

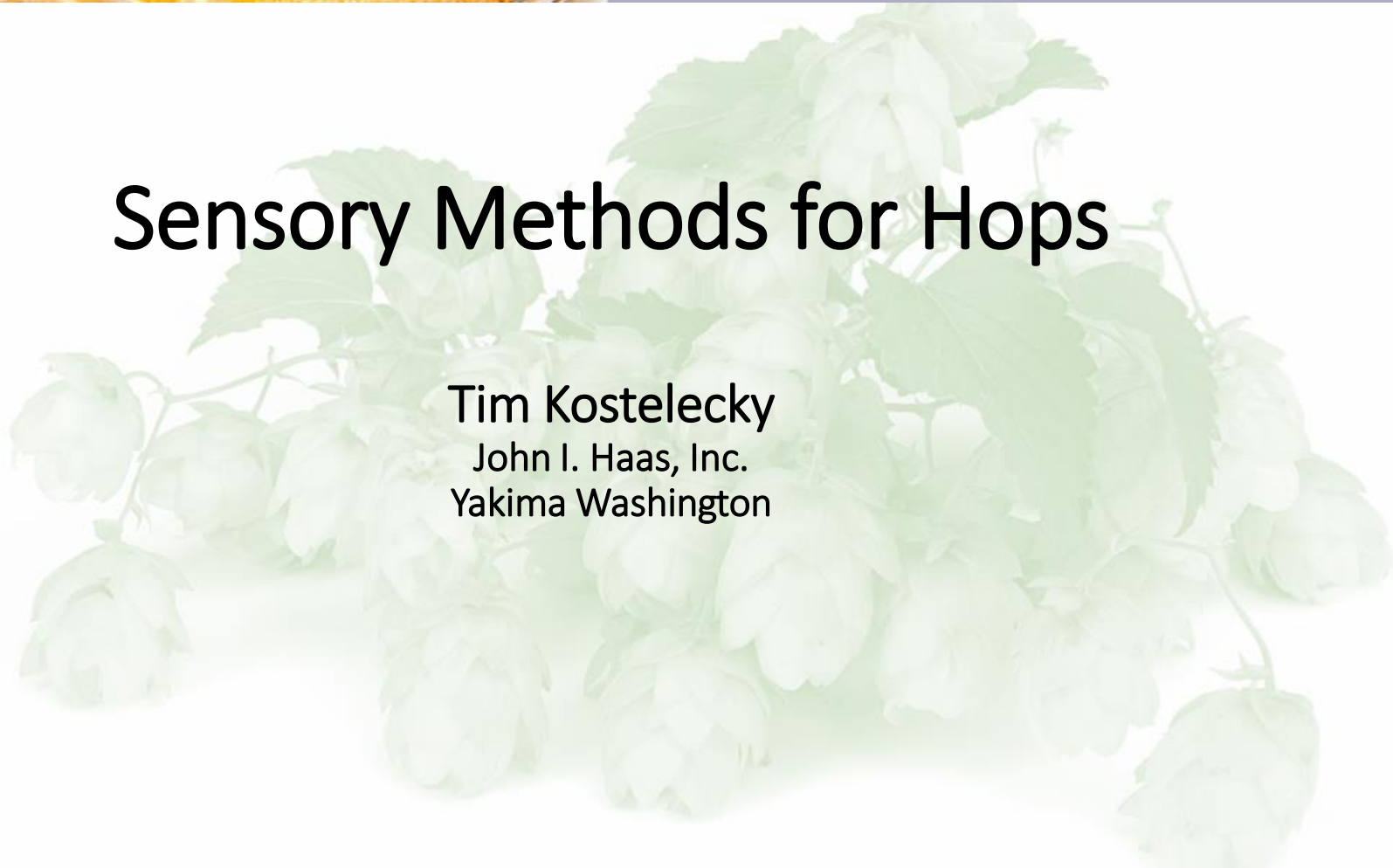


THE
SCIENCE
OF BEER

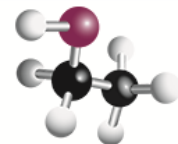


Sensory Methods for Hops

Tim Kostelecky
John I. Haas, Inc.
Yakima Washington



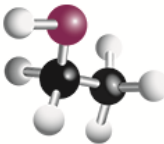
2017 ASBC Meeting



Evaluating Hop Aroma



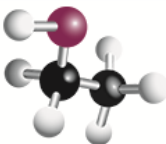
- Hop varieties vary considerably in their aroma profiles and are extremely complicated in scope.
- Sensory is still the most reliable method for evaluating hop aroma despite advancements in instrumental analyses.
- Not much has changed in recent decades in the methods of hop sensory analysis.
- However, the language of the descriptors has broadened and hops are receiving a much high degree of scrutiny in their aroma characteristics.



Evaluating Hop Aroma

Methods Most Used for Hop Sensory:

- Hand Rub
- Hop Tea
- Cold Infusion (dry hop effect)
- Beer



Hop Tea Method

WBC 2016 Poster

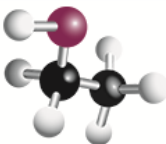
Amanda Benson, Victor Algazzali, Lindsay Barr, Tiffany Pitra
Deschutes Brewery, John I. Haas, New Belgium Brewing Company, Hopsteiner

A cold water extract of hops for sensory analysis. The water extract or “hop tea” can be used to assess the potential aroma quality of hops.

1. Weigh out hop pellets or cones.
2. Using a blade coffee grinder, grind the hop material.
3. Fill a graduated cylinder with 25°C water up to the 1L mark.
4. Place a magnetic stir bar in the bottom of the glass French Press.
5. Add the ground hop material to the French Press beaker.
6. Gently add water and attach the lid plunger and depress the plunger so it gently rests above the material.
7. Place the full French Press on the stir plate and set the mixing speed to allow to stir for 20 minutes.
8. After 20 minutes, turn off the stir plate and remove the beaker.
9. Press down on the plunger filter to strain the hop tea and remove the hop particulate.
10. Decant the hop tea and use for sensory analysis.



