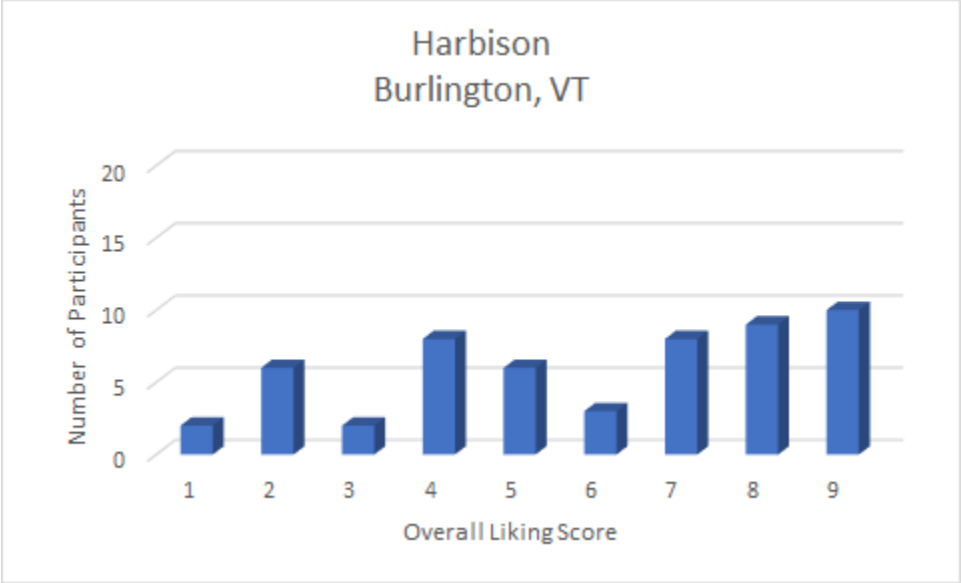
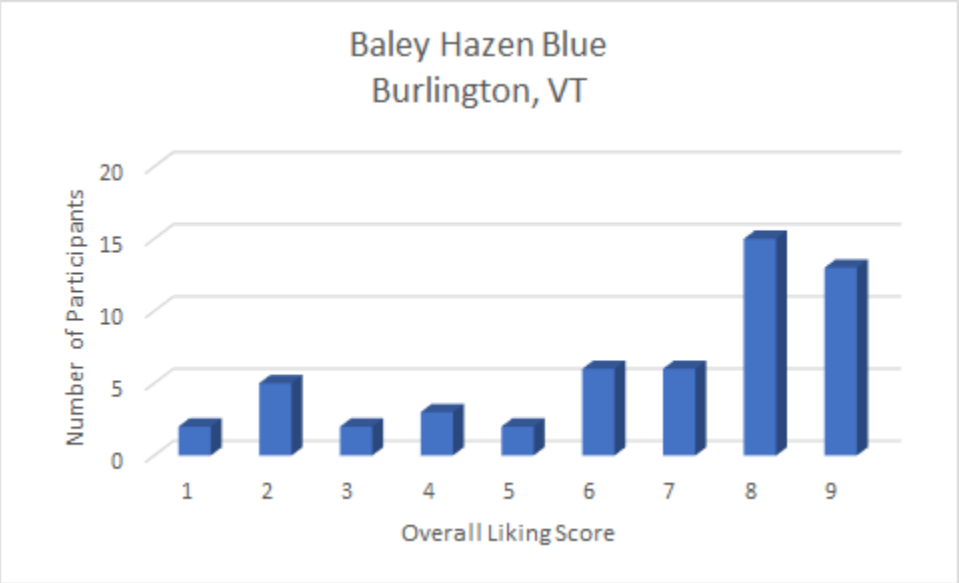


Figure 10: Consumer Overall Liking Distribution for Baley Hazen Blue



Although these overall liking scores are important on their own, the real value is in correlating them against objective data to understand which variables may be driving these differences in the overall cheese flavor quality. We will discuss this further in the core experiment section of this report.

Consumers are very consistent at telling us what they like, and dislike, but struggle to tell us why. To overcome this, ADL developed an innovative consumer testing approach called the Product Attribute Elicitation Method (PEM). We used PEM in May of 2022 to better understand consumer needs for artisan cheese.

The test was conducted as follows:

- Two groups of cheese consumers; (40 total)
  - 25 indicated they sometimes eat artisan cheese (Group A)
  - 15 indicated they mostly eat artisan cheese (Group B)
- Two sites:
  - Alburgh, VT
  - Rutland, VT
- Six total samples:
  - 4 study samples (Reading, Ashbrook, Whitney, and Harbison)
  - 2 additional samples (Cabot 3-year sharp cheddar, Parmesan)

We added the two additional cheese samples to further expand the range of cheese flavor attributes within the complete set.

The steps in the PEM process included:

1. Participants completed a brief questionnaire about their typical cheese consumption

2. Participants assessed each cheese sample, blind and in random order using the standard nine-point degrees of liking ballot described previously, rating each sample and recording descriptive words to support their rating.
3. All descriptive words were compiled into a library of consumer terms.
4. Each consumer group collaboratively categorized their descriptive terms in relation to sensory attributes.
5. Each group named the categories using their own terminology and developed a scale to measure each category.
6. The categories and scales were utilized to develop a consumer PAA scoresheet.
7. Participants used the PAA sheet they developed to objectively assess a second set of cheese samples.
8. Participants then voted on the consumer sensory attributes that they felt most influenced their liking.

The average overall liking scores (OL) for the combined group tested using PEM spanned a much bigger range than the traditional hedonic tests, 4.4 to 7.3 compared to 5.3 to 7.3 (Table 5). This indicates a more diverse group of participants, and the possible need to subsegment the group.

Table 5: Average Consumer Overall Liking PEM Test

Producer	Cheese	OL
Cabot	Cheddar	7.3
SBF	Ashbrook	7.0
SBF	Reading	6.3
Cabot	Parmesan	6.1
JHF	Harbison	4.4
JHF	Whitney	4.4

Breaking out the group by stated cheese type consumption indicated segmentation in the overall cheese category, with consumers who said they mostly consumed artisan cheese scoring the artisan cheese samples, such as Harbison, higher on overall liking than those who stated they only sometimes consumed artisan cheese (Table 6).

Table 6: Average Consumer Overall Liking PEM Test- Segments

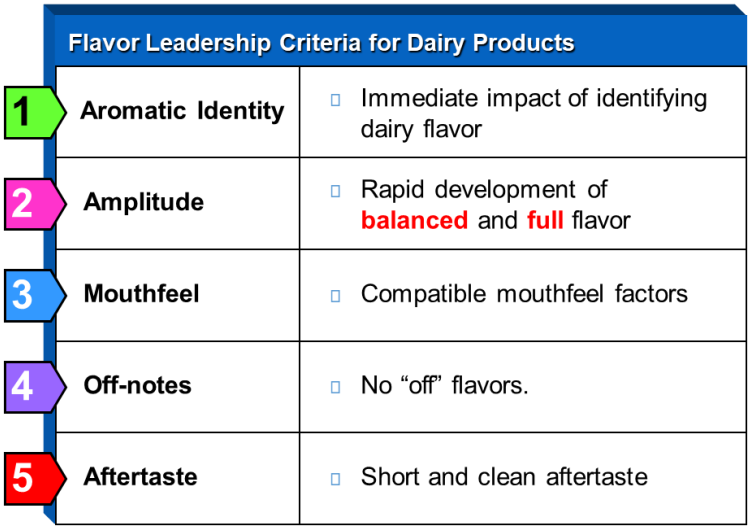
Producer	Cheese	Consumer Segment*	Overall Liking Score
SBF	Ashbrook	A	7.4
		B	6.3
		All	7.0
Cabot	Cheddar	A	7.6
		B	6.8
		All	7.3

JHF	Harbison	A	4.0
		B	5.2
		All	4.4
Cabot	Parmesan	A	6.4
		B	5.5
		All	6.1
SBF	Reading	A	6.0
		B	6.7
		All	6.3
JHF	Whitney	A	3.9
		B	5.2
		All	4.4

*"A" consumers are those who sometimes eat artisan cheese, "B" consumers mostly eat artisan cheese.

We can now begin to correlate consumer overall liking data with objective DSA data to begin to understand which variable impact cheese flavor quality. We begin with the Flavor Leadership Criteria (FLC) Attributes. The FLC are a set of five sensory categories identified by ADL that define market leadership (Figure 11).

Figure 11: Flavor Leadership Criteria Attributes



The correlation graphs for consumer overall liking and the FLC attributes can be found in Appendix VI. The correlations indicate:

- Consumer overall liking increases as balance of flavor increases.
- Consumer overall liking decreases as mouthfeel increases.
- Consumer overall liking decreases as off-notes increase.
- Consumer overall liking decreases as aftertaste increases.

These are all previously known effects that were identified, and confirmed, by ADL in numerous studies involving the FLC. The fact that these criteria held true in this test gives us great confidence in the calculated cheese "*Quality*" Index, which is based on these FLC. We can now use the cheese "*Quality*" Index to correlate against other objective data.

In addition to generating consumer response data (overall liking) that we can correlate against other factors, the participants in the PEM study provided additional insights into how they describe cheese sensory experiences.

First, they provided us with a library of terms that they use to describe the sensory attributes that they like, or dislike, about artisan cheese (Appendix VII).

The nine sensory attributes identified as most influential to consumers were, in their terms:

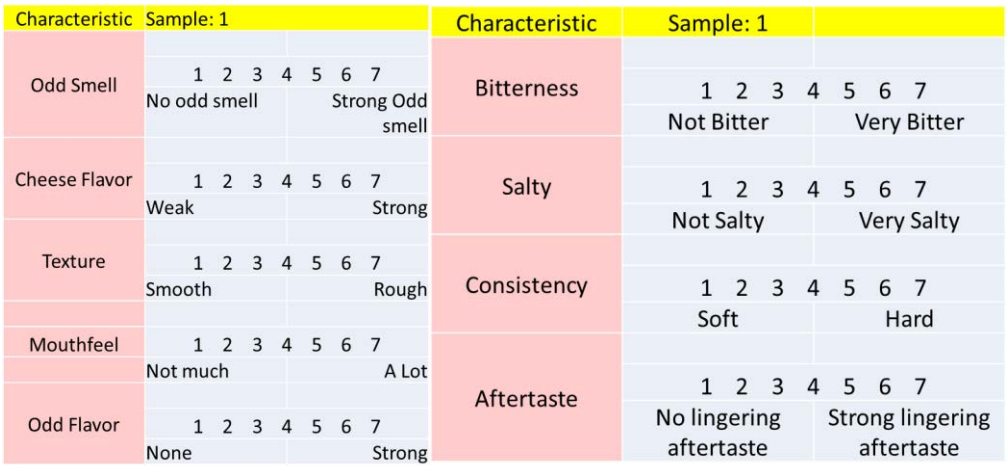
1. Odd Smell
2. Cheese Flavor Intensity
3. Texture
4. Mouthfeel
5. Odd Flavor
6. Bitterness
7. Salty
8. Consistency
9. Aftertaste

They used a multi-vote process to rank the importance of these attributes, and the result from most important to least was:

1. Cheese Flavor Intensity
2. Texture
3. Consistency
4. Odd Smell
5. Salty
6. Odd Flavor
7. Aftertaste
8. Mouthfeel and Bitterness

The participants then worked together to develop a consumer PAA sheet containing these important cheese sensory attributes (Figure 12).

Figure 12: Artisan Cheese Consumer PAA Profile Attribute Analysis Data Collection Sheet



Characteristic	Sample: 1
Odd Smell	1 2 3 4 5 6 7 No odd smell — Strong Odd smell
Cheese Flavor	1 2 3 4 5 6 7 Weak — Strong
Texture	1 2 3 4 5 6 7 Smooth — Rough
Mouthfeel	1 2 3 4 5 6 7 Not much — A Lot
Odd Flavor	1 2 3 4 5 6 7 None — Strong

Characteristic	Sample: 1
Bitterness	1 2 3 4 5 6 7 Not Bitter — Very Bitter
Salty	1 2 3 4 5 6 7 Not Salty — Very Salty
Consistency	1 2 3 4 5 6 7 Soft — Hard
Aftertaste	1 2 3 4 5 6 7 No lingering aftertaste — Strong lingering aftertaste

The participants used this PAA sheet to rate a second set of cheese samples. In addition, they scored the cheese they consume most often from memory and predicted how their "*Ideal*" cheese would score using the same ballot.

The participants indicated objective differences between the four cheeses assessed using their PAA ballot (Figure 12, Table 7).

Table 7: Artisan Cheese Profile Attribute Analysis Consumer Data

Producer, Cheese	Odd Aroma	Cheese Flavor	Texture	Mouth feel	Odd Flavor	Bitter	Salty	Consistency	After taste
SBF, Ashbrook	4.1	3.6	1.8	3.4	2.6	2.8	3.4	1.6	3.9
JHF, Harbison	6.3	4.7	1.1	4.9	5.9	4.8	4.7	1.1	5.9
SBF, Reading	2.6	4.0	1.5	3.4	3.1	2.7	3.3	1.8	3.7
JFH, Whitney	4.4	4.3	1.8	3.7	4.4	2.9	2.6	2.1	4.8

Orange cells indicate high values, green indicate low values.

We correlated the consumer overall liking average scores against the objective consumer PAA measurements to gain further insights (Appendix VIII). The results indicate that:

- The consumer measurement of cheese flavor intensity does correlate with their overall liking scores (CORREL -0.92), and as their measurement of cheese flavor intensity goes up, their liking goes down.
- Overall Liking also goes down with their measurements of odd flavor (CORREL -0.89), aftertaste (CORREL -0.83), and mouthfeel (CORREL -0.70)

- It is not a surprise that some DSA measurements, such as salty, do not have linear correlations to consumer overall liking. The data indicates a slight intensity of salt flavor is preferred, more than that, or less than that, are not liked as much.

We also compared their scores for the cheese they consume most often from memory, to what they consider would be the ideal cheese for them (Table 8).

Table 8: Artisan Cheese Consumer PAA Attribute Average Score for Most Consumed Product and Predicted "Ideal"

	Odd Aroma	Cheese Flavor	Texture	Mouth feel	Odd Flavor	Bitter	Salty	Consistency	After taste
Most Consumed	2.6	5.5	3.4	4.3	2.5	2.5	3.7	4.3	4.1
"Ideal"	2.1	5.1	4.3	3.8	1.6	2.2	3.8	4.3	3.1

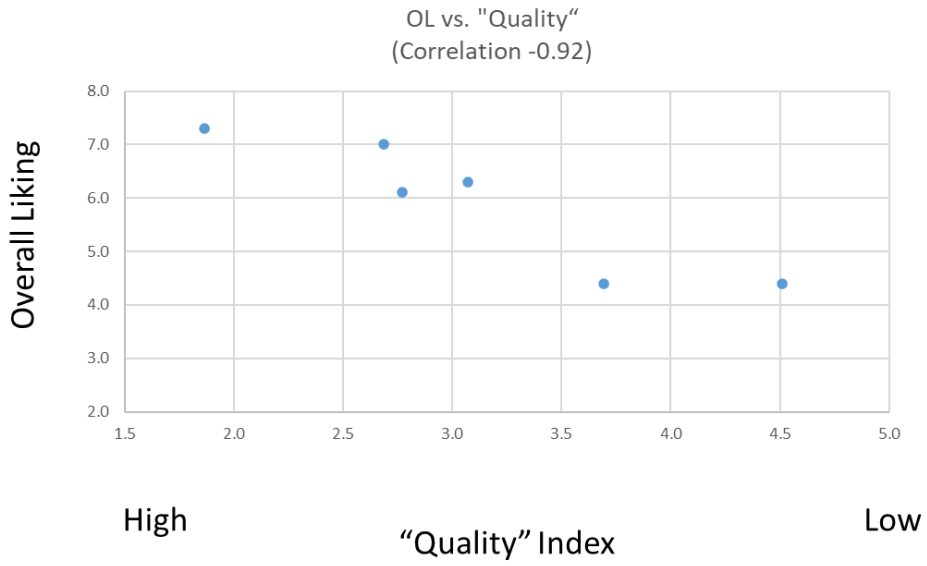
This data indicates that artisan cheese users want (in their terms):

- Less odd aroma
- More texture
- Less mouthfeel
- Less odd flavor
- Less aftertaste

This information is useful in developing brand images and marketing messages. However, we know that consumers do not always know how to describe what they want in terms that we can have confidence in understanding. We can gain more confidence in knowing what they want by correlating consumer overall liking scores against objective DSA data on the same cheese types.

For example, consumer overall liking scores correlate with the DSA panel's "*Quality*" Index (Figure 13).

Figure 13: Artisan Cheese "*Quality*" Index vs. Consumer Overall Liking



As cheese sensory quality goes down, consumer overall liking of the cheese goes down. We also see correlations with the FLC, such as with balance and others (Figures 14 and 15).

Figure 14: "*Quality*" Index vs. DSA Balance of Flavor

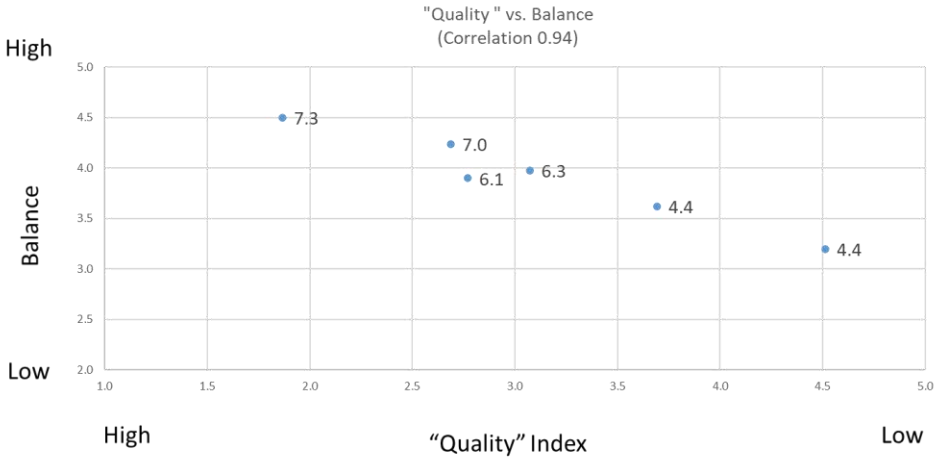
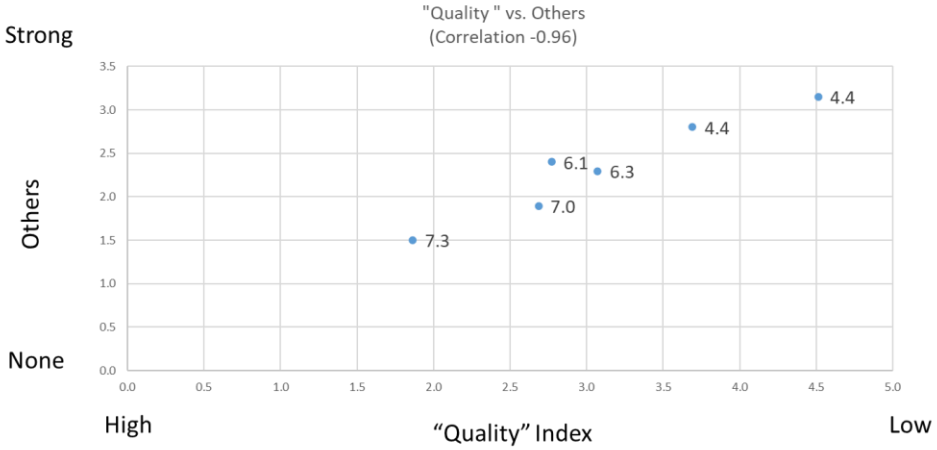


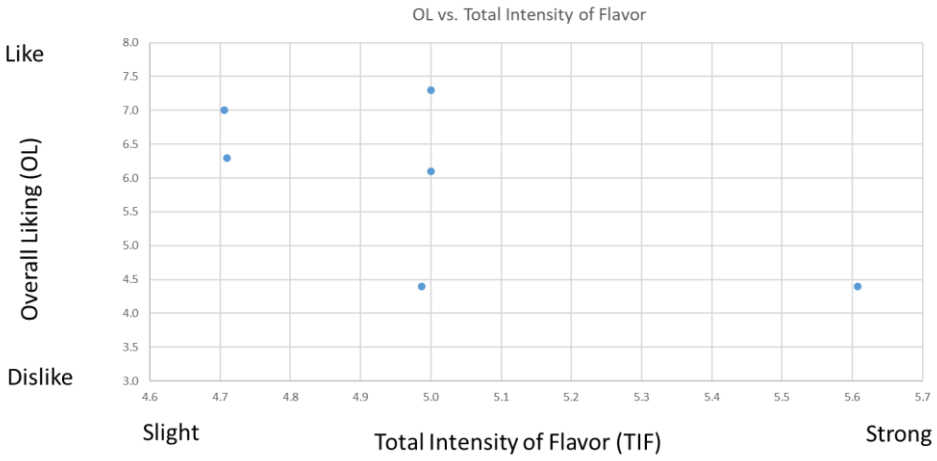
Figure 15: "*Quality*" Index vs. DSA Others Attribute



As the balance of flavor goes down, consumer overall liking of the artisan cheese goes down. As others and off-notes go up, consumer overall liking goes down.

