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GREAT TASTE OF THE MIDWEST

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Global Barley Discussion and 2022 Crop Update

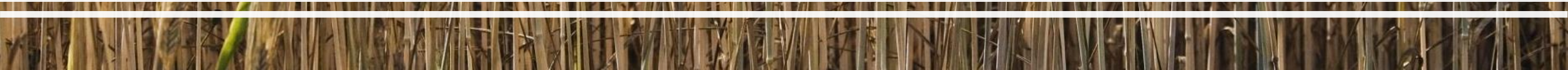
Tim Burke – Sales Manager

Country Malt Group

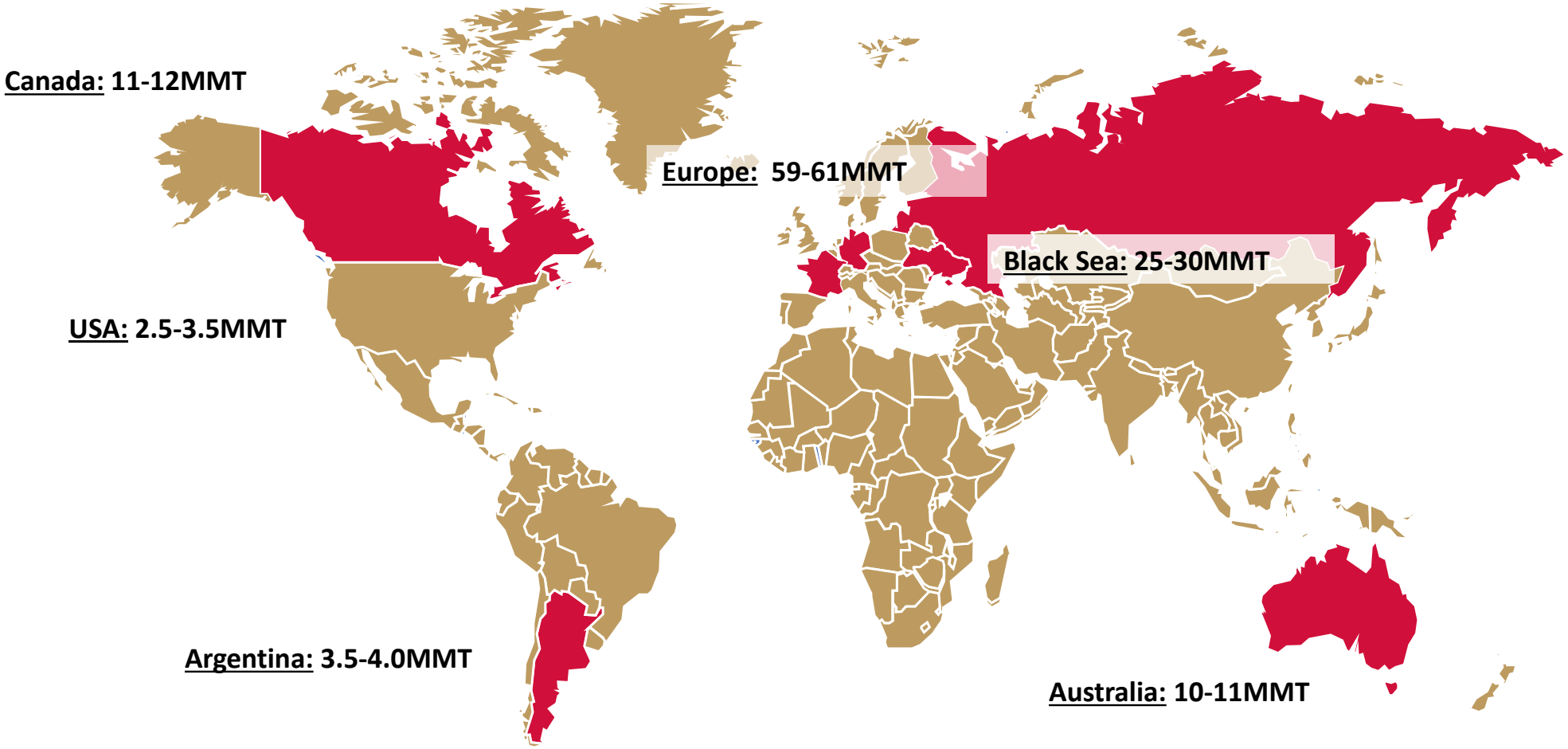
Today’s Agenda

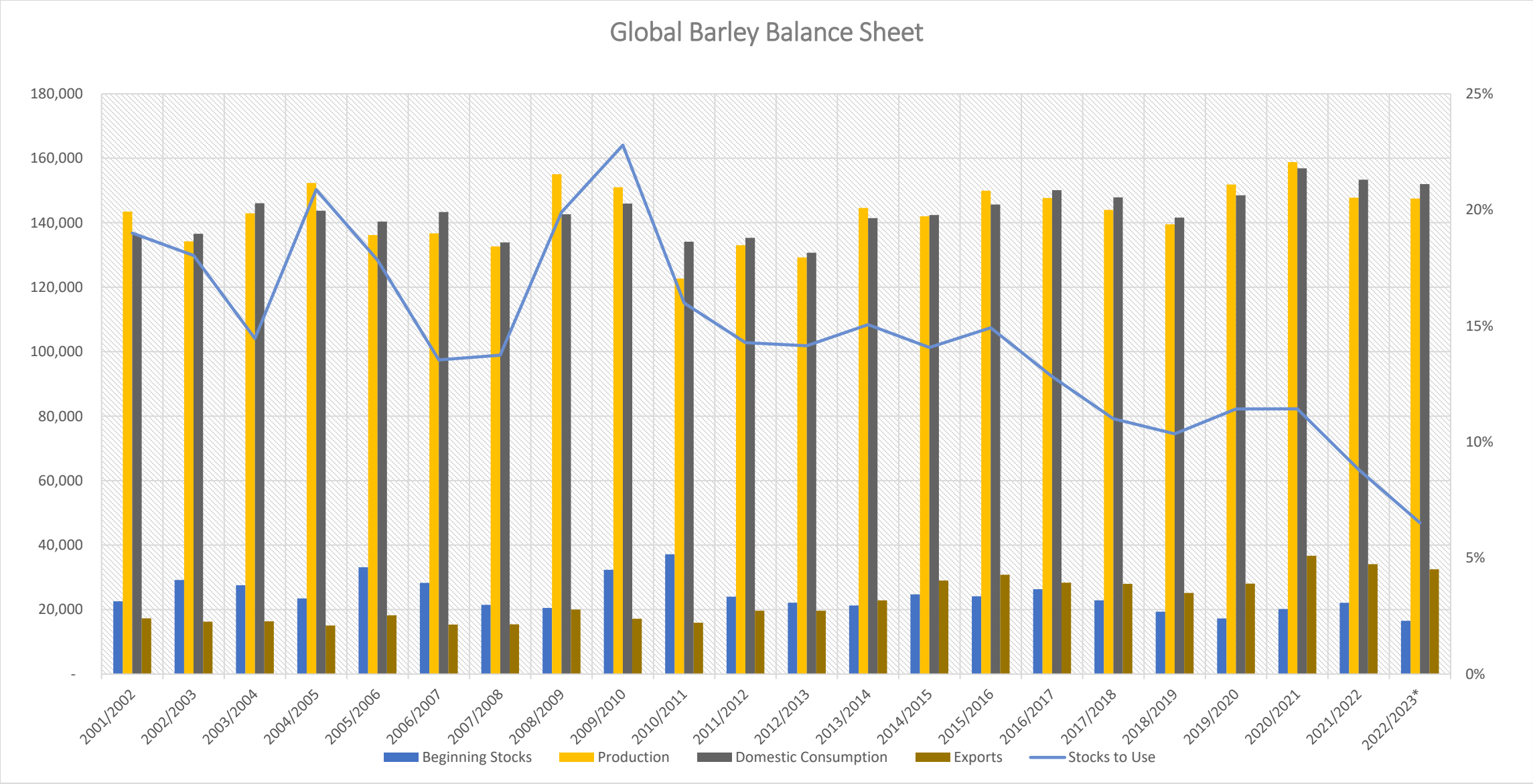
- Global Barley Overview
- Canadian and US Barley/Malt Overview
- 2021 crop CAN/US Re-Cap
- 2022 crop CAN/US Outlook
- CAN/US Barley Varieties
- Questions

Global Barley Overview



Global Barley Production




Global Barley Balance Sheet
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
25%
20%
15%
10%
5%
0%
2001/2002
2002/2003
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2010/2011
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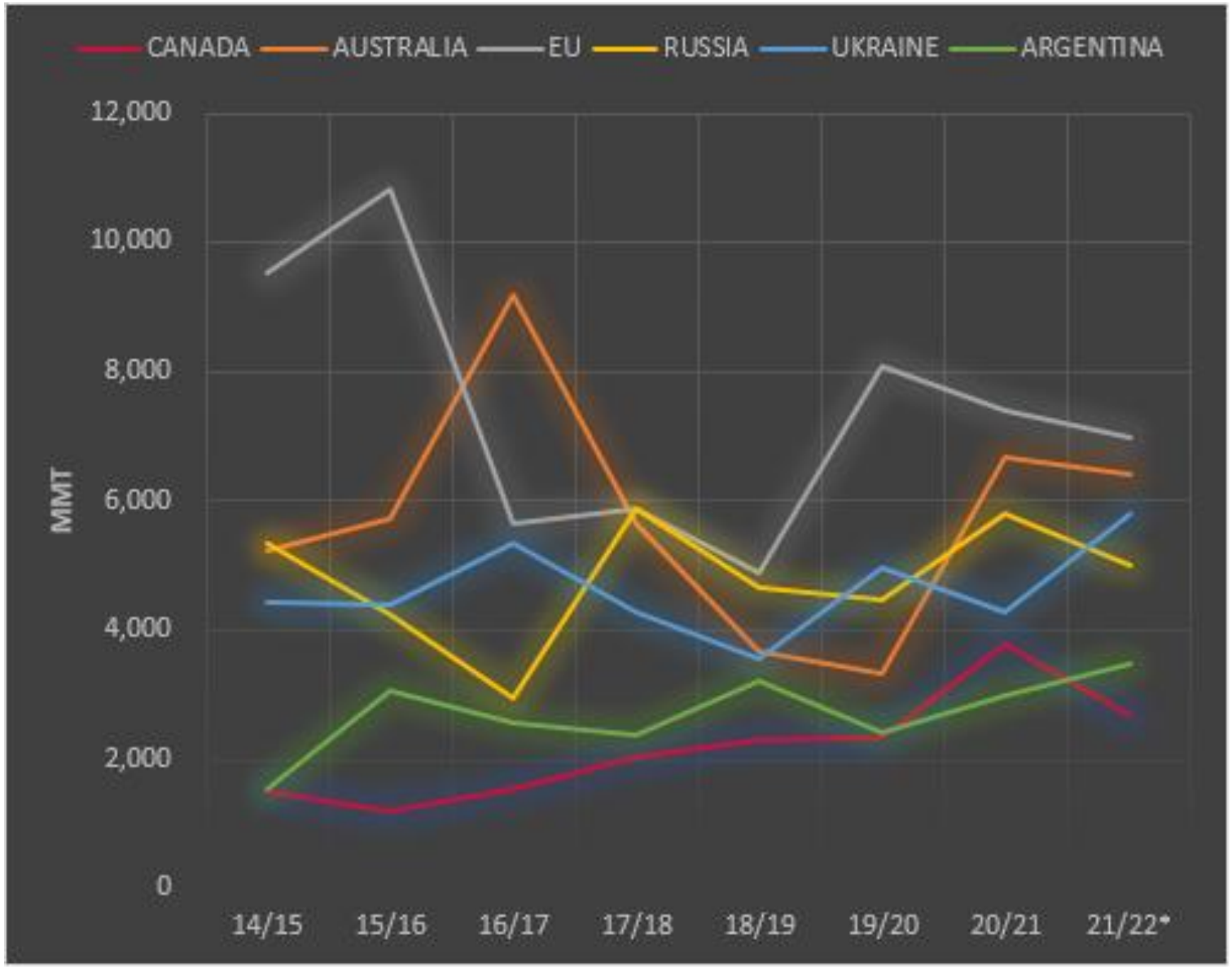
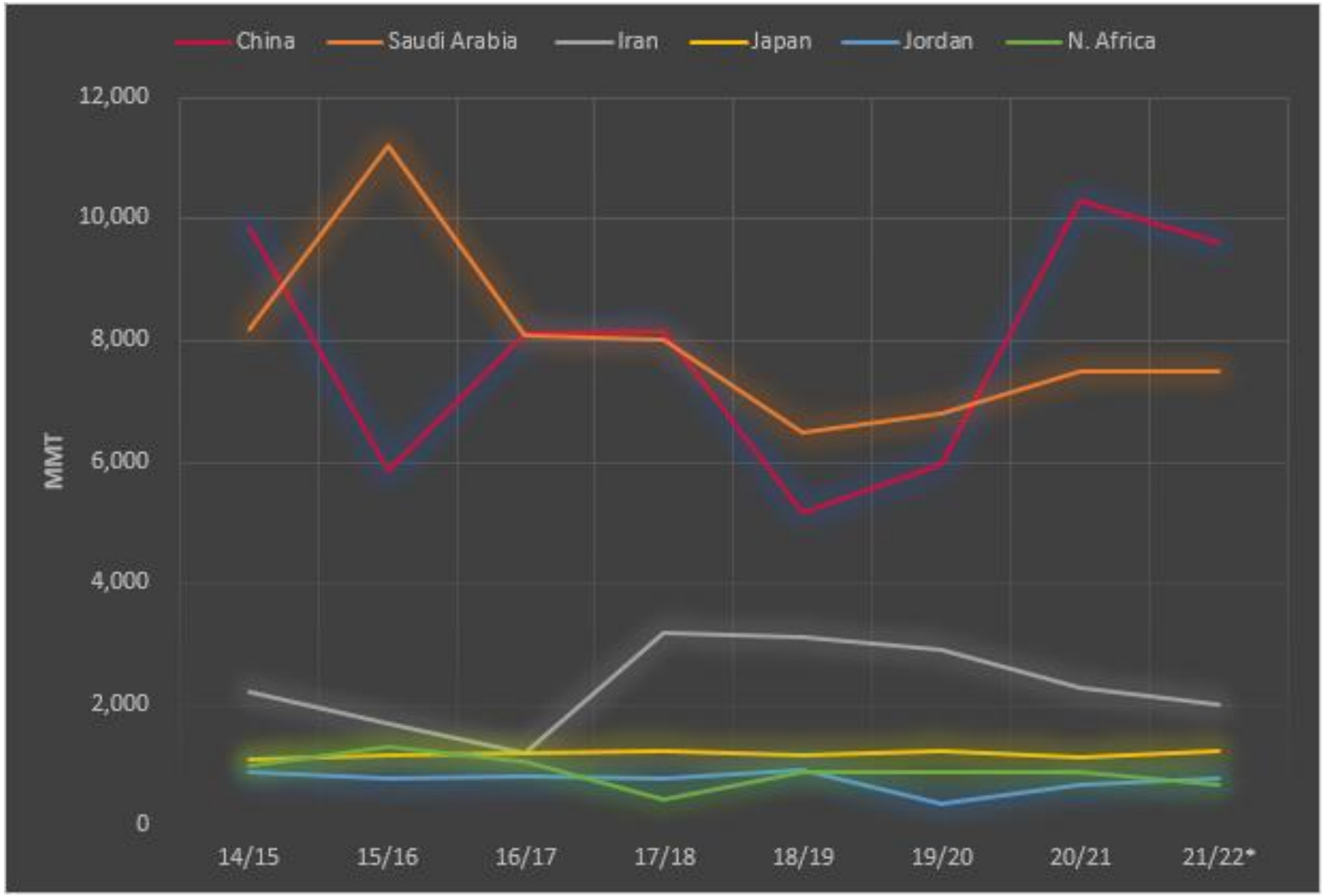
2017/2018
2018/2019
2019/2020
2020/2021
2021/2022
2022/2023*
Beginning Stocks
Production
Domestic Consumption
Exports
Stocks to Use