2017 ASBC Meeting



Hand Evaluation of Hops

- Evaluation is most effectively done with whole hop cones, and to a lesser extent, hop pellets.
- The brewer can select whole hops to be later processed into pellets.

Three senses used for hand examination of hops:

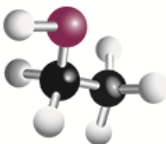
Sight

Feel

Smell



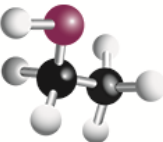
2017 ASBC Meeting



Objectives for Aroma Evaluation



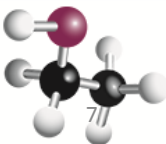
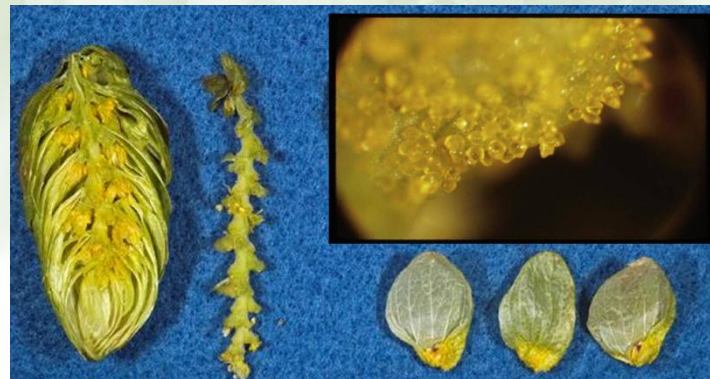
- Ensure consistency and true-to-type
- Seek uniqueness
- Identify off aromas
- Guess effect on beer aroma



Enemies of Hop Quality

1. Time
2. Temperature
3. Oxygen

The primary culprit effecting dried hop quality after harvest is oxidation of bitter and aroma compounds.

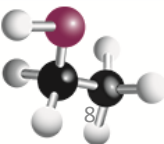


Specific Oxidation Effects on Hop Aroma

Oxidation of hop aroma compounds, primarily the essential oils of hops, occur at a rate similar to that of the hop bitter acids.

Typical hop aromas, including floral, herbal, spicy, fruity and citrus, can be transformed nasty compounds exhibiting sweaty, cheesy, and other unfavorable aromas.

However, some oxidation is good – contributing to the herbal/spicy notes defining “noble” hop aroma.



Hop Storage Index - HSI

HSI is determined by spectrophotometric method (ASBC Hops 6a, 12); gives indication of loss of alpha acids.

0.250 = Typical of fresh hops

0.300 = 10% oxidized

0.400 = 25% oxidized

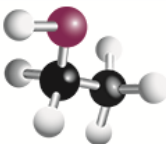
0.500 = 33% oxidized

0.700 = 50% oxidized



Although HSI measures the degree of degradation of alpha acids, one can also assume that the aroma components of the hops experience a similar degree of oxidation.

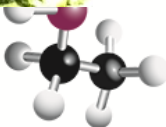
HSI is important to brewers as a quality indicator of hop harvesting, processing, handling, packaging and storage.



Aroma Evaluation Techniques – Whole Hops

Hand-rub technique

- With clean hand, grab “handful” ~ 10 to 20 grams hops
- Rub vigorously in palms to break lupulin glands and warm the sample
- Make note of tactile feel of the hops
- Sniff the sample and evaluate aroma
 - Some use a 2-stage aroma technique – light rub; vigorous rub



Aroma Evaluation Techniques – Whole Hops

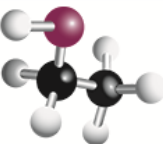
“Dainty” technique

- Select a single hop cone
- Peel apart longitudinally
- Rub two halves together to break lupulin and warm sample
- Sniff sample and evaluate aroma
- Necessary for field evaluation



Alternative Method for Hop Aroma

- Hand-rub evaluation has its limitations
 - Consistency in technique
 - Carryover from residual resins on hands
 - Useful when evaluating many of same variety, e.g. purchase selection
- Alternative method useful for aroma profiling.
 - Generally used with raw hops but can also be used for pellets
 - Use small grinding apparatus, e.g. coffee grinder, Magic Bullet[®]
 - Standardize quantity and grind time, e.g. 5 grams hops/10 sec
 - Ground hops/pellets to scintillation jars approximately one-third full.
 - Samples attemperated on electric warming tray; maintain temperature at about 105 deg F.
 - Evaluate aroma within 1 hour of grind/warming
 - Useful when evaluating many different cultivars/varieties



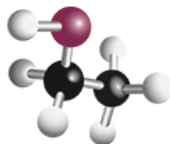
Hop Aroma Profiling – Kostelecky Method



Magic Bullet® works very well for grinding hops or pellets. Use a 1-inch paintbrush to clear out residual hop powder from blades and container between samples.

To emulate temperature created during a vigorous hand rub, keep samples at about 100 to 105 F.

Warming plate setting can be calibrated using thermometer in water.