Other DSA sensory attribute data suggest that the relationships with overall liking are not linear, but rather quadratic. For example, the DSA measure for Total Intensity of Flavor (TIF) is quadratic, with consumers wanting a moderate level of flavor. Their overall liking goes down with less than moderate TIF, as well as more than moderate TIF (Figure 16).

Figure 16: Consumer Overall Liking vs. DSA Total Intensity of Flavor



Task 3: *The Core Research Experiment*

The core research experiment task was completed in August 2022. An overview of the components of this experiment will be briefly described here and then, each more in depth.

The cheeses in this study included:

- Harbison
- Whitney
- Alpha Tolman
- Reading
- Ashbrook
- Tarentaise
    - Prior to this test, our team worked with the participating cheesemakers to adjust production schedules of Whitney, Harbison, Reading, and Ashbrook lots to ensure samples of high sensory quality would be ready for the August 8 test when the Alpha Tolman and Tarentaise samples, already in production due to longer maturation timing, would be ready.

On August 8, 2022, three wheels (six for Harbison due to size) of each cheese were collected from the cheesemakers. Each of the three wheels were partitioned into approximate ¼ pound sections. Sample sets which represented each of the individual wheels of each type of cheese were distributed to project partners and the following analyses conducted:

- DSA by the UVM Extension trained panel using the artisan cheese specific PAA scoresheet (UVM)
- Fatty Acid Analysis (UVM)
- Sensory Directed Chemical Analysis (SDCA-Tufts)
- Microbiology (Tufts)
- Hedonic/Overall Liking and PEM sessions (Conducted on the same cheese types)

In addition, the team at Tufts University analyzed the samples via their Sensory Directed Chemical Analysis (SDCA) Method using a GC/MS/ODP.

All analyses were completed on the same set of cheese samples to allow results between analyses to be correlated.

Descriptive Sensory Analysis (DSA):

The cheese samples collected on August 8, 2022, were assessed by the UVM Extension trained DSA panel. Three replicates of samples were presented blind and in a random order. Samples were assessed using the cheese PAA ballot described previously (Appendix II).

The DSA panel data indicated meaningful sensory attribute differences between the samples (Table 9). Meaningful differences are ones that equal, or exceed, 0.5 units on an attribute panel average score, and are big enough differences to not only be detected by an average cheese user, but to cause them to react by liking, or not liking, the cheese more.

Table 9: DSA Average Scores Per Attribute

Cheese	Aroma	Balance	Fullness	Flavor	Butyric	Isovaleric	Savory	Sulfidy	Ammonia	Barny
ALT	4.3	4.0	4.8	4.9	4.0	3.6	3.2	2.8	1.9	2.3
ASH	3.9	4.2	4.2	4.6	3.9	2.9	2.7	2.6	1.7	1.9
HAR	4.6	3.5	4.8	5.2	3.3	3.5	3.3	4.5	2.4	2.8
REA	4.0	4.0	4.2	4.7	4.2	2.7	2.5	2.7	1.9	2.1
TAR	4.8	2.8	4.4	5.1	3.6	3.4	3.0	3.3	3.1	2.6
WHI	4.1	3.9	4.4	4.9	3.6	3.5	3.1	3.2	1.8	2.2
Cheese	**Musty**	**Oxidized**	**Green**	**Sweet**	**Sour**	**Salty**	**Umami**	**Mouthfeel**	**Others**	**Aftertaste**
ALT	2.3	3.0	1.9	2.7	3.8	4.5	3.1	4.3	2.8	4.3
ASH	2.6	2.2	1.8	3.0	3.9	3.9	2.3	4.4	2.8	4.0
HAR	3.0	2.2	3.2	2.4	3.7	5.0	3.4	4.3	3.6	4.2
REA	2.0	2.4	2.1	2.8	3.9	4.3	2.4	4.3	3.3	4.1
TAR	2.6	2.7	2.2	2.6	4.2	4.4	2.9	4.7	4.8	4.7
WHI	2.9	2.6	1.8	2.6	3.8	4.5	2.3	4.2	2.8	4.1

Cheese abbreviations as follows: Alpha Tolman – ALT, Ashbrook – ASH, Harbison – HAR, Reading – REA, Tarentaise – TAR, Whitney – WHI.

It is important to note that these differences included differences on FLC sensory attributes, which are a big part of the "*Quality*" Index we developed in this study (Table 10).

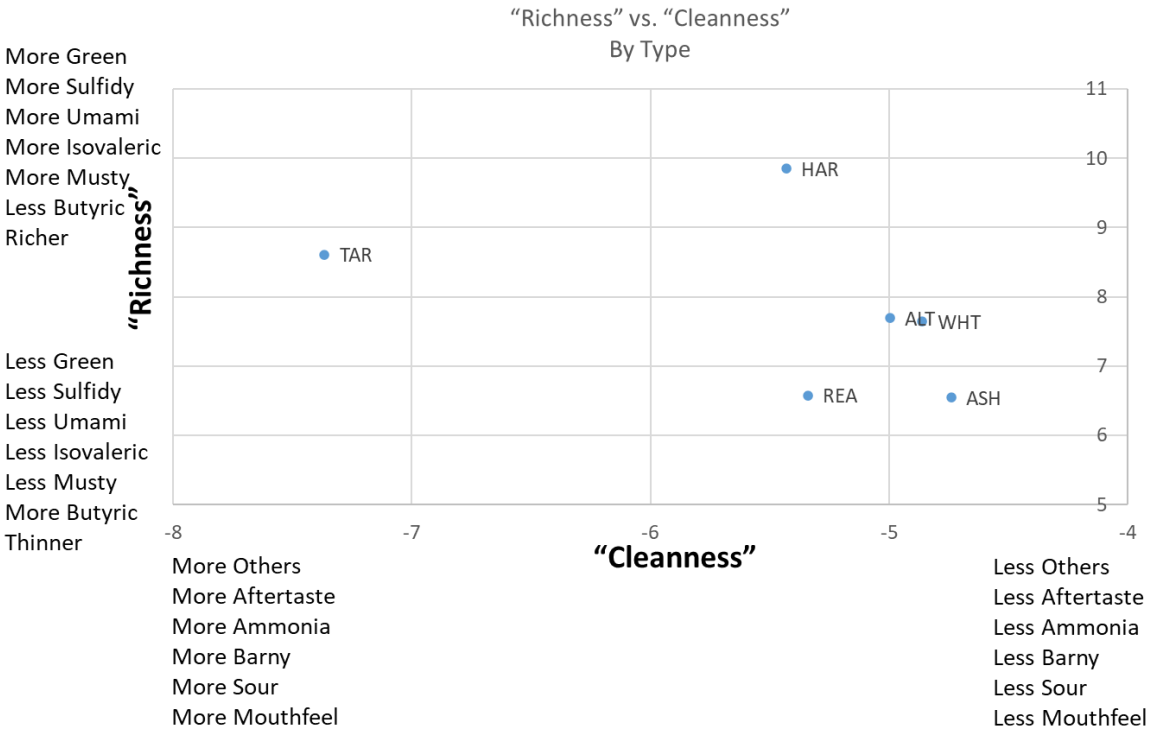
Table 10: DSA Average Scores for FLC Attributes

Cheese	Balance	Fullness	Butyric	Isovaleric	Ammonia	Barny	Mouthfeel	Others	Aftertaste
ALT	4.0	4.8	4.0	3.6	1.9	2.3	4.3	2.8	4.3
ASH	4.2	4.2	3.9	2.9	1.7	1.9	4.4	2.8	4.0
HAR	3.5	4.8	3.3	3.5	2.4	2.8	4.3	3.6	4.2
REA	4.0	4.2	4.2	2.7	1.9	2.1	4.3	3.3	4.1
TAR*	2.8	4.4	3.6	3.4	3.1	2.6	4.7	4.8	4.7
WHI	3.9	4.4	3.6	3.5	1.8	2.2	4.2	2.8	4.1

Cheese abbreviations as follows: Alpha Tolman – ALT, Ashbrook – ASH, Harbison – HAR, Reading – REA, Tarentaise – TAR, Whitney – WHI. Note: The Tarentaise result was very different than the average results on the monthly testing. We are not sure why and elected to use the more consistent monthly results for correlations with other objective variables.

We also applied the PCA results described earlier (Figure 4) to illustrate the variation in cheese flavor in Figure 17.

Figure 17: "*Richness*" vs. "*Cleanness*"

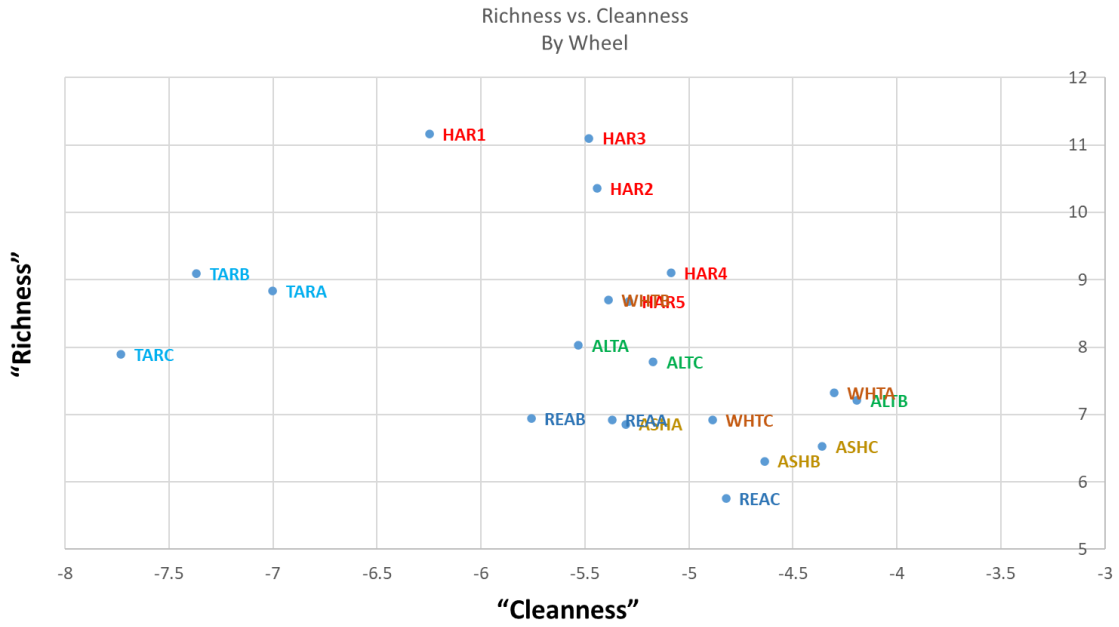


Cheese abbreviations as follows: Alpha Tolman – ALT, Ashbrook – ASH, Harbison – HAR, Reading – REA, Tarentaise – TAR, Whitney – WHI.

This graph shows that the artisan cheese types were clustered by the DSA panel into groups with Tarentaise having a unique flavor position that is lower on "*Cleanness*," Harbison having a unique flavor position that is "*Richer*" in flavor, Alpha Tolman and Whitney close on "*Cleanness*" and "*Richness,"* and last, Reading and Ashbrook close on "*Richness*" and "*Cleanness*" (Figure 17). This clustering was confirmed by a cluster analysis on the average DSA scores for the multiple replications of samples.

We saw some variation on these summary indices between the three wheels of each cheese type, and six for Harbison (Figure 18).

Figure 18: "*Richness*" vs. "*Cleanness*" by Wheel



Cheese abbreviations as follows: Alpha Tolman – ALT, Ashbrook – ASH, Harbison – HAR, Reading – REA, Tarentaise – TAR, Whitney – WHI.

Overall, we detected meaningful differences on aroma and flavor attributes, as well as the summary indices, between the lots/wheels of cheese within each type.

- Harbison had the biggest difference in "*Richness*" of flavor between wheels of all the cheeses tested. Ashbrook had the least.
- All three wheels of Tarentaise had lower "*Cleanness*" of flavor than the rest of the cheeses.
- All the cheese types had meaningful differences in "*Cleanness*" of flavor between lots collected.

These differences highlight the opportunity for cheesemakers to vary their process, submit additional samples to DSA panel to understand the affect and adjust for variations in the final product leading to more consistent high quality artisan cheese flavor.

Fatty Acid Analysis:

Portions of all the cheeses samples were analyzed by Dr. Jana Kraft, Department of Animal and Veterinary Sciences, and her team at the University of Vermont. The main goal was to determine the fatty acid composition (percent) and content (g/serving) of the artisan cheese samples collected in August 2022 (Figures 19 and 20).

Figure 19: Jasper Hill Farm Artisan Cheese Samples

JASPER HILL FARM

Whitney

Style: Alpine
Milk type: Raw Holstein milk
Milk source: Single herd, Glover, VT
Affinage: 3-6 months

Harbison

Style: Bark-wrapped, bloomy rind
Milk type: Pasteurized Holstein (Brown Swiss/Jersey) milk
Milk source: Local herds in Greensboro, VT area
Affinage: 6-13 weeks

Alpha Tolman

Style: Alpine
Milk type: Raw Holstein milk
Milk source: Single herd, Glover, VT
Affinage: 8-12 months

Source: https://www.jasperhillfarm.com

Figure 20: Springbrook Farm Artisan Cheese Samples

SPRING BROOK FARM CHEESE

Reading

Style: Raclette-style
Milk type: Raw Jersey milk
Milk source: Spring Brook Farm, VT and two VT partner dairies
Affinage: ≥ 3 months

Ashbrook

Style: French Morbier inspired
Milk type: Raw Jersey milk
Milk source: Spring Brook Farm, VT and two VT partner dairies
Affinage: ≥ 3 months

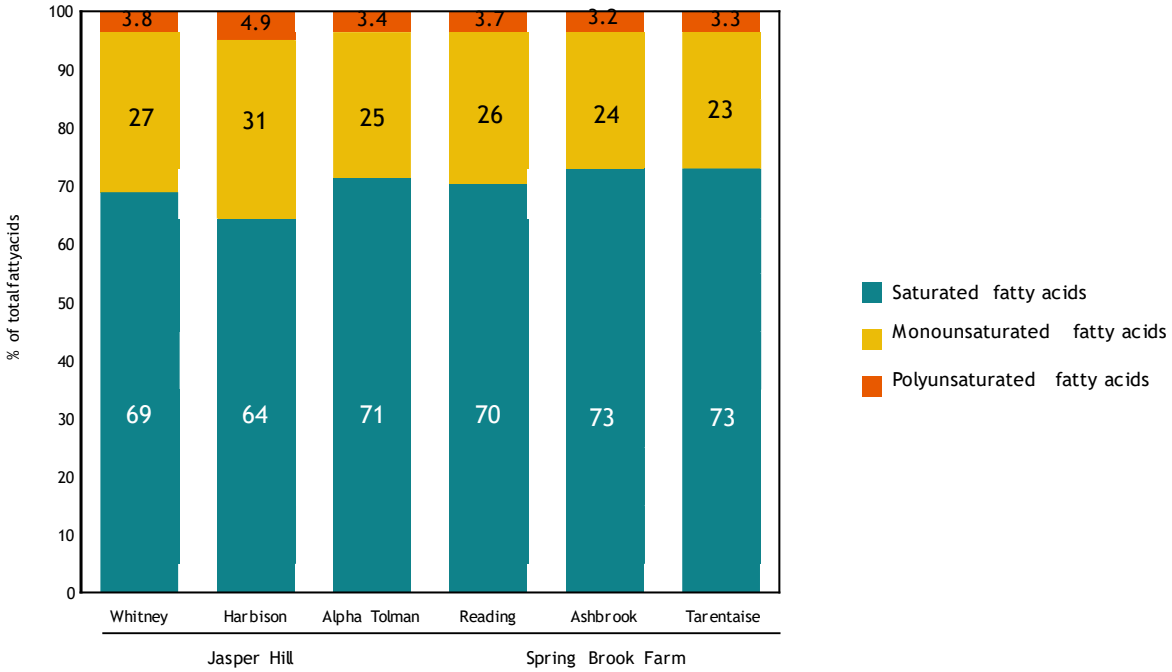
Tarentaise

Style: Alpine
Milk type: Raw Jersey milk
Milk source: Spring Brook Farm, VT
Affinage: ≥ 9 months

Source: https://www.sbfcheese.org/

The fatty acid profiles of the cheese types indicated different percentages of saturated fatty acids, monosaturated fatty acids, and polysaturated fatty acids (Figure 21).

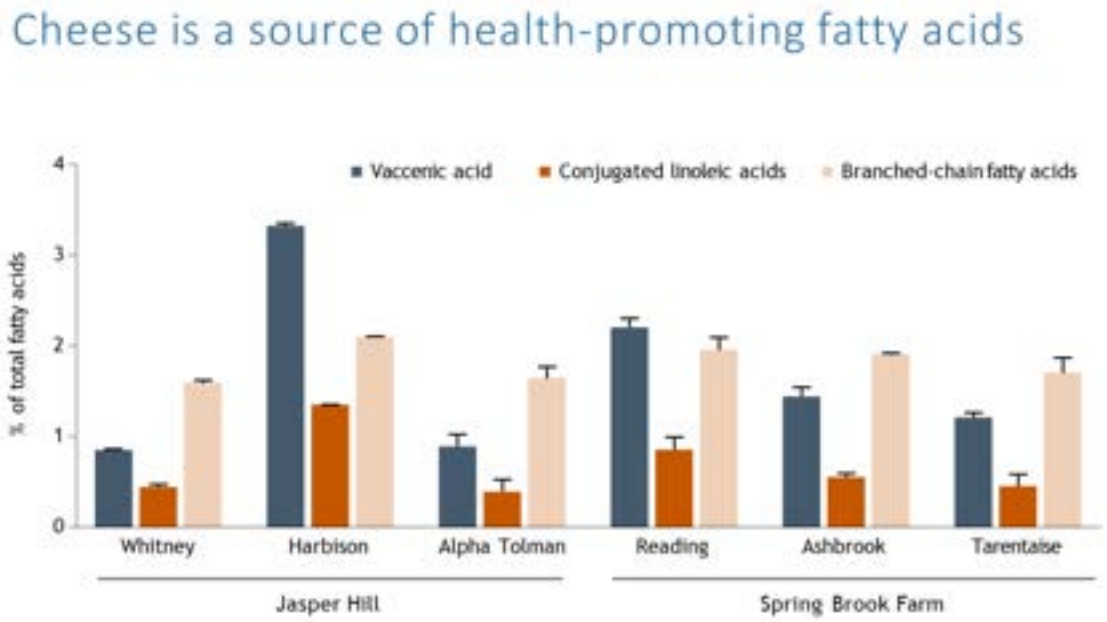
Figure 21: Artisan Cheese Fatty Acid Composition



The data indicate that Harbison had a higher percentage of monosaturated fats compared to the other cheese types (Figure 21). It is interesting to note that the fatty acid profiles seem to be clustered similarly to the DSA results, with Harbison alone, Whitney and Alpha Tolman similar, and Reading and Ashbrook similar. However, Tarentaise does not have a unique fatty acid profile, its profile is similar to the other two SBF cheese types.