Top Barley Exporters



Top Barley Importers



Global 2021 Crop Re-Cap

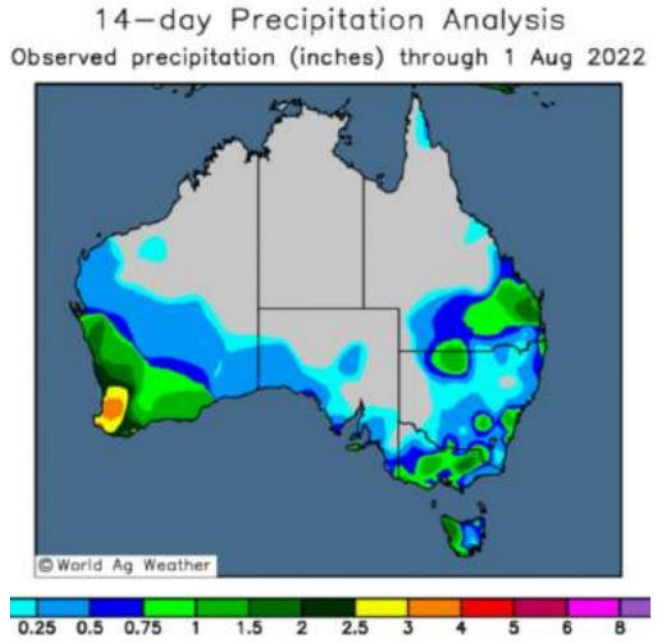
Overall

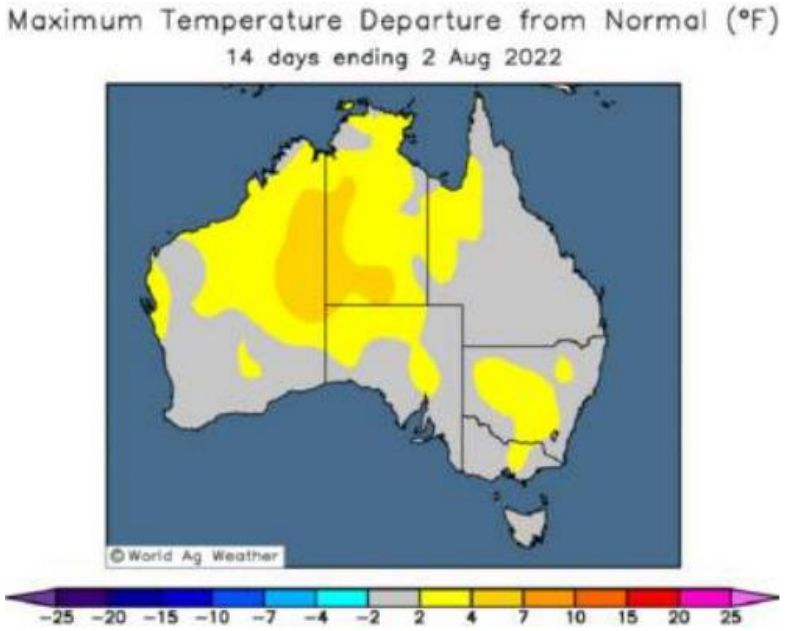
- Quality challenges and poor yields in Canada, U.S. impacted supply and pricing
- Increased EU volume helped with global pricing
- Only minimal quality stocks from last year, mostly feed barley (CAN)
- Australia had one of there best years, but no where to move it due to trade conflict with China
- Pricing remained high in NA and Europe due to increased export demand and lower yields in NA

Global 2022 Crop Update

Australia

- A break in rainfall in central NSW allowed planting to wrap up, including some barley area.
- The rain caused a very late crop start in this region which increase the potential for quality or yield problems.
- Otherwise, Australia's main barley production regions look very good at this stage, as additional rain and moderate temperatures are creating an excellent crop development situation.
- Our crop estimate remains at 11.0M tons, with potential to stretch to 11.5M tons
- Current trade dispute with China will result in excess supply





Global 2022 Crop Update

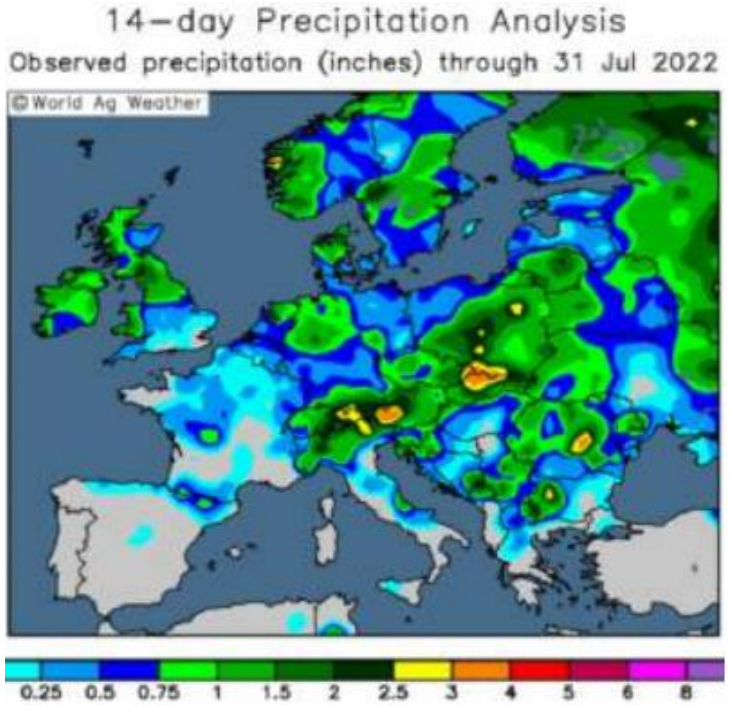
Black Sea

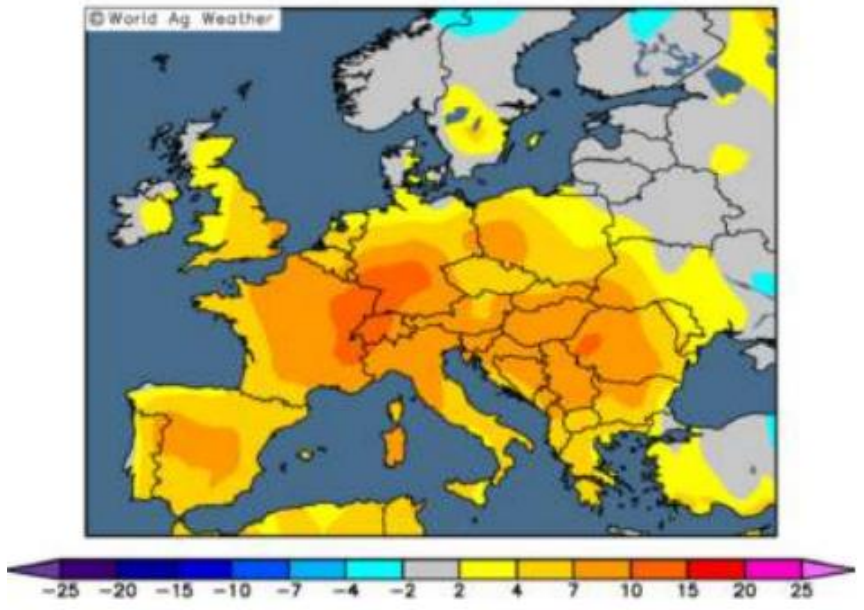
- Ukraine after having largest grain production ever recorded in 2021, the conflict with Russia has disrupted export of grain and planting of new crop???
- Russian harvest just completed, good yields in the West
- Production similar to last year of 28mmt, versus initial expectations of 30mmt
- Mostly sell into China and Saudi Arabia as feed, very little malt quality produced

Global 2022 Crop Update

European Union

- French harvest is now complete with good Winter barley results and a variable Spring barley outcome.
- Recent heat and dry conditions in France and Germany causing some crop stress (see Maps right) will cause projected crop output to drop slightly to 57.6M tons (from 58.0M).
- Overall crop looks positive





Overall Global 2022 Crop Outlook

- Slight reduction in global production to 146.2M tons down from 146.6 tons and a result of recent extreme heat across much of Europe.
- This result is 1.5M tons below Crop'21 and 12.6M tons below Crop'20, leaving a tight supply and demand situation.

World Barley Supply & Demand				
Worldwide	22/23	21/22	20/21	19/20
Harvested Area (Ha)	49.8	52.8	52.1	51.8
Yield	2.9	2.8	3.0	3.0
Production	146.2	147.7	158.8	155.9
Beginning Stocks	19.0	23.9	21.9	20.0
Imports	32.0	34.1	36.7	29.4
Supply	197.1	205.8	217.4	205.2
Use	149.6	152.7	156.8	153.9
Feed	105.0	108.8	111.4	108.9
Industrial	28.1	27.9	28.0	27.9
Other	16.5	16.9	17.4	17.1
Exports	32.0	34.1	36.7	29.4
Ending Stocks	15.5	19.0	23.9	21.9
RMI ANALYTICS	M Hectares & tons;		04.08.2022	

Global Picture – Barley – Russia / Ukraine Impact

Farmer:

- Unknown inputs for agricultural practices this year have slowed contracting of barley with maltsters
- Ukraine / Russian impact on wheat pricing has triggered farmers to think twice about planting barley with more profit residing in wheat

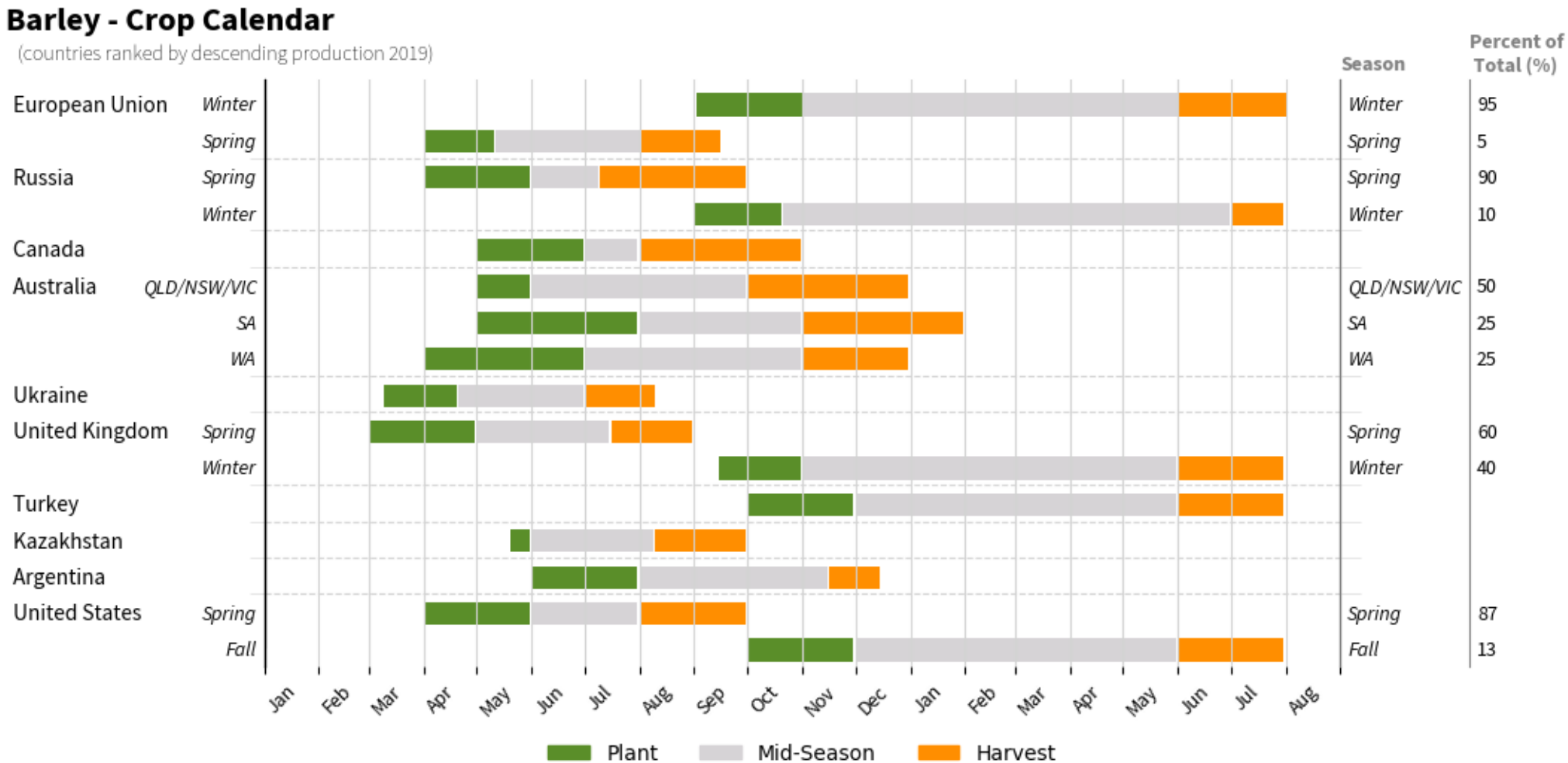
Maltster:

- Losing roughly 40% - 50% of yields last year has forced maltsters to buy barley at elevated pricing for the 2021 crop year / 2022 brew year
- Malt contracting with customers has been delayed, “on and off”
- Maltsters are having to elevate offers to farmers to secure acreage for malting barley

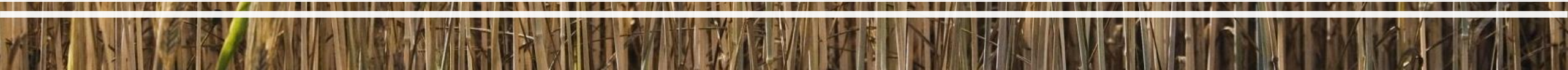
Brewers:

- Crop is progressing quite well but is not a crop until the barley is in the bin, Quality expectations high right now!