Haas/HBC Hop Aroma Evaluation

Hop Aroma Evaluation Sheet

Panelist PS Name Art Jensen

Session K-2 @ Dec 11

Sample ->	983	274	104	538	373	276	730	103	349	715
Cedar		2		1				3	1	
Pine		3				2		2	3	1
Tobacco-Earthy	2		3			3		2	2	
Grassy			2	3	2					
Herbal	2					4				
Floral			2							
Spicy	1			4						

Hop Aroma Evaluation Sheet

Panelist _____ Name Leah Dena

Session K-2 @ Dec 11

Sample ->	538	715	349	373	104	276
Cedar		3		2		3
Pine			4			2
Tobacco-Earthy				3		
Grassy						2
Herbal	4					2
Floral				1		
Spicy	3				3	
Citrus	2				2	
Stone Fruit					2	
Tropical Fruit	2			2		1
Onion/Garlic				1		1
Sweaty						

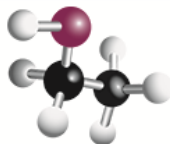
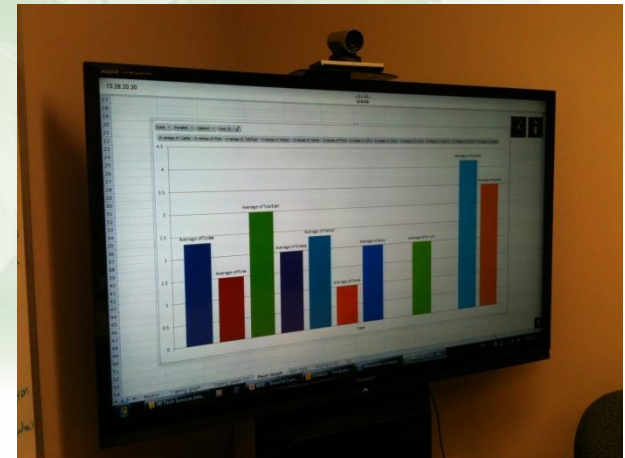
Rate the intensity of each descriptor from 0 to 7 with 7 being most intense

Extra Comments

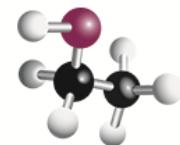
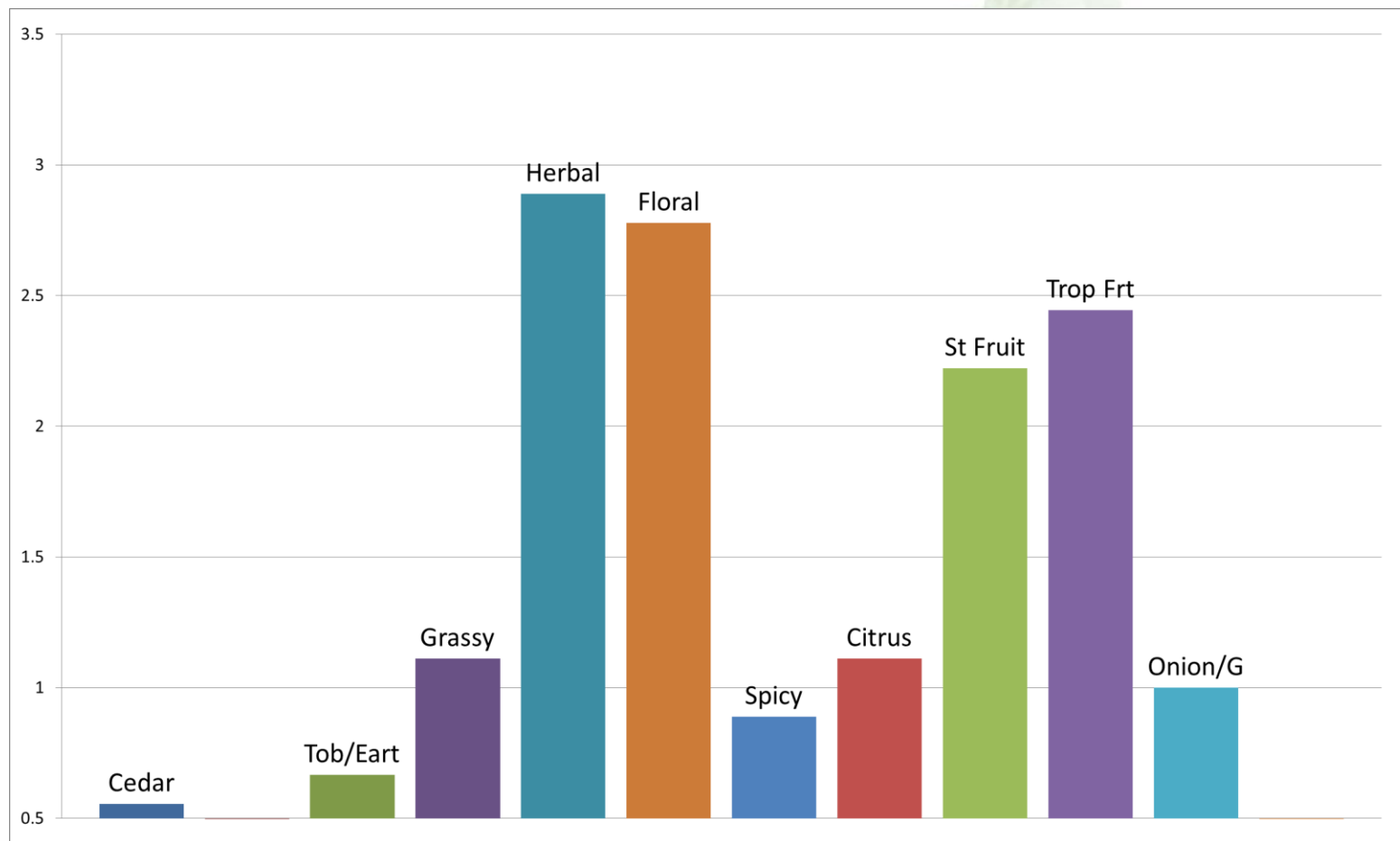
538	
715	
349	
373	

