Expanding Local Markets Through Evaluating Sensory Characteristics and Agronomic Performance of Flint Corn Varieties.

Sensory Workshops

NORTHEAST SARE
Sustainable Agriculture Research & Education

THE UNIVERSITY OF VERMONT EXTENSION
Northwest Crops and Soils Program

"This material is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, through the Northeast Sustainable Agriculture Research and Education program under subaward number ONE20-362."

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A little about me before we begin…..

Work Side – 40 yrs.

- Professional Trained Panelist
- Instructor/Trainer (Global)
- Innovative Consumer Insight
- Sensory Strategy
- Problem Investigation
- Packaging Materials
- Legal

Personal Side

- Happily Married
- Father of three awesome kids
- Proud Grandfather (Papa)
- Love people and stories
- Love to travel

And now, how about you?

Safety Moment – Pay attention to "sensory cues" (heightened awareness)

• ***Sight*** – "Is something out of place?"	Unknown liquids, change in color, bulging tanks, bending pipes/stress, oil stains, etc.
• ***Smell*** – "A strange aroma that should not be there?"	Underwater cherry, sweet odor, scorched paper, smoky, nutty, floral, etc.
• ***Sound*** – "A strange noise that should not be there?"	Dripping, squeaking belts, movement/hissing, clinking, etc.
• ***Touch*** – "A strange feel that should not be there?"	Slippery, sticky, slimy (acids, bases, and microbes), Hot and cold (Active fire, chemical reactions)
• ***Taste*** – "A strange taste that should not be there?"	Bitter (in conjunction with smells)

Simply taking a few moments to be aware of your surroundings can help avoid accidents, and potentially save lives.

Workshop Objectives and Approach

The main objective of today's sensory workshop is to teach you how to conduct objective descriptive sensory analysis (DSA) on grains using Profile Attribute Analysis (PAA), with texture attributes.

I will use presentation materials, and facilitated taste sessions, to achieve my objective.

We will provide you with an electronic copy of the training materials after the workshop has been completed.

A word about safety in sensory:

- Our highest priority is the health and well being of our sensory panelists (Tasters)
- Everything we will provide you is safe to smell and taste
- We take Covid-19 seriously and have taken ever possible precaution to ensure your safety. We recommend that you do the same.
- We do worry about allergies, so be careful
- Smell and taste as little product as you need
- Never taste samples that you do not know the entire history of such as product returns and complaints

Sensory vs. Chemistry

Chemical Name	100% Threshold Concentration (ppb)	Reported Range from Literature (ppb)
Acetone	100,000	200–200,000
Toluene	2,100	21–69,000
n-Butanol	150	50–990,000
Pyridine	21	0.2–10,000
Methyl Mercaptan	2.1	0.00015–500
Ethyl Mercaptan	1.0	0.01–18,000
Dimethyl sulfide	1	0.2–150
Butyric acid	1	0.0007–10
O-Cresol	0.63	.01–20,000,000
Hydrogen sulfide	0.47	0.07–1,500
Trimethylamine	0.21	0.2–2,000
Dodecanethiol	0.1	.0001
o-Chlorophenol	0.10	—
p-Chlorophenol	0.01	—
o-Iodophenol	0.001	—
Methyl Indole	—	0.0001–50

The human nose is more sensitive than any instrument in the world. Analytical chemistry only tells part of the story.

A few words about Sensory Habits and Hygiene:

- Observing good sensory hygiene is critical to sensory panel success. A sensory panel requires more control than the most sophisticated laboratory in the world
- Avoid using products with a fragrance on days that you plan to smell and taste:
  - Perfume and Aftershave
  - Fragrant soaps and shampoo
  - Fragrant detergents

- Wash hands frequently with water and minimal soap and avoid paper towels just prior to panels
- No smoking immediately prior to sensory panels
- No eating or drinking within 30 minutes of a sensory panel
- Do not brush your teeth with 60 minutes of a sensory panel and avoid breath mints and flavored gum.

Sensory Methods And Uses

Sensory Methods

1. Affective tests
2. Difference tests
3. Expert taster
4. Descriptive analysis

Sensory Methods

1 Affective tests

Which do you like better?

Check One ☐ ☐ ☐ ☐ ☐

Advantages:

- Can use untrained people
- Can test many samples– large database
- Inexpensive

Disadvantages:

- Absence of descriptive words
- Doesn't answer the question "Why?"

Common Uses

Testing existing products to determine the role flavor plays in overall preference.

Testing new products for general/degree of acceptance or preference.

Testing prototypes to get directional information. (Sensory Directed Product Development)

Risk assessment for changes in Raw Materials, Processing, and Packaging.

Testing new products from competitors to assess risk of losing market share.

Sensory Methods

2 Difference tests

Which one of these is different? (Triangle Test, Duo-Trio, Paired Comparison, and others)

A B A

Advantages:

- Can use trained or untrained people
- Can apply statistics
- Can determine minute differences

Disadvantages:

- Time-consuming
- Highly variable
- Doesn't answer the question "Why?"

Common Uses

- Used to assess minute differences
- Raw material changes
- Processing changes
- Packaging changes
- Used to assess complaints

Sensory Methods

3 Expert taster

☞ Brewmaster

☞ Wine taster

Advantages:

- ☞ Experienced (highly skilled)
- ☞ Knows in-process and finished product
- ☞ Consistent
- ☞ Descriptive

Disadvantages:

- ☞ Often subjective
- ☞ Limited sensory vocabulary
- ☞ Product-specific

Common Uses

Evaluate in-process beer

Look for minute differences in a beer

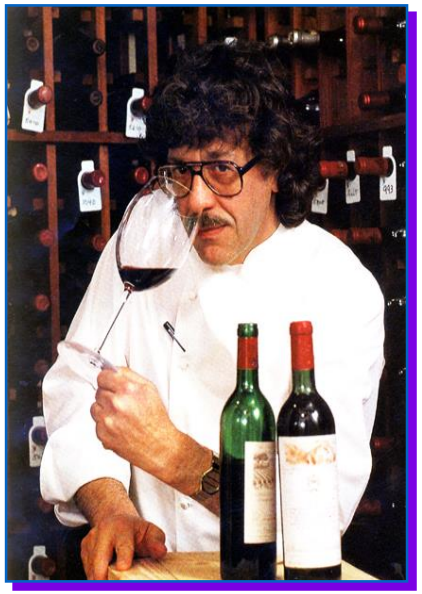
To investigate off-flavor problems

To assess new materials or process

New product development

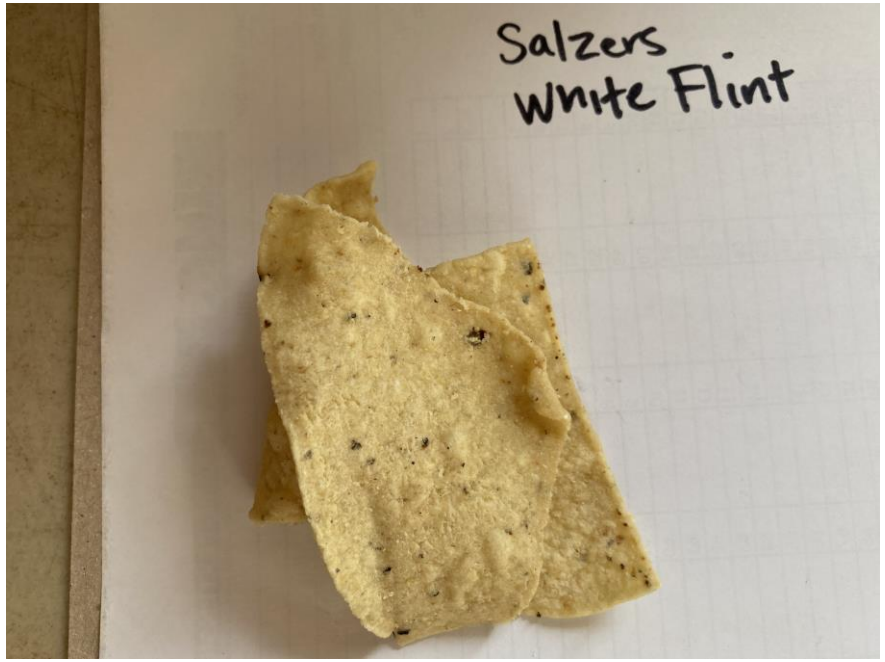
Product Optimization

Quality Assurance



Sensory Methods

4 Descriptive analysis



What does it taste like?

- **i.e., Flavor Profile**
- **Profile Attribute Analysis**

Advantages:

- ☞ Objective
- ☞ Reproducible (can apply statistics)
- ☞ Quantitative and qualitative

Disadvantages:

- ☞ Need properly trained people
- ☞ Need experience in interpretation of data

Common Uses

- New product development
- Product flavor benchmarking
- Problem Solving
- Consumer Intelligence
- Raw material and process changes
- Competitive benchmarking

- Research
- Quality assurance and control
- Strategy
- New package development
- Understanding distribution effects
- More, and more, and more

Descriptive Sensory Analysis

The Flavor Profile Method

Profile Attribute Analysis (PAA)

The Flavor Profile Method of Sensory Analysis was developed by Arthur D. Little during the early 1940's.

First descriptive sensory analysis method in the world

- Basis for descriptive testing done throughout the world today.

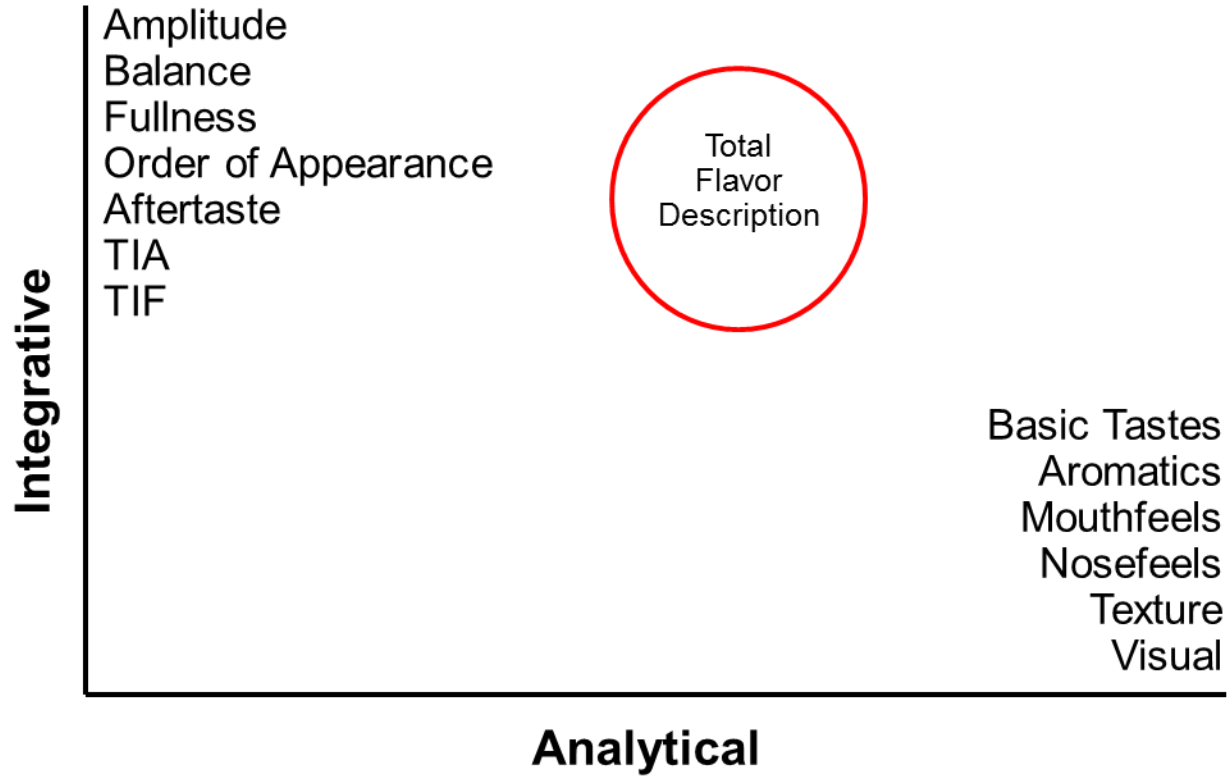
Qualitative as well as quantitative

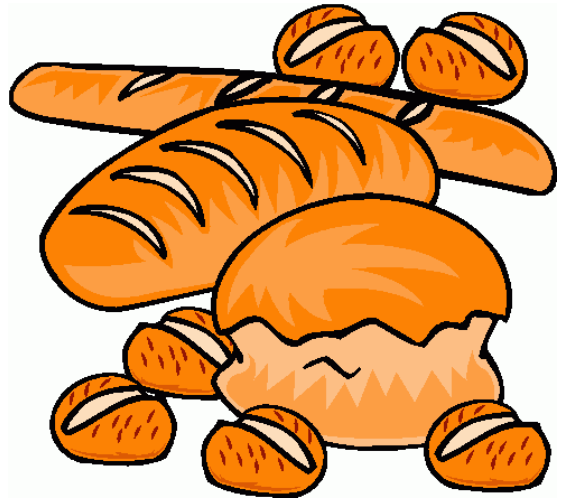
Introduced overall concept of Amplitude

- Balance
- Fullness

Standard Method (ASTM)

The Flavor Profile Method of Sensory Analysis identified both integrative and analytical dimensions of flavor





The most powerful intensity scale, because it can be measured consistently and relates best to end users, is the original seven-point intensity scale developed by ADL and MIT.

Original Flavor Profile Scale (ASTM)

0	=	None
1/2	=	Very Slight
1	=	Slight
1 1/2	=	Slight to Moderate
2	=	Moderate
2 1/2	=	Moderate to Strong
3	=	Strong

How do you produce a flavor profile?

First you smell the sample, Flavor-by-nose, commonly referred to as **Aroma**, and assign a rating for overall balance and fullness.

Next we define individual odor characteristics, in the order that they are perceived, and give them each intensity ratings.
We typically record two types of characteristics in the Aroma:

Aromatics
Feeling Factors

We always describe aromatics that are sweet, or sour, using and adjective. We never use the terms salty, or bitter, in the aroma. Instead we use the terms briny, and resinous.

Flavor Profile - Aroma

Amplitude	Rating
Balance	Rating
Fullness	Rating

Green grassy	1 ½
Fermented hay	1
Citrus. Lemon	1
Sweet floral	1
Nose sting	1
Resinous	½

How do you produce a flavor profile?

Next we taste the sample, Flavor-by-mouth, often referred to as **Flavor**, and rate balance and fullness.

Next we define individual flavor characteristics, in the order that they are perceived, and give them each intensity ratings. We typically record three types of characteristics in the flavor:

Basic Tastes
Aromatics
Feeling Factors (Mouthfeels)

Flavor Profile - Flavor

Amplitude	Rating
Balance	Rating
Fullness	Rating

Sweet	1 ½
Fermented hay	1
Citrus. Lemon	1
Sour	1 ½
Sweet floral	1
Astringent	2
Bitter	1
Dry	1 ½
Metallic	1

How do you produce a flavor profile?

Lastly, we record **Aftertaste** which is the flavor left in your mouth at a specified period of time after your last taste. (Usually 1 minute)

Basic tastes, Aromatics and Mouthfeels can all be recorded if still present. However, order or appearance is not recorded.

We typically do not measure the intensity of the attributes in aftertaste, but can adjust the method to do so.

Flavor Profile - Aftertaste

- Basic tastes
- Aromatics
- Mouthfeels

Example of a complete flavor profile

Flavor Profile - Aroma	
Balance	1 ½
Fullness	2
Toasted grain	1 ½
Yeasty Sour	1 ½
Citrus, lemon	1
Sweet fruity	1
Fresh oil	1
Briny	½

Flavor Profile - Flavor	
Balance	2
Fullness	1 ½
Sweet	1 ½
Toasted grain	1 ½
Fresh Yeast	2
Salty	1
Sour	1
Fruity	1
Dry	2
Bitter	½
PMF	1 ½
Metallic	½

Flavor Profile - Aftertaste
Grainy
Yeasty
Dry

Flavor Profile Limitations

- Flavor Profile provides a complete blueprint of beer:
  - Aroma, Flavor, and Aftertaste
  - Balance and Fullness
  - Detailed characteristics
  - Individual intensities
  - Order of appearance

- But….
  - Takes time (2 per hour)
  - Often generates too much information
  - Difficult to analyze the data (statistics)
  - Not easy to interpret and illustrate results

Flavor Profile- Beer

Pale Ale	
AROMA	
Balance	1 1/2
Fullness	2
Burnt caramelized malt	2
Green resinous hops	1 1/2
Yeasty, fresh bready	1
Diacetyl	1
Alcohols, winy	1 1/2
Resinous	1

Pale Ale	
FLAVOR	
Balance	1
Fullness	1 1/2
Sweet	1
Burnt caramelized malt	2
Green resinous hops	1 1/2
Sour	2
Astringent	1 1/2
Alcohols	1 1/2
Bitter	2 1/2
Yeasty and mouthfeel	1 1/2
Tannin mouthfeel	2
Diacetyl	1
Iron	1 1/2

Pale Ale
AFTERTASTE
Bitter
Hops
Tannin mouthfeel

We use the same seven point scale as Flavor Profile with PAA but change the numbers to eliminate 0 and fractions.