Barley Crop Calendar



CAN/US Barley and Malt Production



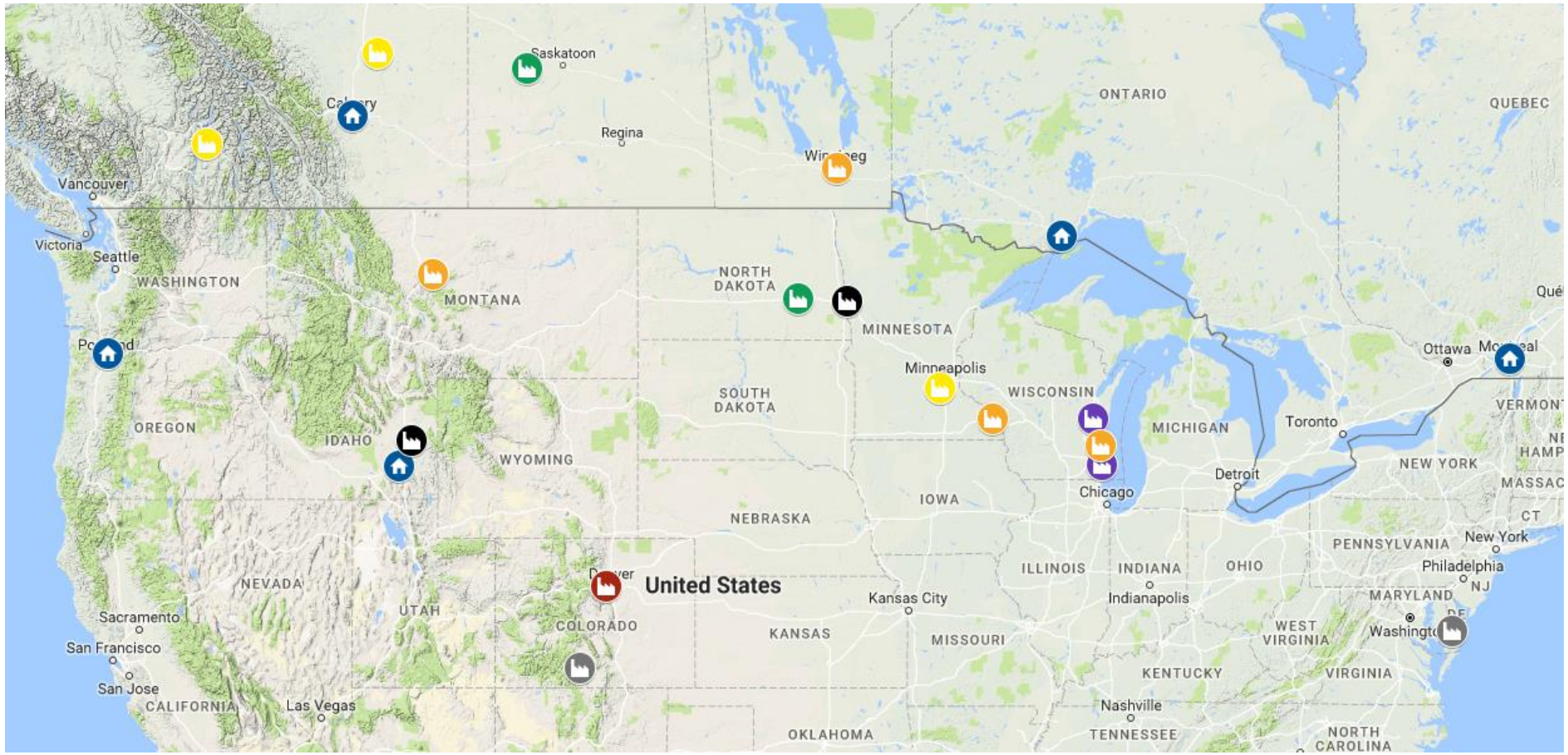
CAN/US Malt Production

R	CS	Company	US/CAD					
			USA		Canada			
1	24.1%	United Malt	120	215	200	125	85	745
2	20.3%	Rahr Malting	USA	Canada				625
			460	140	25			
3	19.9%	Malteurope Groupe	USA			Canada		615
			225	185	125	80		
5	15.2%	*ABI*	USA					470
			340	130				
6	9.1%	*Molson/Miller Coors*	USA					280
			280					
4	5.2%	BoortMalt	Canada					160
			160					
7	4.2%	Briess	USA					130
			30	100				
8	1.9%	Proximity	USA					60
			30	30				

Total Capacity
3085

CS = Capacity Share
Volume (000 mts)

CAN/US Malt Plants



United Malt (745K)

Canada Malting

- Calgary, Alberta (200K)
- Thunder Bay, Ontario (125K)
- Montreal, Quebec (85K)

Great Western Malting

- Vancouver, Washington (135K)
- Pocatello, Idaho (215K)

Rahr Malting (625K)

- Alix, Alberta (140K)
- Armstrong, British Columbia (25K)
- Shakopee, Minnesota (460K)

Boortmalt (previously Cargill Malt)

- Biggar, Saskatchewan (160K)
- ~~Spiritwood, North Dakota (440K)~~

Malteurop (615K)

- Winnipeg, Manitoba (80K)
- Great Falls, Montana (25K)

AB InBev (470K)

- Morehead, Minnesota (130K)
- Idaho Falls, Idaho (340K)

Molson/Miller Coors (280K)

- Golden, Colorado

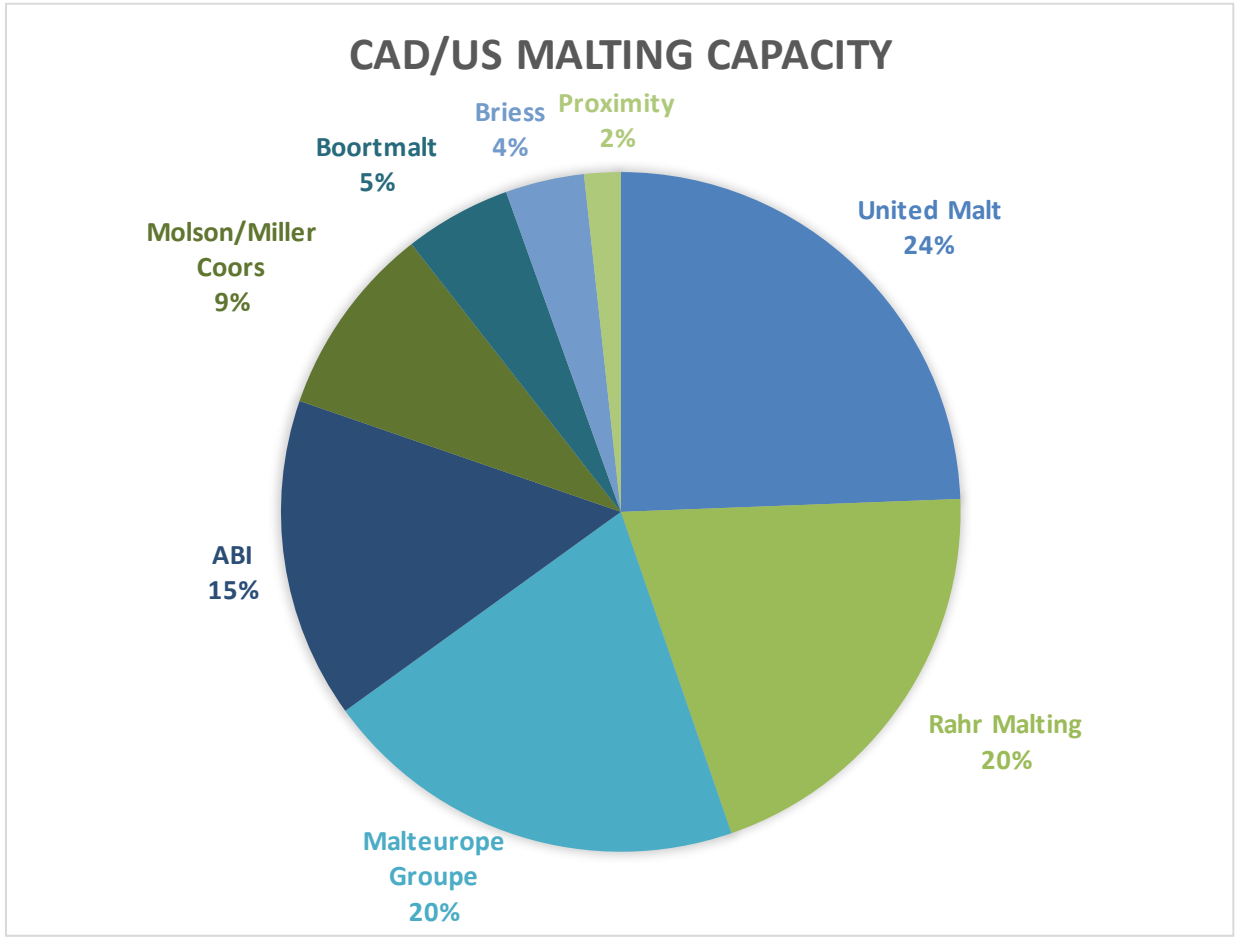
Briess (160K)

- Chilton, Wisconsin (30K)
- Manitowoc, Wisconsin (130K)

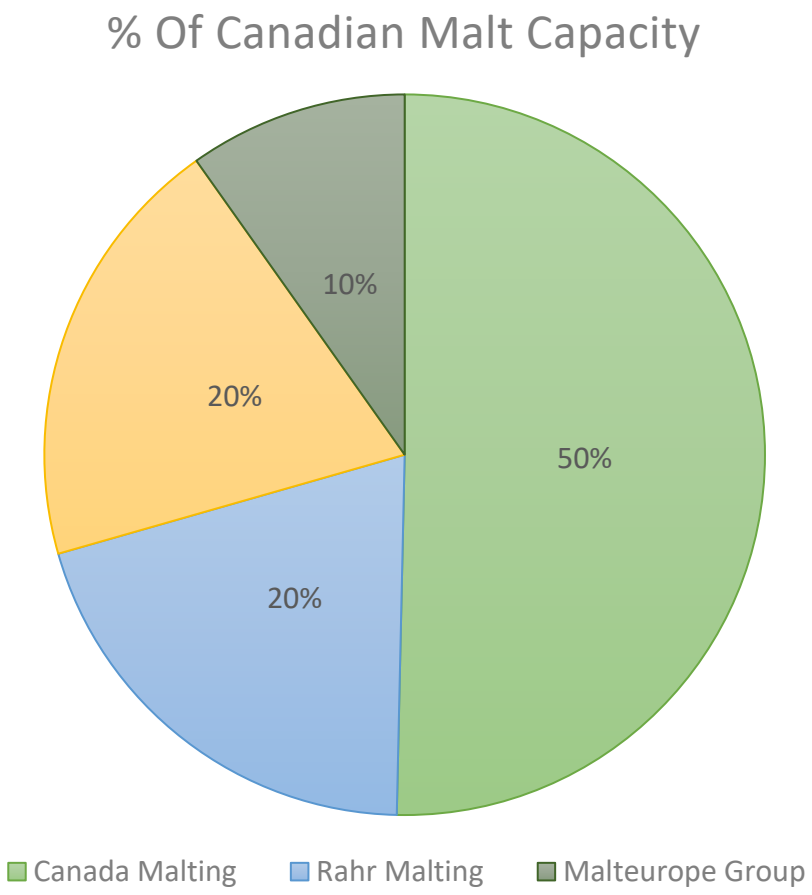
Proximity Malt (60K)

- Monte Vista, Colorado (30K)
- Laurel, Delaware (30K)

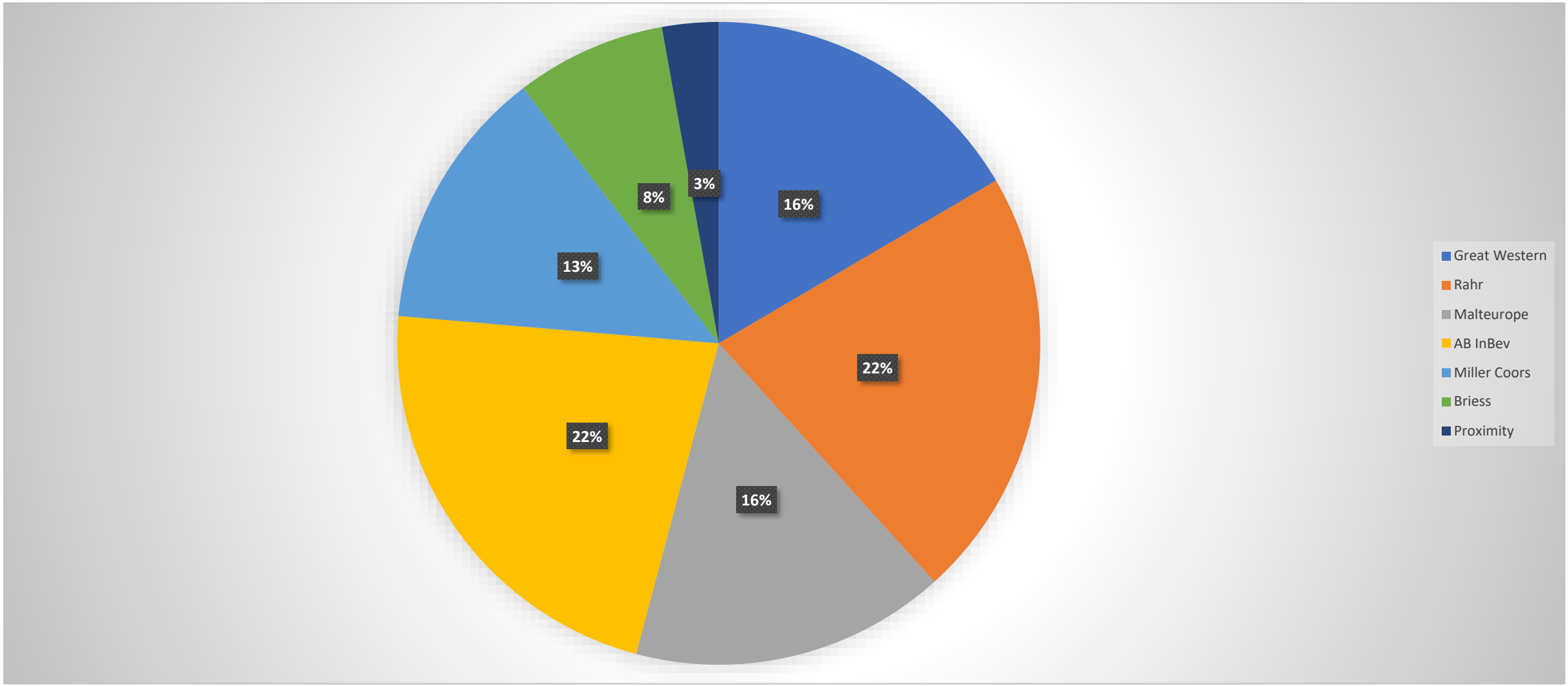
CAN/US Malt Production



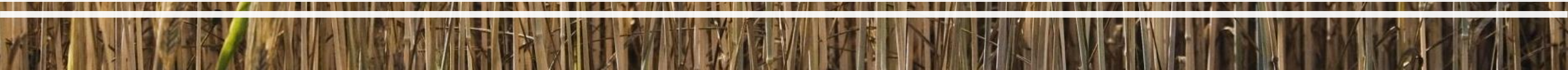
Canadian Malt Production by Co.