25 hop aroma panelists evaluate over 120 experimental hop cultivars per year

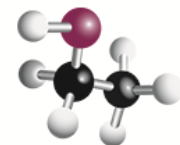
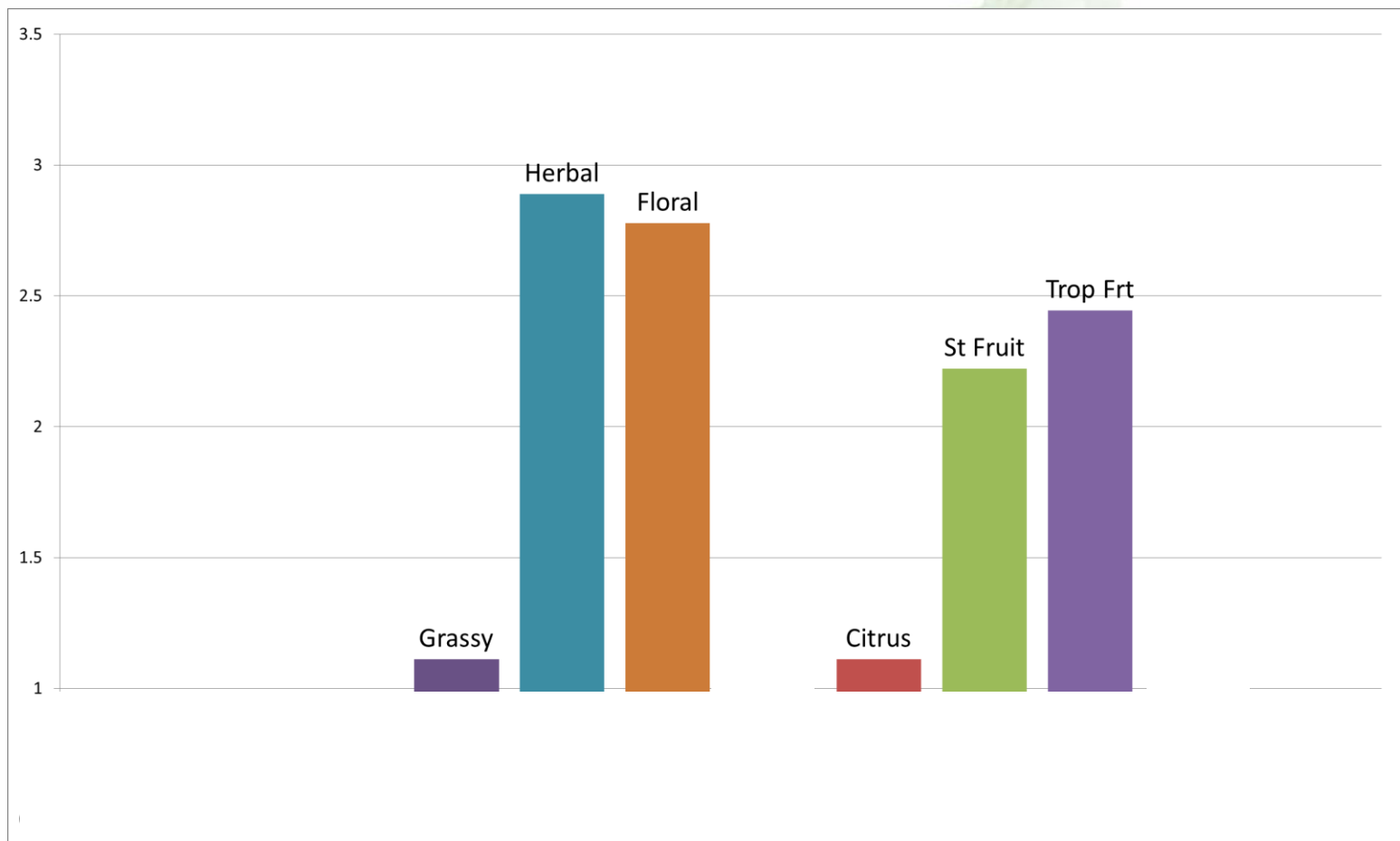
Data is compiled and analyzed