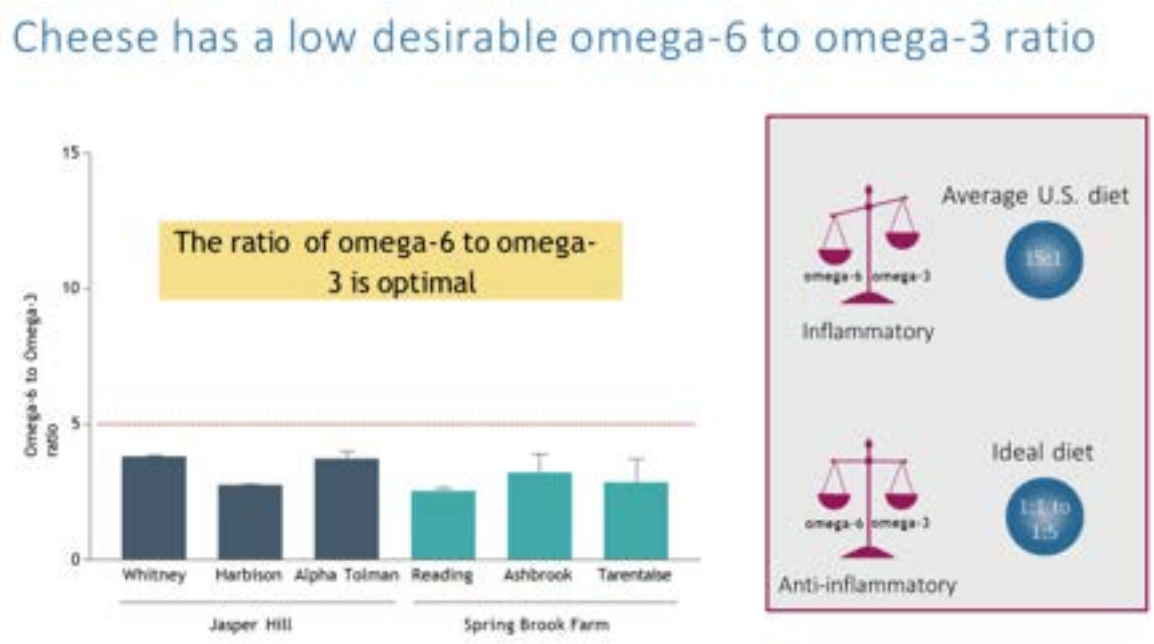
Cheese is a source of health-promoting fatty acids, and the cheese samples tested exhibited a range of fatty acids (Figure 22).

Figure 22: Percent of Total Fatty Acids per Artisan Cheese



The cheeses also had low omega-6 to omega-3 ratios (Figure 23).

Figure 23: Omega 6 to Omega 3 Ratio per Cheese



The fatty acid content per serving varied more between JHF cheeses than SBF cheeses (Figures 24, 25, 26, and 27).

Figure 24: Spring Brook Farms Fatty Acid Content Per Serving

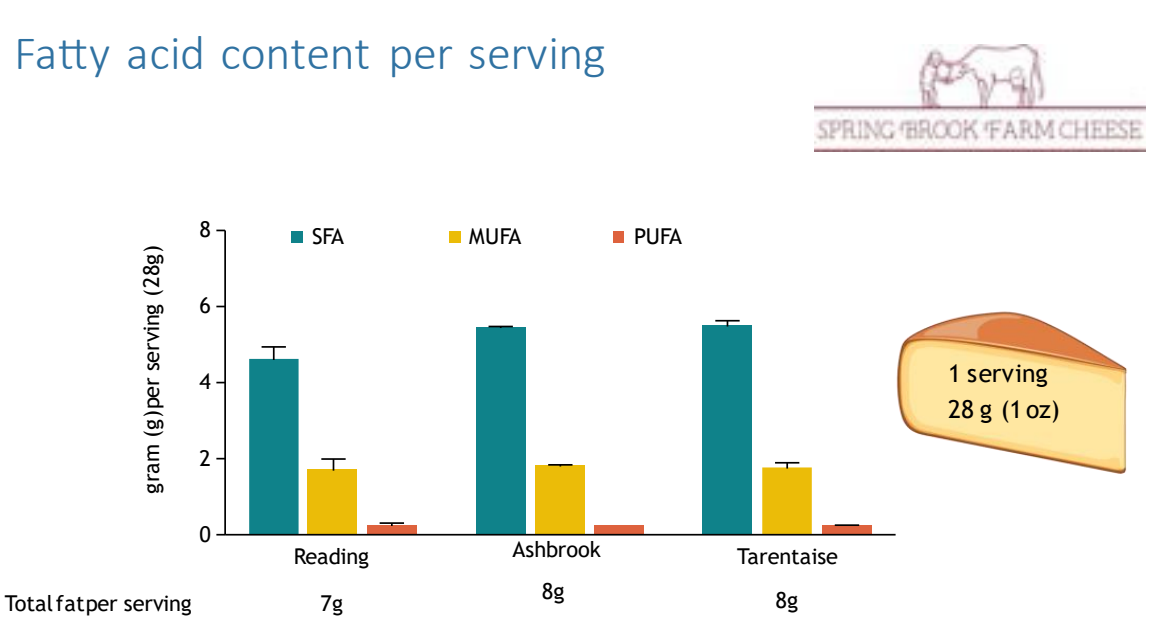


Figure 25: Spring Brook Farms Fatty Acid Composition per Serving

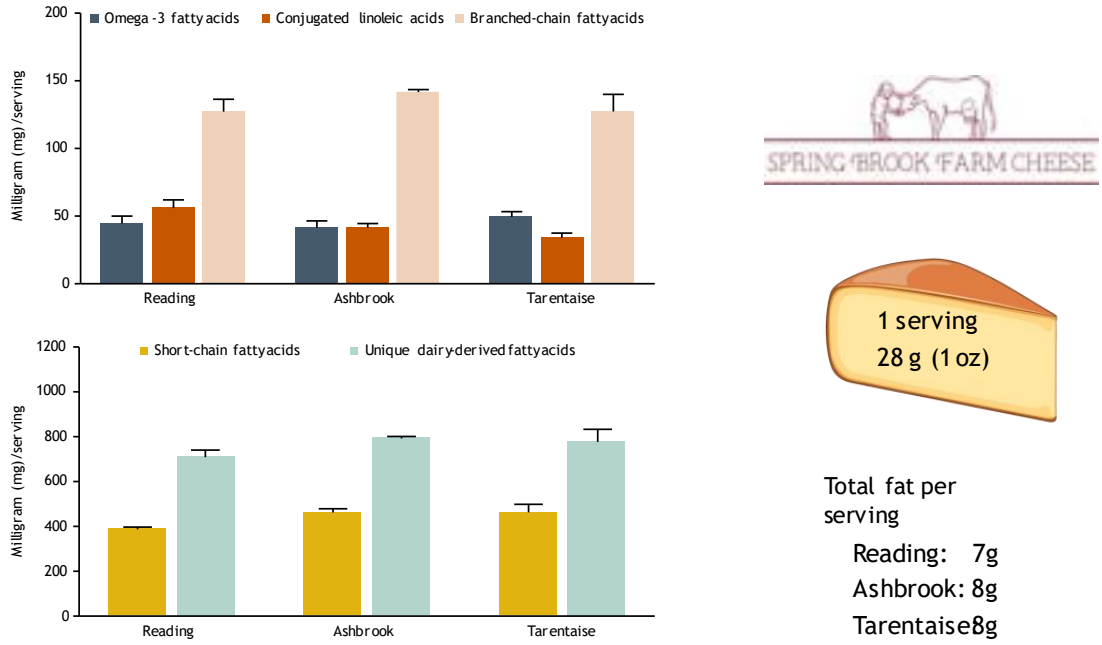


Figure 26: Jasper Hill Farm Fatty Acid Content Per Serving

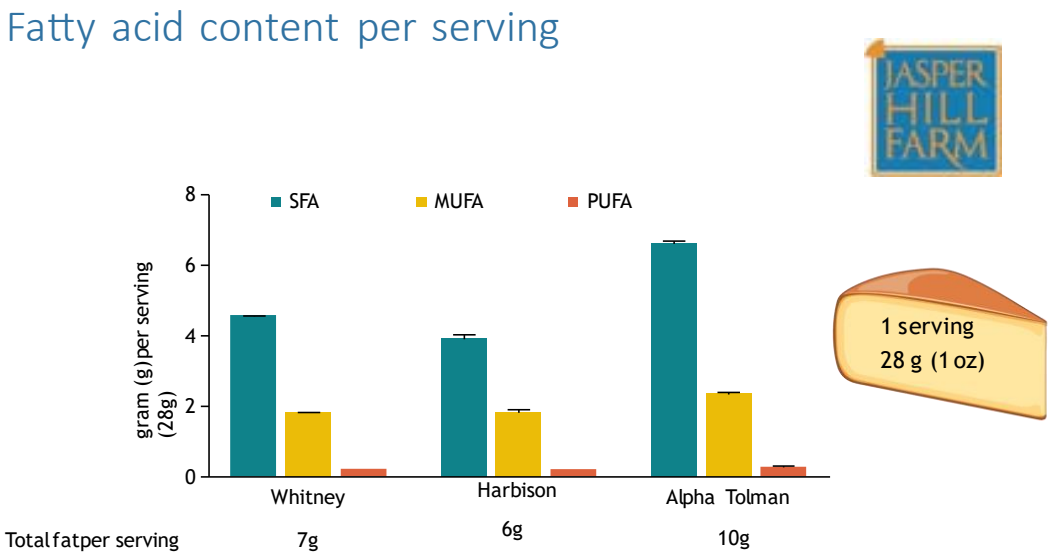
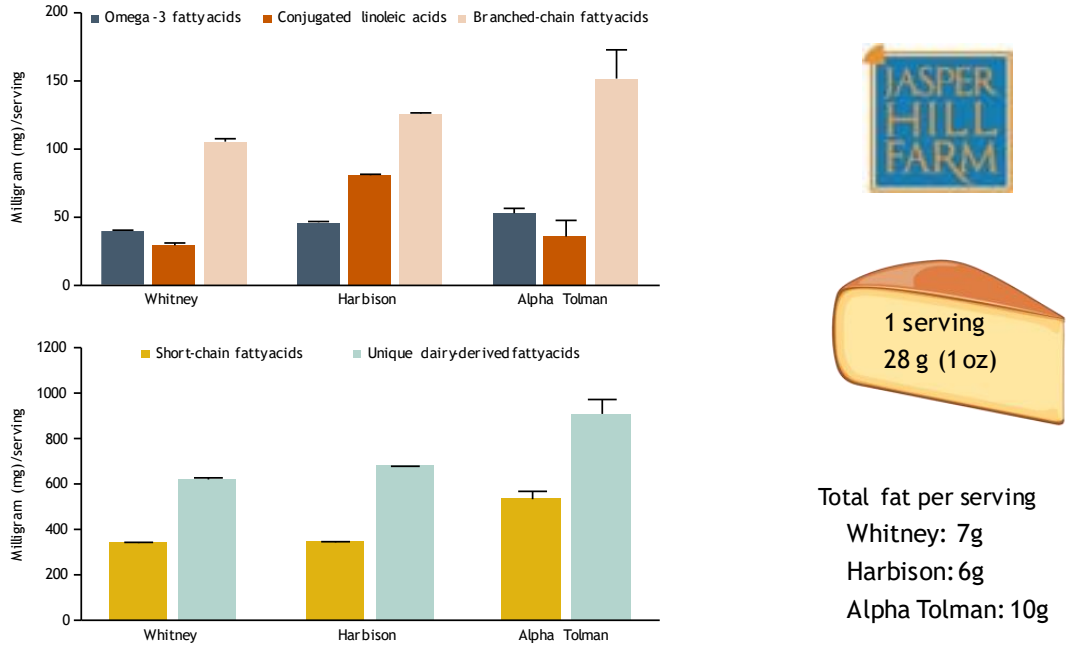


Figure 27: Jasper Hill Farm Fatty Acid Composition per Serving



There is a major opportunity for cheesemakers to incorporate these fatty acid results into their marketing message while linking them to flavor quality.

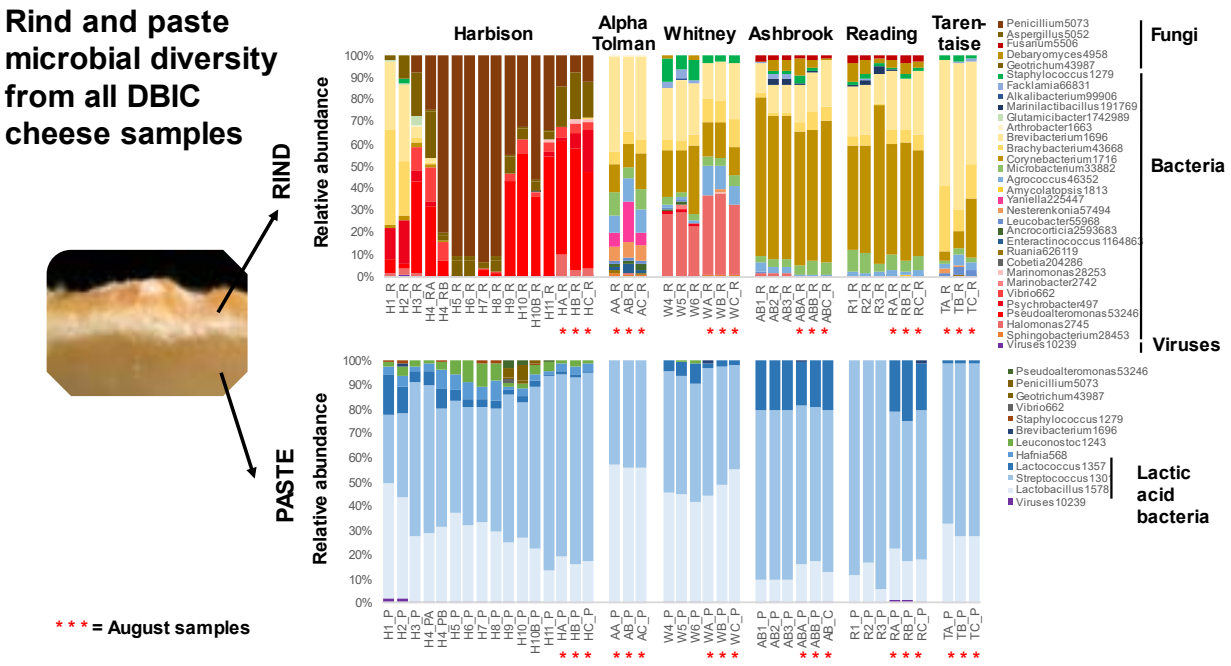
Microbiology Analysis:

Portions of all the cheeses samples were analyzed by Dr. Benjamin E. Wolfe, Department of Biology, and his team at Tufts University. The goal was to measure the artisan cheese microbiome diversity for all the samples collected in August 2022, specifically to determine:

- What is the microbial diversity of the paste/rind of the six VT artisan cheese types?
- Which is more variable across cheese: paste or rind microbiomes?
- How variable is the microbiome of one cheese type over time?

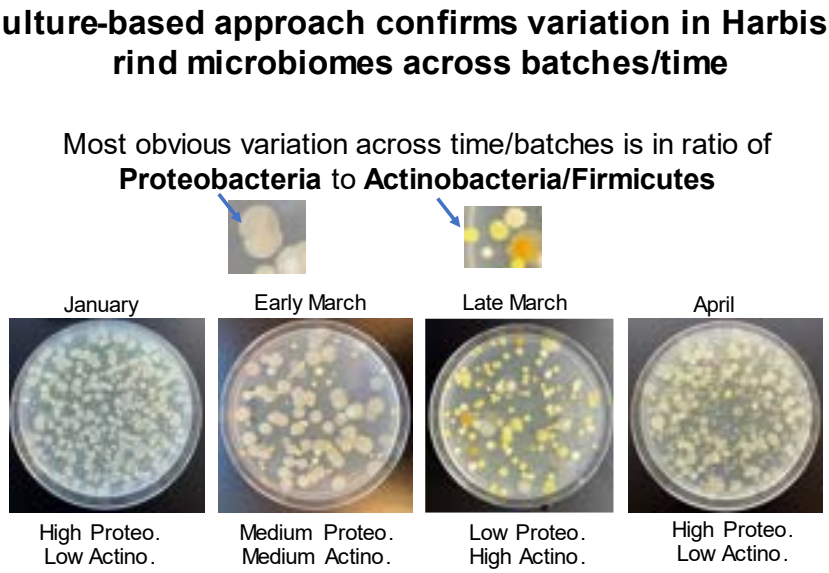
The rind and paste microbial diversity for all of the cheese samples tested can be found in Figure 28.

Figure 28: Rind and Paste Microbial Diversity



Harbison had the most variation in rind microbiomes, specifically the ratio of proteobacteria to actinobacteria/firmicutes, across time and batches (Figure 29).

Figure 29: Harbison Microbial Variation



In summary, the microbiology work:

- Established baseline profiles for rind and paste microbiomes for the six types of cheese tested that can now be compared to other objective data, including DSA and overall liking data.
- Identified the greatest microbiome variation across the six types of cheese was rind, not paste.
- Indicated variation within a cheese rind microbiome, Harbison, over time, that can be explored moving forward.

Chemical Analysis:

Portions of all the cheeses samples were analyzed by Dr. Scott Frost, Department of Biology, and his team at Tufts University. The goal was to identify flavor active compounds for all the samples collected in August 2022, using Sensory Directed Chemical Analysis (SDCA).

The samples were analyzed using a GC/MS at Tufts University that was outfitted with an odor detection port (ODP). Roy Desrochers provided DSA input by assessing the effluent of the GC using the ODP (Figure 30).

Figure 30: Sensory Directed Chemical Analysis – Smelling Using an Odor Detection Port (ODP)

The chemical analysis results can be found in Appendix IX. This data can be correlated with DSA results on the same cheese types to begin to understand the chemistry that is responsible for various sensory characteristics. For example, fatty acid Sour (FAS) butyric/cheesy flavor as measured by the DSA trained panel correlates to Acetic Acid, 2-methylpropyl ester, and FAS sweaty correlates with propanoic acid, hexyl ester (Figures 31 and 32).