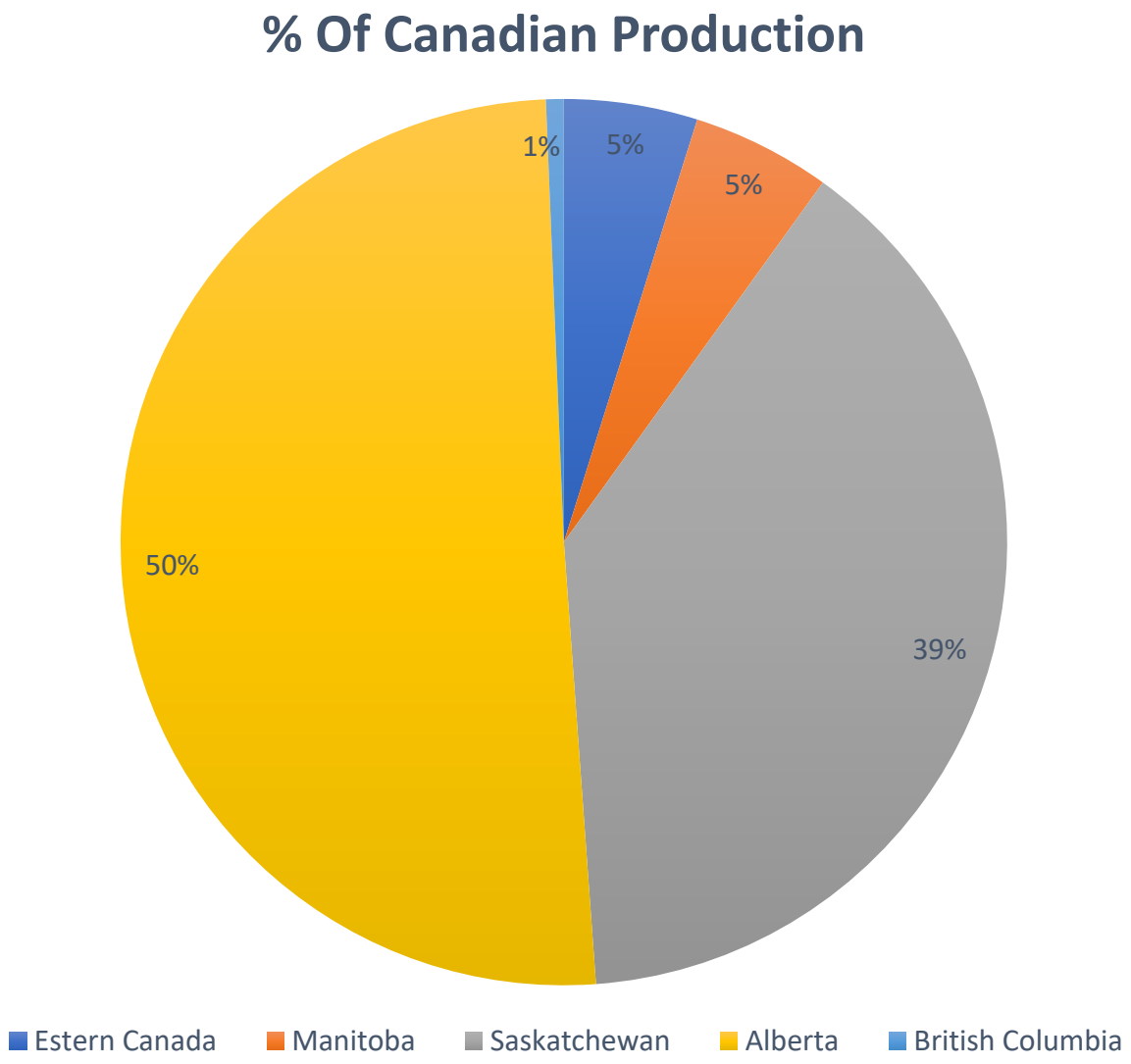
US Malt Production by Co.



Canadian Barley Production

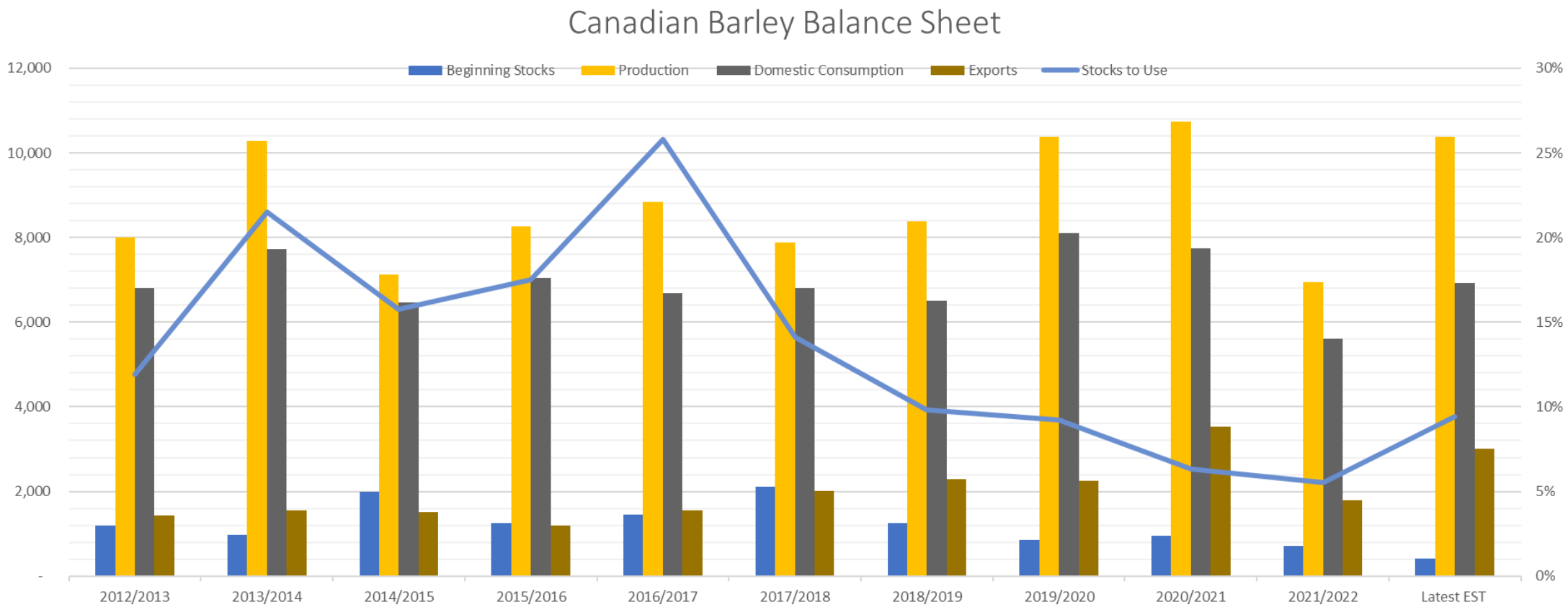


Canadian Barley Production by Province

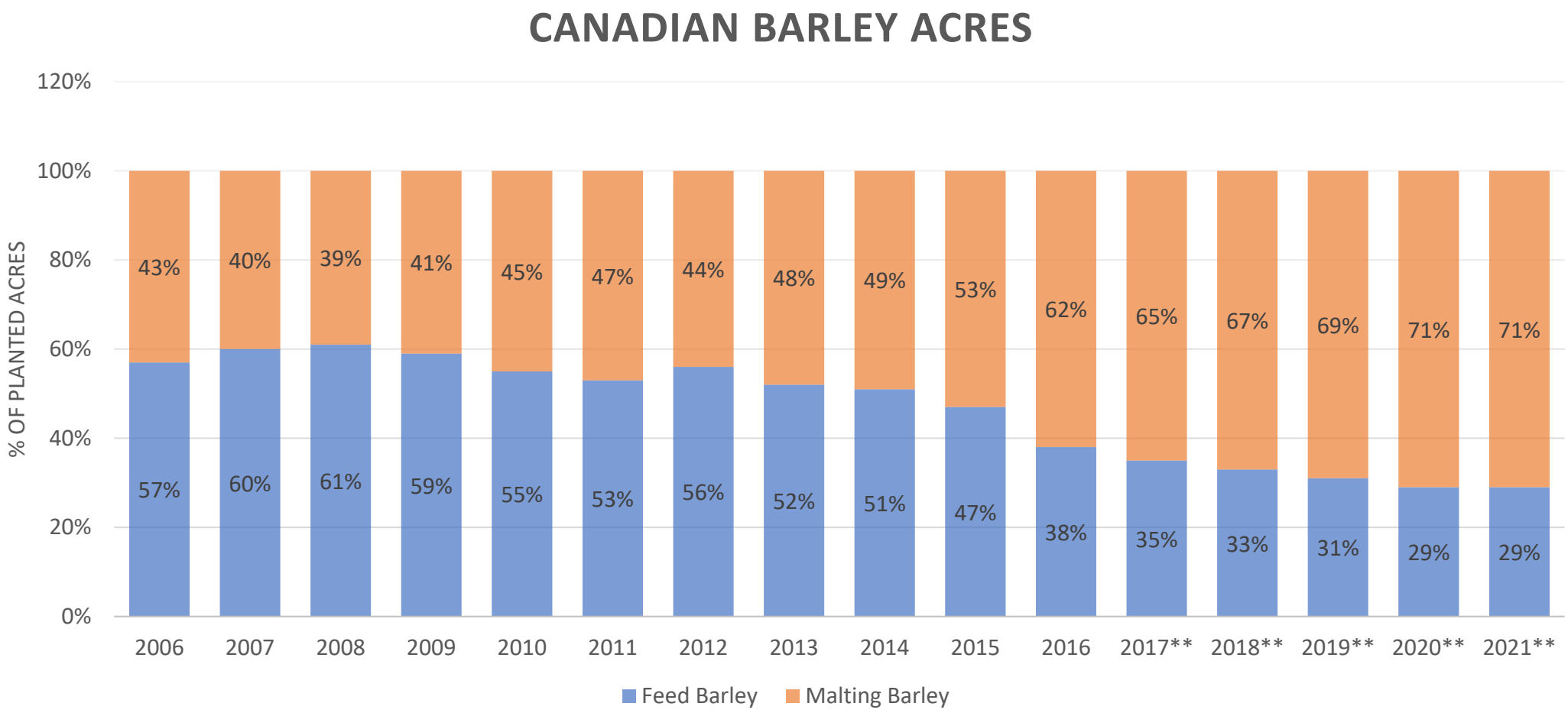


Canadian Barley Balance Sheet

Attributes	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023*
Beginning Stocks	1,502	1,195	983	1,995	1,260	1,443	2,120	1,244	863	957	711	409
Area Harvested (Hectres)	2,402	2,765	2,687	2,167	2,352	2,266	2,114	2,395	2,728	2,809	3,002	2,852
Yield (H/ACRE)	3.29	2.90	3.83	3.28	3.51	3.90	3.73	3.50	4	4	2	3
Production	**7,892**	**8,012**	**10,282**	**7,117**	**8,257**	**8,839**	**7,891**	**8,380**	**10,383**	**10,741**	**6,948**	**9,813**
Imports	16	19	9	136	161	64	59	43	63	294	150	135
Total Supply	**9,410**	**9,226**	**11,274**	**9,248**	**9,678**	**10,346**	**10,070**	**9,667**	**11,309**	**11,992**	**7,809**	**10,358**
Feed Dom. Consumption	5,731	5,701	6,538	5,271	5,860	5,540	5,715	5,171	6,861	6,418	4,500	5,693
FSI Consumption	1,185	1,110	1,180	1,200	1,180	1,140	1,090	1,337	1,247	1,329	1,100	1,228
Domestic Consumption	6,916	6,811	7,718	6,471	7,040	6,680	6,805	6,508	8,108	7,747	5,600	6,921
Exports	**1,299**	**1,432**	**1,561**	**1,517**	**1,195**	**1,546**	**2,021**	**2,296**	**2,244**	**3,534**	**1,800**	**2,511**
Total Demand	**8,215**	**8,243**	**9,279**	**7,988**	**8,235**	**8,226**	**8,826**	**8,804**	**10,352**	**11,281**	**7,400**	**9,432**
Ending Stocks	1,195	983	1,995	1,260	1,443	2,120	1,244	863	957	711	409	925
Stocks to Use	15%	12%	22%	16%	18%	26%	14%	10%	9%	6%	6%	10%


Canadian Barley Balance Sheet
Beginning Stocks
Production
Domestic Consumption
Exports
Stocks to Use
12,000
10,000
8,000
6,000
4,000
2,000
-
30%
25%
20%
15%
10%
5%
0%
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
2018/2019
2019/2020
2020/2021
2021/2022
Latest EST

Silver Lining?