Experimental 1113

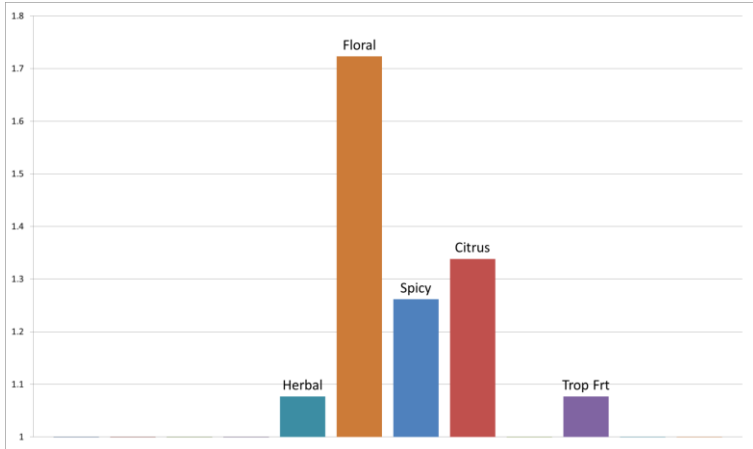


Experimental 1113

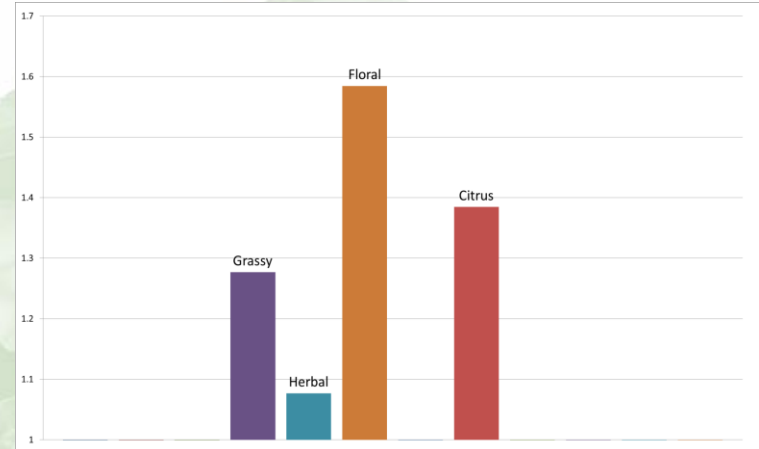


Hop Aroma Profile

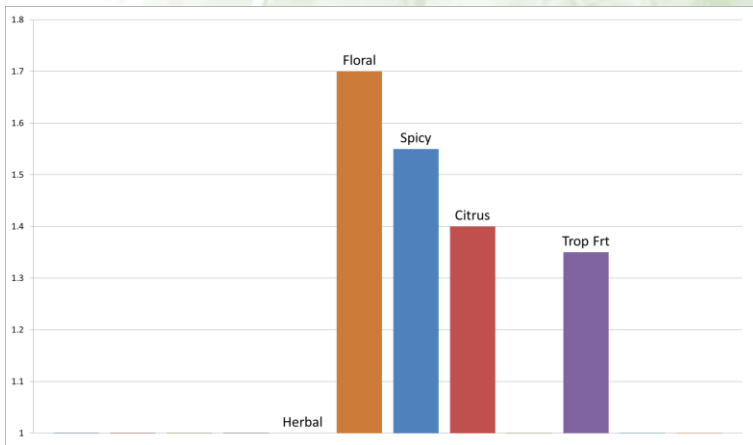
Centennial



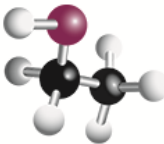
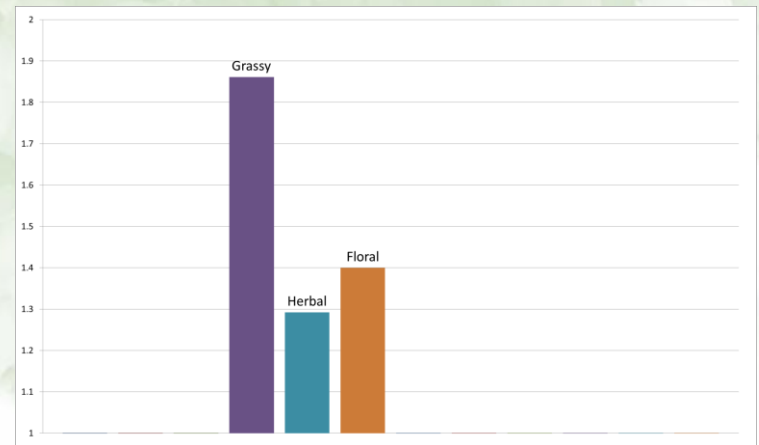
Chinook



Galaxy



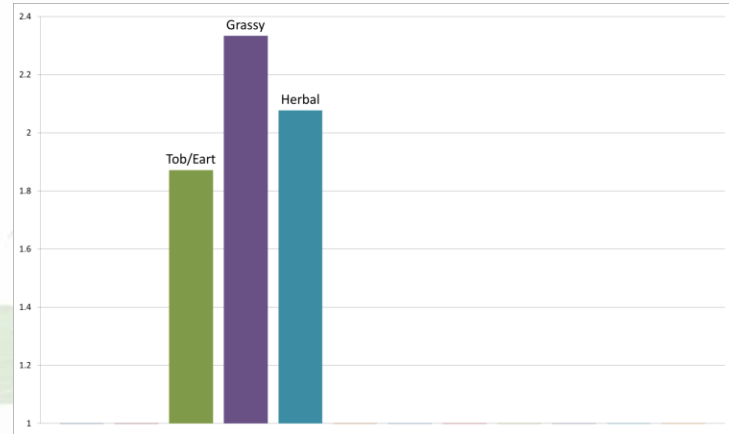
Cascade



Hop Aroma Profile

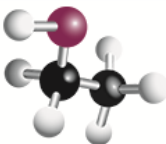
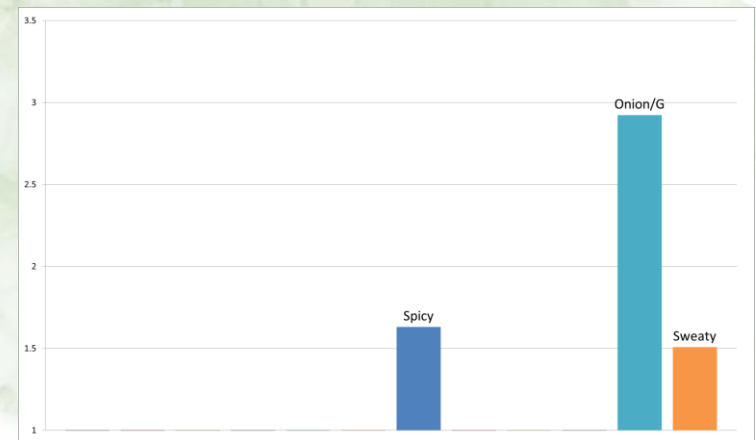
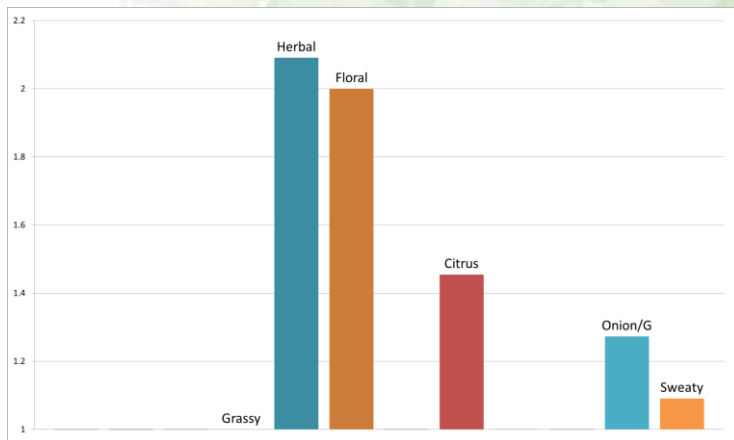
Summit