Figure 31: DSA Cheesy (FAS Butyric) vs. Chemistry

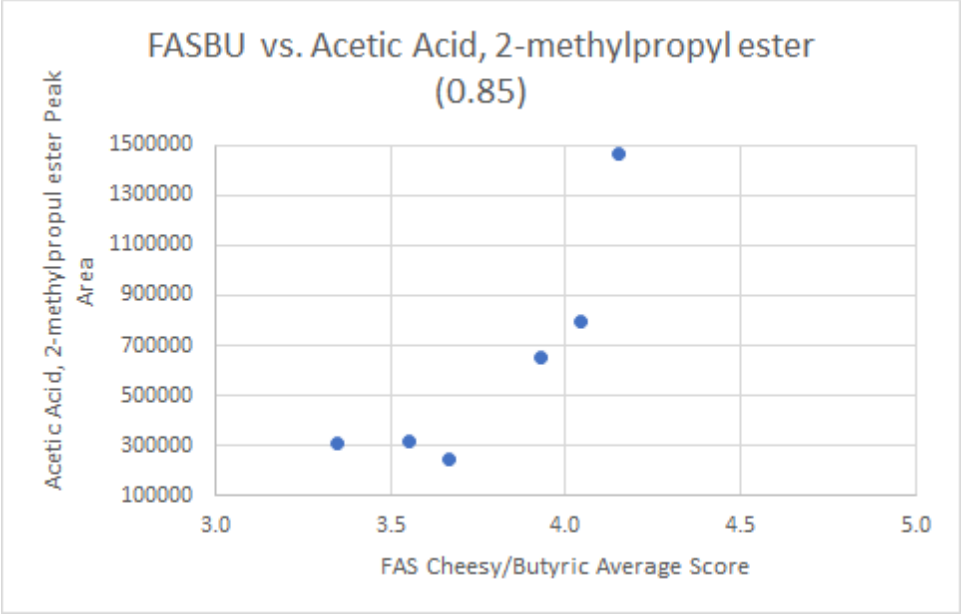
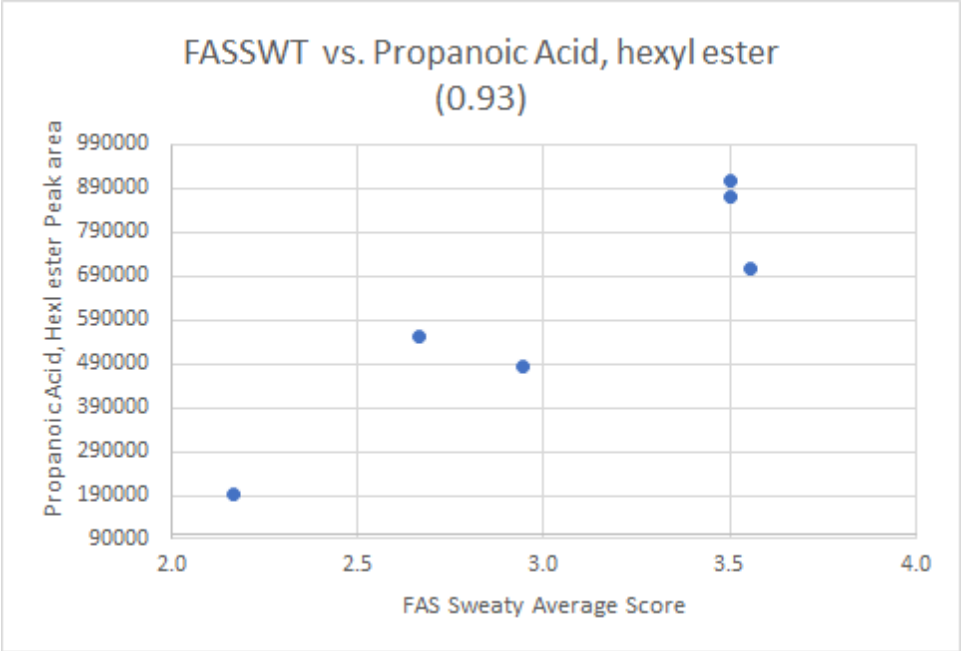


Figure 32: DSA Sweaty (FAS sweaty) vs. Chemistry



The chemical database on the artisan cheeses in this study is extensive, and much more work will be done to look for important correlations to better understand the chemical nature of artisan cheese flavor.

Core Research Experiment Executive Summary:

In this study we were able to generate a range of objective analytical data on a set of artisan cheese samples that were collected in August of 2022. The objective data included:

- Descriptive Sensory Analysis (DSA)
- Fatty Acid Analysis
- Microbiology Analysis
- Chemical Analysis

The samples that were tested included three cheese types from Jasper Hill Farm (Harbison, Whitney, and Alpha Tolman), and three cheese types from Spring Brook Farm (Reading, Ashbrook, and Tarentaise).

Overall, the DSA data showed meaningful differences between the Flavor Leadership Criteria (FLC) sensory attributes of the cheese samples. Specifically, there were meaningful differences on balance of flavor, mouthfeel, others, and aftertaste. The DSA data also showed meaningful differences in three summary flavor indices that were identified by PCA: "*Richness*," "*Cleanness*," and "*Cheese Type*."

The consumer insights work indicated that:

- Artisan cheese users prefer “mature cheese flavor”, such as that with Alpha Tolman and Tarentaise.
- Unique cheese flavor such as with Harbison and Whitney is polarizing to cheese users indicating the presence of cheese flavor segments.
- Artisan cheese users feel that “cheese intensity” is important.
- Artisan cheese users prefer cheese with less odd aroma, less odd flavor, more texture, less aftertaste, and less mouthfeel.
- The FLC are effective in predicting consumer overall liking response to artisan cheese flavor.
- Quadratic relationships exist indicating some key sensory attributes that must fall in a small target range to maximize consumer acceptance, including:
    - Total Intensity of Flavor (TIF)
    - Cheese identity (butyric compared to isovaleric)
    - Savory
    - Maturity/nutty

The fatty acid analysis results showed that fatty acid profiles of the cheese samples are segmented and vary by cheese type.

The microbiology results indicated clustering of microbial diversity in both rind and paste, with a bigger range of diversity found in the rind.

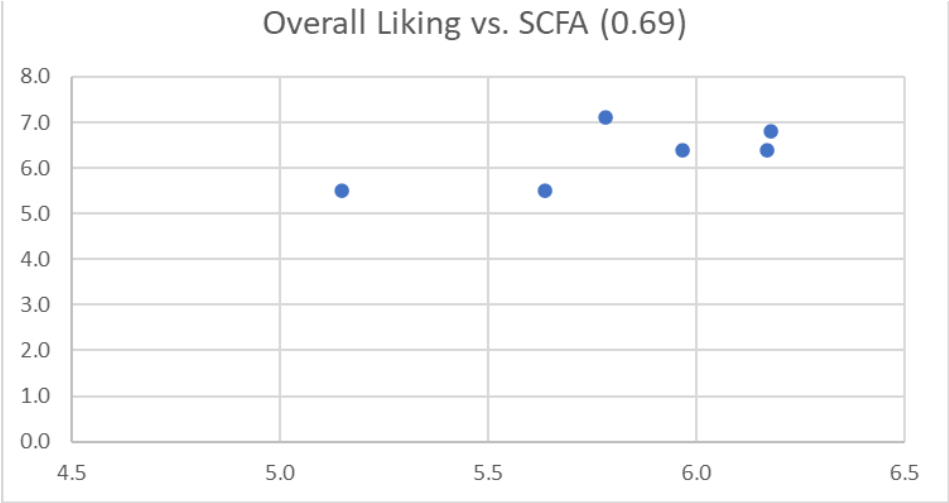
The fatty acid profile data, microbial diversity of rind data, and DSA data, were consistent in placing the August 2022 artisan cheese samples into four clusters:

1. Harbison
2. Tarentaise
3. Alpha Tolman and Whitney
4. Ashbrook and Reading

This is a strong indication of the link between fatty acids composition, microbial diversity, and sensory quality.

In addition, we see specific correlations emerge from the various databases. For example, we begin to see a correlation of consumer overall liking with increased healthy fatty acids, C4-C6 (Figure 33).

Figure 33: Consumer Overall Liking vs. Short Chained Fatty Acids (SCFA – considered "healthy")



Not only do we see consumer overall liking increase with healthy fats levels, but we also see the Cheese "*Quality*" Index that was developed in this study increase with consumer overall liking and healthy fats levels (Figure 33). The "*Quality*" Index is now a powerful tool for future research on artisan cheese quality and understanding ways to increase market success.

Task 4: Education and Outreach

The outreach on this project includes:

A series of detailed webinars entitled "A Sensory Directed Approach to Understanding Artisan Cheese" have been published on the NWCS YouTube channel (http://www.youtube.com/user/cropsoilsvteam) covering various aspects of this work.

Below is a list of the individual webinars along with their respective web addresses:

- Descriptive Sensory Analysis (DSA) - https://youtu.be/qXusNv3SJR8
- Consumer Insights – Hedonic and Innovative - https://youtu.be/gUXtXn-s5rA
- Microbiology - https://youtu.be/7fmGscn4jAc
- Fatty Acids Analysis - https://youtu.be/ZP3WEPsfbMg
- Overall Project Executive Summary - https://youtu.be/QspSgryH8WU

We conducted intense Descriptive Sensory Analysis (DSA) training programs at both JHF and SBF in 2021 and 2022. Each was attended by about 12 staff members, each of whom participated in an interactive taste session using flavor reference standards to learn the basics of DSA. DSA is a powerful tool that they can add to their existing sensory

activities to understand cheese flavor, optimize quality, and grow and sustain market success.

Figure 34: Sensory Training at Jasper Hill Farm

Figure 35: Sensory Training at Spring Brook Farm

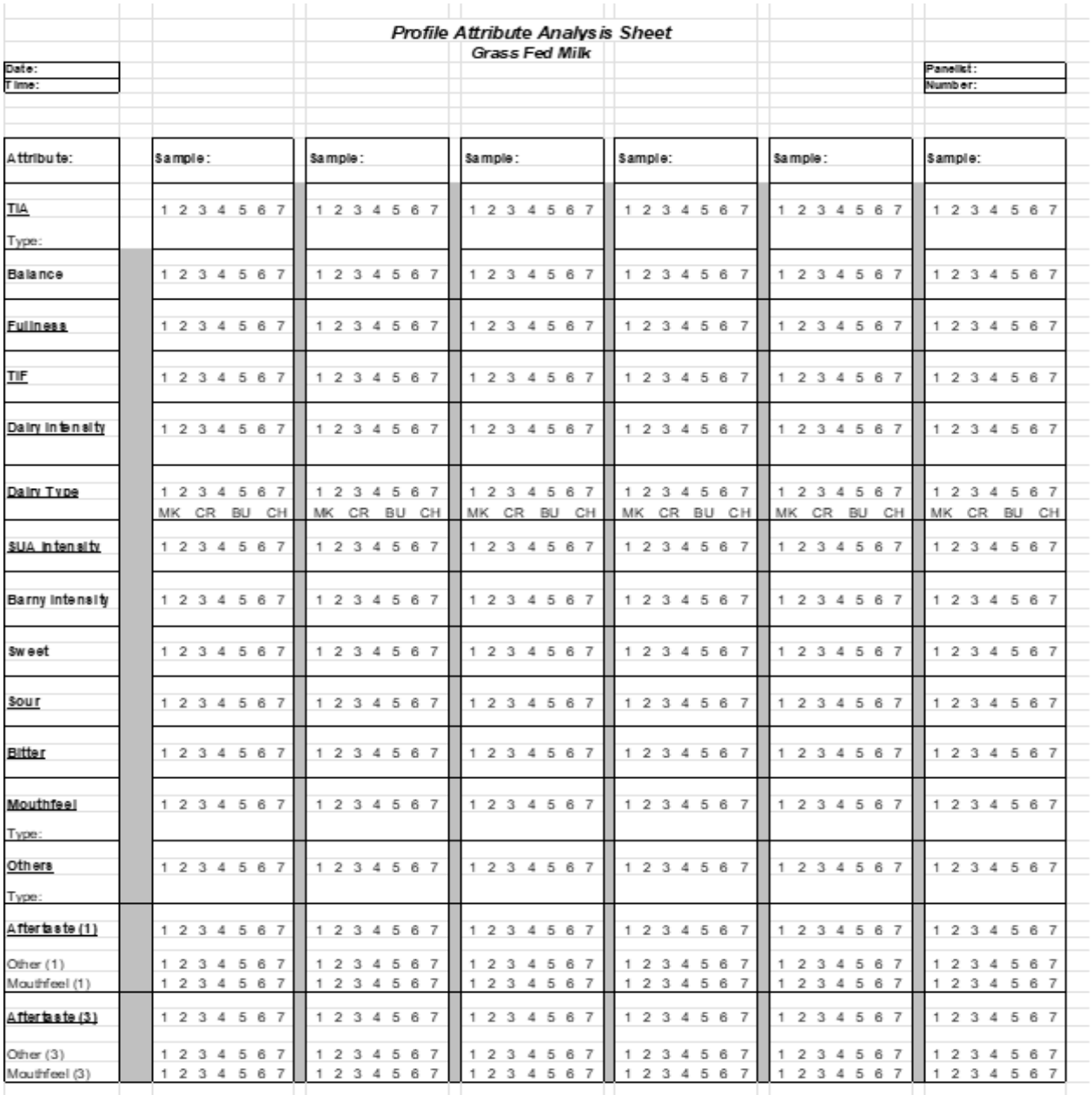
We presented information and conducted a cheese taste test at our annual field day at Borderview Research Farm in Alburgh, VT, in 2021with over 100 people in attendance.

We conducted a special sensory workshop for undergraduates and post-docs working at Tufts University in chemistry and microbiology.

Figure 36: Sensory Workshop at Tufts University

Figure 37: Sensory Workshop at Tufts University

Appendix I: Milk Profile Attribute Analysis Sheet



Profile Attribute Analysis Sheet
Grass Fed Milk

Date:							Panellist:
Time:							Number:

Attribute:	Sample:	Sample:	Sample:	Sample:	Sample:	Sample:
TIA	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Type:						
Balance	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Fullness	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
TIF	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Dairy Intensity	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Dairy Type	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
	MK CR BU CH	MK CR BU CH	MK CR BU CH	MK CR BU CH	MK CR BU CH	MK CR BU CH
SUA Intensity	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Barny Intensity	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Sweet	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Sour	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Bitter	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Mouthfeel	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Type:						
Others	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Type:						
Aftertaste (1)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Other (1)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Mouthfeel (1)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Aftertaste (3)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Other (3)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
Mouthfeel (3)	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Appendix II: Cheese Profile Attribute Analysis Sheet

Profile Attribute Analysis Sheet
Cheese

Date:	Panelist:
Time:	Number:

Attribute:	Sample:	Attribute:	Sample:
TIA Type:	1 2 3 4 5 6 7	Mouthfeel Type:	1 2 3 4 5 6 7
Balance	1 2 3 4 5 6 7	Others:	1 2 3 4 5 6 7
Fullness	1 2 3 4 5 6 7	Type:	
TIF	1 2 3 4 5 6 7	Aftertaste	1 2 3 4 5 6 7
FA Sour: Vomit, BU, Dsour	1 2 3 4 5 6 7	Type:	
FA Sour: Sweaty, animal	1 2 3 4 5 6 7	Firmness	1 2 3 4 5 6 7 Soft Firm
Savory: Brothy, Mushroom	1 2 3 4 5 6 7	Crumbly	1 2 3 4 5 6 7 Creamy Crumbly
Sulfidy: Veg. onigar, Meaty	1 2 3 4 5 6 7	Particulate	1 2 3 4 5 6 7 None Many
Ammonia/pungent	1 2 3 4 5 6 7		
Barny	1 2 3 4 5 6 7		
Musty, earthy, mold	1 2 3 4 5 6 7		
Oxid, nutty, woody Type:	1 2 3 4 5 6 7		
Green, grass, hay Type:	1 2 3 4 5 6 7		
Sweet	1 2 3 4 5 6 7		
Sour	1 2 3 4 5 6 7		
Salty	1 2 3 4 5 6 7		
Umami	1 2 3 4 5 6 7		

Attribute:	Sample:	Attribute:	Sample:
TIA Type:	1 2 3 4 5 6 7	Mouthfeel Type:	1 2 3 4 5 6 7
Balance	1 2 3 4 5 6 7	Others:	1 2 3 4 5 6 7
Fullness	1 2 3 4 5 6 7	Type:	
TIF	1 2 3 4 5 6 7	Aftertaste	1 2 3 4 5 6 7
FA Sour: Vomit, BU, Dsour	1 2 3 4 5 6 7	Type:	
FA Sour: Sweaty, animal	1 2 3 4 5 6 7	Firmness	1 2 3 4 5 6 7 Soft Firm
Savory: Brothy, Mushroom	1 2 3 4 5 6 7	Crumbly	1 2 3 4 5 6 7 Creamy Crumbly
Sulfidy: Veg. onigar, Meaty	1 2 3 4 5 6 7	Particulate	1 2 3 4 5 6 7 None Many
Ammonia/pungent	1 2 3 4 5 6 7		
Barny	1 2 3 4 5 6 7		
Musty, earthy, mold	1 2 3 4 5 6 7		
Oxid, nutty, woody Type:	1 2 3 4 5 6 7		
Green, grass, hay Type:	1 2 3 4 5 6 7		
Sweet	1 2 3 4 5 6 7		
Sour	1 2 3 4 5 6 7		
Salty	1 2 3 4 5 6 7		
Umami	1 2 3 4 5 6 7		

Appendix III: Flavor Profile Method (FPM) and Profile Attribute Analysis (PAA)

The Flavor Profile Method of evaluation was developed by Messrs. Sjöström and Cairncross of Arthur D. Little in 1948. It is a standard approach to the measurement and analysis of aroma and flavor. The flavor profile is empirically based, i.e., developed and learned through experience. It employs perceptual judgments of both the elements and structure of aroma and flavor impressions. These judgments are made by carefully selected and extensively trained panelists who work as a team to reach a composite judgment. While statistics may be employed to analyze profile data, confidence in profile results, reproducibility, is generally based upon the skill of the individuals' carefully monitoring each other's performance and employing objective reference materials to eliminate discrepancies.

Perception has been defined as the integration into a complex whole of single stimuli or sensations, as well as the isolation of single elements within the complex whole. The Flavor Profile Method introduced a similar concept to flavor evaluation by an overall impression or perception created by the aroma and flavor, termed *amplitude*, as well as characterization of the individual elements which contribute to that impression. The amplitude characteristic measures the integration of balance and fullness in aroma and flavor. This perception has been found to be used both by consumers and experts to distinguish among samples.

Aroma, which is defined as the sensation perceived by the nose when the product is sniffed, is comprised of volatile components (such as the sweet fragrance of vanilla) and feeling sensations (such as the coolness of menthol).

Flavor is perceived when the sample is taken into the mouth and swallowed. It is a combination of aromatics (volatile components which reach the olfactory area), basic tastes (sweet, sour, salty bitter, and umami), and feeling factors (sensations in the mouth and throat, such as pepper bite).

The flavor profile panel defines these character notes in terms of reference materials and assigns numerical intensities reflecting the strength of the note in the product. The order of appearance of these aroma and flavor notes is recorded, as is the aftertaste, one minute after swallowing.

The Flavor Profile Method is based on the use of a panel of four or five persons who have normal ability to smell and taste, are trained in techniques of smelling and tasting, have had considerable experience as panel members, and undergo a training period for

orientation to the particular product to be analyzed. One of the panel members is also selected to act as the panel leader.

The flavor profile panel acts as an analytical instrument in that the panel members write down objective, descriptive terms for the different components they perceive in the product's aroma and flavor. Control is maintained over extraneous variables, and the panel works in a well-lighted, clean, quiet, odor-free, temperature-controlled room equipped with a table and chairs. The panel sessions are held at a scheduled time, and no interruptions are permitted during any session. The samples to be profiled are as uniform as possible, and each panel member receives an aliquot for his or her own independent analysis. Each member follows a standardized procedure adopted for the most useful and complete analysis of each particular product. The number of panel sessions necessary for completing a flavor profile varies according to the complexity of the product. It is customary, however, to allocate the first session to orientation and general descriptions of the overall impressions and characteristics of the product under study. Subsequent sessions are used to reach agreement on the aroma and flavor components called character notes, their intensities or strength, and their order of appearance.

To eliminate confusion as to the meaning of the various descriptive terms used by the panel members, extensive use is made of reference materials. These references may be chemicals or natural materials as long as they adequately represent the particular term described by the panel members. All the panel members examine the reference materials and if it and the component it represents is agreed upon, the term and the reference material is accepted.