FP		Intensity Words		PAA
0	=	None	=	1
1/2	=	Very Slight	=	2
1	=	Slight	=	3
1 1/2	=	Slight to Moderate	=	4
2	=	Moderate	=	5
2 1/2	=	Moderate to Strong	=	6
3	=	Strong	=	7

We create a PAA ballot by predetermining which aroma and flavor characteristics best define and differentiate products.

ATTRIBUTES	SCALE 1 2 3 4 5 6 7	
Balance	Unblended ⟷	Blended
Fullness	Thin ⟷	Full
Hop Intensity	None ⟷	Strong
Grain Intensity	None ⟷	Strong
Fruity/Alcohols/Yeast	None ⟷	Strong
Sweet	None ⟷	Strong
Sour	None ⟷	Strong
Bitter	None ⟷	Strong
Mouthfeel	None ⟷	Strong
Others	None ⟷	Strong
Aftertaste	None ⟷	Strong

What do changes and what do we lose?

- Numbers change to whole, but scale remains the same
- Aftertaste – measure intensity after 1 minute
- Mouthfeel – Overall intensity or specific
- We only measure what we are asked to measure
- Lose order of appearance

What do we gain?

- Speed/more samples per hour
- Statistical power
- Interpretive and illustrative power
- Increased ability to correlate with consumer data
- Easier to use in sensory directed product development

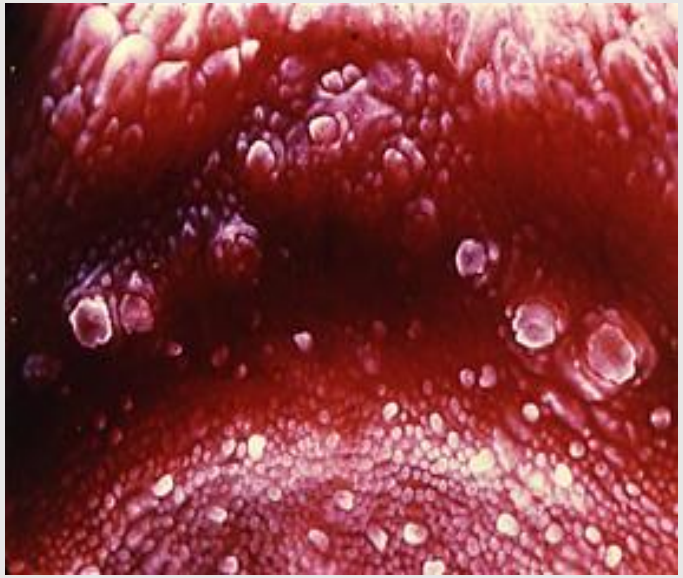
The Basics of Descriptive Sensory Analysis

Flavor is made up of three components.

1. Basic Tastes
2. Aromatics
3. Mouthfeels

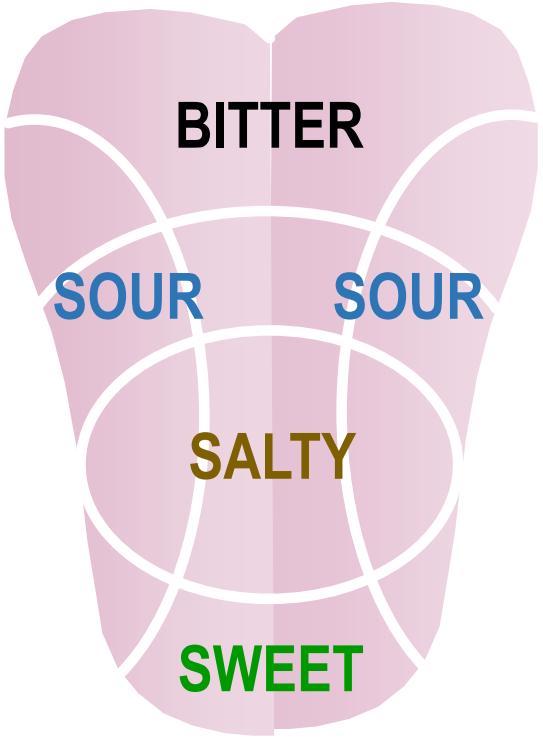
Basic Tastes Measured by our taste buds

Basic tastes refer to those sensations perceived through the stimulation of the receptor cells enclosed within the taste buds on the tongue.



The taste must dissolve in the saliva in your mouth to be carried into the taste bud and detected.

Basic Tastes Where are they perceived?

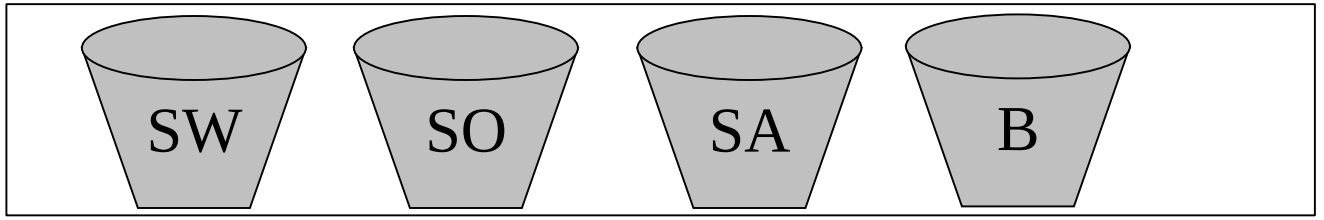


BASIC TASTE	PERCEIVED…
SWEET	Tip of Tongue
SALTY	Front Sides of Tongue
SOUR	Back Sides of Tongue
BITTER	Back of Tongue

Note: We recognize umami as a fifth basic taste.

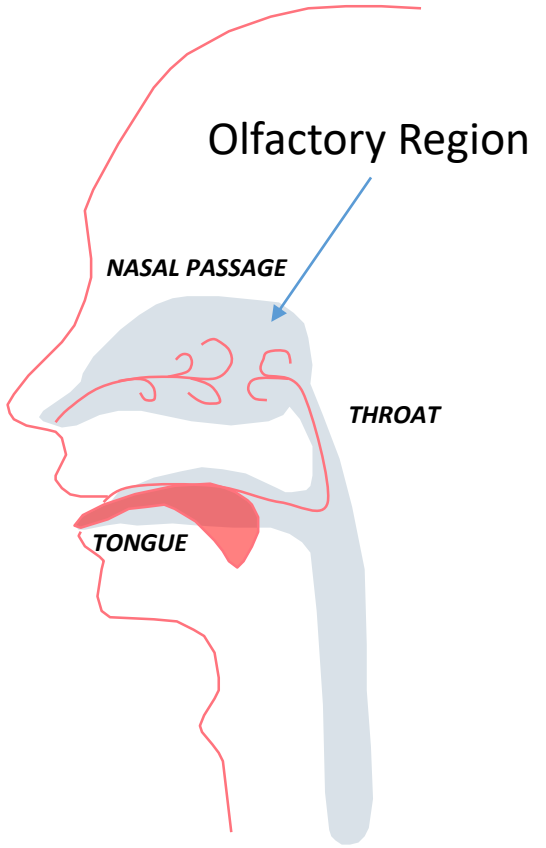
We can only detect basic tastes in our mouth since we only have these 5 types of taste buds.

Basic Taste Solutions



Aromatics Practice

Aromatics have two paths they can take to be detected in the olfactory region.



Aroma aromatics travel directly through the nose, and are detected in the olfactory region of the nose.

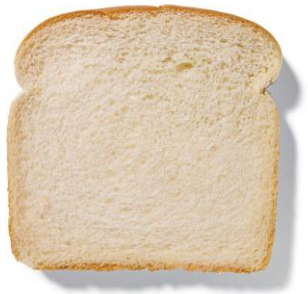
Flavor aromatics are compounds volatized in the mouth, travel up the back passage, and are detected in the olfactory region of the nose.

Mouthfeels describe chemical or physical sensations that are felt in the mouth, nose, or throat.

Astringent

Dry/tannin

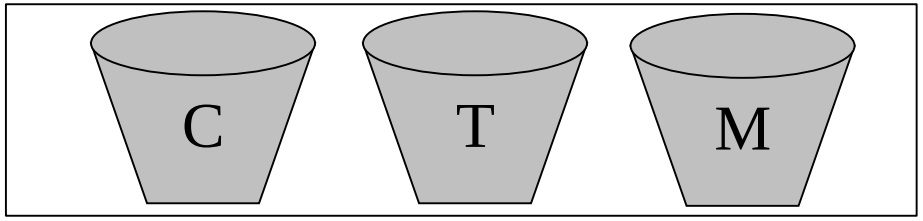
Yeasty



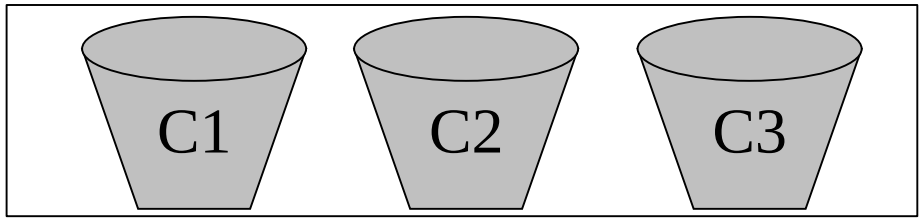
Harsh

Bite and burn

Mouthfeels Practice



Chocolate Quiz



Intensity Measurement Review and Practice

The most powerful intensity scale, because it can be measured consistently and relates best to end users, is the original seven-point intensity scale developed by ADL and MIT.

Original Flavor Profile Scale (ASTM)

0	=	None
1/2	=	Very Slight
1	=	Slight
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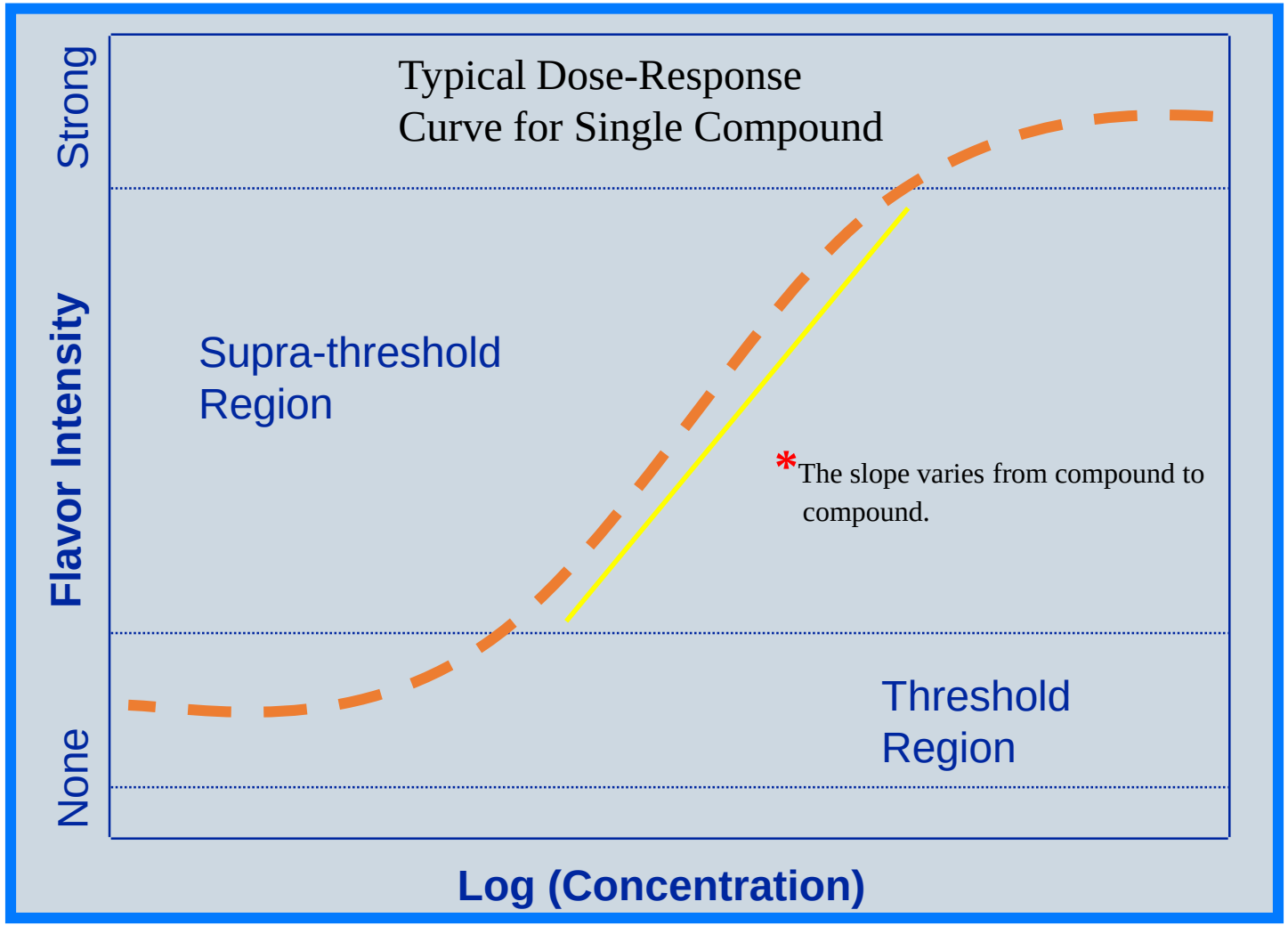
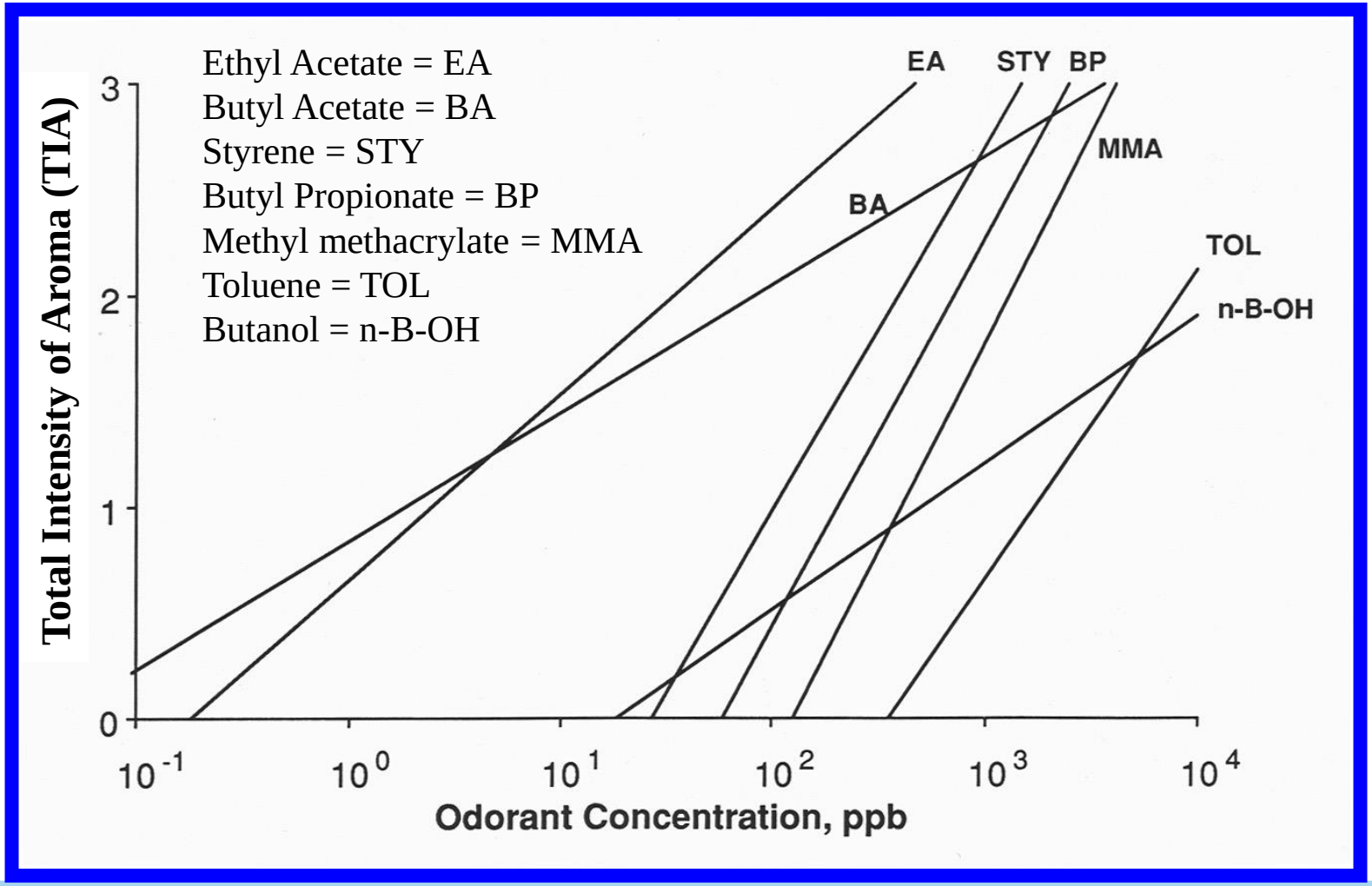
2 1/2	=	Moderate to Strong
3	=	Strong