Saaz



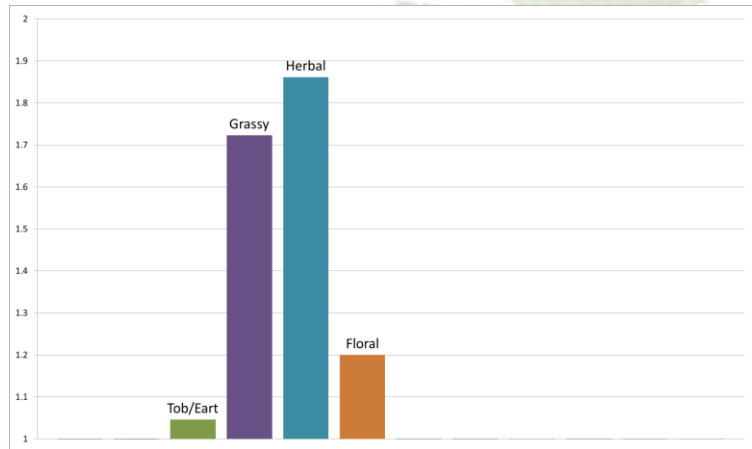
Ella

Summit

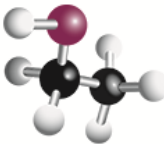
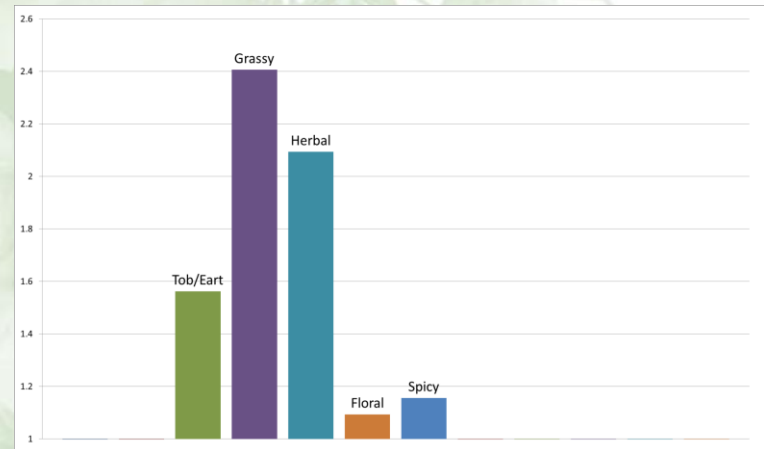


Hop Aroma Profile

Willamette 2011

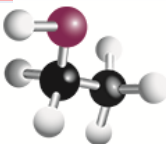


Willamette 2012



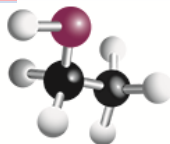
Heat Map – Experimental Varieties

Variety	Ceda	Pine	Tob/Ea	Grass	Herba	Flora	Spicy	Citru	St Fru	Trop F	Onion	Sweat
1001	0.53	0.53	0.59	0.84	1.31	1.72	1.13	1.50	0.84	0.91	0.47	0.13
1002	0.59	0.88	0.94	1.38	1.32	1.68	0.74	0.59	1.03	0.91	0.41	0.29
1003	0.35	0.38	1.18	0.47	1.59	0.91	0.88	0.65	1.41	1.24	1.76	0.82
1004	0.58	0.23	2.84	1.65	1.71	0.77	1.45	0.42	0.39	0.45	1.10	0.32
1005	0.31	0.63	0.66	0.80	1.50	1.17	0.91	0.91	0.91	0.60	1.29	1.03
1006	0.44	0.56	0.59	0.85	1.38	1.53	1.00	1.59	0.79	0.88	1.21	0.53
1007	0.34	0.28	1.03	0.45	1.38	1.76	1.55	1.52	1.03	1.17	0.31	0.14
1008	0.61	0.65	1.35	2.68	1.58	0.32	0.87	0.19	0.97	0.68	0.42	0.55
1009	0.16	0.84	0.74	0.74	1.94	0.97	1.42	0.71	1.10	0.61	2.16	1.32
1010	0.45	0.79	0.55	1.14	1.69	1.34	1.07	1.28	0.76	0.69	0.52	0.38
1011	0.47	0.23	0.60	0.67	1.07	1.23	1.27	1.27	0.73	1.23	1.23	0.33
1012	0.07	0.56	0.78	0.81	1.85	0.85	1.48	0.81	0.96	1.44	1.56	0.59
1013	0.72	0.24	0.28	0.93	1.59	1.41	0.93	0.86	1.00	2.21	0.83	0.17
1014	0.15	0.65	0.53	0.68	1.15	1.59	0.62	1.47	1.29	1.53	0.97	0.47
1015	0.48	0.87	0.97	1.55	1.26	0.81	1.16	1.23	0.39	0.68	0.74	0.90
1016	0.28	0.45	0.52	0.55	1.86	0.97	1.34	0.83	0.86	0.55	1.83	1.62
1017	0.46	0.39	0.71	1.07	1.61	1.14	1.57	0.93	0.46	0.36	2.36	0.79
1018	0.39	0.50	1.11	1.75	1.29	1.32	0.71	1.50	1.32	1.43	0.64	0.25
1019	0.52	0.94	1.03	1.09	1.03	1.48	0.82	1.09	1.06	1.18	0.82	0.12
1020	0.21	0.45	0.88	0.88	1.73	1.70	1.09	0.85	1.00	0.85	0.91	0.24
1021	0.21	0.43	0.43	0.75	1.57	2.07	1.54	1.46	1.64	1.11	0.75	0.57
1022	0.56	0.75	1.00	0.63	1.91	0.84	1.69	1.06	0.75	0.38	1.47	0.69
1023	0.05	0.53	0.79	1.11	1.37	1.58	1.00	0.89	0.53	1.05	1.37	1.16