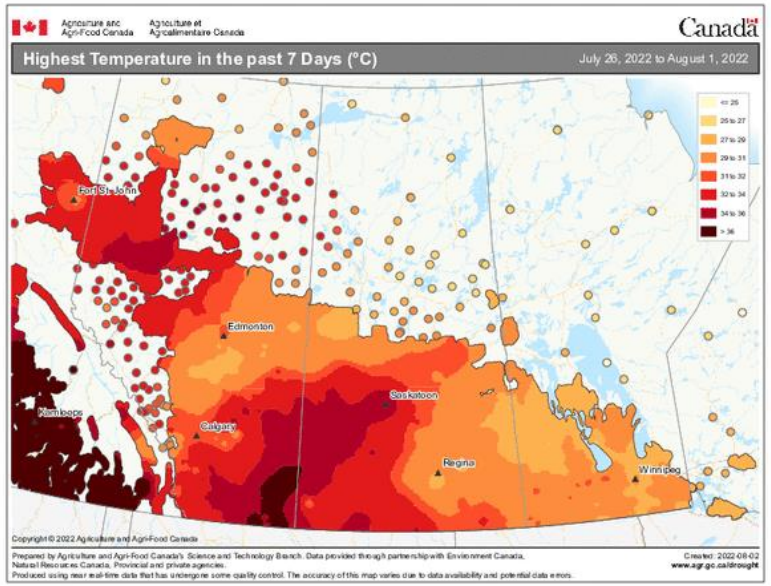


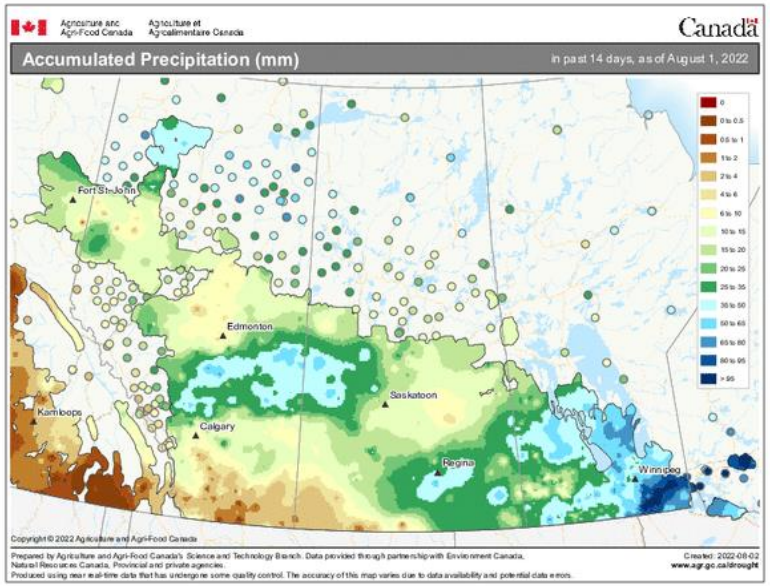
Canadian Crop 2021 Re-Cap

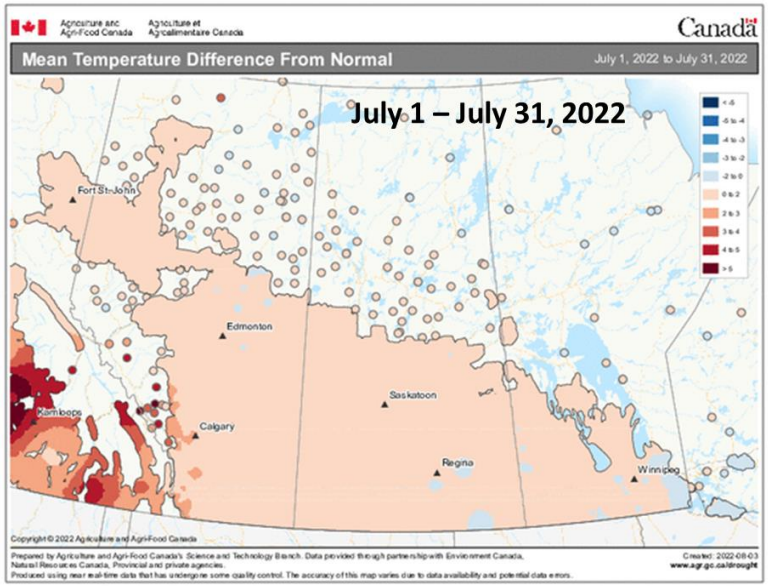
- Canadian quantity was extremely low (Spring forecast was at 12.5 mmt, Crop came in under 7.0 mmt: **-45%!**)
- Quality was below average (plumps 10% lower and protein averaging 13+%)
- Substantial loss of acres occurred during growing season and harvest due to:
  - Drought (minimal moisture and excessively high temperatures)
  - Hail
  - Insects
- Lack of carry out
- 2021 crop barley stocks will run out at approximately August/September, 2022

Recent Weather Patterns

Canadian Prairies



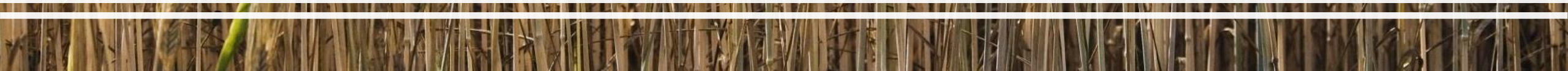




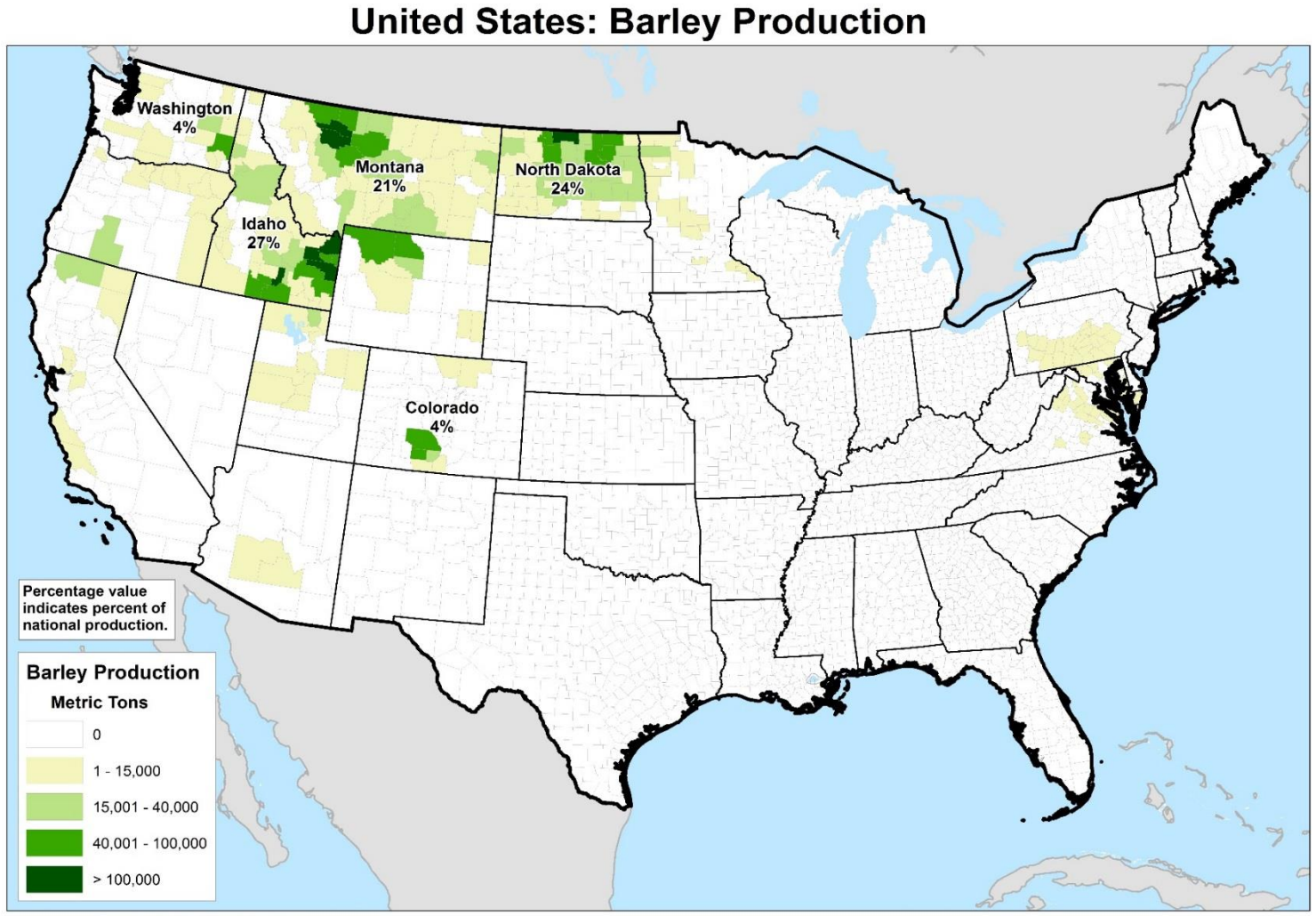
Canadian 2022 Crop Update

- Crop progress:
  - Rain events have slowed substantially, with severe thunder showers and hail storms ensuing during this two week period throughout the prairies.
  - Minimal sporadic showers are forecasted continuing throughout the next 2-3 weeks.
  - Temperatures continue to be in the range of 25-30+ degrees Celsius have been the norm over the last two weeks helping the maturation process with slight concerns as to having too much heat.
  - Growth stages: all barley has headed and in the soft/hard dough stages (more advanced in the southern regions). Some regions starting to turn.
  - Still looking to be a slightly later crop (5-10 days) with harvest expected to start in southern AB by mid-August.
  - Expectation is that yields will be average to above average (60-90 bu/ac).
  - Projecting a 10 mmt crop agw.

US Barley Production



US Barley Growing Regions



US Barley Production Summary

BARLEY PRODUCTION SUMMARY

	Seeded (000s acres)		Harvested (000s acres)		Yield (bu/acre)		Production (000s bushels)		
State	**2021**	**2022**	**2021**	**2022**[1]	**2021**	**2022**[1]	**2020**	**2021**	**2022**[1]
Arizona	18	18	14	16	125.0	126.0	976	1,750	2,016
California	40	50	13	22	63.0	45.0	1,457	819	990
Colorado	49	71	47	60	111.0	137.0	6,525	5,217	8,220
Idaho	500	600	490	560	89.0	111.0	55,000	43,610	62,160
Minnesota	45	55	34	35	55.0	65.0	2,350	1,870	2,275
Montana	920	1,090	625	855	38.0	42.0	45,675	23,750	35,910
North Dakota	580	690	430	565	51.0	73.0	28,980	21,930	41,245
Virgina	30	40	7	11	75.0	78.0	441	525	858
Washington	75	90	70	75	38.0	78.0	6,390	2,660	5,850
Wyoming	79	66	70	51	91.0	99.0	5,952	6,370	5,049
Other States[2]	267	276	148	145	62.0	70.9	11,578	9,172	10,279
Total U.S.	**2,603**	**3,046**	**1,948**	**2,395**	**60.4**	**73.0**	**165,324**	**117,673**	**174,852**

Source: USDA NASS Agriculture Statistics Board, July 12, 2022 Crop Production Report

[1]Forecasted July 1, 2022

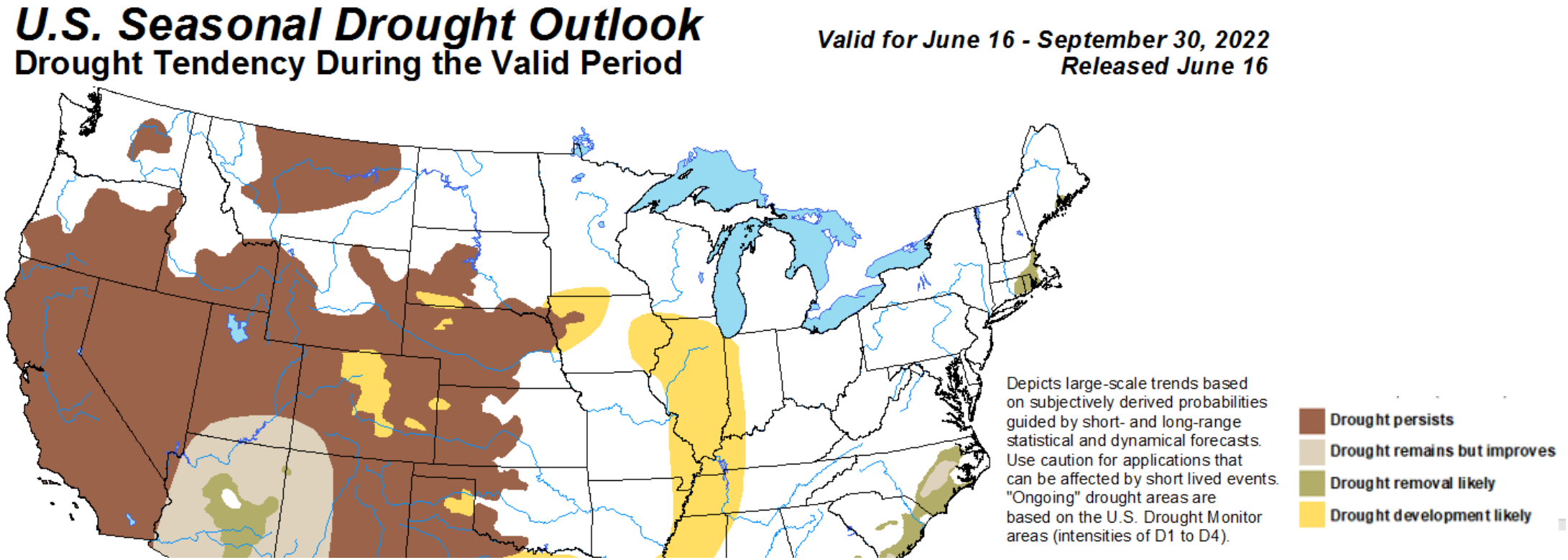
[2]Other States include: Alaska, Delaware, Kansas, Maine, Maryland, Michigan, New York, North Carolina, Oregon, Pennsylvania, South Dakota, Utah, and Wisconsin. Individual State level estimates will be published in the Small Grains 2022 Summary.

US Drought Outlook

10-day Outlook:
Warmer temperatures arriving this weekend, with temps in the 70s to 80s for the Palouse and Most of Washington…

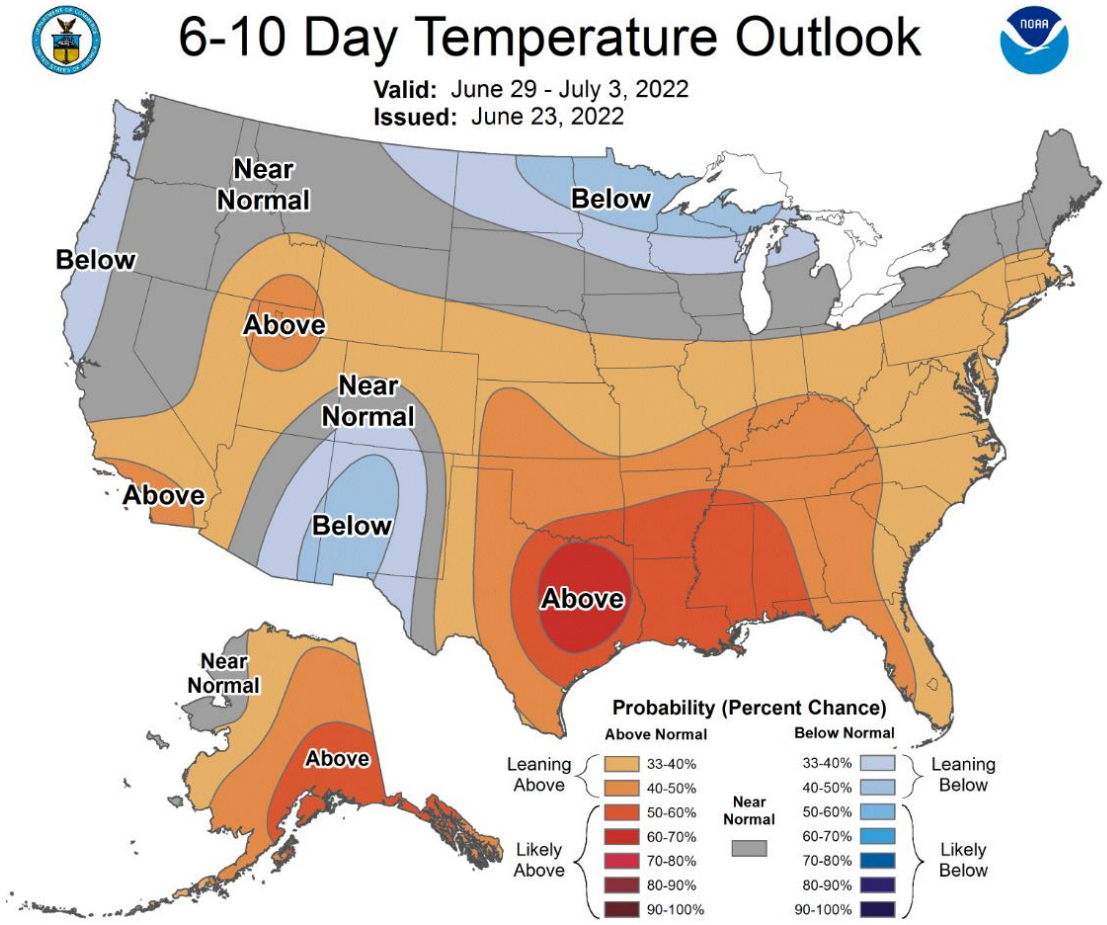
Look for Mid 70's to low 80s for Klamath Falls area.