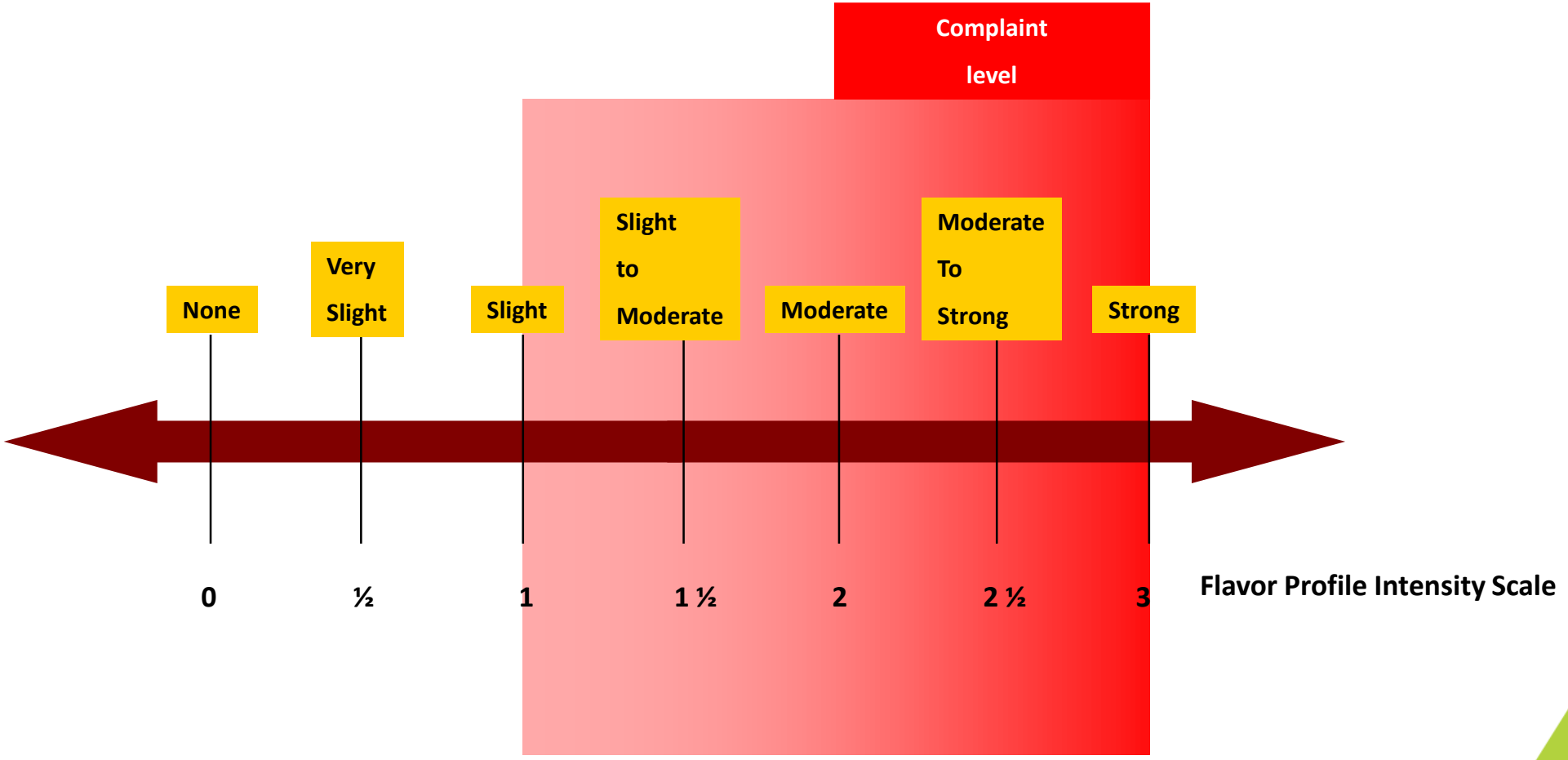
Dose-Response Curves – Intensity behavior of aroma and flavor compounds.



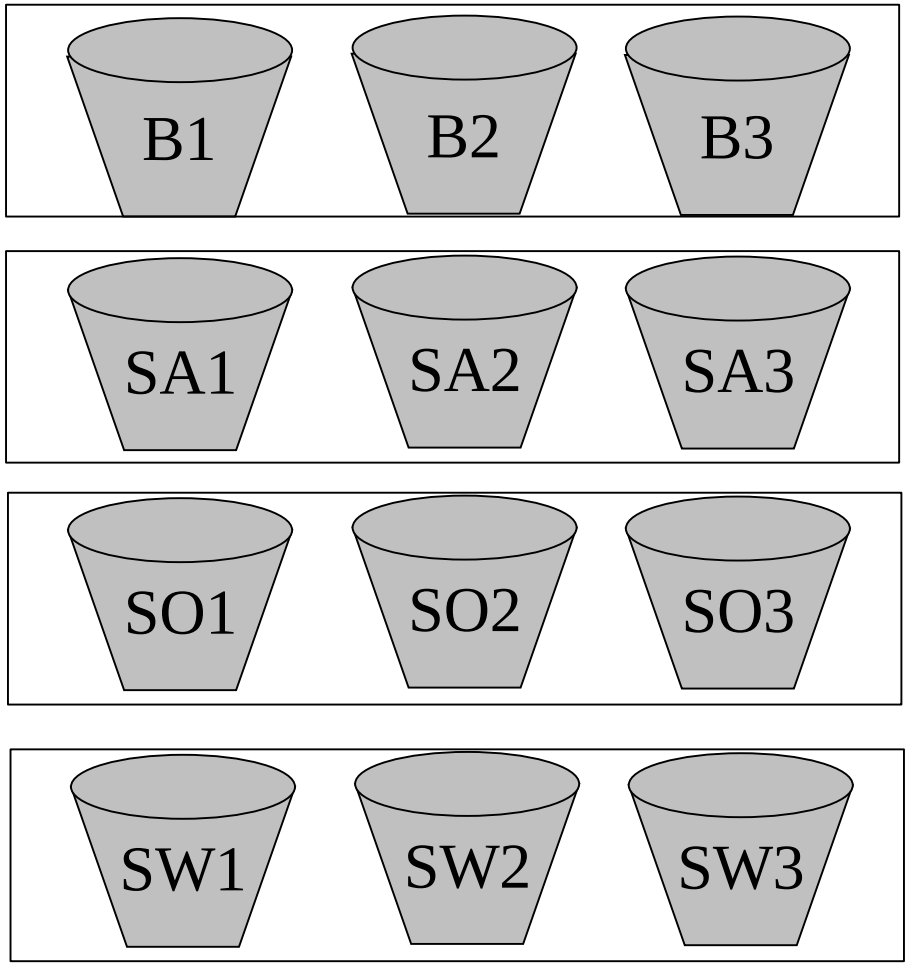
Dilution example:



Intensity drives consumer reactions, both Overall Liking and Complaint.



Basic taste reference intensities with food examples



Sweet (cups SW1, SW2, and SW3)

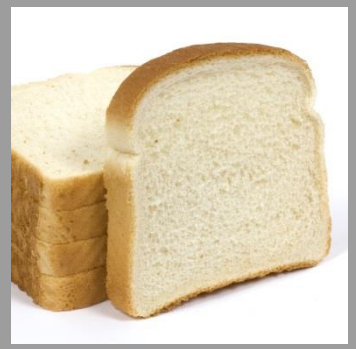
Slight	*Moderate*	*Strong*
5% Sucrose	10% Sucrose	15% Sucrose

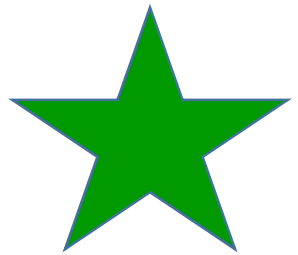
Sour (cups SO1, SO2, and SO3)

Slight	*Moderate*	*Strong*
0.05% Citric Acid	0.10% Citric Acid	0.20% Citric Acid
		
		

Salt (cups SA1, SA2, and SA3)

Slight	*Moderate*	*Strong*
0.4% Sodium Chloride	0.7% Sodium Chloride	1.0% Sodium Chloride





Bitter (cups B1, B2, and B3)

Slight	*Moderate*	*Strong*
0.05% Caffeine	0.10% Caffeine	0.20% Caffeine

Integrative Attributes

Balance and fullness are defined as:

Balance is a measure of the **harmony** of flavor characteristics. It is measured on a scale of unblended to blended.

Fullness is a measure of the **complexity** of flavor of a food product. It is measured on a scale of thin to full.

Example products:

Balance = 2
Fullness = 2

Balance = 1 ½
Fullness = 1 ½

Balance = 2 ½
Fullness = 3

Balance = 1 ½
Fullness = ½

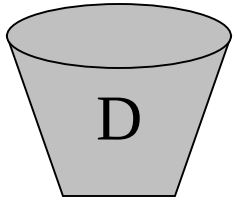
Balance and Fullness Practice

Order of Appearance

The order in which we detect odor and flavor characteristics using The Flavor Profile Method is called the **Order of Appearance**.

Aftertaste is a measure of the flavor detected one minute after your last taste, and includes basic tastes, aromatics, and mouthfeels.

Order of Appearance And Aftertaste Practice



Flint Corn Project

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We had a major project funded by SARE to conduct agronomy and innovative sensory research on varieties of flint corn to help expand their local markets. The key questions included:

- Which flint corn varieties are best suited for growing in the Northeast?
- Are the production practices (i.e. populations) for flint corn different than dent corn?
- **What consumer food products are each flint corn variety suitable for producing?**
- **Which flint corn varieties result in food products that best meet consumer aroma and flavor preferences?**
- **What metrics can be used at the farm-level to predict processing performance and suitability in addition to sensory quality of end products?**

We used objective descriptive sensory analysis to answer the questions highlighted in red.

What is objective Descriptive Sensory Analysis (DSA)?

- Uses trained tasters
- Objective sensory methodology:
  - **The Flavor Profile Method**
  - Total Intensity of Aroma and Flavor
  - Profile Attribute Analysis
- Appropriate experimental design (good science)

The UVM Extension Northwest Crops and Soils Program has a properly trained DSA group that was used to objectively assess the flint corn samples and products included in this study.

We used the sensory directed product development process to generate data to answer the project questions.

- Ingredient screening (flint corn samples) using modified flavor profile – Profile Attribute Analysis (PAA)
- Final product sensory testing using PAA:
  - Corn Tortillas
  - Corn Chips

The corn products were produced by All Souls Tortilleria using a standard recipe and process.

Arthur D. Little, the pioneer in developing DSA methods, also developed the Flavor Leadership Criteria.

Flavor Leadership Criteria	
1 **Aromatic Identity**	◆ Immediate impact of identifying flavor
2 **Amplitude**	◆ Rapid development of balanced, full flavor
3 **Mouthfeel**	◆ Compatible mouthfeel factors
4 **Off-notes**	◆ No “off” flavors.
5 **Aftertaste**	◆ Short clean aftertaste

These criteria help us predict market leadership by measuring sensory attributes known to drive consumer acceptance.

Corn Tortilla Profile Attribute Analysis (PAA) Scoresheet for flavor:

ATTRIBUTES	*Intensity Scale* 1 2 3 4 5 6 7	
Total Intensity of Aroma (TIA)	None	Strong
Balance	Unblended	Blended
Fullness	Thin	Full
Toasted corn	None	Strong
Other corn	None	Strong
Other grain	None	Strong
Green, grassy	None	Strong
Sweet	None	Strong
Sour	None	Strong
Salty	None	Strong
Mouthfeel	None	Strong
Others	None	Strong
Aftertaste	None	Strong

1 = None
2 = Very Slight
3 = Slight
4 = Slight-to-Moderate
5 = Moderate
6 = Moderate-to-Strong
7 = Strong

Corn Tortilla Profile Attribute Analysis (PAA) Scoresheet for texture:

ATTRIBUTES	*SCALE* 1 2 3 4 5 6 7	
Hardness	Soft ⟷	Hard
Crumble	Not Crumbly ⟷	Crumbly
Grain size	Small ⟷	Large
Moistness	Not Moist ⟷	Very Moist

Corn Chip Profile Attribute Analysis (PAA) Scoresheet for flavor:

ATTRIBUTES	*Intensity Scale* 1 2 3 4 5 6 7	
Total Intensity of Aroma (TIA)	None	Strong
Balance	Unblended	Blended
Fullness	Thin	Full
Toasted corn	None	Strong
Other corn	None	Strong
Other grain	None	Strong
Fresh Fried Oil	None	Strong
Oxidized, Rancid Oil	None	Strong
Sweet	None	Strong
Sour	None	Strong
Salty	None	Strong

1 = None
2 = Very Slight
3 = Slight
4 = Slight-to-Moderate
5 = Moderate
6 = Moderate-to-Strong
7 = Strong

Corn Chip Profile Attribute Analysis (PAA) Scoresheet for flavor: (continued)

Intensity Scale

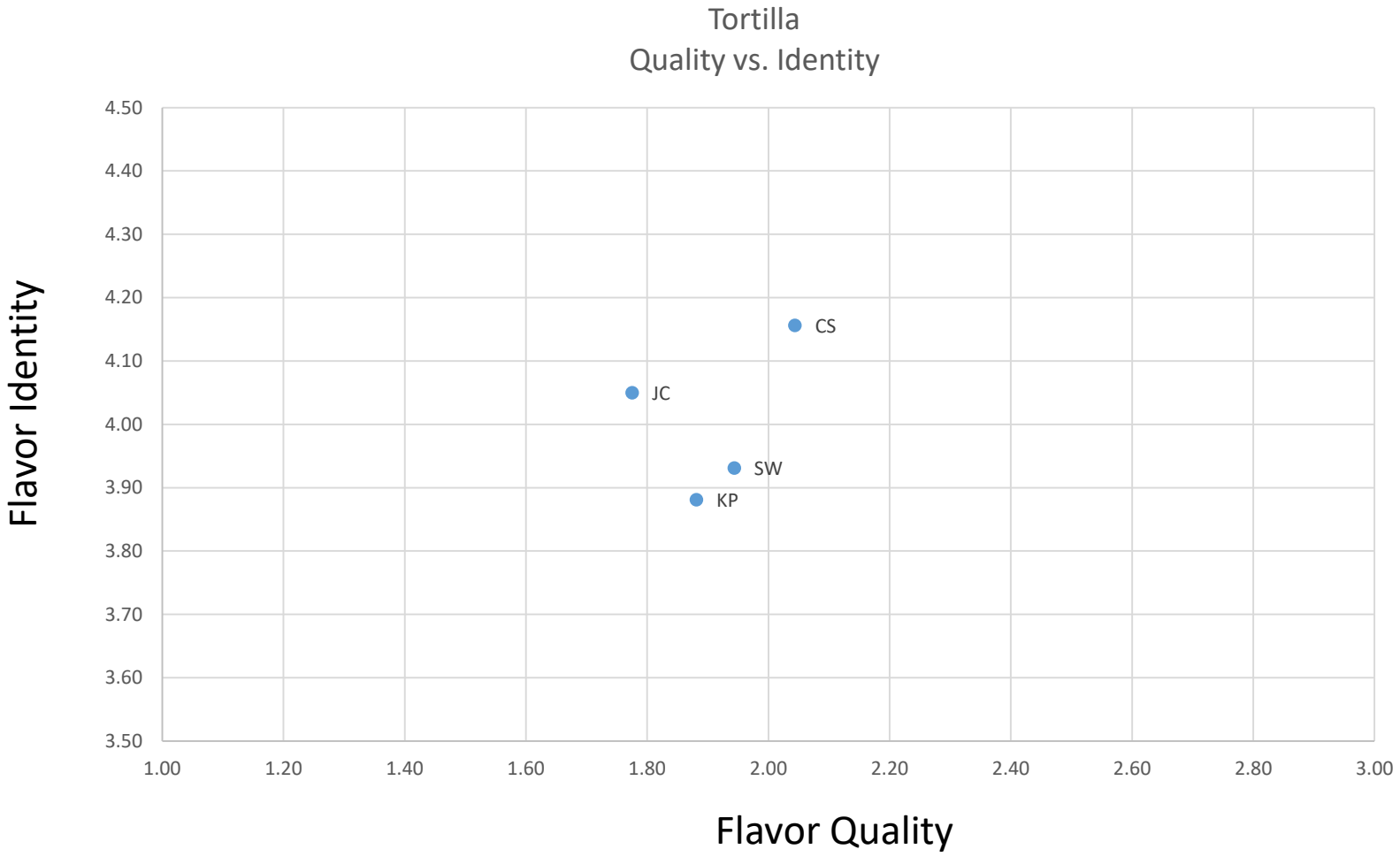
ATTRIBUTES	1 2 3 4 5 6 7
Oily/greasy Mouthfeel	None ⟷ Strong
Dry Mouthfeel	None ⟷ Strong
Astringent Mouthfeel	None ⟷ Strong
Others	None ⟷ Strong
Aftertaste	None ⟷ Strong