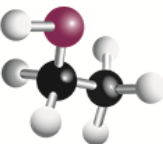
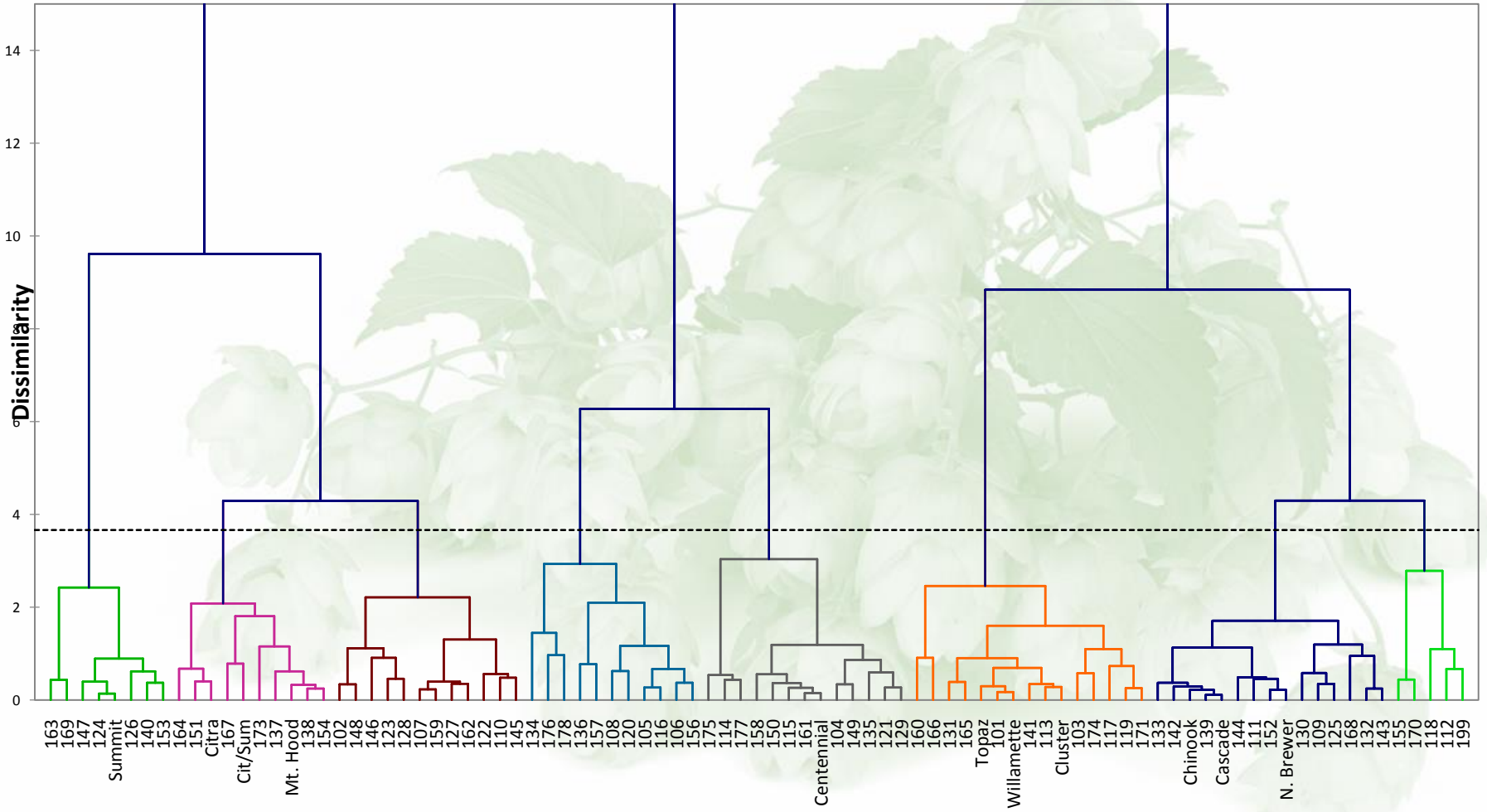
Heat Map – Experimental Varieties