A product's aroma is analyzed first and then the flavor, with each panel member taking a minimum, but uniform, number of sniffs or tastes for a complete analysis. The specifics of the smelling and tasting techniques are worked out during an orientation period. A description of aftertaste, the sensations which are still present in the mouth one minute after swallowing, is also included in the flavor profile.

The characteristics of a product that each panel member looks for when doing a flavor profile are (1) a rating of the degree of blend and the amount of fullness present in the aroma and flavor as a whole; (2) an identification of the individual components of aroma and flavor (3) the strength, or intensity, at which these components appear (4) the order in which they appear; and (5) a description of the aftertaste one minute after swallowing. In addition, when texture is important to the product's description, this is also noted during the panel session.

The impression of blend and fullness is termed *amplitude*. When rated by a person trained in the method, amplitude measures the degree of integration of the perceptual experience, the complexity and structure of the aroma or flavor. Usually, the greater the degree of this blended complex supporting the character notes, the higher the amplitude.

The ratings for amplitude are on a scale from ½ representing a very low amplitude, to a high of 3, where 1 is low and 2 moderate. This scale is used for all classes of products, and, therefore, does not describe its qualitative attributes. Amplitude is not a measure of aroma or flavor strength, but rather reflects fullness (ampleness) and the degree of blend. The trained panel can also separate the two sensory measurements of balance and fullness, and rate them independently.

The scale used to denote the intensity or strength of the aroma and flavor character notes in the product is the following:

0	none
½	very slight
1	slight
1 ½	slight-to-moderate
2	moderate
2 ½	moderate-to-strong
3	strong

This is a constant scale; that is, when sweetness is designated at a slight-to-moderate strength (1½) in both chocolate and orange juice, for example, the sweetness level detected can be related to a reference material of a slight-to-moderate level of sweetness exemplified by a certain concentration of sugar (sucrose).

After each panel member has finished his independent study of the product's aroma and aftertaste, the individual recites his findings, and an open discussion period is led by the panel leader. The findings are compiled by the panel leader into a preliminary flavor profile. The prototype is used in subsequent panel sessions, and the examinations continue until a composite flavor profile is agreed upon. All products are studied singularly until a final session when a comparison with a companion product may yield more information and determine if the profile descriptions correctly discriminate between samples.

The Flavor Profile Method characterizes the perceptual attributes of a product which to a large measure identify it and set it apart from similar products. Typically, flavor profile

analyses are conducted on a product under normal conditions of use, with the preparation and presentation of the samples standardized to end user conditions.

Profile Attribute Analysis (PAA)

Profile Attribute Analysis (PAA) is an objective method of sensory analysis that uses a trained panel to numerically describe the complete sensory experience through profile attributes. These attributes are a limited set of characteristics which, when properly selected and defined, provide a complete description of the sensory characteristics of a sample with little descriptive information lost. Additional detail is provided by panel comments which are stored in association with the attribute data. By limiting the number of sensory attributes the panelist measures, it is possible to evaluate four or more samples per session compared to one sample per Flavor Profile session. PAA data can be efficiently stored in automated data handling systems and is amenable to statistical analysis and data summarization.

PAA is based on the Flavor Profile Method (developed at Arthur D. Little, Inc. and reported in 1948) in concept and implementation. It makes use of the expertise of trained panelists to identify and appropriately define the critical set of attributes for a specific project. A group of four or five trained panelists, drawn from a pool of six to eight familiar with the specific study, produces sufficiently uniform results that two or three replications can provide significant discrimination among samples.

The Flavor Profile Method introduced the concept of integrative perceptual measures of flavor in the amplitude characteristic. This measure includes aspects of balance and fullness which are perceptions used by both consumers and experts to distinguish among samples. PAA uses both of these terms as independent measures.

Flavor profiling requires the description of character notes in three chemical sensory pathways -- smell, taste, and (chemical) mouthfeel. These are extended in PAA to include visual and tactile measures. Both the visual and tactile sensations provide ways of differentiating among samples and may influence judgments of smell, taste, and mouthfeel either by altering or modifying one's perception.

PAA is a cost-effective and efficient method of sensory analysis. It is used to objectively describe the perceptual differences among samples in terms of average panel scores for a set of defined attributes. The method draws on decades of experience in descriptive

sensory analysis using small, trained panels to measure both integrative and analytic perceptions.

Description of Profile Attribute Analysis Method

The sensory or perceptual characteristics of a food or beverage are multi-variant. That means there are a variety of ways in which people distinguish among samples. These perceptions may be grouped into two sets -- integrative and analytic.

Integrative perceptions can be measured as the overall aroma and flavor impression of a food or beverage. Integrative perceptual attributes are an essential part of the product description. Not only do the attributes of balance and fullness distinguish among samples, but they closely correlate with consumers' descriptions of products. Additional integrative measures such as total intensity of flavor, complexity, impact and aftertaste may be necessary to differentiate among samples and, with concurrent laboratory work, record progress in optimizing formulations.

Analytic sensations in sensory measurement are the three chemical senses: smell, taste, and mouthfeel (e.g., astringency). Each of these three chemical senses can be distinguished in terms of strength, quality, and time. Visual and tactile sensations also provide data which differentiate among samples and, like the chemical senses, can have more than one perceptual dimension.

The flavor of a product (in its broadest meaning) is multi-dimensional and is composed of both integrative and analytic perceptions. The attributes often included in PAA studies can be characterized as follows:

Attributes Describing Integrative Perceptions	Attributes Describing Analytics Perceptions
Balance	Color
Fullness	Textural
Aftertaste	Aromatics
Basic Tastes	
Mouthfeels	

Other appropriate attributes will be included or substituted depending on the particular problem under study.

Based on data analysis and interpretation, there appears to be some merit in having a similar number of integrative and analytic attributes. However, it is essential to the success of any study that at least one attribute provides a measure of difference between any two samples that are not perceived to be alike.

In order to provide a manageable set of measures, PAA takes measures for each sensory modality in terms of a seven-point scale (1 to 7). These measures express perceptual differences from a reference and are relative to a standard. Thus, they cannot of themselves uniquely identify all possible variations.

The definition and uniform understanding of each attribute is key to the successful application of the method. It is here that Flavor Profile Method experience is essential. When coupled with the objective description (as opposed to a value judgment) and controlled sample presentation, the attribute scores provide a numerical characterization of the sensations associated with any food or beverage. A more detailed qualitative description can be included from panel comments which are stored in association with specific attribute scores.

Identification of Profile Attributes for a Study

To identify the specific attributes necessary to conduct a PAA study and to develop their definitions, the trained panel will initially hold product orientation sessions. The panel is presented with a wide variety of products that span the range of sensory differences to be included in the actual study. The panelists characterize the sensory properties of these products using descriptive analysis. From this characterization, the profile attributes necessary to completely describe the range of products are selected.

Once the profile attributes are selected, the attribute scales are defined. The panelists are familiar with the definitions and anchor points with the use of reference standards. All attributes are defined along an integer scale of 1 to 7, with each unit representing a difference the panelists can detect with confidence on repeated analyses.

Data Analysis

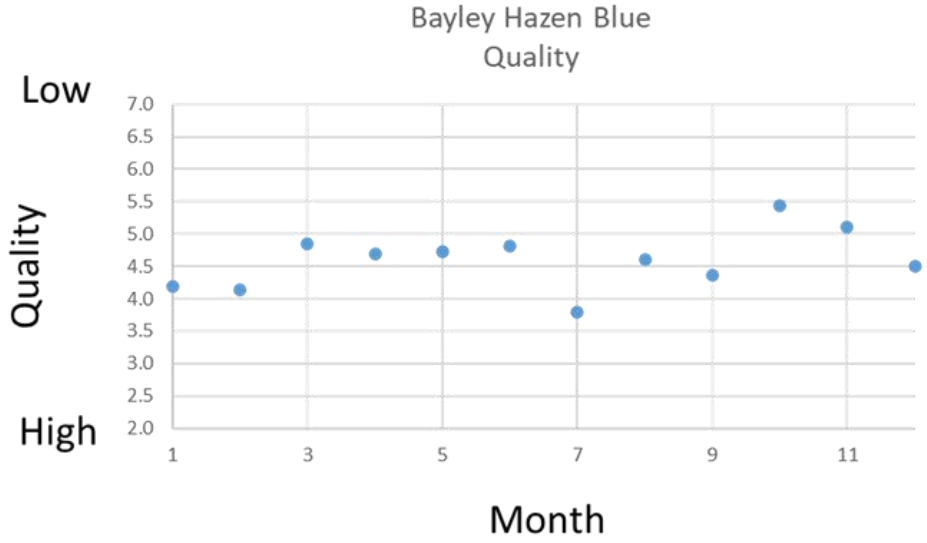
Since PAA relies on numerical measures to describe differences among samples, it is essential to design experiments which often include an independent variable such as storage stability, method of serving or formulation. Such independent variables can be

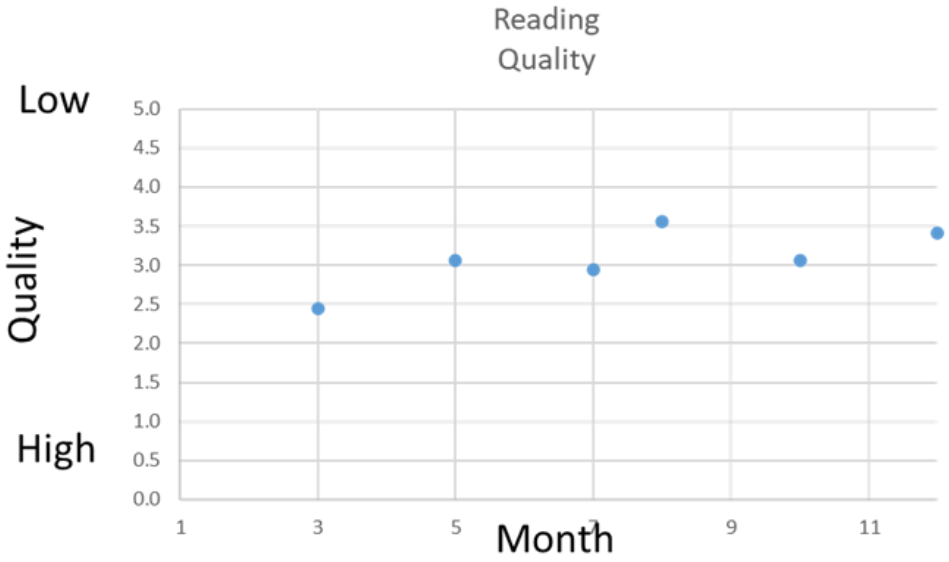
useful in assuring that the panel is operating effectively. Sufficient replication is included to come to statistically valid conclusions. The panel average is treated as the single result, in an effort to represent the population and the fact that people differ in their perceptions of foods and beverages.

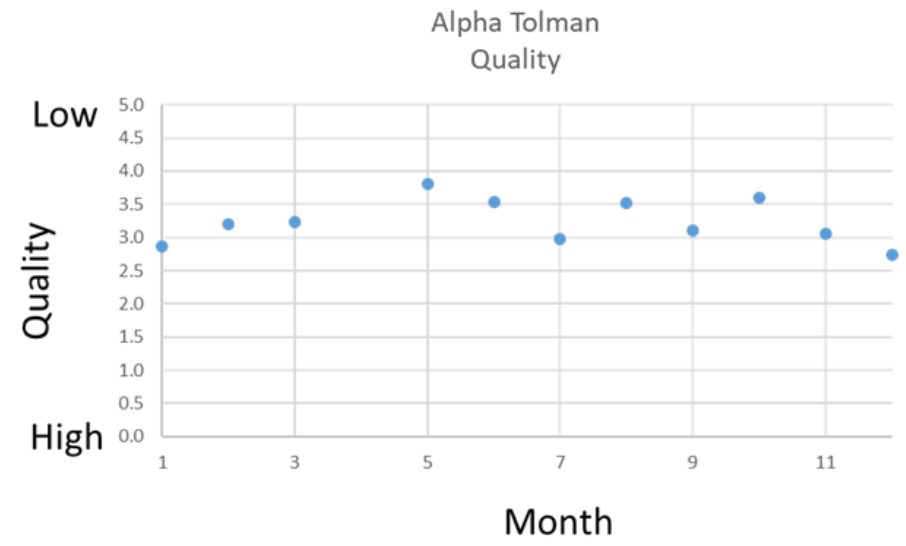
The panel average attribute scores can be analyzed in more than one way. The average scores can be treated as ranks and the ranks can be analyzed using nonparametric statistics. Typically, we summarize the data using principal components analysis or variable cluster analysis taking the first principal component of each cluster as the summary statistic. Multivariate analysis of variance is then performed on the summary statistics and each of the average attribute scores. This analysis provides an overall F test for significance both for the main effects in the test design and their interactions.

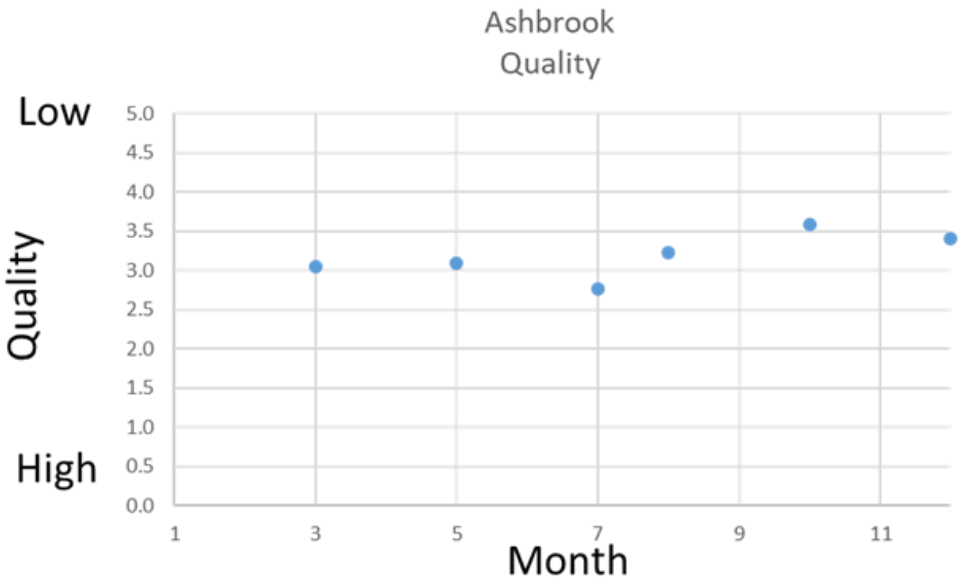
If there are two or three summary statistics, they can be usefully displayed as flavor maps. Such maps with appropriately labeled axes are helpful in visualizing the differences among samples, or brands, particularly over time.

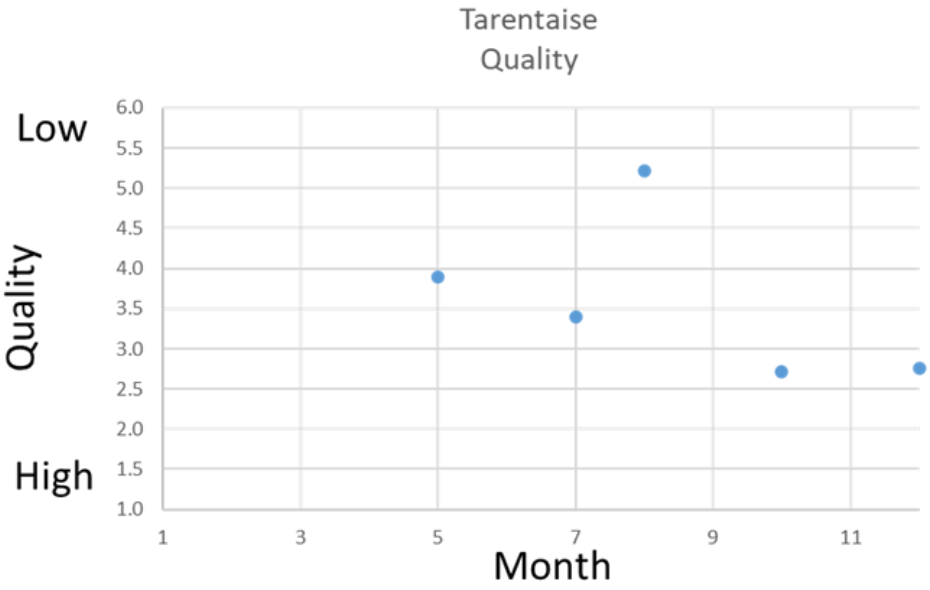
Appendix IV: Flavor maps: "*Quality*" vs. 2022 Month by Cheese Type

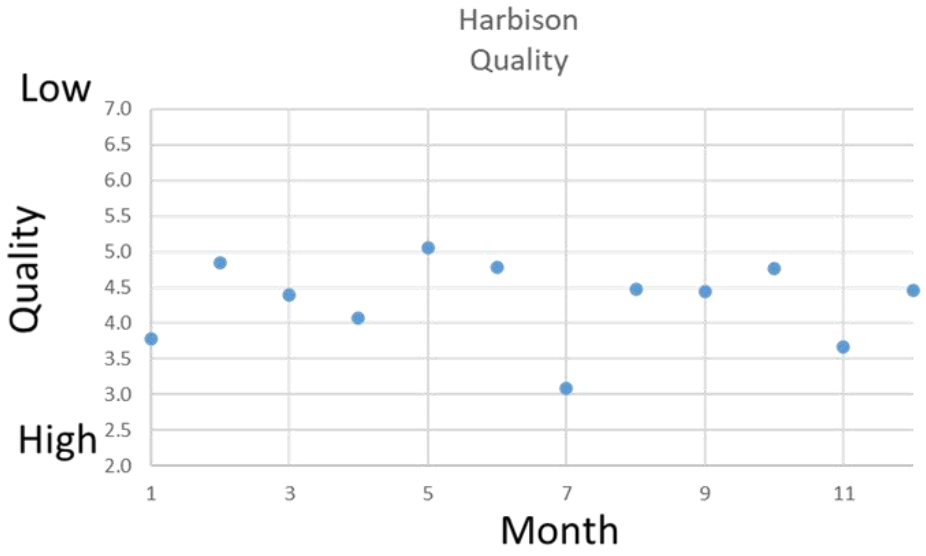





Alpha Tolman
Quality
Low
High
Quality
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
3
5
7
9
11
Month

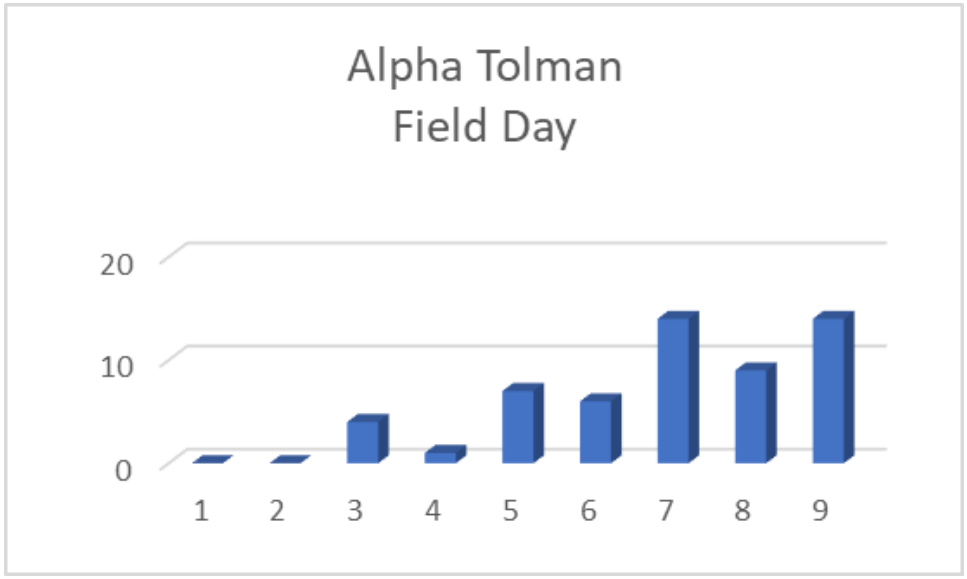

Ashbrook
Quality
Low
High
Quality
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
3
5
7
9
11
Month