1 = None
2 = Very Slight
3 = Slight
4 = Slight-to-Moderate
5 = Moderate
6 = Moderate-to-Strong
7 = Strong

Corn Chip Profile Attribute Analysis (PAA) Scoresheet for texture:

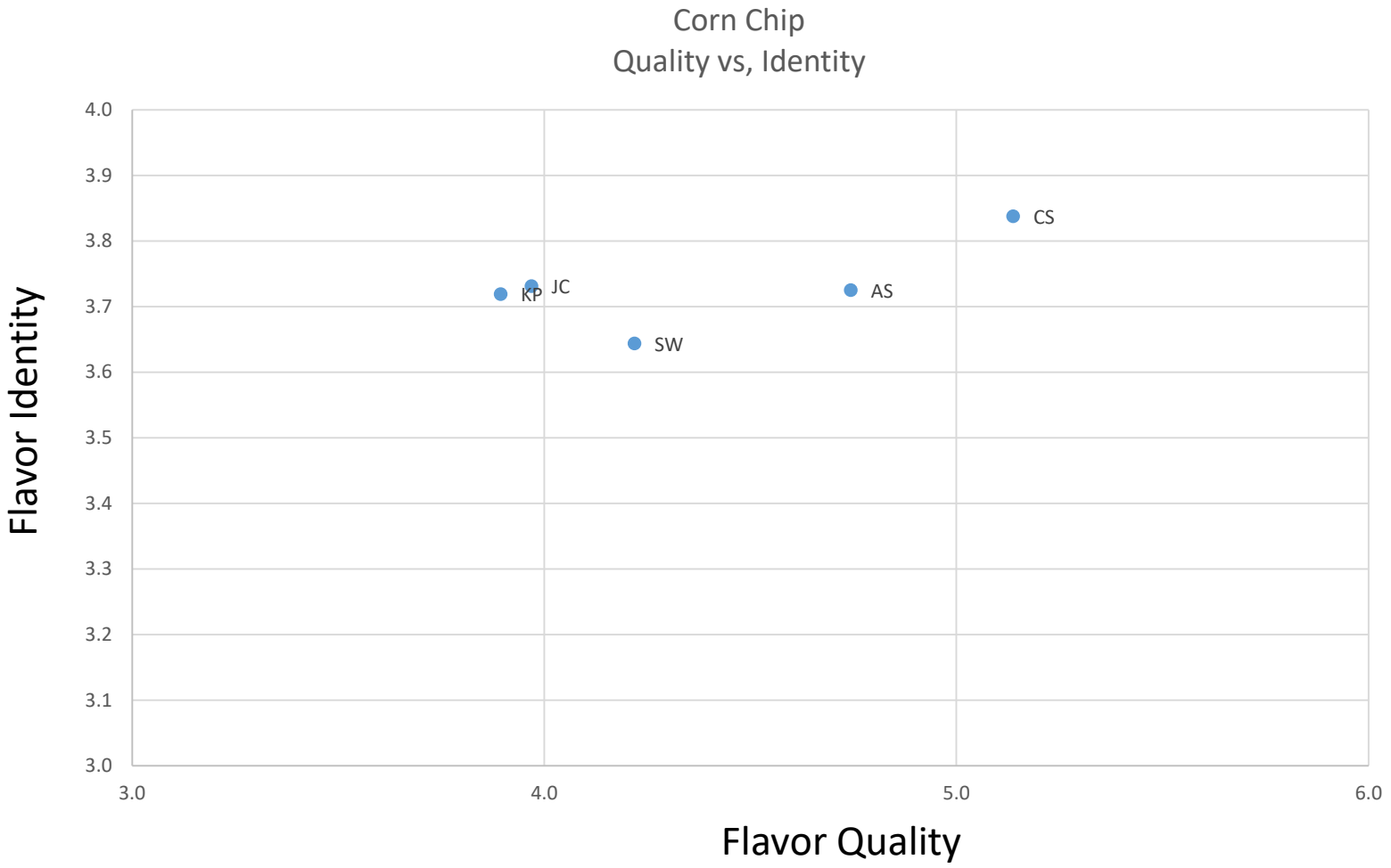
ATTRIBUTES	*SCALE* 1 2 3 4 5 6 7	
Hardness	Soft ⟷	Hard
Crispiness	Not Crispy ⟷	Crispy
Crumble	Not Crumbly ⟷	Crumbly
Grain size	Small ⟷	Large
Oily/greasy	Not Oily ⟷	Greasy

Corn Tortilla: Flavor Quality vs. Flavor Identity



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Flavor Identity



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Flint Corn Grits Data

Profile Attribute Analysis (PAA) average data for corn grits – Flavor:

	Corn Type					
Sample	TIA	Raw Corn	Cooked Corn	Canned	Creamed Corn	Sweet Corn
CS	3.8	1.9	3.1	2.1	2.4	2.0
JC	3.5	1.9	2.4	1.8	2.2	1.6
KP	3.7	2.2	3.3	2.2	2.1	1.8
SW	3.4	2.2	2.8	2.0	2.2	1.7

Legend

CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

	Grain Type				Sulfidy			
Sample	Starchy Grain	Cooked Grain	Cream of Wheat	Flour	Paper/cdb dy/woody	Vegetable/ Peas	Odd/Rubb ery	Brothy
CS	3.4	3.0	3.0	2.1	2.5	2.4	1.3	2.7
JC	3.5	2.8	2.8	1.8	2.9	2.2	1.5	2.5
KP	3.2	2.8	2.5	2.1	2.8	2.5	1.5	2.7
SW	3.4	2.7	3.3	2.0	2.6	2.5	1.6	2.7

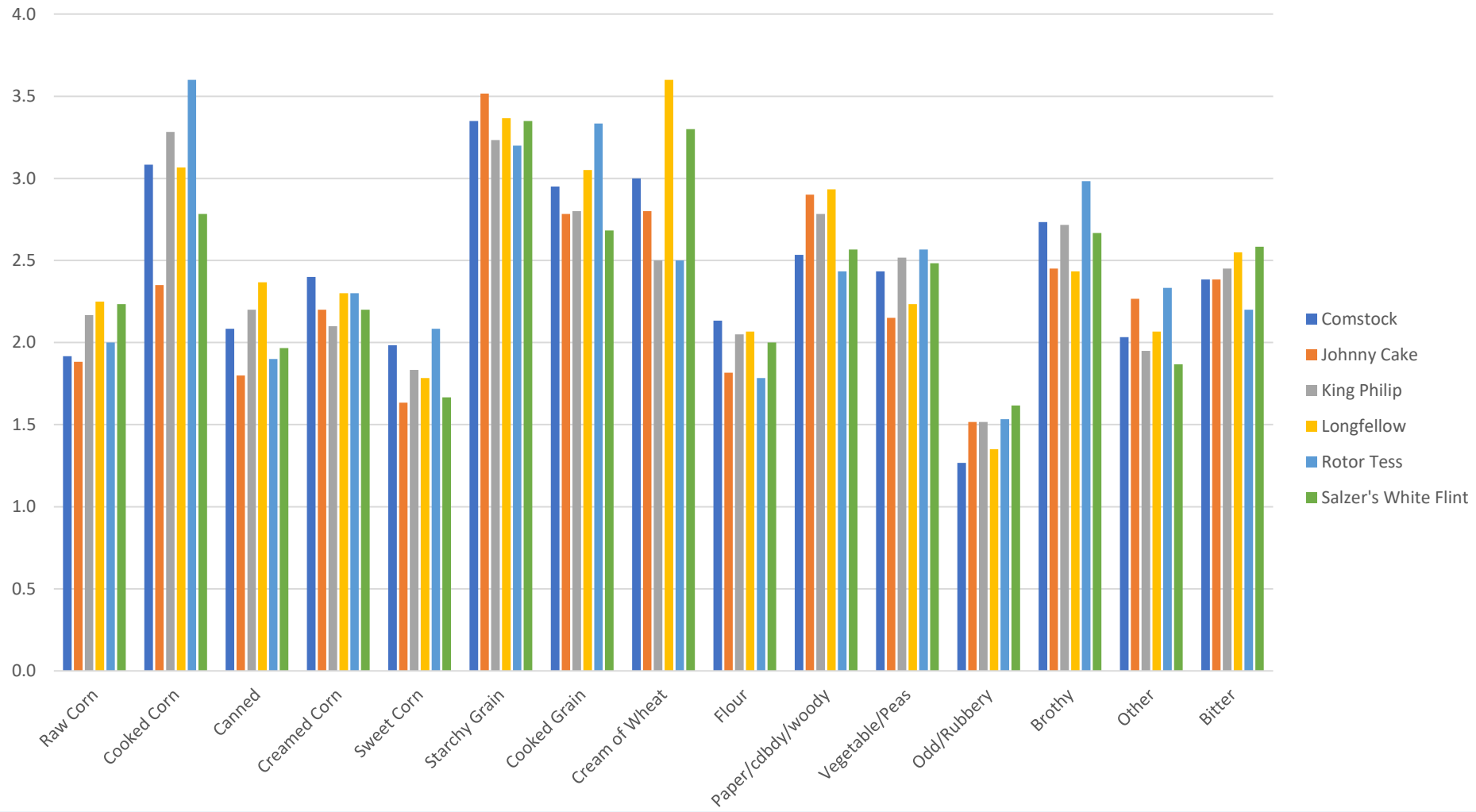
Sample	Other	Bitter
CS	2.0	2.4
JC	2.3	2.4
KP	2.0	2.5
SW	1.9	2.6

Profile Attribute Analysis (PAA) average data for corn grits – Texture:

	Texture	
Sample	P1	P2
CS	5.0	4.3
JC	4.4	4.4
KP	4.9	4.4
SW	4.3	3.7

Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn grits descriptive comparison.



Flint Corn Tortilla Data

Profile Attribute Analysis (PAA) average data for corn tortillas – Flavor:

Sample	Total Intensity of Aroma	Balance	Fullness	Toasted Corn	Other Corn	Other Grain	Green Grassy	Sweet	Sour	Salt	Mouthfeel	Others	Aftertaste
CS	3.5	3.4	3.6	3.3	3.5	3.0	3.1	2.6	2.4	1.8	3.9	2.5	3.6
JC	3.8	3.6	3.3	3.4	3.8	2.8	2.8	2.6	2.9	2.0	3.4	3.0	3.0
KP	3.8	3.3	3.1	3.3	3.0	3.5	2.6	2.8	2.6	2.0	3.5	2.9	3.0
SW	3.9	3.5	2.9	3.5	3.6	2.9	2.5	2.8	2.4	2.0	4.1	2.5	3.0

Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Profile Attribute Analysis (PAA) average data for corn tortillas – Texture:

Sample	Hardness	Crumbly	Grain Size	Moisture
CS	3.3	2.3	3.1	3.1
JC	2.9	1.9	3.5	3.1
KP	3.4	2.3	2.8	3.0
SW	3.4	2.4	2.9	2.8

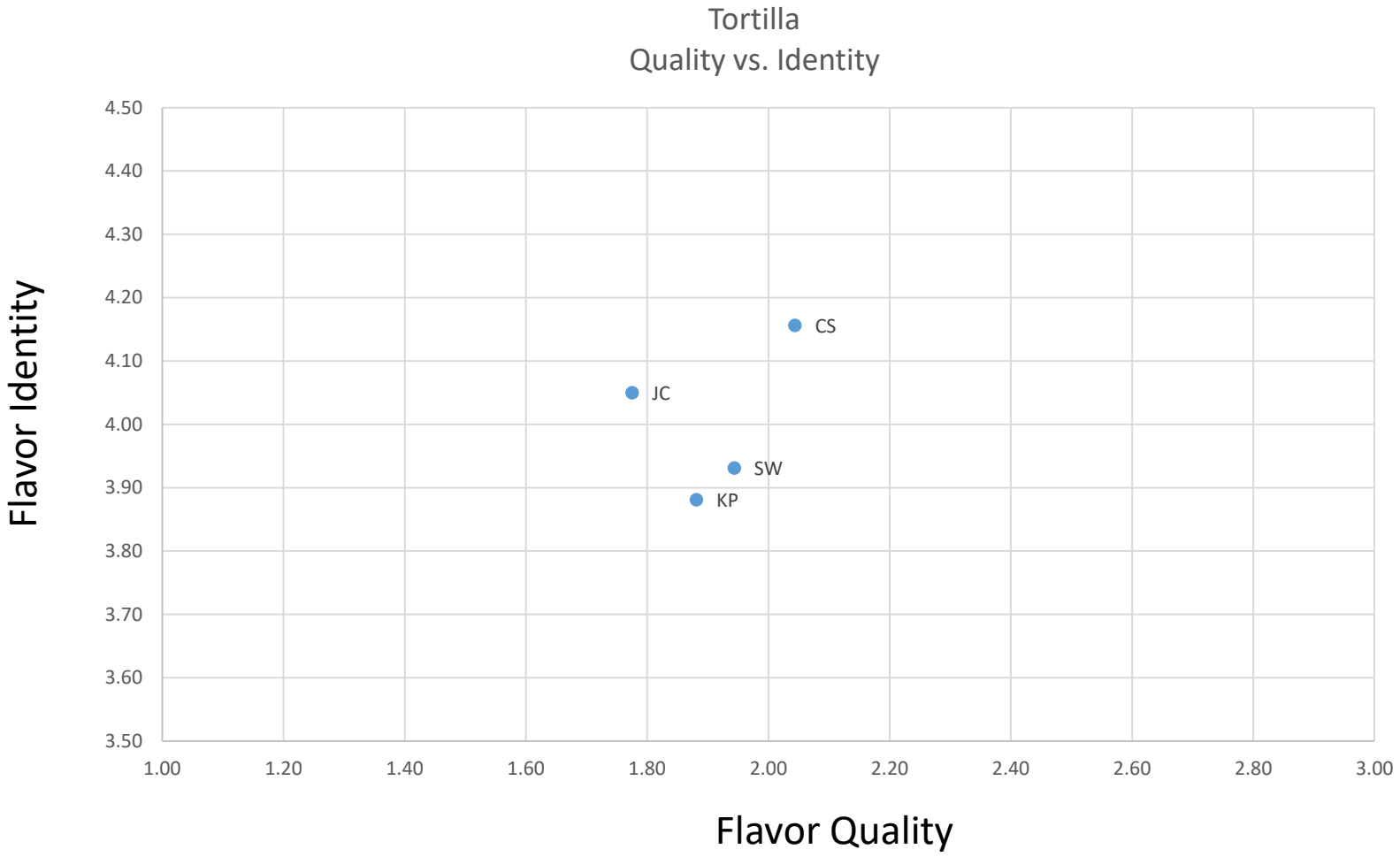
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Profile Attribute Analysis (PAA) summary Indices for corn tortillas:

Sample	"Quality"	"Identify"	"Texture"
CS	2.0	4.2	0.2
JC	1.8	4.1	0.2
KP	1.9	3.9	0.2
SW	1.9	3.9	0.1