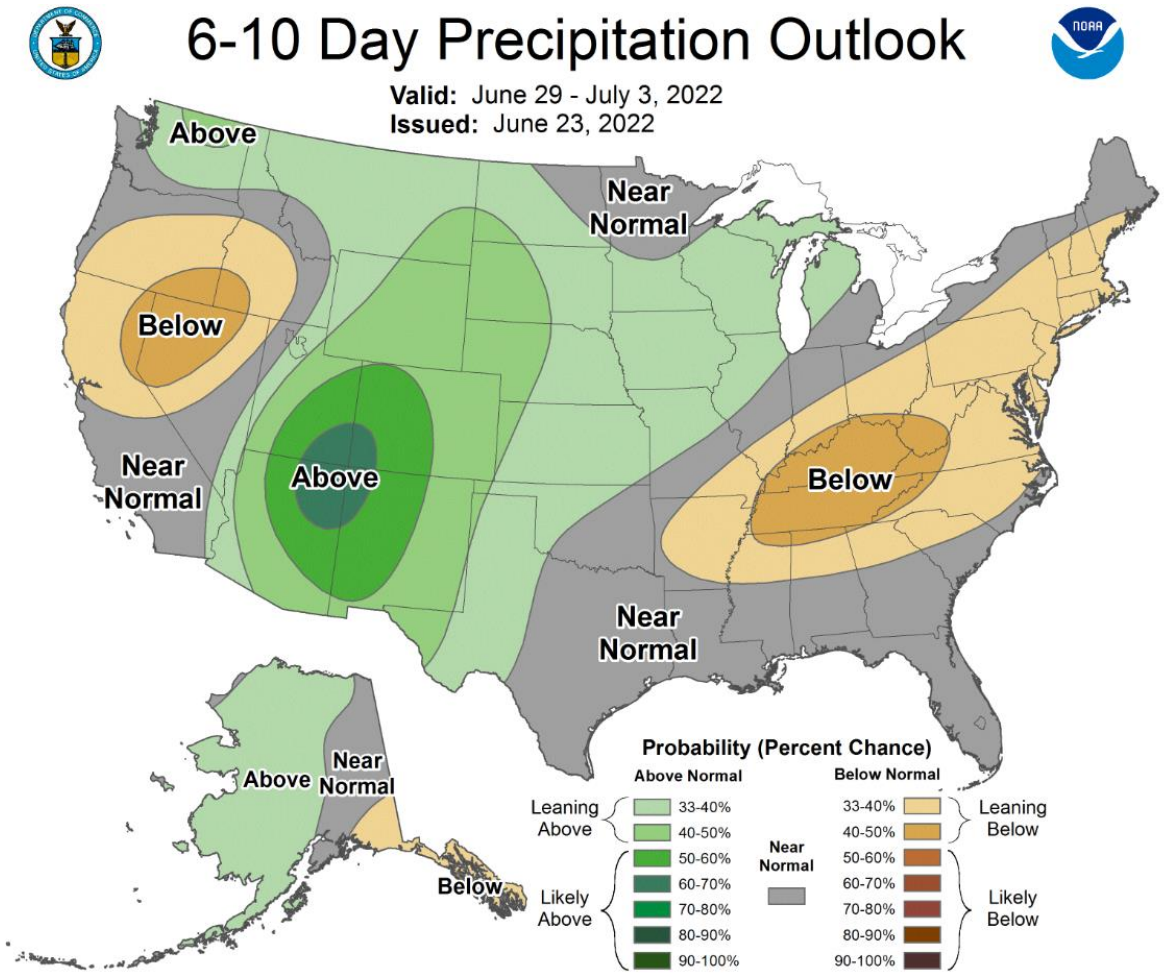
Look for Mid 80s to Mid to upper 90s for central Idaho area this weekend with temps coming back into the 70's mid week.



Immediate Weather Outlook

Temperatures are warming into the weekend in our growing regions. We will see most of our regions getting into the 90's but coming back to near normal temps (70's-80's) for the next 10 days.





US 2022 Crop Update - AMBA Crop Report

Eastern WA

- 2 inches of rain last weekend with warmer growing days to follow in the fourth week of June
- Growers feeling confident about moisture profile and seeing strong yields
- Crop is up and looking good with nice head development and plump kernels

US 2022 Crop Update - AMBA Crop Report

North Dakota

- 98% planted according to the National ag stats service
- Crop is running 10-14 days behind on average regarding crop development
- Ten-day forecast calls for normal temps with no extreme heat

US 2022 Crop Update - AMBA Crop Report

Idaho

- Winter barley field irrigation is complete.
- Early spring barley fields are starting to head out this week.
- 10-day forecast calls for temps in the mid to low 80's which should continue for the rest of June
- Temps in southern Idaho have been 20-30 degree F lower than a year ago
  - In 2021 June 13 was over 100 F
  - 2022's highest temp has been 87 F (Temperature recorded in Blackfoot Idaho)

US 2022 Crop Update - AMBA Crop Report

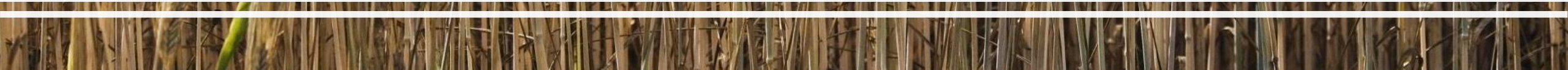
Montana

- Showers in the north central part of the state have been beneficial for the barley crop
- Cool weather has been the norm
- 3 inches have come in the past week giving the barley an excellent chance, but we will need to see more timely rains to get expected yields

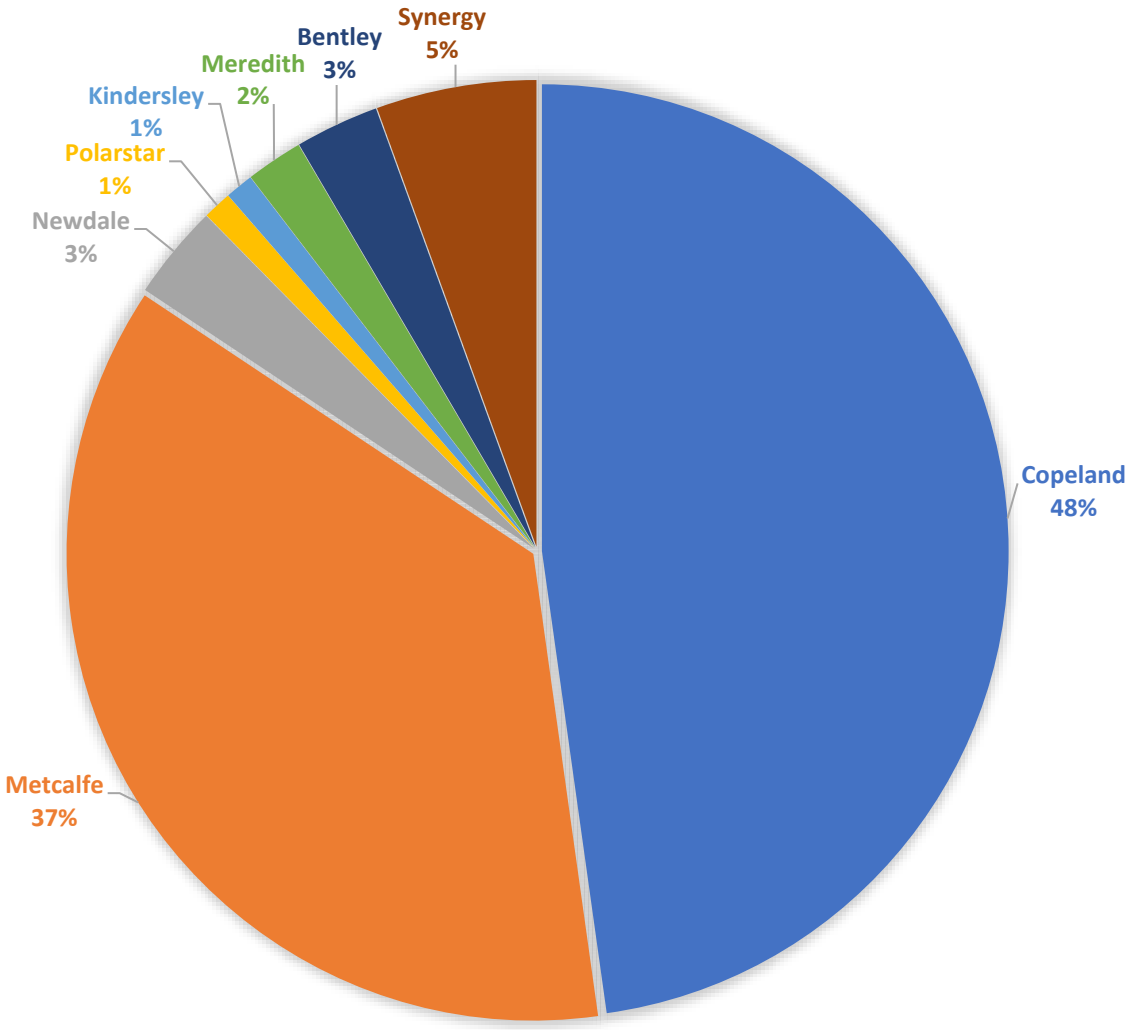
US 2022 Crop Overview

- Production is forecast at 175 million bushels, up 49% from 2021.
- Based on conditions as of July 1, the average yield is forecast at 73.0 bushels per acre, up 12.6 bushels from last year.
- Area harvested for grain or seed, at 2.40 million acres is up 23% from 2021.
- A record high yield is expected in Idaho.
- Nationwide, 97 percent of the barley acreage was sown by June 12
- Overall, 53 percent of the barley acreage was reported in good to excellent condition on June 26, compared to 31 percent at the same time last year.
- Positive Outlook