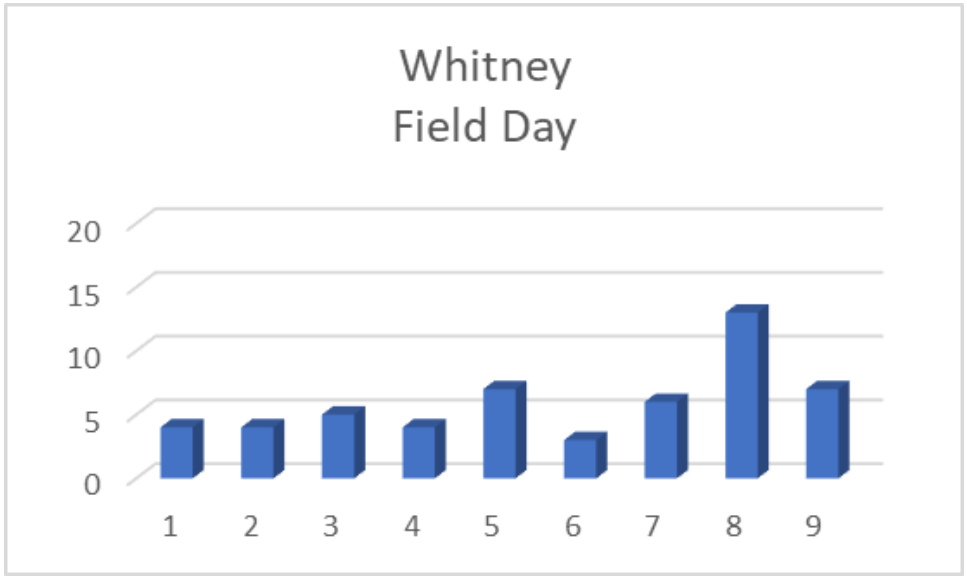

Tarentaise
Quality
Low
Quality
High
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1
3
5
7
9
11
Month

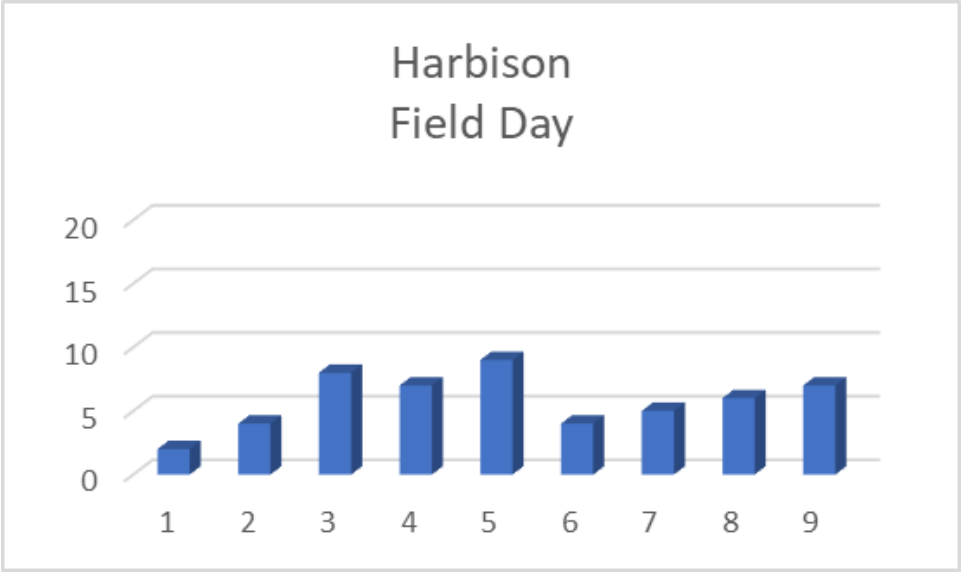

Harbison
Quality
Low
Quality
High
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1
3
5
7
9
11
Month

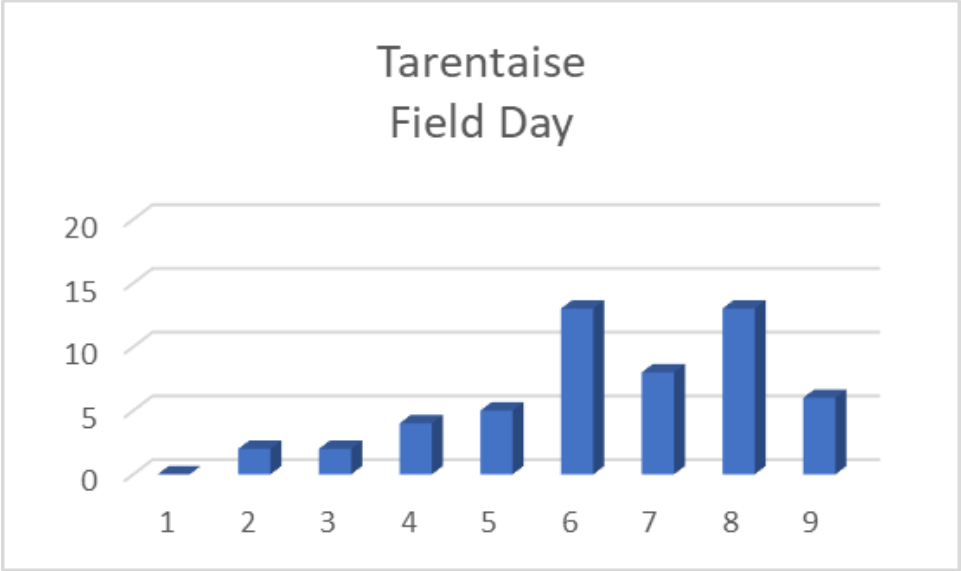
Appendix V: Overall Liking Distribution Graphs for Hedonic Test at UVM Field Day October 2021

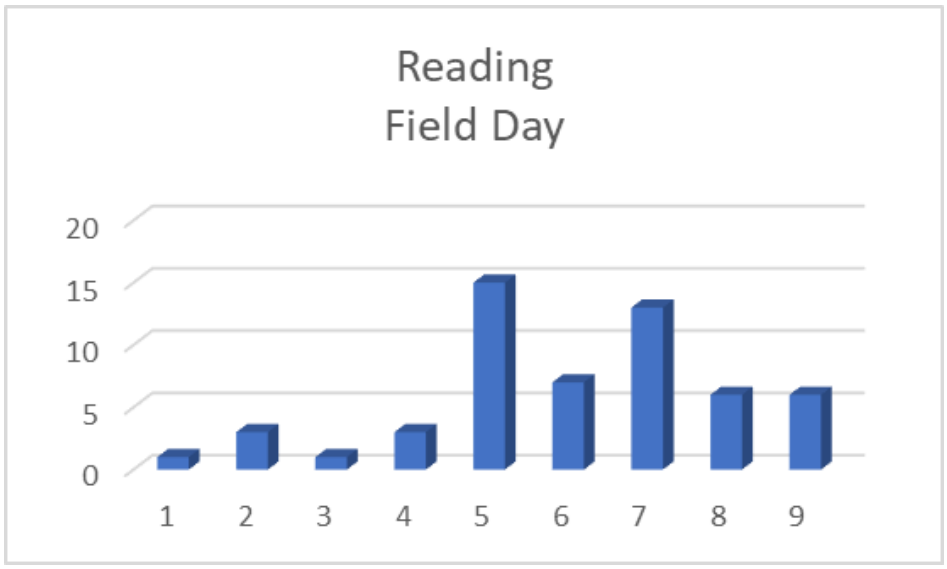
Note: X axis is the average overall liking score from 1 to 9, (1 = dislike very much, 5= neutral, and 9 = like very much), and Y axis is number of people who gave that overall liking score.

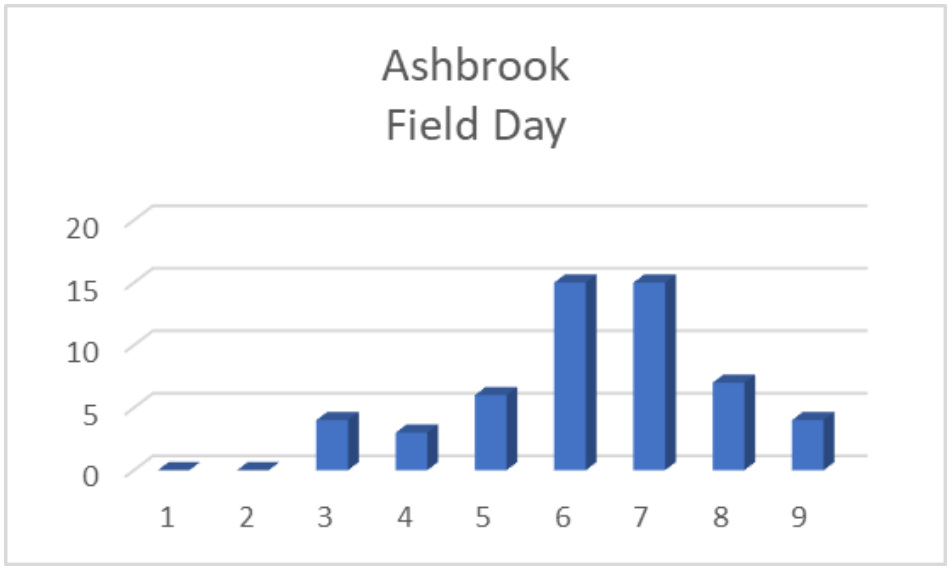





Harbison
Field Day
20
15
10
5
0
1
2
3
4
5
6
7
8
9

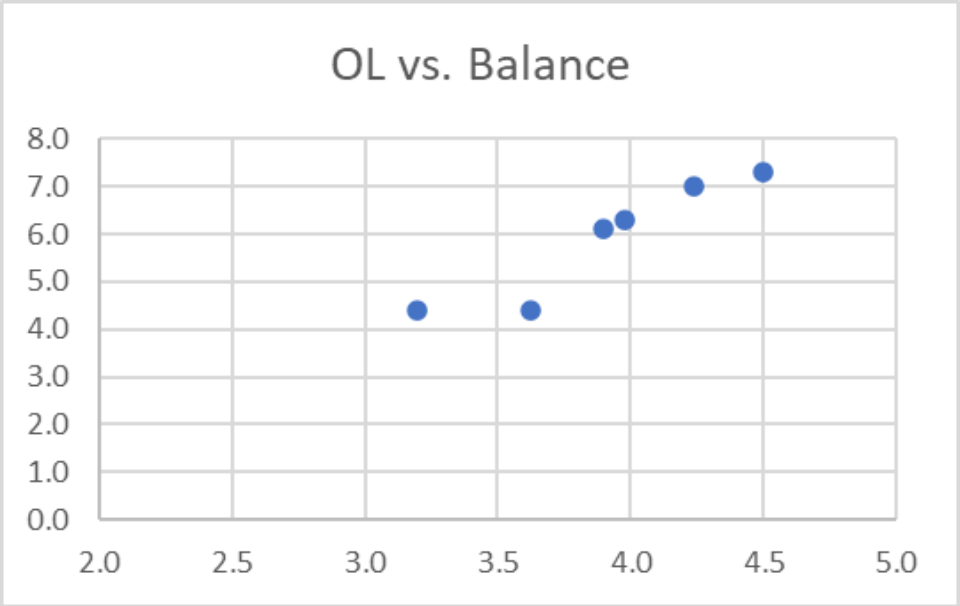

Tarentaise
Field Day
20
15
10
5
0
1
2
3
4
5
6
7
8
9

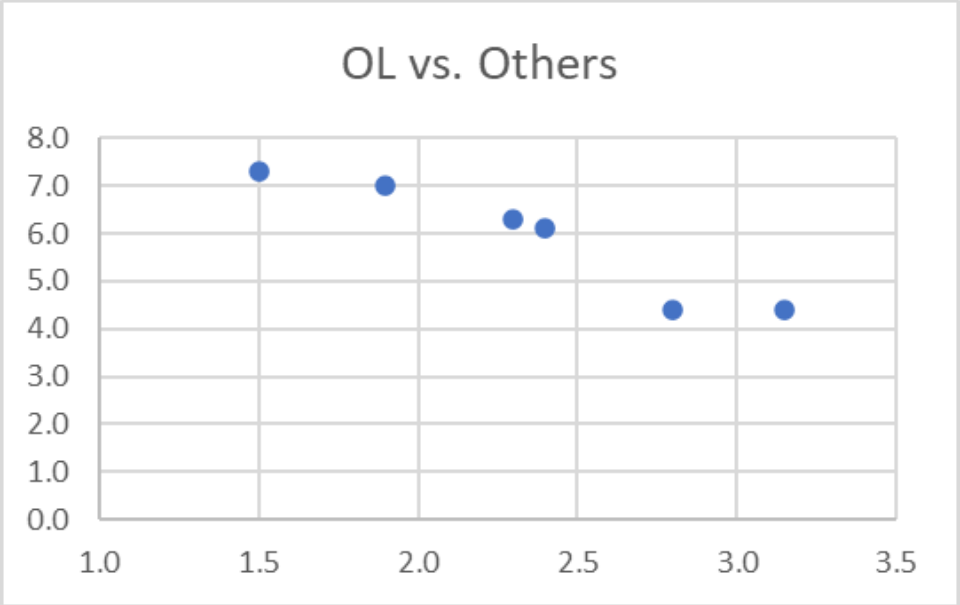


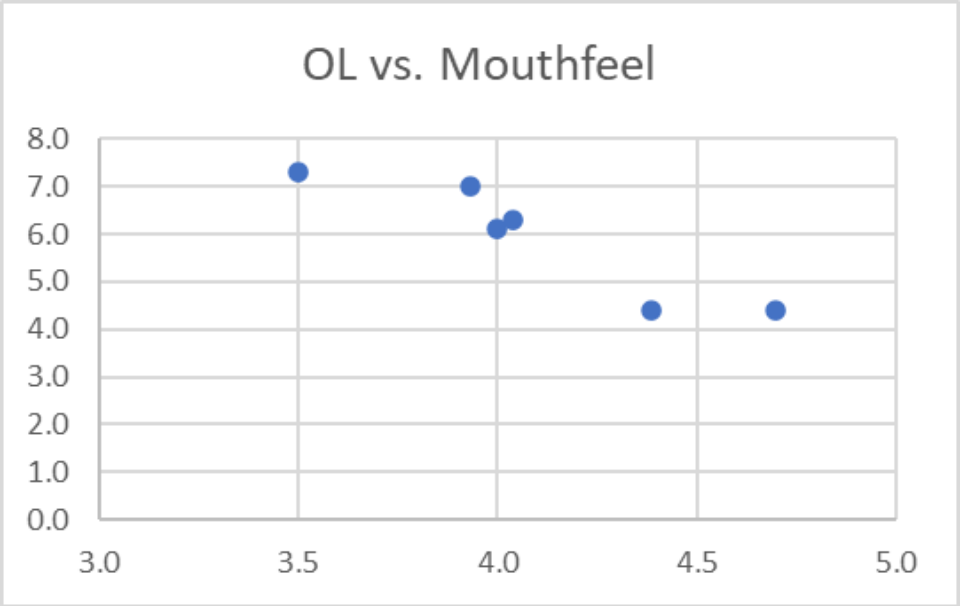


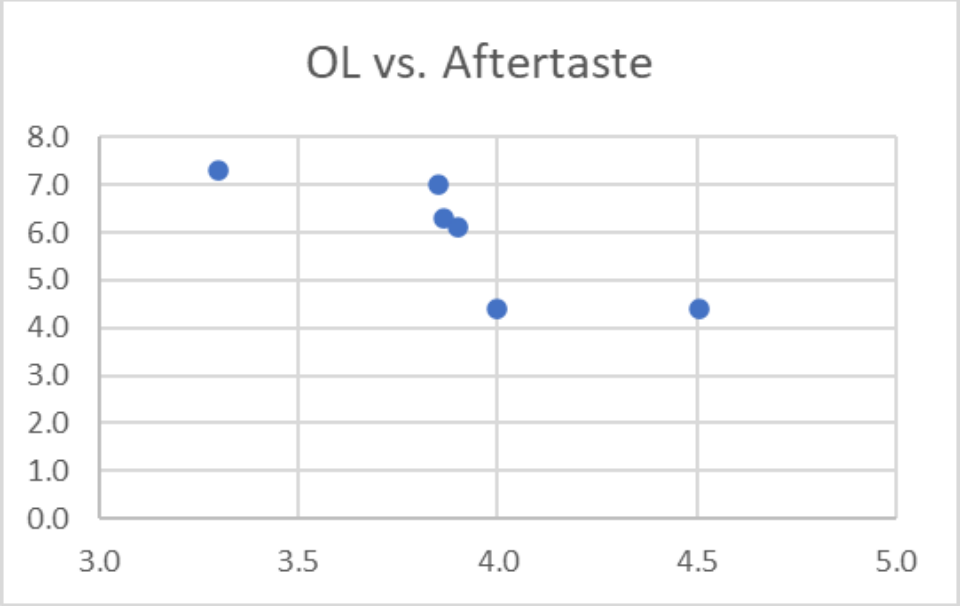
Appendix VI: Consumer Overall Liking vs. FLC Attributes

Note: The X axis is the average overall liking score for the titled FLC attribute from 1 to 7, (1 = None, 5 = Moderate, and 7 = Strong), and Y axis is the average overall liking score, from 1 to 9.