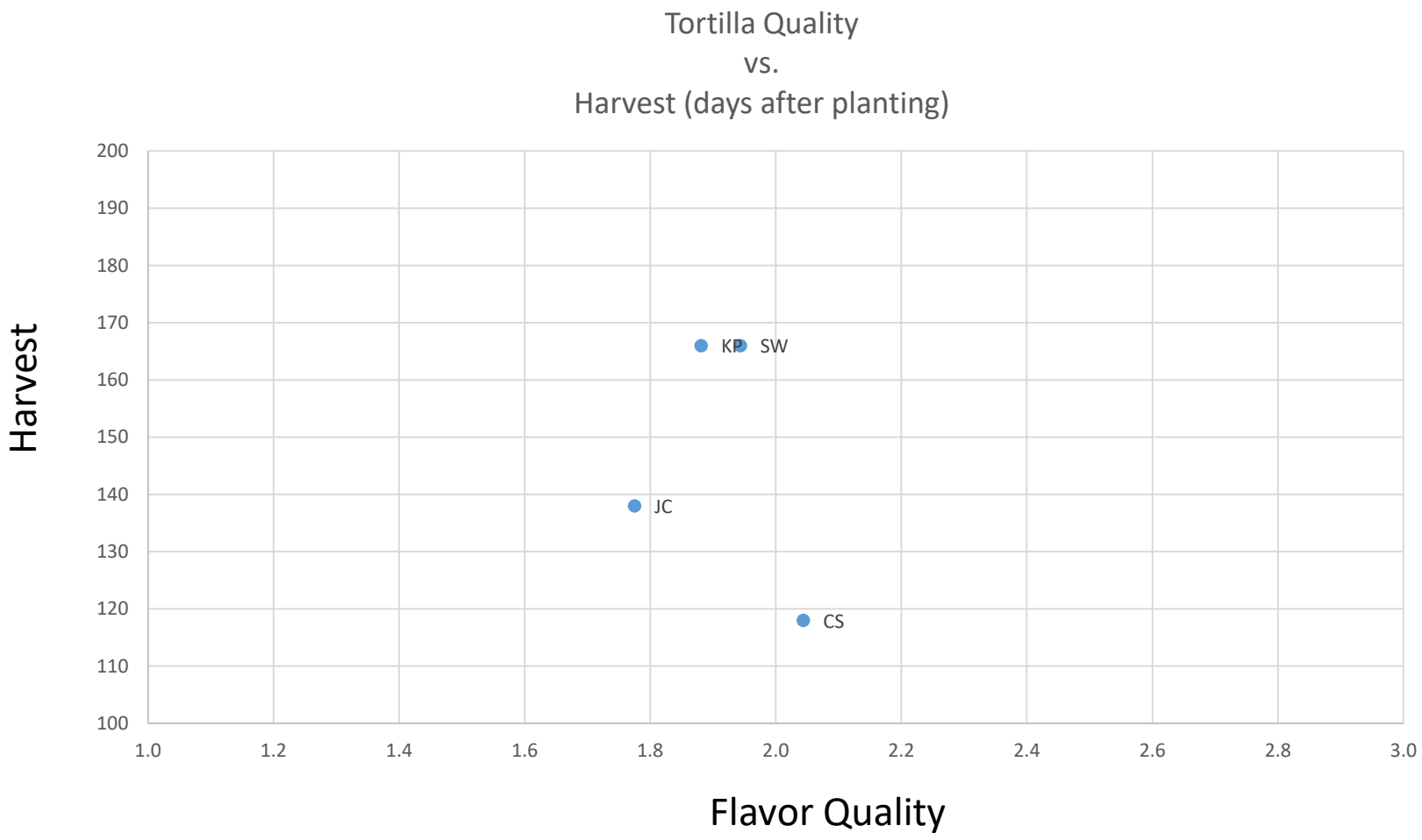
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Flavor Identity



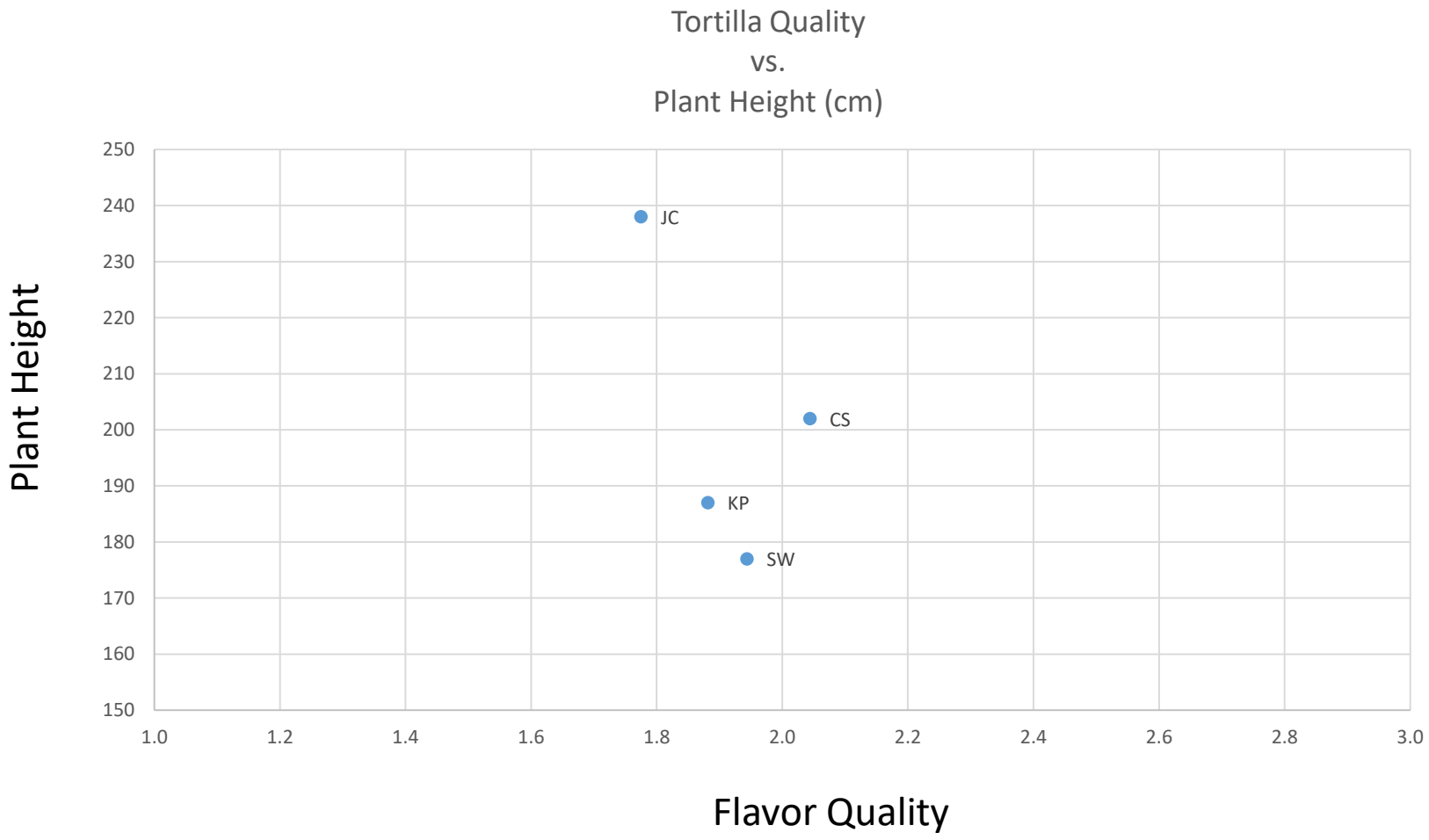
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Harvest (days after planting)



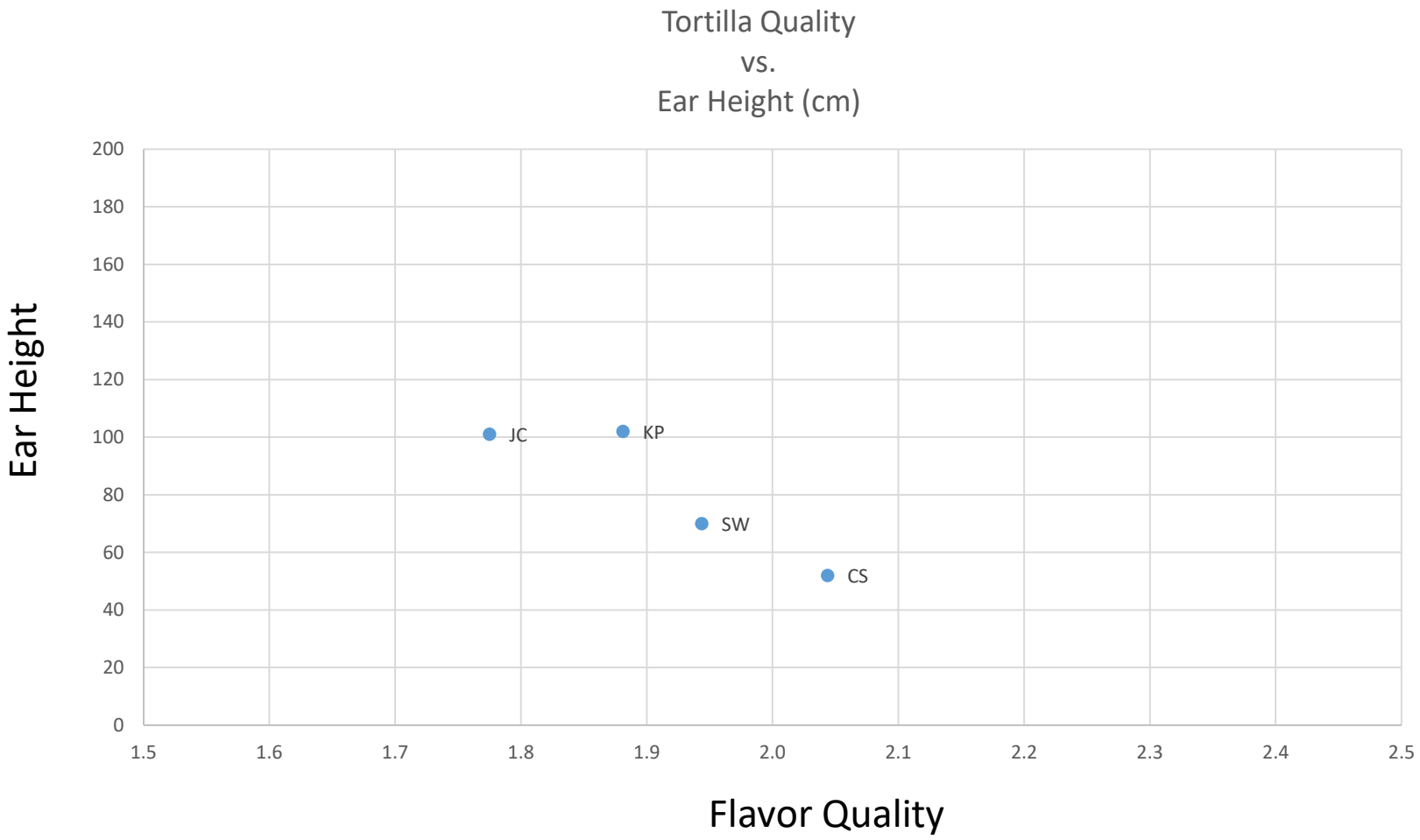
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Plant Height (measured in cm)



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Ear Height (measured in cm)

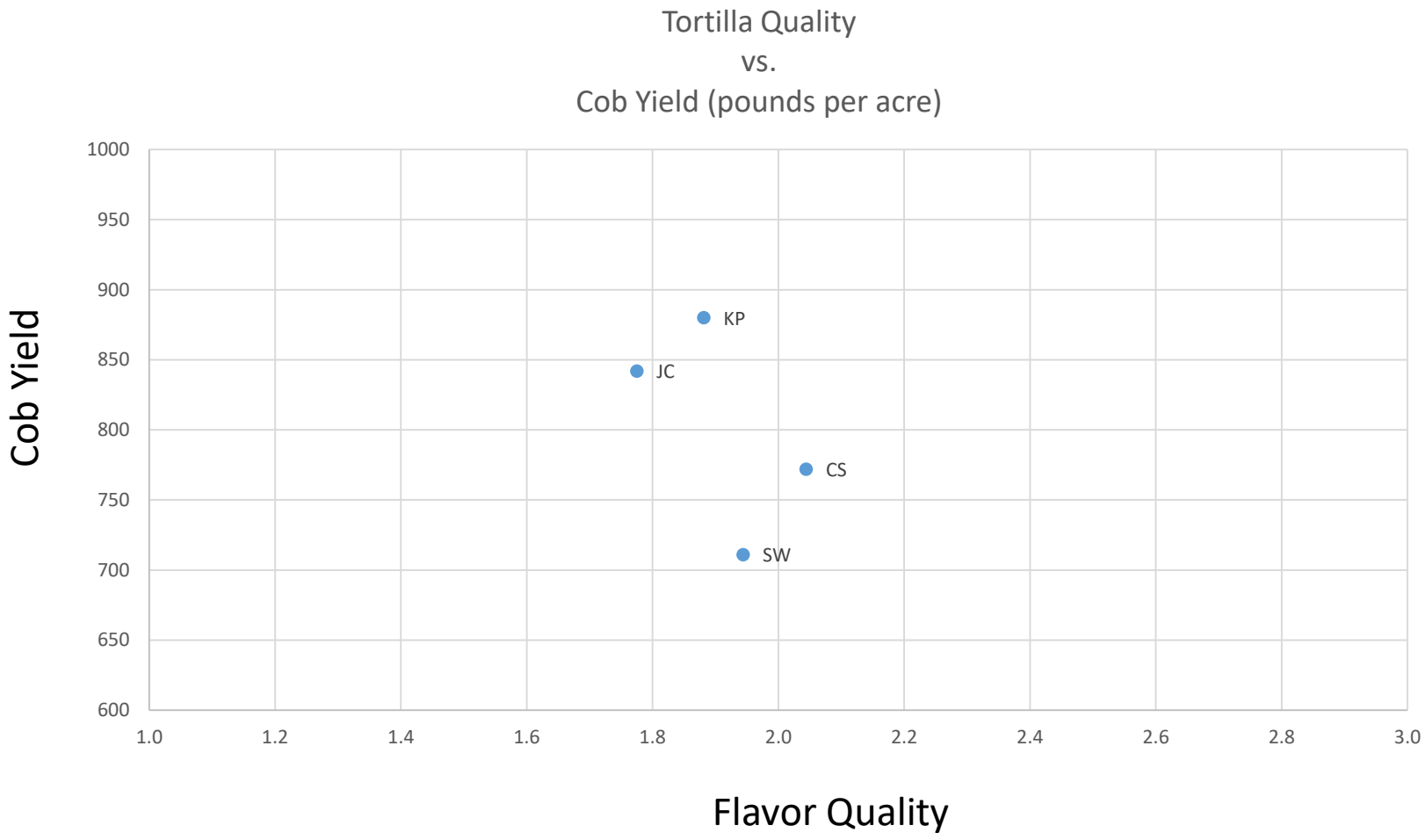


Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Population (plants per acre)