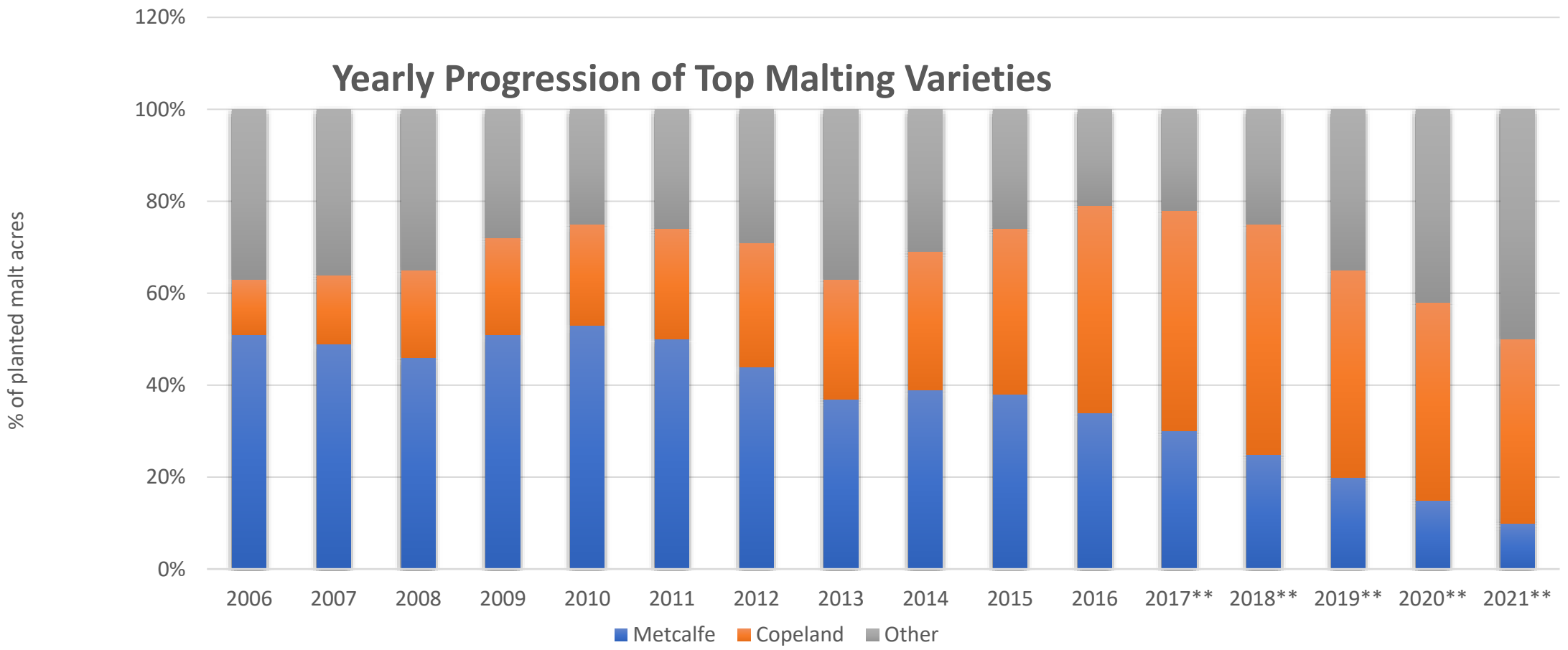
Canadian Barley Varieties



Canadian Malting Barley Varieties 2019

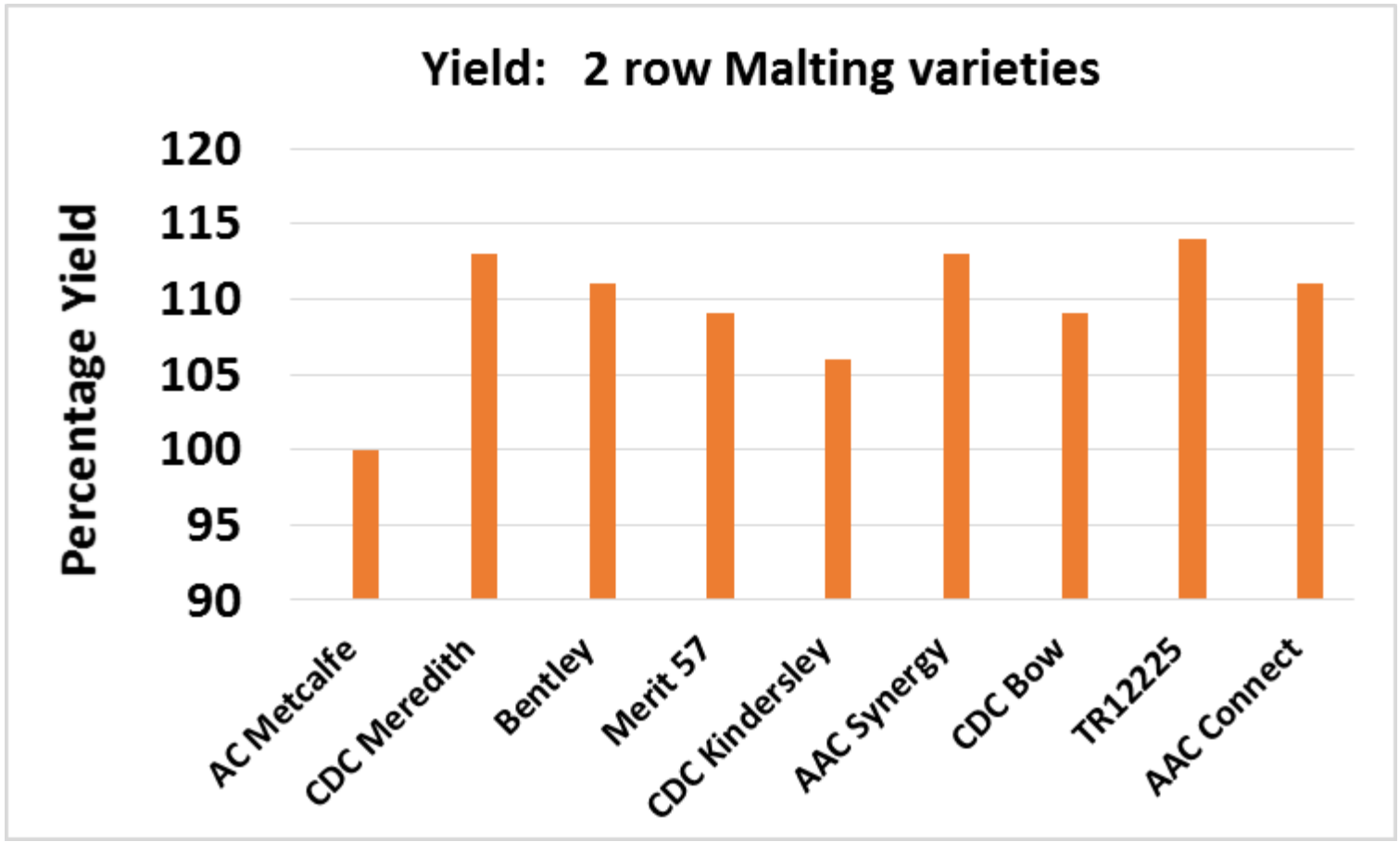


Yearly Progression of Canadian Varieties



New variety to market timeline (US-CAN)

2-Row Yields


Yield: 2 row Malting varieties
Percentage Yield
120
115
110
105
100
95
90
AC Metcalfe
CDC Meredith
Bentley
Merit 57
CDC Kindersley
AAC Synergy
CDC Bow
TR12225
AAC Connect

Two Row Variety Selection 2020/21

Two Rowed Cultivars: % Seeded to Malting Barley						
Crop Year:	2016	2017	2018	2019	% Change (18->19)	2020 (est.)
CDC Copeland	45.0	48.5	46.2	44	- 4.8 %	42.5 (-3.4%)
AC Metcalfe	32.0	30.5	29.7	23.7	- 20.2 %	18 (-24%)
CDC Meredith	3.0	0.7	0.7	0.5	- 28.6 %	0.1 (-80%)
Newdale	4.8	2.3	2.1	1.5	- 28.6 %	1.1 (-27%)
Bentley	4.0	1.8	1.3	0.7	- 46.2 %	0.4 (-43%)
CDC Kindersley	3.5	0.5	0.4	0.2	- 50 %	0.1 (-50%)
CDC Polarstar	1.0	0.4	0.2	0.1	- 50 %	0.1 (nc)
AAC Synergy	3.0	7.4	11.1	19.2	+ 73 %	22 (-14.6%)
Other *	3.0	4.0	3.5	6.1	+ 74.3 %	12.4 (+103%)
Total 2 Row	94.0	95.2	95.3	96		96.7
Total 6 Row	6.0	4.8	4.7	4.0		3.3
	100%	100%	100%	100%		100%

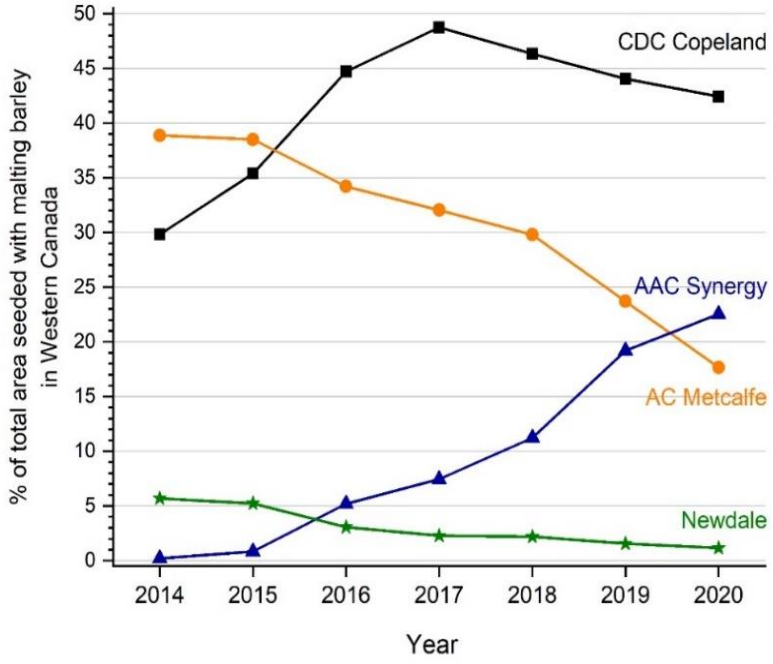
- *% change from 2019 to AAC Connect, CDC Bow, CDC Fraser, Cerveza, Lowe, Sirish, other
- *Decrease in number of introductions; increase in acres of established new varieties
- Source: Barley Production Quality of Western Canadian Malting Barley, Canadian Grain Commision, Fall 2020 (numbers in brackets are estimated 2020)

Two Row Variety Selection

Please note the variety trends exhibited in the graph to the right:

- **Copeland is slowly decreasing in % of total of seeded acres**
- **Metcalfe has substantially decreased and good quality is now a challenge to source (agronomics and disease)**
- **Newdale is steadily decreasing in % of total seeded acres**

- **Synergy, being the only alternative for new Canadian malting varieties for 4 years, aggressively increased in acres until crop 2020. It has now slowed and is expected to decrease in the coming years due to better, new varietals that are up and coming.**



Source: Barley Production Quality of Western Canadian Malting Barley, Canadian Grain Commision, Fall 2020

Commentary on new, major varietal trends

- **AC Connect:**
  - **Registered in 2016**
  - **Excellent yield: +15% compared to Metcalfe**
  - **Best disease package of Canadian malt barley**
- **CDC Bow:**
  - **Registered in 2016**
  - **Excellent yields: +15% compared to Metcalfe**
  - **Best lodging resistance of Canadian malt barley**
- **CDC Fraser:**
  - **Registered in 2016**
  - **Excellent yield: + 15% compared to Metcalfe**
  - **Highly enzymatic variety, Low in DMSP**

What can Brewers do to support barley?

- Barley is now a specialty crop, no longer a commodity
- The Canadian and US Governments are no longer funding barley development – leaving industry to manage

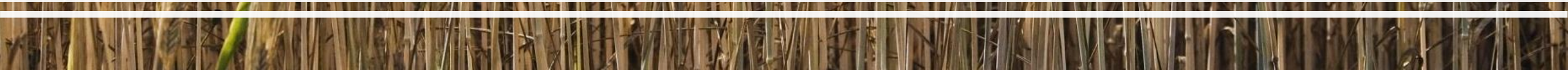
BMBRI – Brewing & Malting Barley Research Institute

www.bmbri.ca

The BMBRI organization is responsible for the development of barley varieties in North America

Out of 8,000+ Brewers in North America, there are less than 15 Brewery members of BMBRI!

US Barley Varieties



2022 AMBA Recommended Varieties

2022 AMBA recommended varieties:

TWO-ROW

AAC Connect
AAC Synergy
ABI Cardinal
ABI Eagle
ABI Growler
ABI Voyager
AC Metcalfe
Bill Coors 100
CDC Copeland
Charles*
Conrad
Endeavor*
Expedition
Explorer
Flavia*
Hockett
LCS Genie
LCS Odyssey
LCS Violetta*
Mayflower
Merit 57
Moravian 37
Moravian 69
Moravian 164
Moravian 165
Moravian 170
Moravian 179
ND Genesis
Newdale
Pinnacle
Puffin*
Regina*
Thunder*
Wintmalt*

SIX-ROW

Celebration
Innovation
Lacey
Legacy
Quest
Thoroughbred*
Tradition

* winter

AMBA Recommended Barley Varieties past 20 yrs

AMBA Recommended Malting Barley Variety List 2001-22

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Two Row Varieties																			AAC Connect	AAC Connect	AAC Connect
*winters														AAC Synergy	AAC Synergy	AAC Synergy	AAC Synergy	AAC Synergy	AAC Synergy	AAC Synergy	AAC Synergy
																					ABI Cardinal
																			ABI Eagle	ABI Eagle	ABI Eagle
																		ABI Growler	ABI Growler	ABI Growler	ABI Growler
													ABI Voyager	ABI Voyager	ABI Voyager	ABI Voyager	ABI Voyager	ABI Voyager	ABI Voyager	ABI Voyager	ABI Voyager
				AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe	AC Metcalfe
B1202	B1202	B1202	B1202	B1202	B1202	B1202															
B26/01																					
																		Bill Coors 100	Bill Coors 100	Bill Coors 100	Bill Coors 100
						CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland	CDC Copeland
												CDC Meredith	CDC Meredith	CDC Meredith	CDC Meredith	CDC Meredith					
								Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*	Charles*
Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	Conlon	
						Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	Conrad	ABI Conrad
						Craft	Craft	Craft													
Crystal																					
														Endeavor*	Endeavor*	Endeavor*	Endeavor*	Endeavor*	Endeavor*	Endeavor*	Endeavor*
												Expedition	Expedition	Expedition	Expedition	Expedition	Expedition	Expedition	Expedition	Expedition	Expedition
																	Explorer	Explorer	Explorer	Explorer	Explorer
	Garnet	Garnet	Garnet																	Flavia*	Flavia*
Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington	Harrington				
									Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett	Hockett
																LCS Genie	LCS Genie	LCS Genie	LCS Genie	LCS Genie	LCS Genie
																			LCS Odyssey	LCS Odyssey	LCS Odyssey
																		LCS Violetta*	LCS Violetta*	LCS Violetta*	LCS Violetta*
																				Mayflower	Mayflower
Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit	Merit						
									ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57	ABI Merit 57
									Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37	Moravian 37
									Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69	Moravian 69
																			Moravian 164	Moravian 164	Moravian 164
																		Moravian 165	Moravian 165	Moravian 165	Moravian 165
																			Moravian 170	Moravian 170	Moravian 170
																				Moravian 179	Moravian 179
															ND Genesis	ND Genesis	ND Genesis	ND Genesis	ND Genesis	ND Genesis	ND Genesis
																	AC Newdale	AC Newdale	AC Newdale	AC Newdale	AC Newdale
										ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle	ND Pinnacle
																	Propinio				
																	Puffin*	Puffin*	Puffin*	Puffin*	Puffin*
																					Regina*
							Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett	Scarlett		
																		Thunder*	Thunder*	Thunder*	Thunder*
												Witmalt*	Witmalt*	Witmalt*	Witmalt*	Witmalt*	Witmalt*	Witmalt*	Witmalt*	Witmalt*	Witmalt*
Six Row Varieties																					
*winters										ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration	ABI Celebration
	Drummond	Drummond	Drummond	Drummond	Drummond	Drummond	Drummond	Drummond	Drummond												
Excel	Excel	Excel	Excel	Excel	Excel	Excel															
Foster	Foster	Foster	Foster	Foster	Foster	Foster	Foster														
													ABI Innovation	ABI Innovation	ABI Innovation	ABI Innovation	ABI Innovation	ABI Innovation	ABI Innovation	ABI Innovation	ABI Innovation
	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey	Lacey
	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy	ABI Legacy
Morex	Morex	Morex	Morex	Morex																	
										Quest	Quest	Quest	Quest	Quest	Quest	Quest	Quest	Quest	Quest	Quest	Quest
								Rasmusson	Rasmusson	Rasmusson											
Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust								
Stander	Stander	Stander	Stander	Stander	Stander	Stander	Stander														
					Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND	Stellar-ND					
														Thoroughbred*	Thoroughbred*	Thoroughbred*	Thoroughbred*	Thoroughbred*	Thoroughbred*	Thoroughbred*	Thoroughbred*
			ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition	ABI Tradition

Summary

- 2022 Barley Crop estimated 146,200MMT
- Global production volume down slightly from estimate due to High Temps in Europe and the Russia/Ukraine Conflict impacts
- US Production projected up 49% over 2021 Crop
- Quality is expected to be better than average
- Pricing will remain high due to lack of carryover stocks from 2021 and increased cost of inputs (fuel, energy, fertilizer)
- AMBA and BMBRI are excellent malting barley resources
- New Barley Varieties can take up to 20 years to develop (may only be in market for 10-20 yrs)
- Remember it is not a crop until it is in the bin!

Thank you!

Tim Burke – Sales Manager

Country Malt Group

(Based in Chicago, IL)

224.254.8246, tburke@countrymalt.com

Hello, my name is Tim Burke of Country Malt Group, I have 18 years of experience in food and beverage with 9 years in the beer and brewing space. For the past 8 years, I've worked with Country Malt Group. During this time, I have had the privilege to work with some of the most creative and passionate people in the industry. I have also been fortunate enough to visit and consult with craft breweries and distilleries in over 25 States and 3 Canadian Provinces, visit hop farms and conduct hop selections in Yakima Valley, walk barley fields in Idaho and the Canadian Prairie and visit malt houses in Canada and the US giving me a unique perspective of the growing craft brewing and distilling industry.

DRY HOP CREEP

YCH Hop and Brew School

Great Taste of the Midwest 2022

Laura Burns

Omega Yeast

… and other hop topics

OMEGA YEAST

Who are we?

Omega Yeast Labs
Chicago, IL / St. Louis, MO

High quality, pitch-ready liquid yeast. Handful of microbiologists, homebrewers, professional brewers and craft beer fans who made it our express purpose to make brewing easier and better for everyone.