OL vs. Balance
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2.0
2.5
3.0
3.5
4.0
4.5
5.0


OL vs. Others
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1.0
1.5
2.0
2.5
3.0
3.5


OL vs. Mouthfeel
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
3.0
3.5
4.0
4.5
5.0


OL vs. Aftertaste
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
3.0
3.5
4.0
4.5
5.0

Appendix VII: Consumer PEM Descriptive Terms Categories for Artisan Cheese

Odd Smell
Strange Smell
Unpleasant smell
Pungent
Cow puss
Smells like feet
Bad milk
Sour
Pungent
Barny
Dog poop
Chicken poop
Dust
Multi-vote: 12

Cheese Flavor Intensity
Strong cheese flavor
Mild cheese flavor
Tart
Sharp
Tangy
Romano-like
Bland
Too sour
Too mild
Not overwhelming
Flavorful
Nutty
Cheesy
Multi-vote: 28

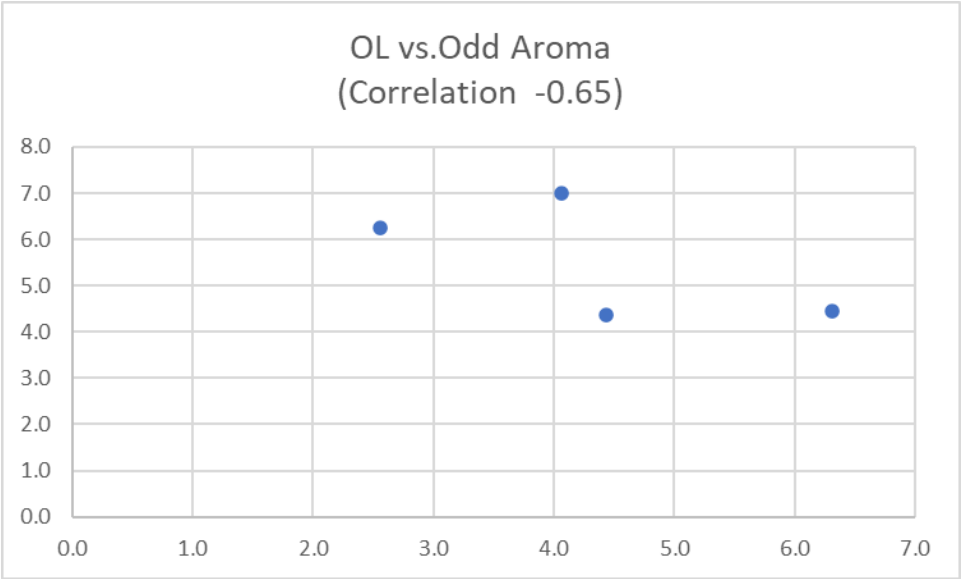
Texture	
Pasty	Rubbery
Crumbly	Creamy
Flakey	
Smooth	
Chewy	
Nice Bite	
Gritty	
Rubbery	
Creamy	
Elastic	
Chunky	
String Cheese	
Spongy	
Multi-vote: 16	

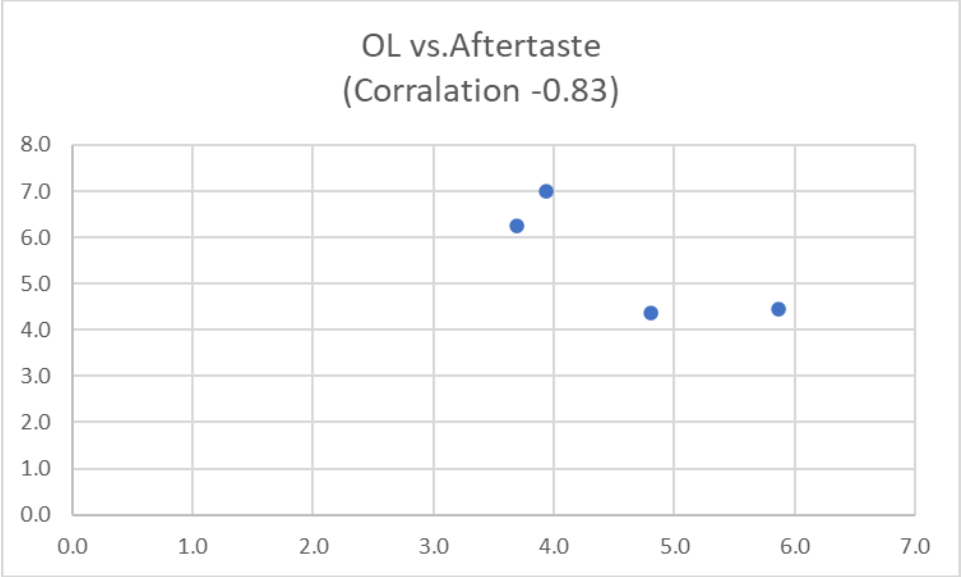
Mouthfeel
Coats my mouth
Sting
Watery mouthfeel
Burn
Crystals in mouth
Hits the back of my throat
Melts in my mouth
Sticky
Sticks to roof of my mouth
Multi-vote: 2

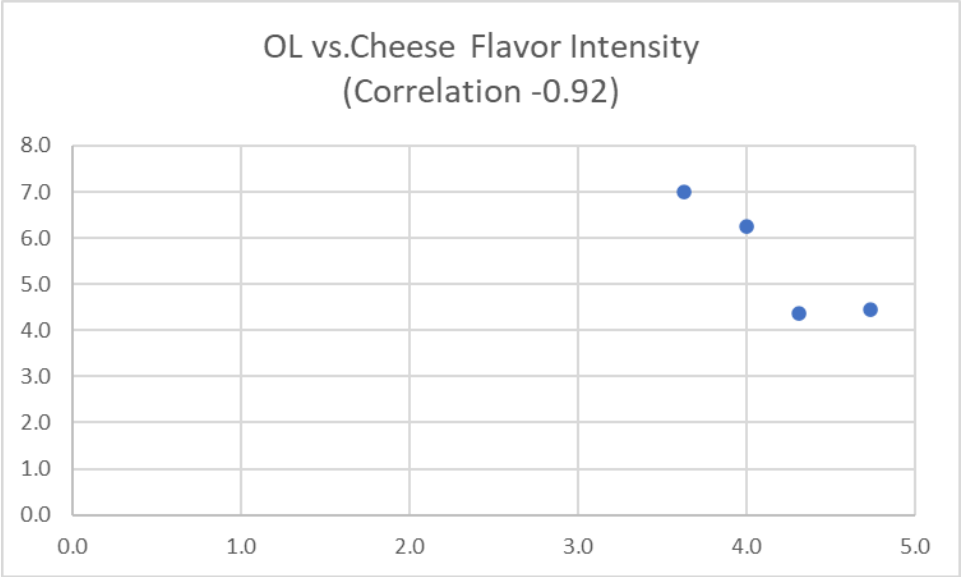
Odd Flavor	
Bad taste	Coffee
Like dirt	Chicken poop
Sweaty	Goat
Mushroomy	Off-flavor
Footy	Chalk
Spoiled	
Putrid	
Acidy	
Barny	
Moldy	
Gym socks	
Too sour	
Dirt	
Grassy	
Multi-vote: 10	

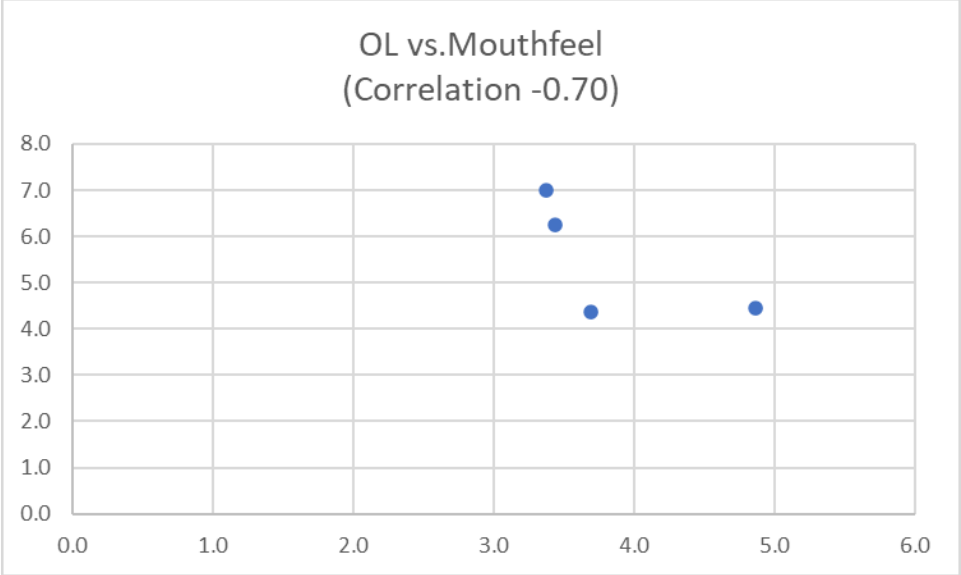
Bitterness
Very bitter
A little bit bitter
Multi-vote: 2

Appendix VIII: Consumer PEM PAA Attributes Vs. Overall Liking for Artisan Cheese






OL vs.Cheese Flavor Intensity
(Correlation -0.92)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0


OL vs.Mouthfeel
(Correlation -0.70)
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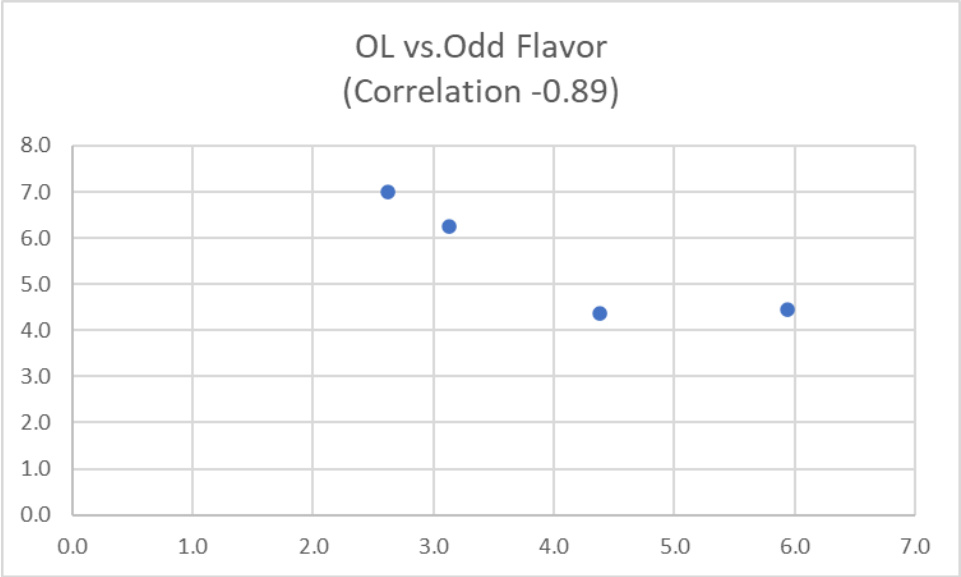
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0


OL vs.Odd Flavor
(Correlation -0.89)
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7.0
6.0
5.0
4.0
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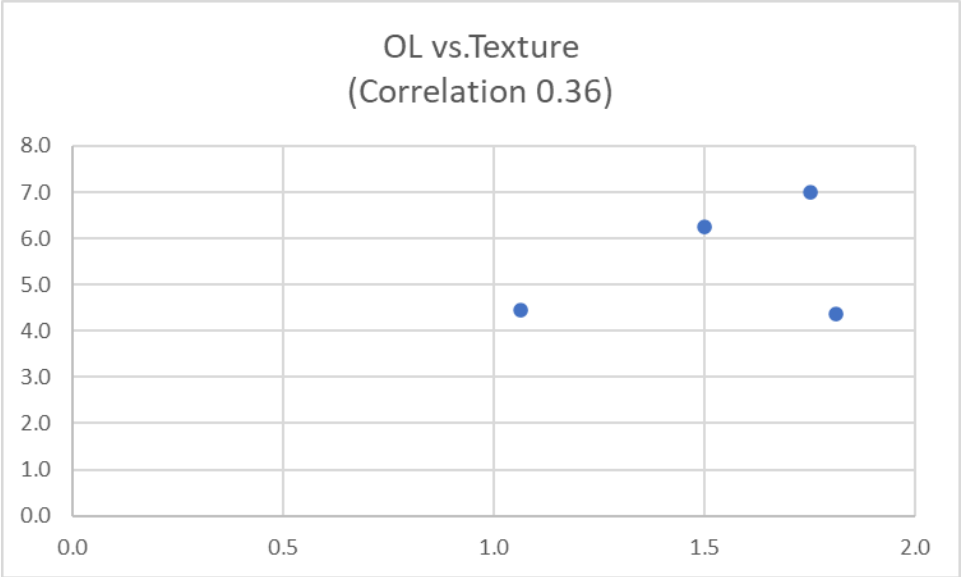
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0


OL vs.Texture
(Correlation 0.36)
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7.0
6.0
5.0
4.0
3.0
2.0
1.0
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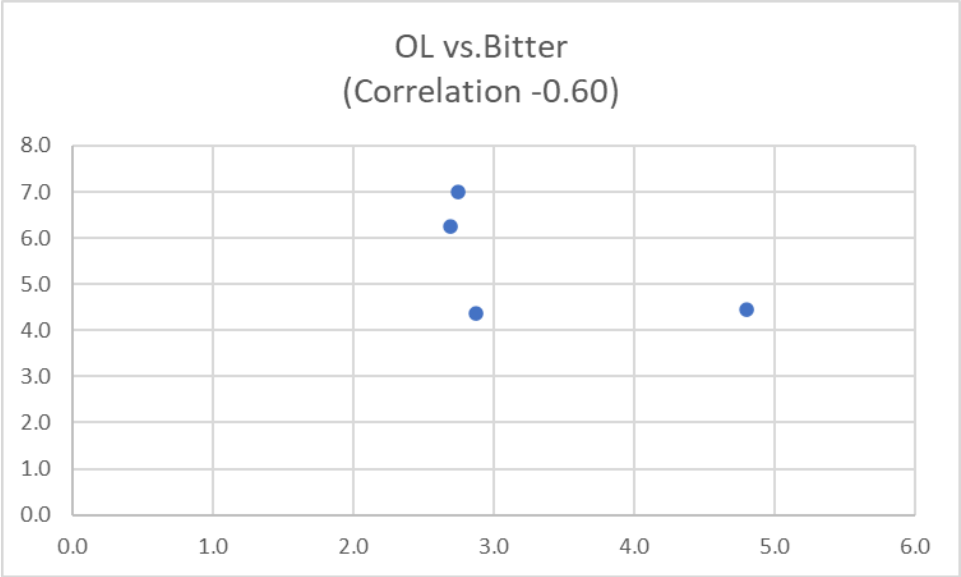
0.0
0.5
1.0
1.5
2.0


OL vs.Bitter
(Correlation -0.60)
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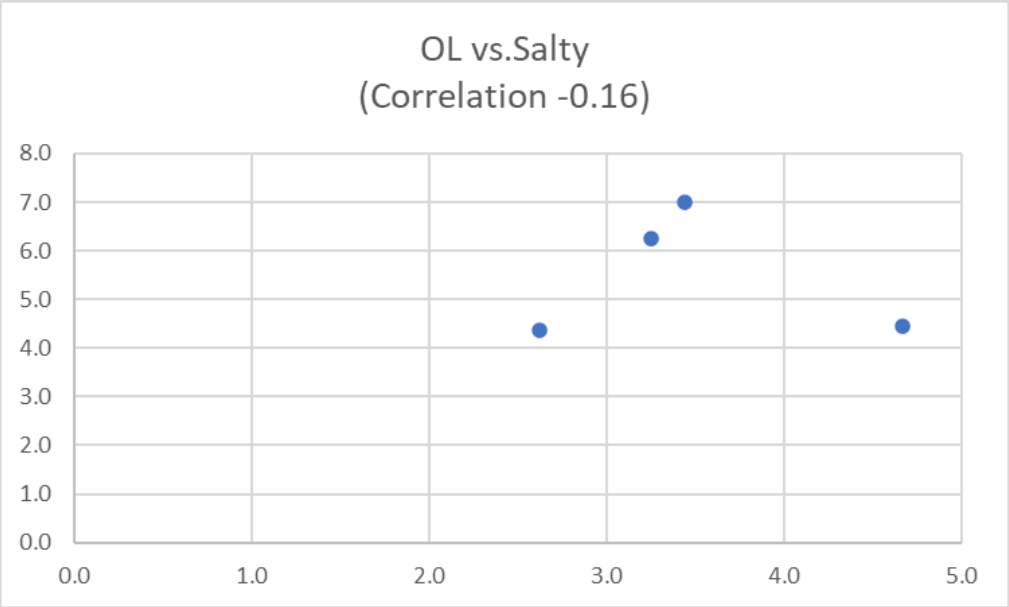
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0


OL vs.Salty
(Correlation -0.16)
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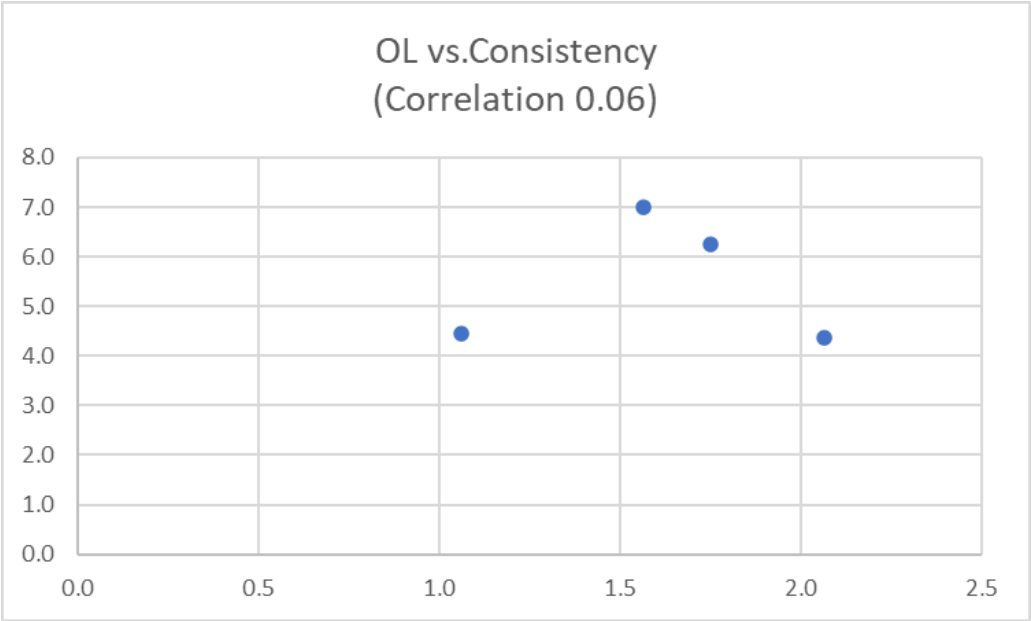
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0


OL vs.Consistency
(Correlation 0.06)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.0
0.5
1.0
1.5
2.0
2.5

Appendix IX: Artisan Cheese Chemical Analysis Results

	Peak Area/Concentration					
Compound	**Reading**	**Ashbrook**	**Whitney**	***Harbison***	***Tarentaise***	**Alpha Tolman**
2-Butanone	4880945	561816	762685	*3375727*	*597150*	237152
Ethyl Acetate	3503456	0	0	2762131	349045	464309
Acetic acid	5282437	1970740	3214724	1165965	1965173	1713268
2-Butanone, 3-methyl-	9346068	3288648	1207225	2083988	2515053	1352324
unk 1 FC 04 - 05	0	0	0	1005489	72325	769311
3-Penten-2-one	0	0	0	321404	61088	785667
Propanoic acid, 2-methyl-, methyl ester	0	0	18999	68961	0	63124
2-Pentanone	11836034	3957724	5350184	4358455	3048406	4402736
2,3-Pentanedione	0	0	546335	0	0	0
Pentanal	0	0	0	67471	0	0
Propanoic acid	0	0	0	1668	0	0
Furan, 2,5-dimethyl-	0	0	50525	1699979	0	0
Propanoic acid, ethyl ester	187787	400770	464192	1066642	103174	397634
n-Propyl acetate	6932611	1562352	1544908	9701320	1511710	1329124
Vinylfuran	756999	286764	30963	0	512162	173730
unk 1	38178	0	12629	0	12015	38810
1,2-propanediol	0	0	0	471982	0	0
1-Butanol, 3-methyl-	315643	0	528144	25825358	0	1105336
Disulfide, dimethyl	0	0	7421277	73513225	0	286092
Methyl Isobutyl Ketone	419635	373995	2064084	590181	957473	1061599
2-Pentanone, 3-methyl-	1394128	1544038	2162486	2447061	441936	2084332
Propanoic acid, 2-methyl-, ethyl ester	302649	613135	140331	500723	1036090	575010
1-Methylcyclohexa-1,3-diene	3833	33337	25122	0	32090	30645
Toluene	611382	335152	367444	11131946	363030	372853
Acetic acid, 2-methylpropyl ester	1466754	654875	316887	307584	243201	799312