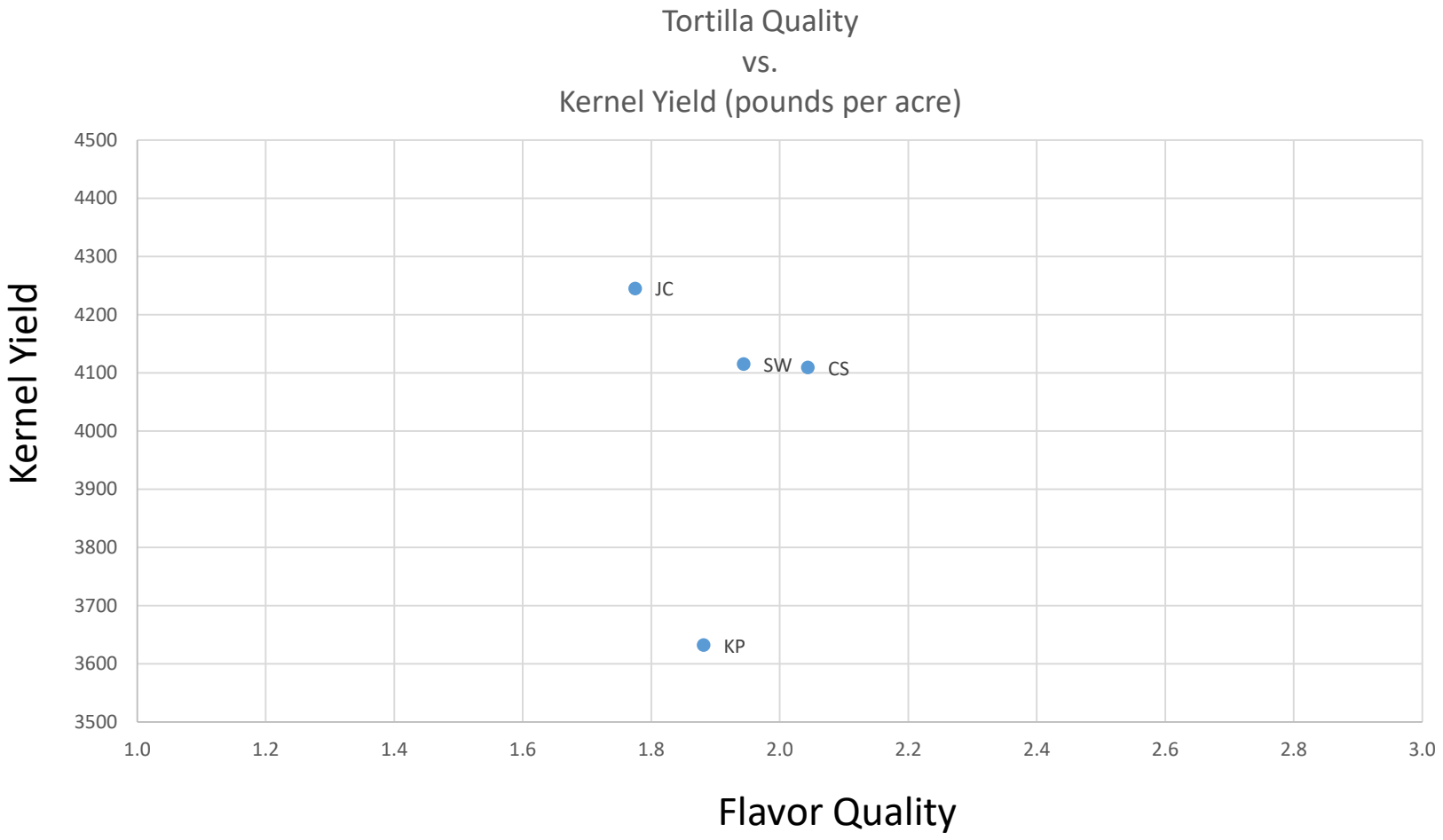
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Cob Yield (pounds per acre)



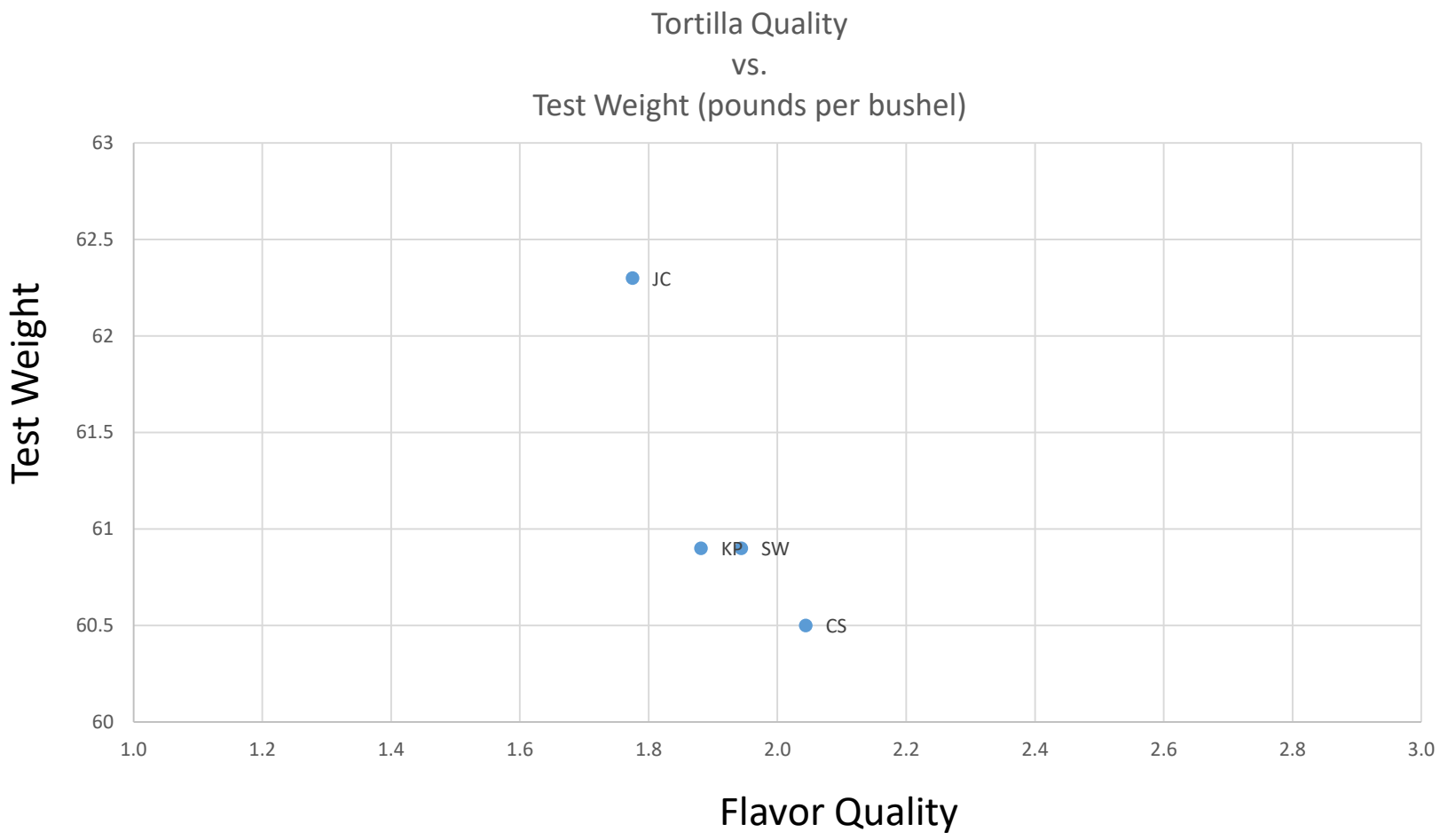
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Kernel Yield (pounds per acre)



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Tortilla: Flavor Quality vs. Test Weight (pounds per bushel)



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Flint Corn Chip Data

Profile Attribute Analysis (PAA) average data for corn chips – Flavor:

Sample	Total Intensity of Aroma	Balance	Fullness	Toasted Corn	Other Corn	Other Grain	Fresh Fried Oil	Oxidized Oil	Sweet
AS	3.8	3.4	3.5	3.9	2.6	2.8	3.5	3.0	2.6
CS	3.4	3.4	3.5	3.4	3.4	3.0	3.1	3.1	2.6
JC	3.6	3.6	3.1	3.3	3.5	2.9	3.3	2.6	2.8
KP	3.9	3.5	2.9	3.4	3.8	2.8	3.5	2.4	2.8
SW	3.4	3.8	3.4	3.6	2.5	3.1	3.3	2.8	3.0

Sample	Sour	Salty	Oily/Greasy Mouthfeel	Dry Mouthfeel	Astringent Mouthfeel	Others	Aftertaste
AS	2.4	3.5	4.0	3.6	2.4	2.9	3.8
CS	2.9	3.4	4.4	3.8	2.6	2.9	4.3
JC	2.6	3.5	3.5	3.9	2.9	2.5	3.4
KP	2.4	3.1	3.0	4.0	2.5	2.6	3.8
SW	2.6	3.4	3.4	3.6	2.9	2.8	3.5

Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Profile Attribute Analysis (PAA) average data for corn chips – Texture:

Sample	Hardness	Crispiness	Crumbly	Grain Size	Oily/Greasy
AS	3.6	4.6	3.8	3.3	3.9
CS	5.0	3.9	4.0	3.4	4.0
JC	4.8	4.0	3.4	3.6	3.4
KP	4.6	4.1	3.0	3.5	3.0
SW	4.9	3.9	3.6	3.6	3.1

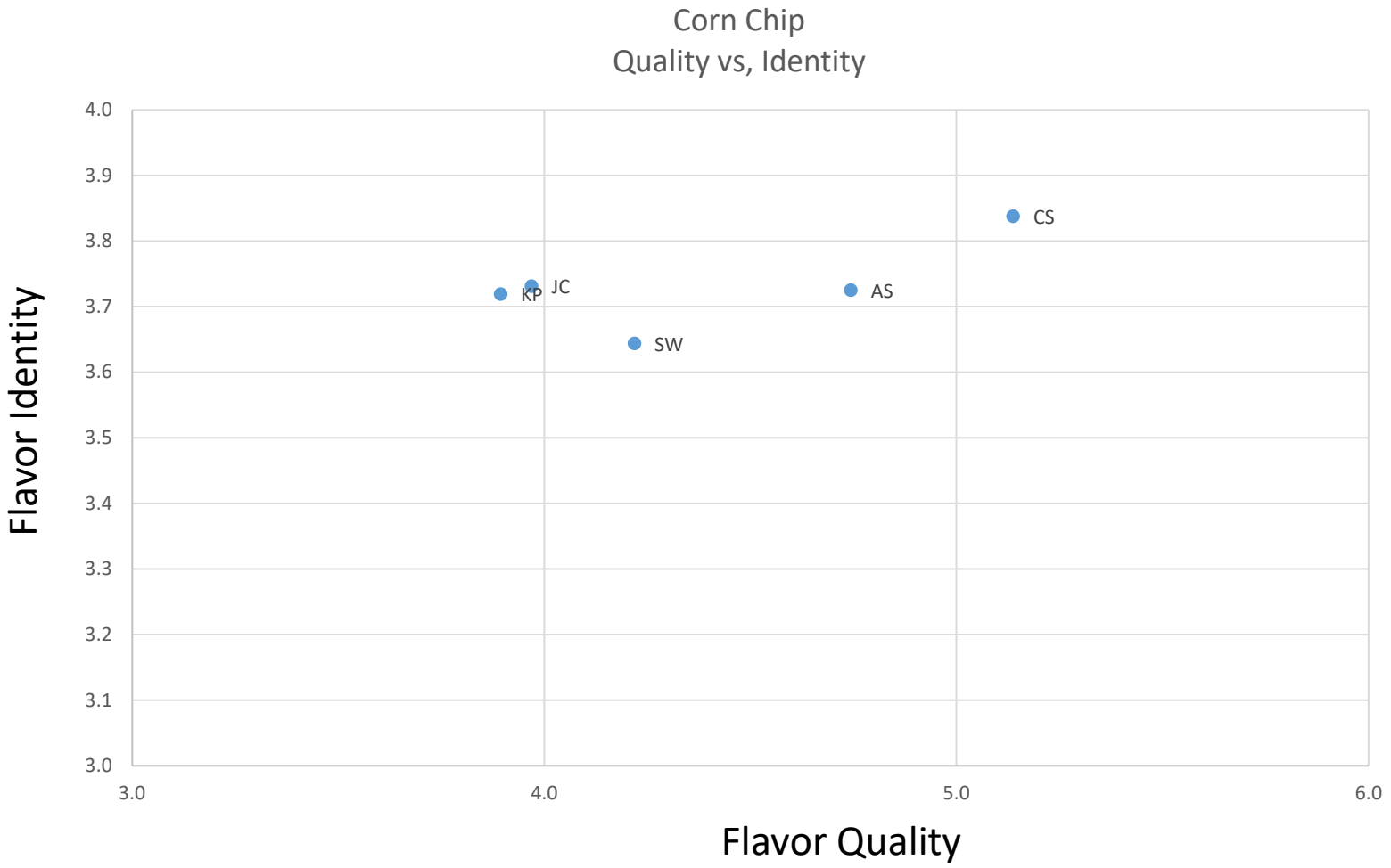
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Profile Attribute Analysis (PAA) summary Indices for corn chips:

Sample	"Quality"	"Identity"	"Texture"
AS	4.7	3.7	0.5
CS	5.1	3.8	0.2
JC	4.0	3.7	0.4
KP	3.9	3.7	0.5
SW	4.2	3.6	0.4

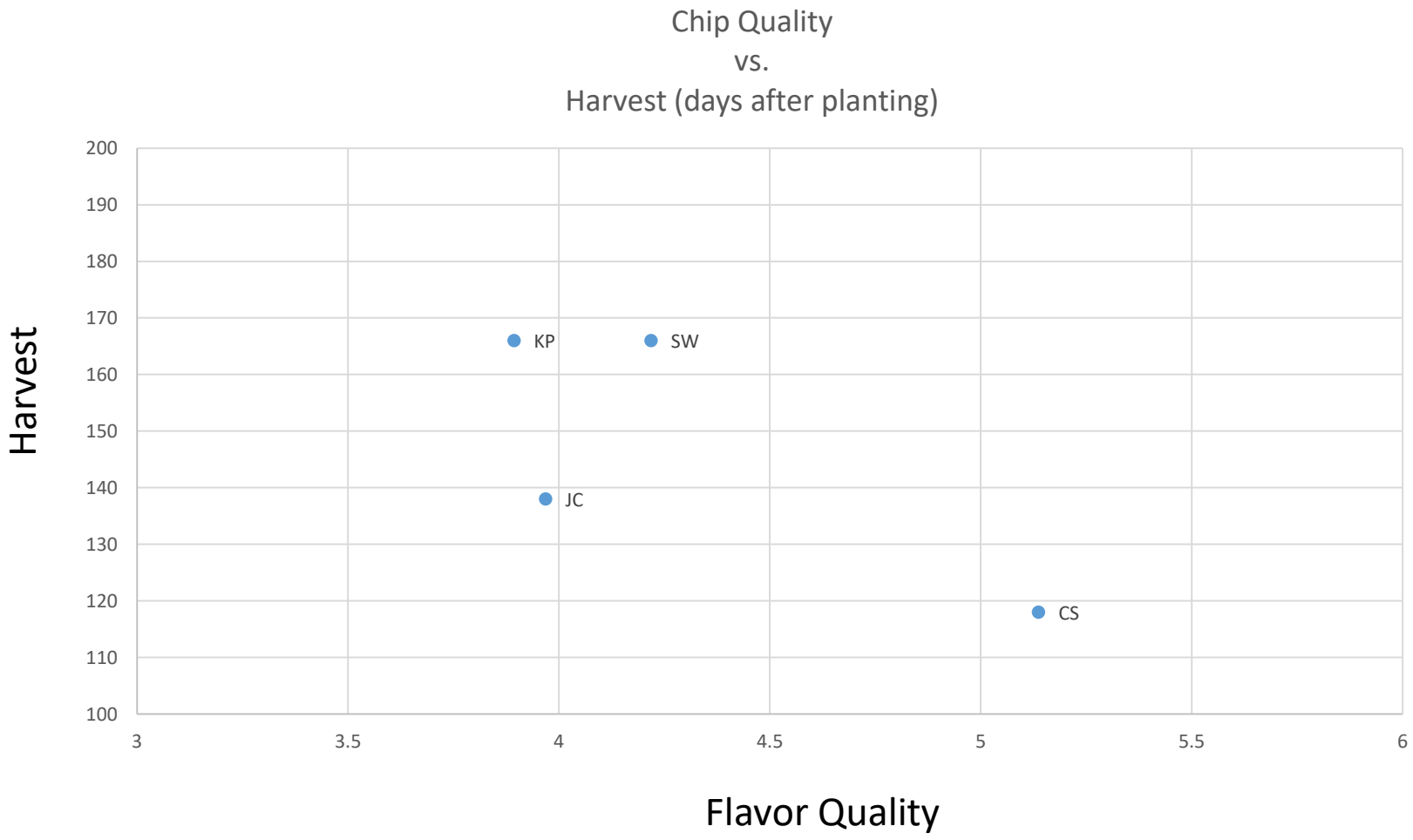
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Corn Chip: Flavor Quality vs. Flavor Identity