Variety	Ceda	Pine	Tob/Ea	Grass	Herba	Flora	Spicy	Citru	St Fru	Trop F	Onion	Sweat
1077	0.21	1.11	0.54	0.68	0.68	1.75	1.61	2.18	1.04	1.36	1.39	0.46
1076	0.57	0.70	0.57	1.10	1.10	2.33	1.10	2.07	1.83	1.77	0.40	0.27
1092	0.57	0.61	0.57	1.29	1.18	1.46	1.00	1.86	0.96	0.46	0.86	0.32
1075	0.57	0.67	0.37	0.77	1.27	1.53	1.50	1.77	1.87	1.57	0.80	0.10
1078	0.12	0.58	0.65	0.69	1.65	2.04	0.92	1.73	1.73	1.65	0.58	0.19
1116	0.15	0.15	0.38	0.77	1.46	1.92	0.85	1.62	1.31	1.92	0.92	0.23
1006	0.44	0.56	0.59	0.85	1.38	1.53	1.00	1.59	0.79	0.88	1.21	0.53
1110	0.52	1.07	0.59	1.07	1.41	1.66	1.07	1.59	0.83	1.55	0.66	0.45
1007	0.34	0.28	1.03	0.45	1.38	1.76	1.55	1.52	1.03	1.17	0.31	0.14
1001	0.53	0.53	0.59	0.84	1.31	1.72	1.13	1.50	0.84	0.91	0.47	0.13
1018	0.39	0.50	1.11	1.75	1.29	1.32	0.71	1.50	1.32	1.43	0.64	0.25
1108	0.78	0.68	0.61	1.68	1.80	2.17	0.63	1.49	0.98	1.00	0.54	0.18
1014	0.15	0.65	0.53	0.68	1.15	1.59	0.62	1.47	1.29	1.53	0.97	0.47
1021	0.21	0.43	0.43	0.75	1.57	2.07	1.54	1.46	1.64	1.11	0.75	0.57
1094	0.26	0.44	0.70	0.93	1.81	1.74	1.33	1.44	1.19	1.59	1.19	0.22
1036	0.50	1.03	0.78	0.47	1.44	1.19	0.88	1.44	1.31	0.63	0.91	0.31
1088	0.48	0.87	0.68	1.35	1.42	1.03	1.06	1.42	0.65	0.77	1.16	0.39
1101	0.48	0.55	0.28	1.31	1.38	1.21	1.24	1.41	0.90	1.07	1.59	0.41
1043	0.65	1.12	0.96	0.77	1.15	2.12	1.15	1.38	1.62	1.62	0.81	0.46
1090	0.38	0.38	0.84	1.13	1.19	1.63	1.69	1.38	0.88	0.81	1.31	0.38
1041	0.44	0.59	0.89	0.96	1.19	1.15	1.41	1.33	0.48	0.74	1.85	0.96
1083	0.23	0.35	0.71	2.16	1.52	1.97	0.77	1.32	1.23	1.90	0.58	0.06
1051	0.41	0.21	1.14	0.45	1.10	0.66	2.03	1.31	0.17	0.62	3.14	1.14



Hop Aroma Cultivar Dendrogram

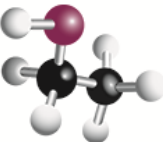
Select Commercial and Experimental Cultivars



Hop Selection

Objectives for Hop Selection:

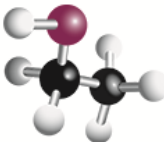
- Selecting preferred hop lots to fulfill purchase agreement
- Determining sample varietal true-to-type
- Evaluating consistency
- Inspecting for damage and disease
- Ensuring hops have been processed properly
- Developing relationship with your suppliers



Hop Selection & Quality Evaluation

Representative sample of hop lot cut from hop bale.

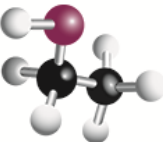
- Evaluating the cut:
 - Outward appearance
 - Seeds & stems
 - Color
 - Damage
 - Ripeness
 - Tactile evaluation
 - Moisture (shatter)
 - Resins, oil, “silkeness”
 - Aroma
 - Typically with Hand-Rub Technique



Hop Selection Scoring

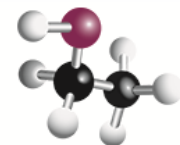
Brewer's generally have their own selection and/or scoring system, from very simple to complex:

- Accept/Reject – Subjective analysis on a go/no-go basis or preference rating.
- Quality score rating system
 - More systematic method often necessary when selecting a large number of lots.
 - Often Involves a weighted quality score
 - Differentiates between hop types, e.g. Aroma/Flavor-type hops and bitter hops



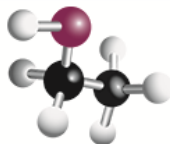
Example: Quality Scoring - Aroma Variety

<u>Weight</u>	<u>Sample</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
50%	Aroma Characteristics	9	8	9	7	5	8
30%	Physical/Pest	9	10	9	8	10	8
5%	Alpha Acids	7	9	6	5	8	9
15%	H S I	10	8	8	9	7	10
<u>Calculated</u>							
	Aroma Characteristics	4.50	4.00	4.50	3.50	2.50	4.00
	Physical/Pest	2.70	3.00	2.70	2.40	3.00	2.40
	Alpha Acids	0.35	0.45	0.30	0.25	0.40	0.45
	H S I	1.50	1.20	1.20	1.35	1.05	1.50
	Quality Score	9.05	8.65	8.70	7.50	6.95	8.35



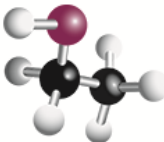
Example: Quality Scoring - Bitter Variety

	<u>Weight</u>	<u>Sample</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	
	15%	Aroma Characteristics	9	8	9	7	5	8	
	30%	Physical/Pest	9	10	9	8	10	8	
	40%	Alpha Acids	7	9	6	5	8	9	
	15%	H S I	10	8	8	9	7	10	
	<u>Calculated</u>								
		Aroma Characteristics	1.35	1.20	1.35	1.05	0.75	1.20	
		Physical/Pest	2.70	3.00	2.70	2.40	3.00	2.40	
		Alpha Acids	2.80	3.60	2.40	2.00	3.20	3.60	
		H S I	1.50	1.20	1.20	1.35	1.05	1.50	
		Quality Score	8.35	9.00	7.65	6.80	8.00	8.70	



Hop Pellet Quality – Beyond Aroma

- Hop pellet quality and how the pellets will perform in brewing can be determined by visual and tactile means.
- Density and hardness of pellet is important
- Hard, shiny pellets have often been scorched by too high a temperature through the pelleting die.
- Good pellets will show nice, green color, be dull in appearance, and will break relatively easily with fingers. Pellets should not be too soft.

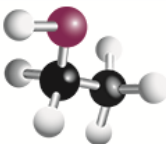


Final Thoughts

- Hops are a natural product and subject to variations in brewing performance characteristics.
- A very wide range of aroma, even within the same variety can be caused by a number of factors including agronomics, weather, pests, damage, and hop handling.
- Brewers are encouraged to define hop quality and develop their method of evaluation accordingly to meet their specific demands.



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