2,3-Butanediol, [S-(R*,R*)]-	1353395	159892	3733052	1893805	976320	53247
2,3-Butanediol	1197406	176096	3971294	1840223	1078901	66461
Octane, 4-chloro-	0	0	0	2630083	0	0
Octane	1163180	528573	1643383	2212648	799895	258165
Propanoic acid, 2-methyl-, 1-methylethyl ester	778833	1682996	555046	1699775	1521494	3070837
Hexanal	166879	21813	108647	0	162465	104619
Butanoic acid, ethyl ester	63922	0	45297	1101013	1255919	1045109
1,3-Cyclopentadiene, 5,5-dimethyl-2-ethyl-	0	0	0	0	0	215
Furfural	0	0	0	0	7303	0
3-Hexanone, 5-methyl-	196720	0	1224323	0	513763	0
Butanoic acid, 2-methyl-, ethyl ester	24240	13135	5399	0	975	0
Butanoic acid, 3-methyl-, ethyl ester	0	0	0	2078	0	0
2-Furanmethanol	0	0	1391	23440	0	0
Ethylbenzene	138549	147319	124879	737721	141150	90819
p-Xylene	705493	975697	211082	3370557	508677	167237
1-Butanol, 3-methyl-, acetate	444872	55884	211540	1625097	319821	1707289
2,4-Dithiapentane	0	0	0	36460944	0	0
1-Butanol, 2-methyl-, acetate	32953	0	0	697514	172411	969951
Styrene	462849	364557	225738	374783	114959	124911
Butanoic acid, 3-methyl-	3998819	2794935	4158233	232926	3766727	5573584
Pentanoic acid, ethyl ester	0	0	4514	3229	0	0
Butyrolactone	13448	2295	0	142032	161423	0
beta-Myrcene	17143	563472	0	242751	124438	341180
2(5H)-Furanone	163796	230007	330317	296618	98702	303648
1,2,4,4-Tetramethylcyclopentene	0	0	0	39815	0	0
Propanoic acid, 2-methyl-, 2-methylpropyl ester	0	223633	0	0	39817	0
2-Pentanol, propanoate	786240	695092	682429	373187	652436	1657135
Hexanoic acid, methyl ester	1753174	1571297	1633938	279975	1369183	3721171

1-Methyl-6-methylenebicyclo[3.2.0]heptane	2484	0	1261	54794	9814	0
alpha-Pinene	959677	766114	713724	67381500	752739	1069145
S-Methyl 3-methylbutanethioate	22402	0	34856	765859	0	68929
Camphene	290138	262107	107495	2689496	138439	261661
Benzaldehyde	0	0	252113	0	21080	323235
2-Furancarboxaldehyde, 5-methyl-	0	0	24950	11817	7647	65846
Dimethyl trisulfide	638656	686474	1251252	30979520	1028873	1982140
Heptanol	85665	329464	33732	302865	136822	57106
1-Butanol, 2-methyl-, propanoate	700072	682390	129228	337559	1138451	0
Pentanoic acid, 4-methyl-	0	0	0	0	0	44045
3-Pentenoic acid, 4-methyl-	0	0	0	0	0	13702
2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	0	0	0	0	0	17896
1-Octen-3-ol	1158260	1151536	766846	859751	434672	250656
Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-, (1S)-((beta-Pinene))	562235	176995	570073	47905216	292686	828307
3-Octanone	0	0	71570	0	0	2110207
3(2H)-Thiophenone, dihydro-2-methyl-	27813	0	847218	0	47846	437679
Benzene, 1,3,5-trimethyl-	2740322	5712436	53175	1263578	2059127	40704
2-Octanone	643524	1852424	275531	242040	684230	385266
1,6-Octadiene, 2,7-dimethyl-	0	240186	0	19860186	0	0
2,6-Octadiene, 2,7-dimethyl-	0	89024	0	19155132	0	0
beta-Pinene	127047	0	39314	7266831	0	52608
2-Furanmethanol, acetate	92794	69958	36257	20772	41437	34157
2-Octanol	173683	0	4516	0	50592	20901
Hexanoic acid, ethyl ester	1518502	2232478	596180	699314	1771769	3623956
Hexanoic acid	2747277	620963	3121948	2372168	2701036	3126984
3-Hexenoic acid, ethyl ester	47440	181914	6551	80999	34628	16711

3-Carene	284504	283976	167291	5781158	224038	182624
Acetic acid, hexyl ester	391919	674917	228119	464561	224492	618311
Propanoic acid, 2-methyl-, 3-methylbutyl ester	0	0	0	76788	0	0
Butanoic acid, 3-methylbutyl ester	0	52115	0	325007	0	0
Benzene, 1-methyl-3-(1-methylethyl)-	2075925	845271	173972	4810737	491762	556290
Cyclohexene, 1-methyl-5-(1-methylethenyl)-, (R)- inst 1	296349	384386	118939	20508831	246374	249352
Cyclohexene, 1-methyl-5-(1-methylethenyl)-, (R)- inst 2	237561	278215	142299	19899562	88780	124372
Benzeneacetaldehyde	642168	513331	753997	464284	1322385	657735
Butanoic acid, 3-methylbut-2-enyl ester	0	253661	0	32223	0	0
1,4-Cyclohexadiene, 1-methyl-4-(1-methylethyl)-	0	0	2978	749158	148	10825
Butanoic acid, 2-methylbutyl ester	0	0	0	568648	0	0
Ethyl 5-methylhexanoate	0	0	699	0	0	1143
Acetophenone	244243	329527	199031	359762	302217	217403
1-Octanol	674165	829576	291784	544207	575612	502756
alpha-Methyl-?-[4-methyl-3-pentenyl]oxiranemethanol	0	0	0	3689442	0	0
Benzene, 1-ethenyl-4-ethyl-	432525	410530	415343	630842	435214	562999
Cyclohexene, 1-methyl-4-(1-methylethylidene)-	6483	0	89816	2524418	3838	81113
Octanoic acid, methyl ester	0	0	649	0	0	6052
Phenol, 2-methoxy-	0	0	0	1588122	0	0
Benzene, 1-ethenyl-3-ethyl-	373183	359589	372795	654095	383315	503393
Benzoic acid, methyl ester	0	0	1128	0	0	0
4H-Cyclopenta[c]furan, hexahydro-1,1-dimethyl-4-methylene-	17191	0	34808	63822	9077	42589
2-Nonanone	23500246	73052050	11258083	24798353	18957161	9464006
Nona-3,5-dien-2-ol	620112	2028464	360645	872393	436643	153344
Heptanoic acid, ethyl ester	10152	30964	5982	6483	10893	44187
(3S,4R,5R,6R)-4,5-Bis(hydroxymethyl)-3,6-dimethylcyclohexene	0	0	13936	0	8157	17683

Furan, 3-(4-methyl-3-pentenyl)-	111893	0	0	0	98439	0
3,5-Heptadien-2-one, 6-methyl-, (E)-	0	0	0	254731	0	0
Butanoic acid, 2-methyl-, 2-methylbutyl ester	0	0	0	0	0	24248
1,6-Octadien-3-ol, 3,7-dimethyl-	0	0	11236	1075959	0	0
2-Pentenoic acid, 2-methyl-	1534031	1673617	13816	828340	146032	43608
Butanoic acid, 3-methyl-, 3-methylbutyl ester	7997	14750	0	597169	40227	83329
Nonanal	563238	1042034	210695	1012261	538948	112900
Propanoic acid, hexyl ester	552059	482397	908784	870799	191215	708467
Butanoic acid, 3-methyl-, 2-methylbutyl ester	73216	119849	7479	18373	0	25692
Bicyclo[2.2.1]heptan-2-ol, 1,3,3-trimethyl-	176522	157466	107171	169811	189025	69307
Benzene, 1,3-diethenyl-	130077	166491	164747	166699	157188	230270
2-Nonanol	4273299	5239056	22308	3487063	886685	42414
Acetic acid, heptyl ester	1028142	1958196	1278641	1225432	550106	664007
Maltol	0	0	29008	0	0	69544
Phenylethyl Alcohol	386936	1447178	1760417	23643678	594524	543597
7-Octen-2-ol, 2-methyl-6-methylene-	35255	0	10567	31589	22602	4099
1-Allylcyclopropanecarboxylic acid	127056	185883	3742	3046	14541	5529
Disulfide, methyl (methylthio)methyl	6021	0	0	7018988	4182	48972
Benzene, 1,4-diethenyl-	168754	191651	184994	298155	195669	264110
Benzyl methyl ketone	924829	625774	2387976	487330	629835	1470922
Heptanoic acid	14731	8737	6071	23783	14799	6631
Cyclohexane, 2-ethenyl-1,1-dimethyl-3-methylene-	58635	192060	32252	298310	76465	19711
(S)-(+)-6-Methyl-1-octanol	12864	158779	0	381192	6547	0
Bicyclo[3.1.1]heptan-3-ol, 6,6-dimethyl-2-methylene-, [1S-(1?,3?,5?)]-	97079	154845	407657	4839514	75120	397333
2,7-Octadien-4-ol, 2-methyl-6-methylene-, (S)-	1660	0	46438	0	2051	30160
Butanoic acid, hexyl ester	0	0	1406	360777	0	0

4-Isopropylcyclohexanone	30422	185766	6482	445702	44512	0
1,5,7-Octatrien-3-ol, 2,6-dimethyl-	15836	58087	679	642810	79333	0
Borneol	113080	89870	65213	7657571	47289	61399
unk X	1168	6699	4674	0	18593	7941
2(10)-Pinen-3-one, (?)-	20539	18691	35769	2251174	20324	16820
Benzoic acid, ethyl ester	1859	946	0	0	779	0
3-Cyclohexen-1-ol, 4-methyl-1-(1-methylethyl)-, (R)-	21637	44521	25379	188124	18238	26388
Bicyclo[3.1.1]heptan-3-one, 2,6,6-trimethyl-, (1?,2?,5?)-	116044	116750	94182	6526372	86516	142799
7-Decen-2-one	68822	111664	70110	272637	47315	87576
Naphthalene	149107	168619	88119	176895	149939	82920
3-Cyclohexene-1-methanol, alpha, alpha, 4-trimethyl-	36644	0	35531	3190585	8880	81937
2-Decanone	185042	780987	162909	442308	171346	100734
Benzoic acid, 2-hydroxy-, methyl ester	11831	5354	16124	0	9884	13579
Bicyclo[3.1.1]hept-2-ene-2-carboxaldehyde, 6,6-dimethyl-	14698	14174	73458	1875018	5921	9644
2-Decanol	0	0	13425	84007	0	24870
Bicyclo[3.1.1]hept-2-ene-2-methanol, 6,6-dimethyl-	0	0	0	10394097	0	0
4-Octenoic acid, ethyl ether	122	269	81	5361	1217	0
Octanoic acid, ethyl ester	390693	668989	7518	806	202040	174214
Decanal	41822	50611	75946	217971	140665	20166
4-Nonenoic acid, methyl ester	8536	5185	5871	0	12798	327
Bicyclo[3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-	185090	108652	80961	2443662	67812	202082
Cyclohexanol, 2,2,6,6-tetramethyl-	31721	26405	34721	116801	15438	21238
2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)- INST 1	15347	25338	27082	89347	24794	21806
6-Octen-1-ol, 3,7-dimethyl-, (R)-	15041	30290	8579	230198	11591	10456
p-Mentha-1(7),8(10)-dien-9-ol	4911	3173	655	243723	3714	4111
2-Propenoic acid, octyl ester	183952	182957	247304	361136	123483	125787
2-Octen-1-ol, 3,7-dimethyl- YOU Can see both SI	19544	41522	21917	142207	25521	20084
Octanoic Acid	12940	21227	2725	0	129125	4230
Benzeneacetic acid, ethyl ester	12639	7434	5115	114479	7227	44426
Isopentyl hexanoate	122548	95590	10964	29101	47148	15083

2-Cyclohexen-1-one, 3-methyl-6-(1-methylethyl)-	31371	34726	8053	80338	14815	12870
p-menth-1-en-8-ol	3941	3971	2548	0	3984	5222
Acetic acid, 2-phenylethyl ester	0	0	0	4546371	0	0
2,6-Octadien-1-ol, 3,7-dimethyl-, (E)-	0	2555	0	0	6620	0
Octanoic acid, 4-methyl-, ethyl ester	2452	1891	6486	5614	4594	4702
2,6-Octadienal, 3,7-dimethyl-	56336	155077	14631	915722	32371	0
trans-Shisool	2535	984	3434	182256	2862	6093
3-Octen-2-ol	91378	362670	26399	135634	116038	32273
1-Decanol	91425	86680	83445	254273	107629	76584
Pentadecane	740822	531976	803397	1573785	466965	543823
2,6-Octadienoic acid, 3,7-dimethyl-, methyl ester, (Z)-	24631	89887	61701	229653	64000	39304
3-Nonenoic acid, ethyl ester	180	0	1621	0	2615	3116
Indole	79537	45261	1677512	490009	355906	4267097
Nonanoic acid	129698	112583	233492	202678	173887	186411
Nonanoic acid, ethyl ester	5438	0	17906	5901	0	47295
2-Undecanone	3580607	15006663	1855693	7838913	2134977	1154218
1-Cyclohexene-1-methanol, 4-(1-methylethenyl)-	5381	13901	7319	62349	3056	6246
2-Undecanol	131859	501671	2085	408429	16460	7464
Formamide, N,N-dibutyl-	126861	101986	109412	187399	123576	134409
4-Decenoic acid, methyl ester	0	0	7012	0	0	15792
2-Methoxy-4-vinylphenol	2014	3064	6337	509827	5545	16237
Heptadecane	568566	269905	510301	357201	338060	455995
2,6-Octadienoic acid, 3,7-dimethyl-, methyl ester	26378	29838	85567	53531	43698	55431
Tricyclo[5.4.0.0(2,8)]undec-9-ene, 2,6,6,9-tetramethyl-	0	0	0	559927	0	0
Benzenepropanoic acid, ethyl ester	0	795	0	89433	0	0
3-Decenoic acid	545758	279014	323771	423005	490932	624655
Copaene	3393	2086	4620	38273	7562	5963
Ethyl trans-4-decenoate	8303	12998	33786	29647	14274	16063
2-Buten-1-one, 1-(2,6,6-trimethyl-1,3-cyclohexadien-1-yl)-	8348	7606	11107	12445	14502	3448
Hexanedioic acid, diethyl ester	0	743	4622	18899	2963	802

10-Methyl-3,4,5,8,9,10-hexahydrooxecin-2-one	187654	41331	34820	53042	40226	118456
2-Dodecanone	0	0	6061	9988	0	0
Decanoic acid, ethyl ester	293717	259482	64109	333327	124156	145183
Tetradecane	380968	351904	412209	879142	398162	319304
n-Decanoic acid	2089056	1334469	1707825	2073127	2154390	2363012
1,4-Methanoazulene, decahydro-4,8,8-trimethyl-9-methylene-, [1S-(1?,3a?,4?,8a?)]-	9130	8211	10429	435373	14372	10810
Caryophyllene	5112	7304	10296	137584	71857	18649
1H-Cyclopenta[1,3]cyclopropa[1,2]benzene, octahydro-7-methyl-3-methylene-4-(1-methylethyl)-, [3aS-(3a?,3b?,4?,7?,7aS*)]-	0	0	0	59176	0	0
5,9-Undecadien-2-one, 6,10-dimethyl-, (E)-	76279	82562	101876	129446	71276	76823
2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)- DROP	2534	3092	4340	25842	6520	8345
alpha-Caryophyllene	52	1197	6978	174447	12268	10914
1,6-Octadiene, 3-ethoxy-3,7-dimethyl-	66718	84579	73559	175342	75184	84481
2-Propenoic acid, 3-phenyl-, ethyl ester	0	276	0	0	0	663
2,6-Octadien-1-ol, 3,7-dimethyl-, acetate, (Z)-	4909	5453	13469	24875	8604	12538
Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1?,4a?,8a?)-1	13103	8210	18179	56736	5034	10636
Naphthalene, 1,2,4a,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1?,4a?,8a?)-	3112	2609	4036	23364	2261	2907
Unk ABA 1	148401	740102	99770	124397	33467	75467
Naphthalene, decahydro-4a-methyl-1-methylene-7-(1-methylethenyl)-, [4aR-(4a?,7?,8a?)]-	1006	1023	4428	51102	6986	5887
1,5-Dimethyl-1-vinyl-4-hexenyl butyrate	0	0	0	126382	0	0
Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-4a,8-dimethyl-2-(1-methylethenyl)-, [2R-(2?,4a?,8a?)]-	2389	2709	3571	36231	3924	5794

2H-Pyran-2-one, tetrahydro-6-pentyl-	681828	700509	1006579	206645	890110	1014076
2-Tridecanone	0	85296	0	685304	0	0
Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-1	4188	2629	19772	69225	5178	9677
alpha-Farnesene	21719	19810	13564	42270	32680	42481
(-)-Myrtenyl acetate	0	0	0	806507	0	0
Benzenamine, N,N,3,5-tetramethyl-	14412	19654	12814	19433	19576	17965
Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-4-methylene-1-(1-methylethyl)-, (1?,4a?,8a?)-	0	0	9102	45829	0	0
Butanoic acid, 3,7-dimethyl-2,6-octadienyl ester, (E)-	3663	3035	4397	31506	2147	4620
Naphthalene, 1,2,3,4-tetrahydro-1,6-dimethyl-4-(1-methylethyl)-, (1S-cis)-	1768	5405	3588	18000	7848	1358
Spiro[2.3]hexan-4-one, 5,5-diethyl-6-methyl-	4360	2640	3454	7904	3275	4748
Nerolidyl acetate	1908	2535	2091	9490	2423	1108
Caryophyllenyl alcohol	7696	7886	4380	9079	11791	7707
10-Undecen-1-yl acetate	3053	2312	2768	15936	4098	6772
Dodecanoic acid	269603	96533	614951	609678	296541	476250
3,6-Dodecadienoic acid, methyl ester	0	721	0	57112	0	0
Dodecanoic acid, ethyl ester	59113	49847	36408	49764	36574	42495
Caryophyllene oxide - inst 2	0	0	0	60041	0	0
3,7-Cycloundecadien-1-ol, 1,5,5,8-tetramethyl-	0	0	0	22569	0	0
12-Oxabicyclo[9.1.0]dodeca-3,7-diene, 1,5,5,8-tetramethyl-, [1R-(1R*,3E,7E,11R*)]-	706	626	699	20753	1071	667
1-Naphthalenol, decahydro-1,4a-dimethyl-7-(1-methylethylidene)-, [1R-(1?,4a?,8a?)]-	402	535	954	3891	701	234
Cubenol - inst 2	151	0	167	28561	149	218
Benzophenone	7131	15874	12328	21491	46381	12102
tau-Muurolol	575	858	2482	6180	5080	3395
1-Naphthalenol, 1,2,3,4,4a,7,8,8a-octahydro-1,6-dimethyl-4-(1-methylethyl)-, [1R-(1?,4?,4a?,8a?)]-	0	0	0	6395	0	0

2-Naphthalenemethanol, 1,2,3,4,4a,5,6,8a-octahydro-?,?,4a,8-tetramethyl-, [2R-(2?,4a?,8a?)]-	370	247	2721	2716	1941	2132
alpha-Cadinol	1969	964	1999	4170	1824	4618
Caryophyllene oxide - inst 1	0	0	0	90041	0	0
2,6-Octadienedioic acid, 2,6-dimethyl-, dimethyl ester, (E,E)-	563	255	289	2158	560	374
2-Pentadecanone	0	7751	22030	271095	23340	12178
2H-Pyran-2-one, 6-heptyltetrahydro-	155088	168151	262024	136192	244801	283131
2,6,10-Dodecatrien-1-ol, 3,7,11-trimethyl-, (E,E)-	1863	5034	6245	3542	3479	2928
Tetradecanoic acid	103070	55855	225552	268934	90108	190152
n-Hexadecanoic acid	2782009	2467029	3788054	3839730	3340053	2643518
4,4,5',5'-Tetramethyl-bicyclohexyl-6-ene-2,3'-dione - inst 2	0	0	31	181	0	0
9,12-Octadecadienoic acid (Z,Z)-	16745	0	31349	32923	1777	20299
Octadecanoic acid	874853	899736	1107577	1093016	1037547	888348
Eicosanoic acid	4702	2414	5718	5230	3469	5412