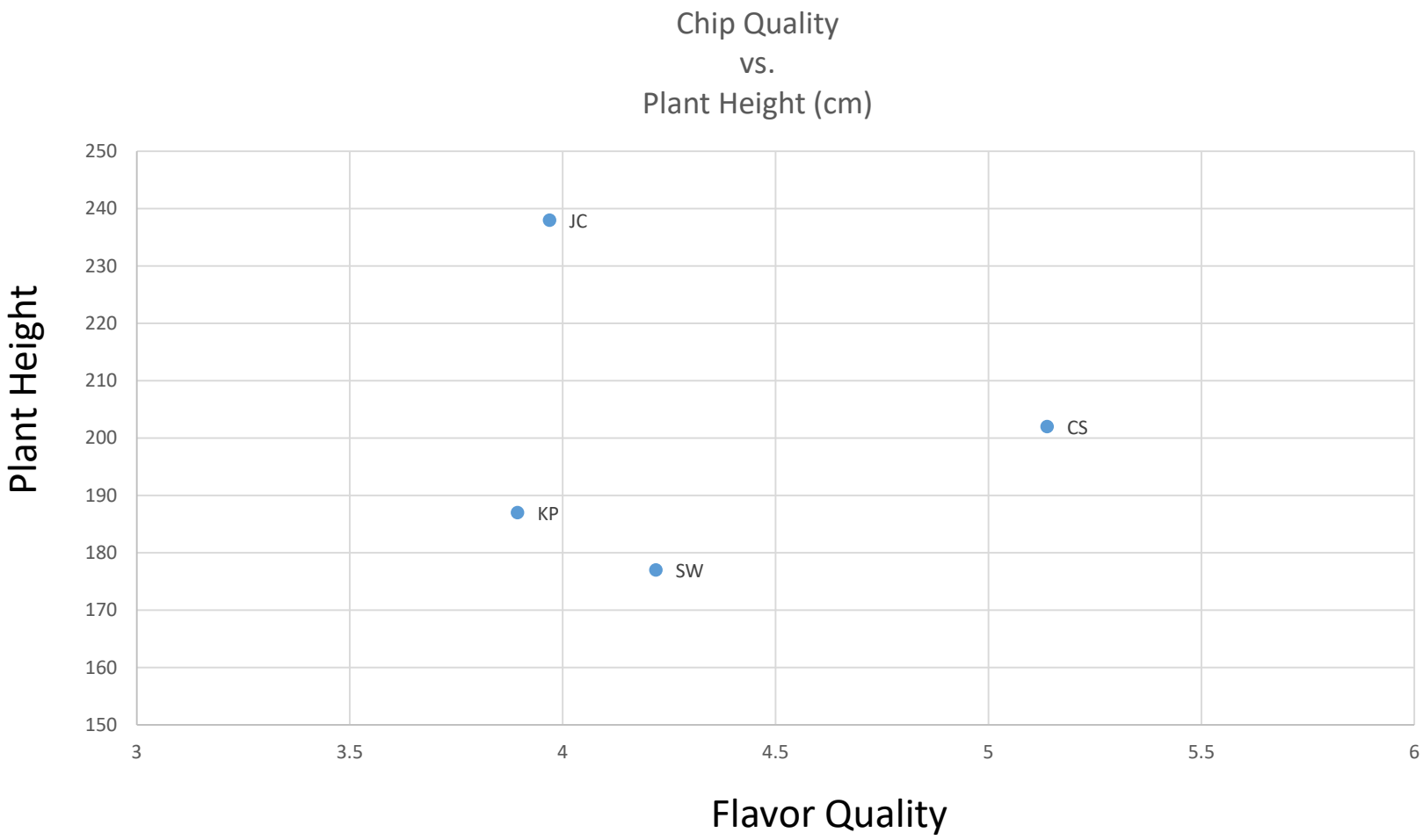
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White
AS	=	All Souls

Corn Chip: Flavor Quality vs. Harvest (days after planting)



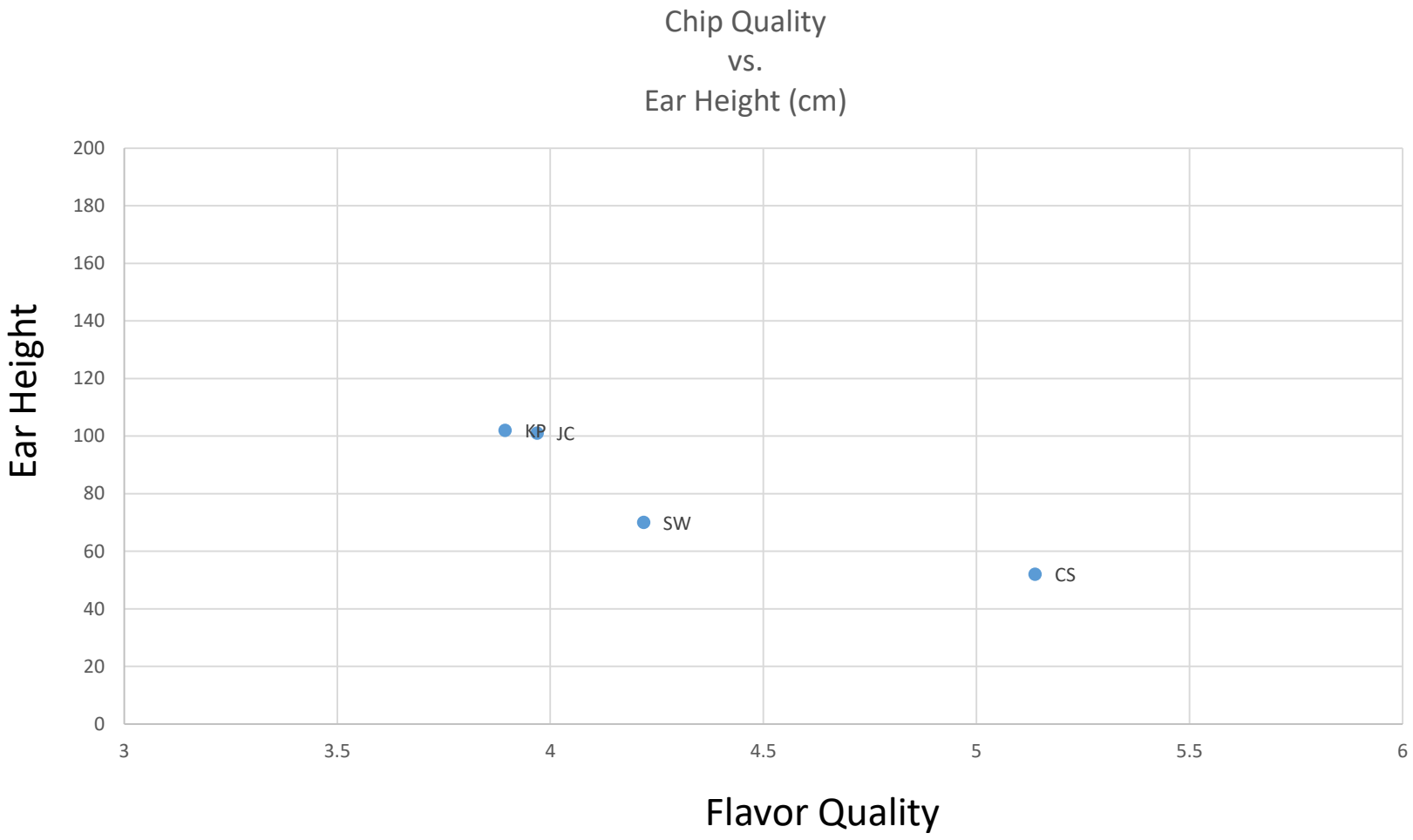
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Plant Height (measured in cm)



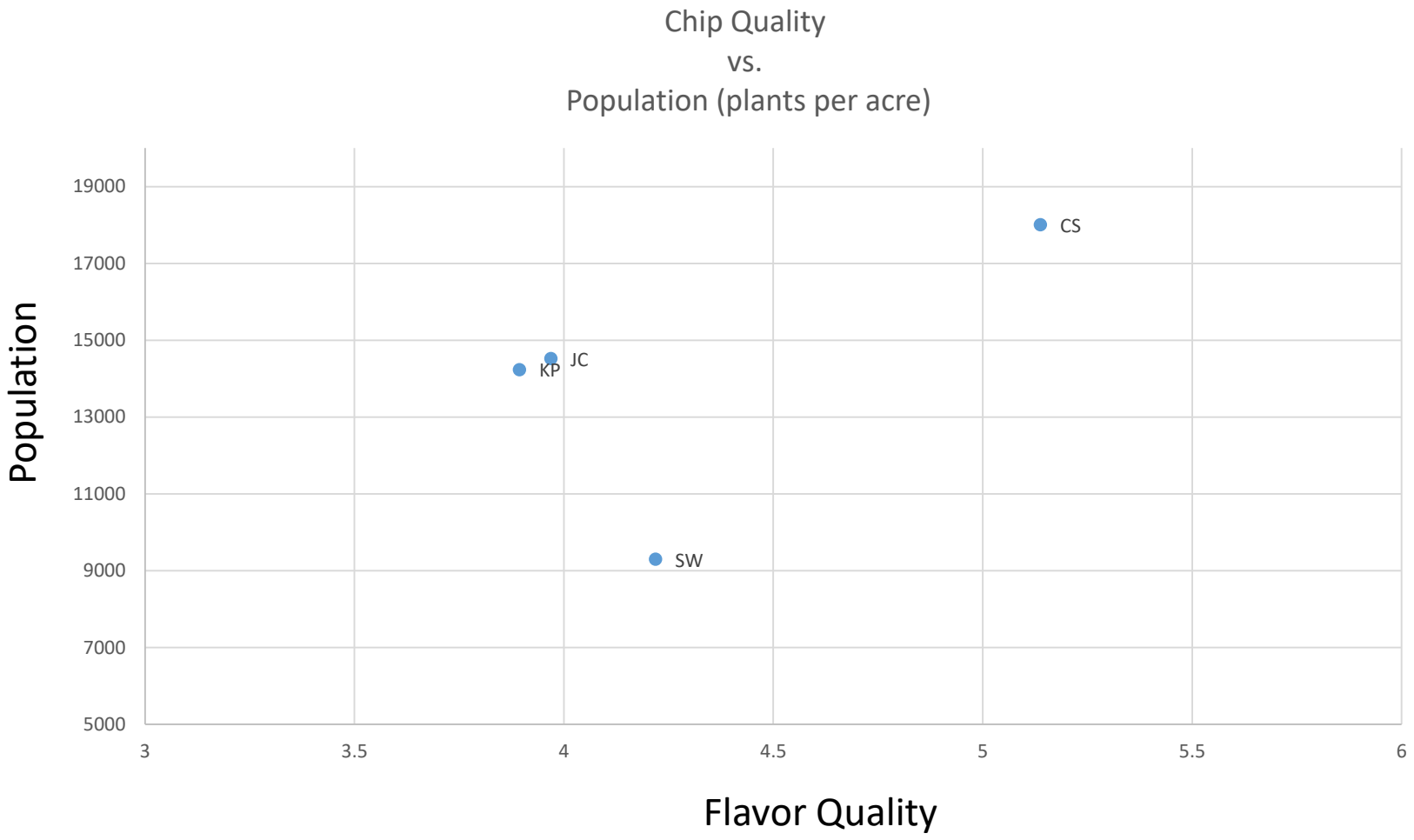
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Ear Height (measured in cm)



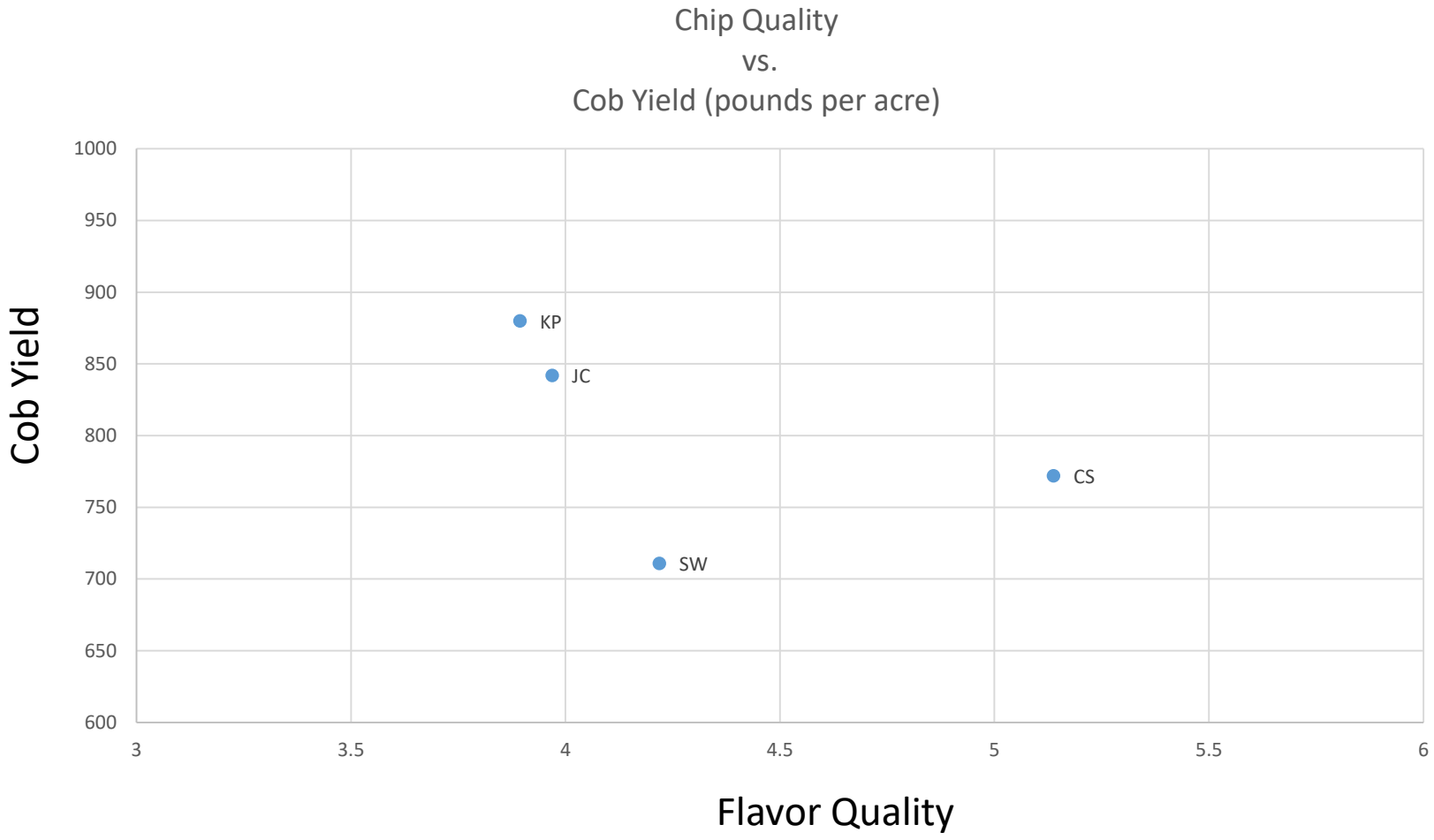
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Population (plants per acre)



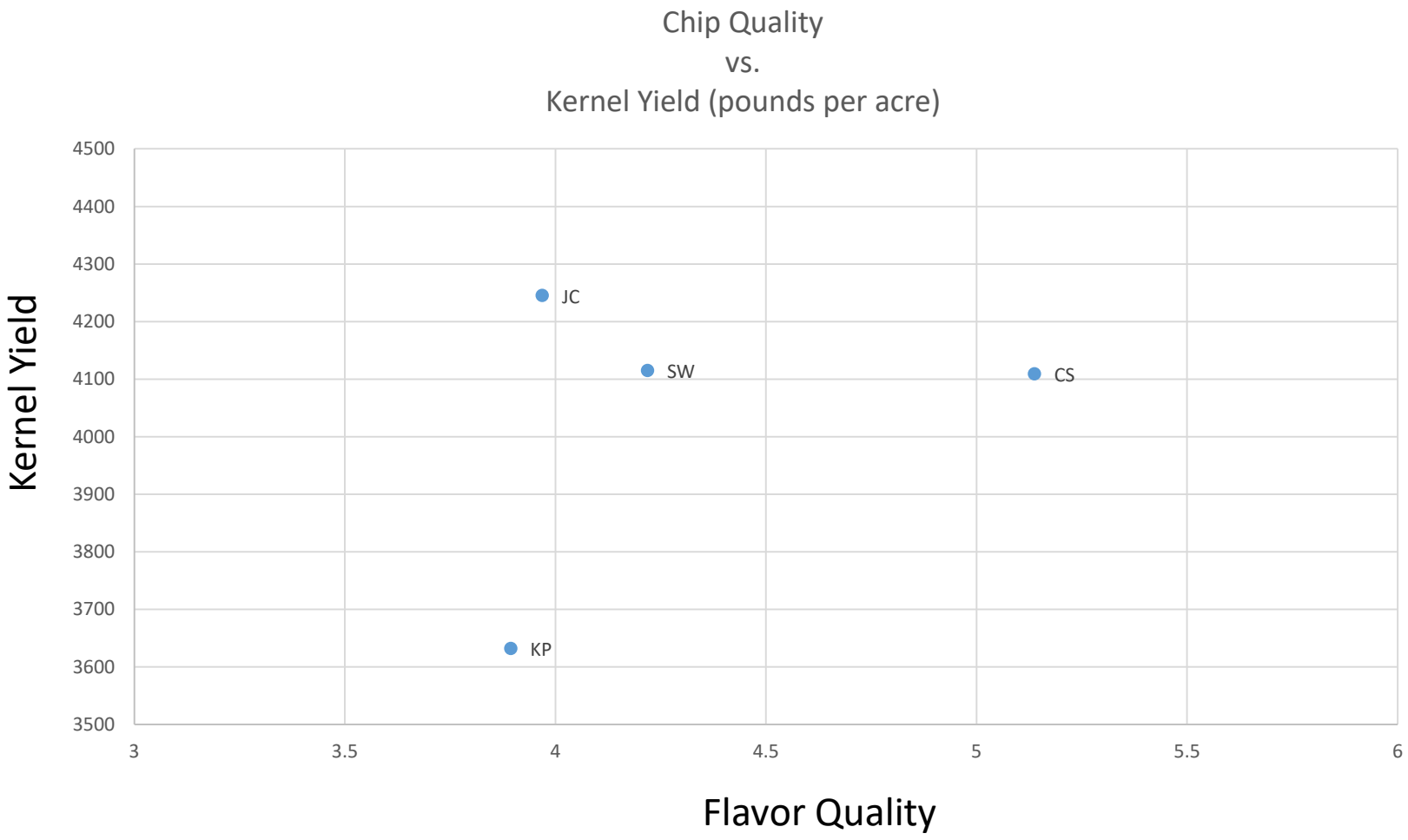
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Cob Yield (pounds per acre)



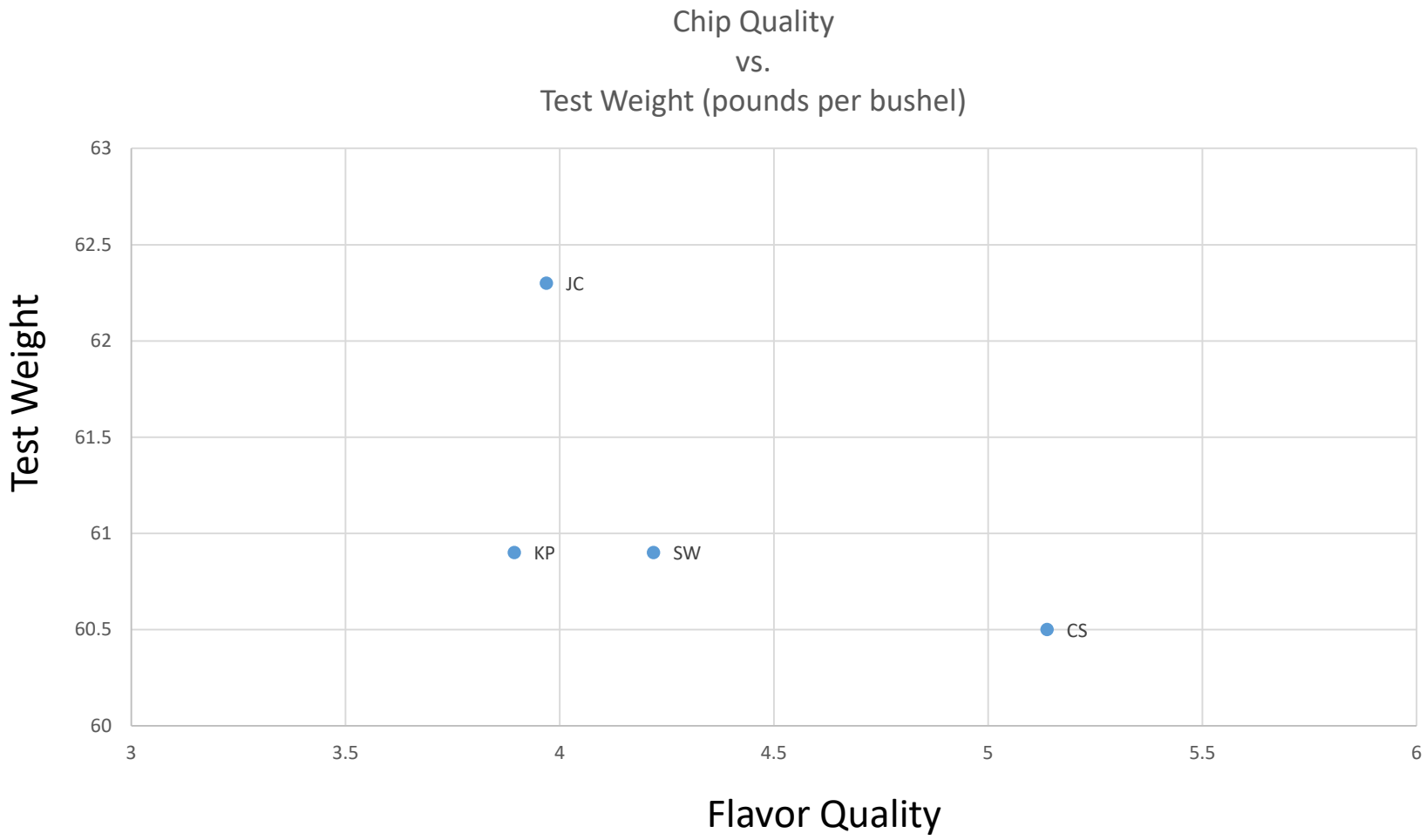
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Kernel Yield (pounds per acre)



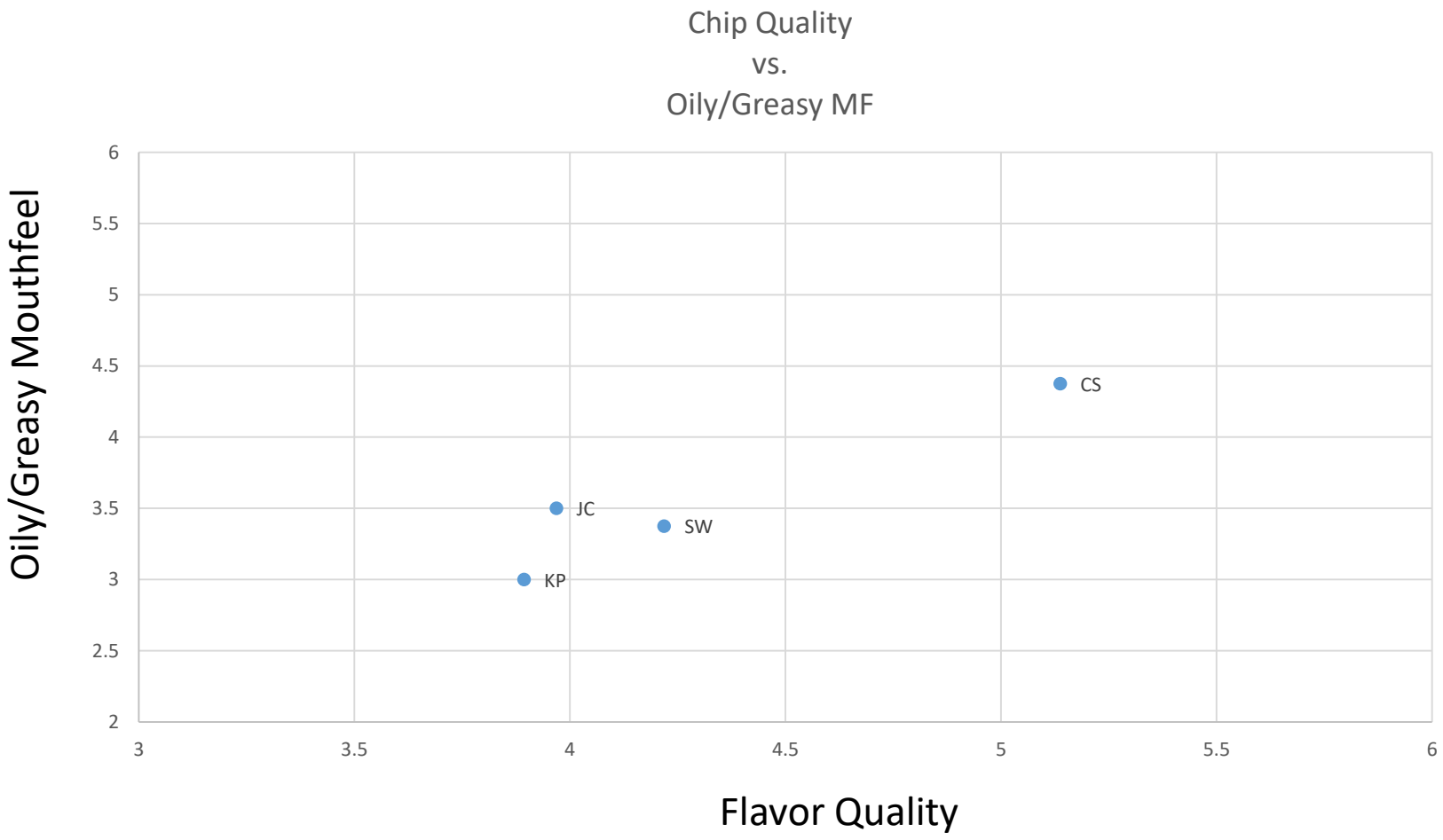
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Test Weight (pounds per bushel)



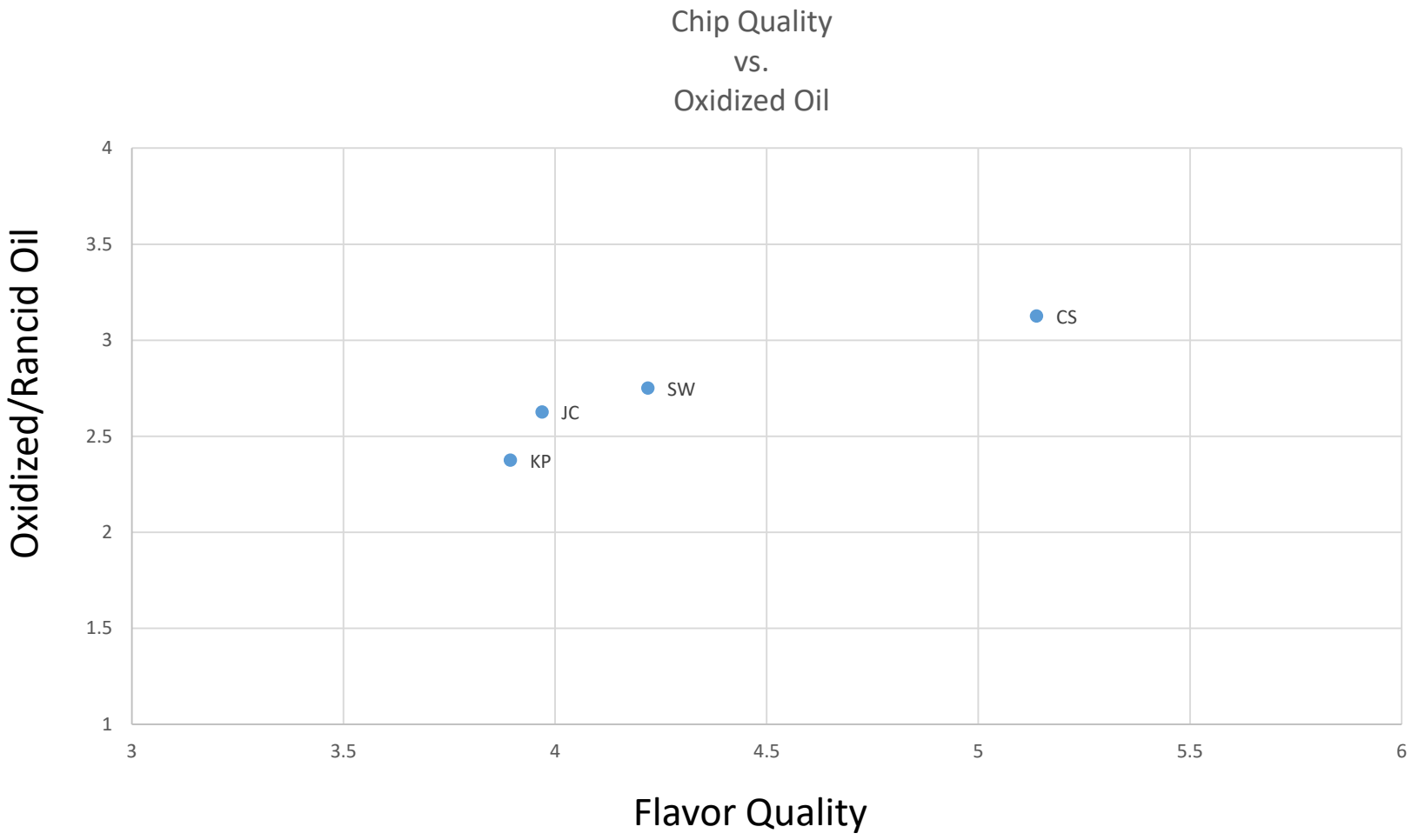
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Oily/Greasy Mouthfeel



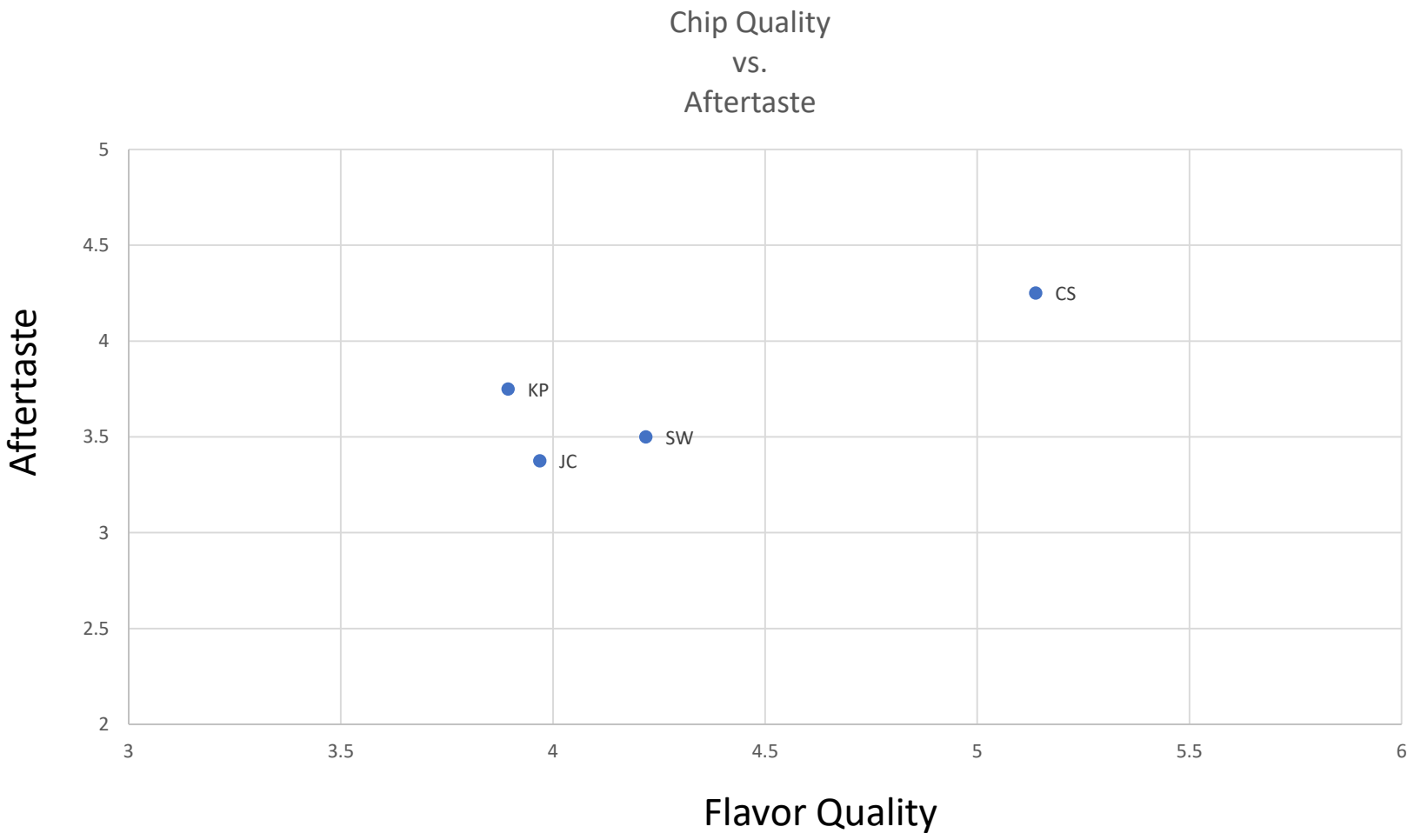
Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Oxidized/Rancid Oil



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White

Corn Chip: Flavor Quality vs. Aftertaste



Legend		
CS	=	Comstock Family
JC	=	Johnny Cake
KP	=	King Philip
SW	=	Salzer's White