- Be Helpful
- Be Creative
- Be Fresh

Laura Burns
Director of R&D

w w w . o m e g a y e a s t . c o m

OMEGA YEAST

DRY HOP CREEP: A LITTLE HISTORY

1893 Horace T. Brown “Freshening Power of Hops”

1941 Janicki et al. “Maltase in Hops”

2017, and 110 years later… “Hop Creep”

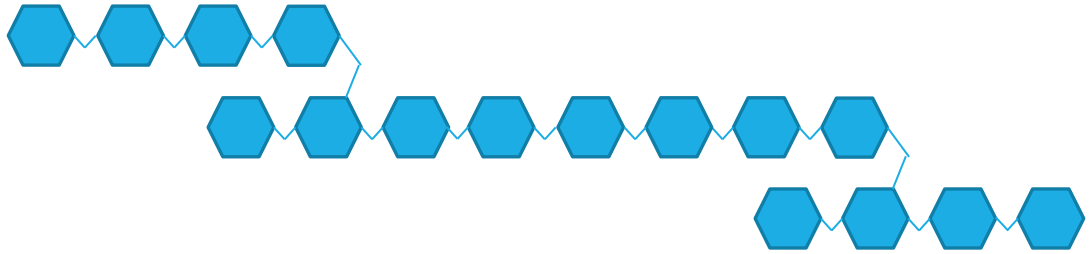
Shellhammer Lab, Allagash, Bell’s, Russian River … Hop diastase enzymes and refermentation in dry hopped beers

Horace T. Brown.

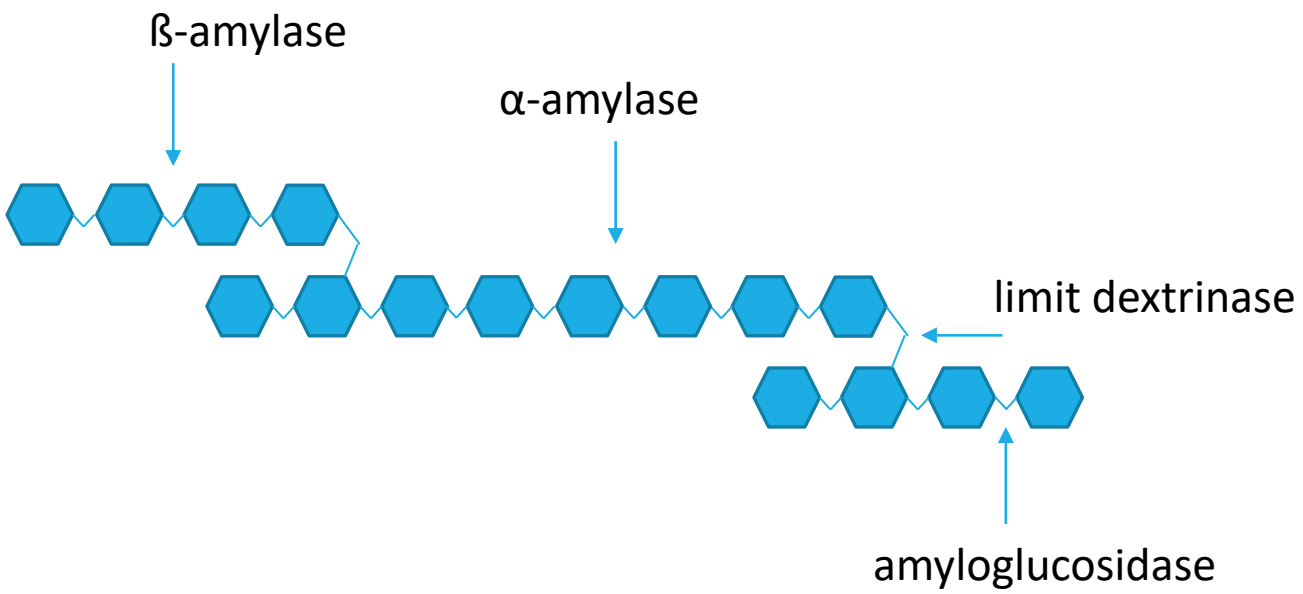
CURRENT UNDERSTANDING OF DRY HOP CREEP

Finished beer

Unfermentable dextrin/maltodextrin



CURRENT UNDERSTANDING OF DRY HOP CREEP



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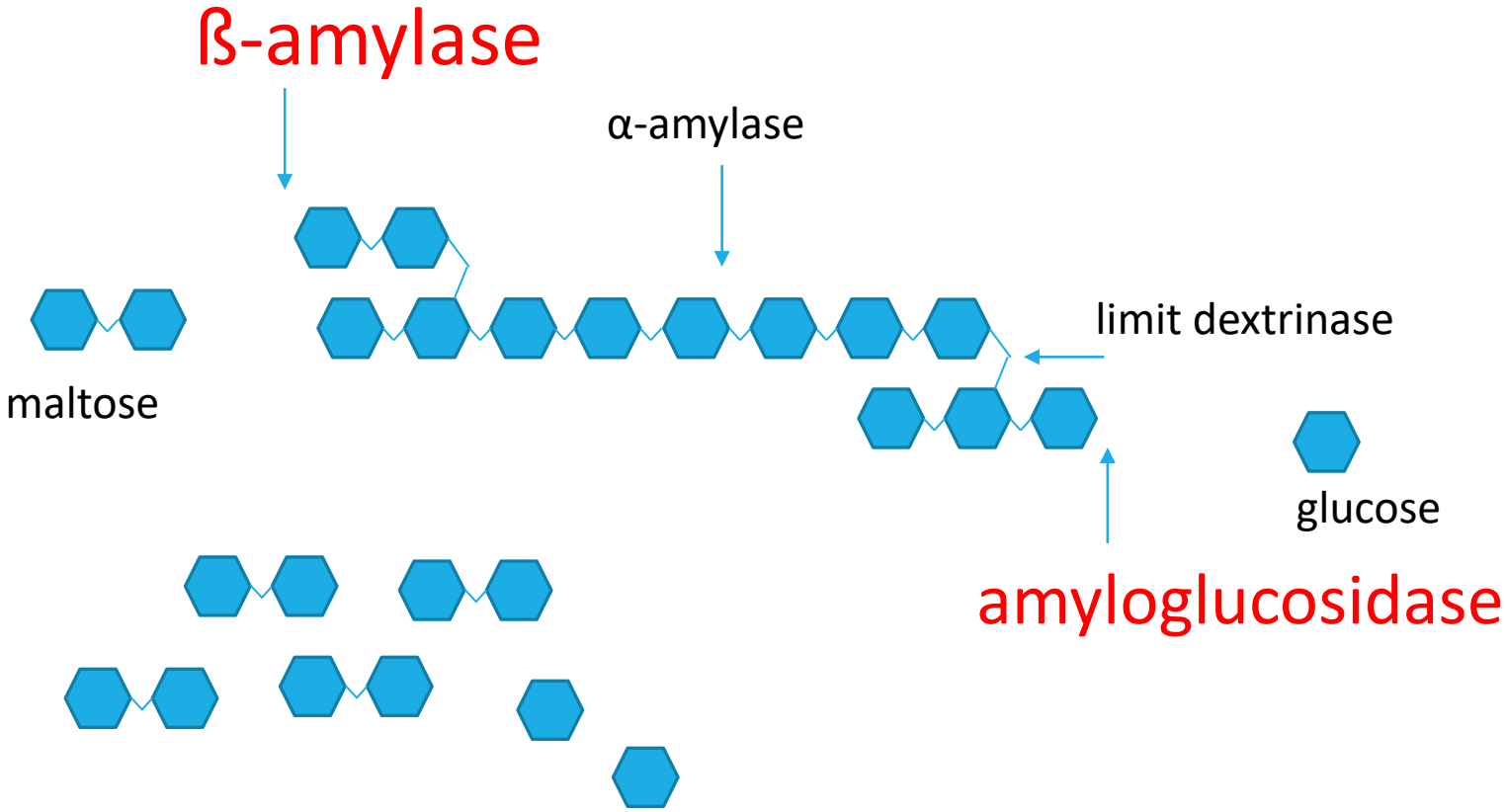

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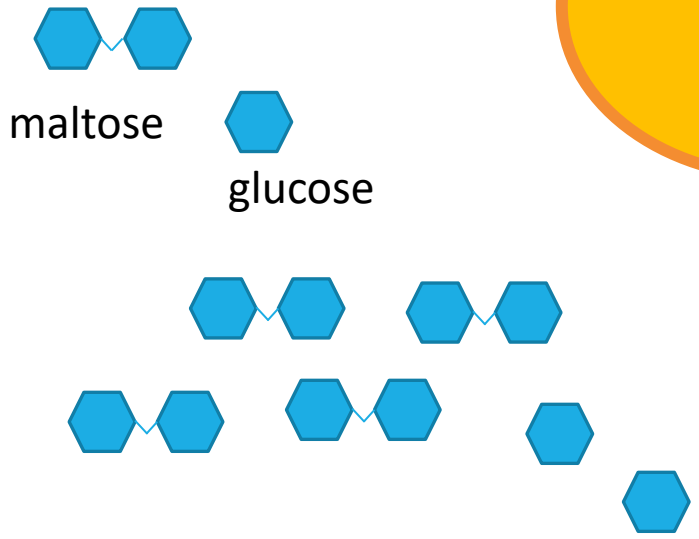


Refermentation!

CO_2

ABV

Diacetyl

WHERE DO THE ENZYMES COME FROM?

Hops

Or

Microorganisms on Hops

WHERE DO THE ENZYMES COME FROM?

Hops

JOURNAL OF THE AMERICAN SOCIETY OF BREWING CHEMISTS
2022, AHEAD-OF-PRINT, 1-13
https://doi.org/10.1080/03610470.2022.2084327

Taylor & Francis
Taylor & Francis Group

Open access

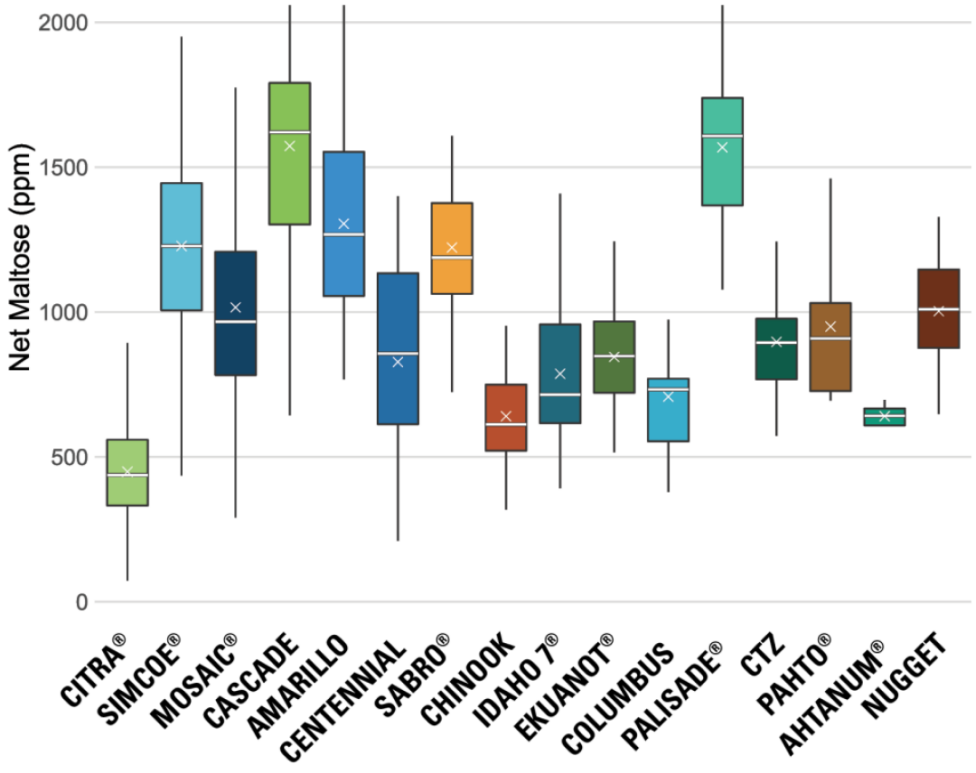
A Search for Diastatic Enzymes Endogenous to *Humulus lupulus* and Produced by Microbes Associated with Pellet Hops Driving "Hop Creep" of Dry Hopped Beer

Matthew T. Cottrell

Heavy Seas Beer, Halethorpe, MD, U.S.A.

WHAT VARIABLES IMPACT HOP CREEP: HOPS

- Variety
  - Ex. Citra low, Cascade high
- Hop Products
  - Extracts < Cryo < T90
- Processing/Handling
  - Kilning
  - Storage
- Agricultural Influences
  - Terroir
  - Crop Year

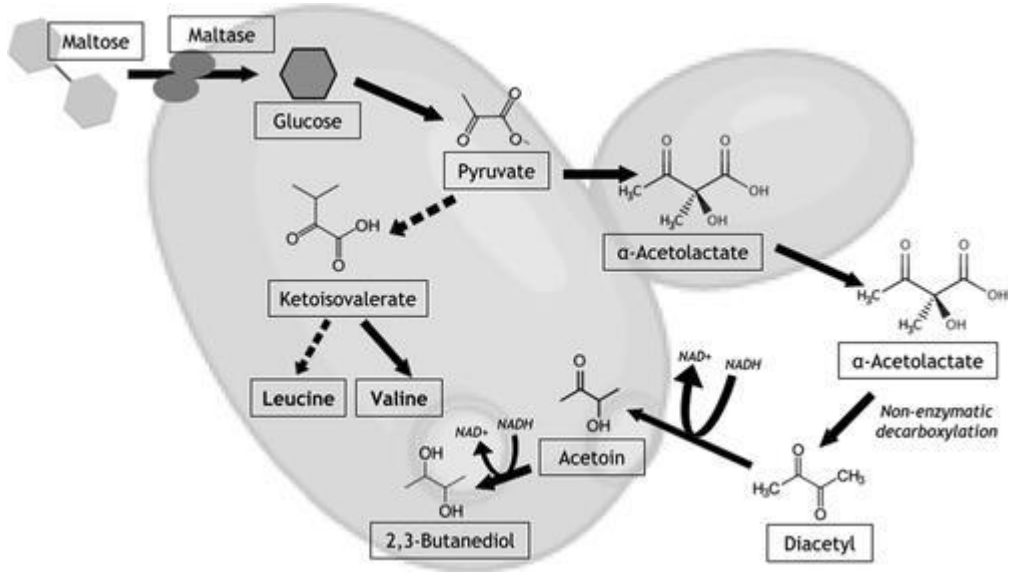


Rob Ring, Yakima Chief

OMEGA YEAST

WHAT VARIABLES IMPACT HOP CREEP: YEAST

- Certain yeast are prone to diacetyl
  - Lager
  - Chico
  - English Strains
- Not correlated to flocculation
- Yeast engineered to prevent diacetyl formation!



James Bruner, UC Davis/Creature Comforts

OMEGA YEAST

WHAT VARIABLES IMPACT HOP CREEP: YEAST

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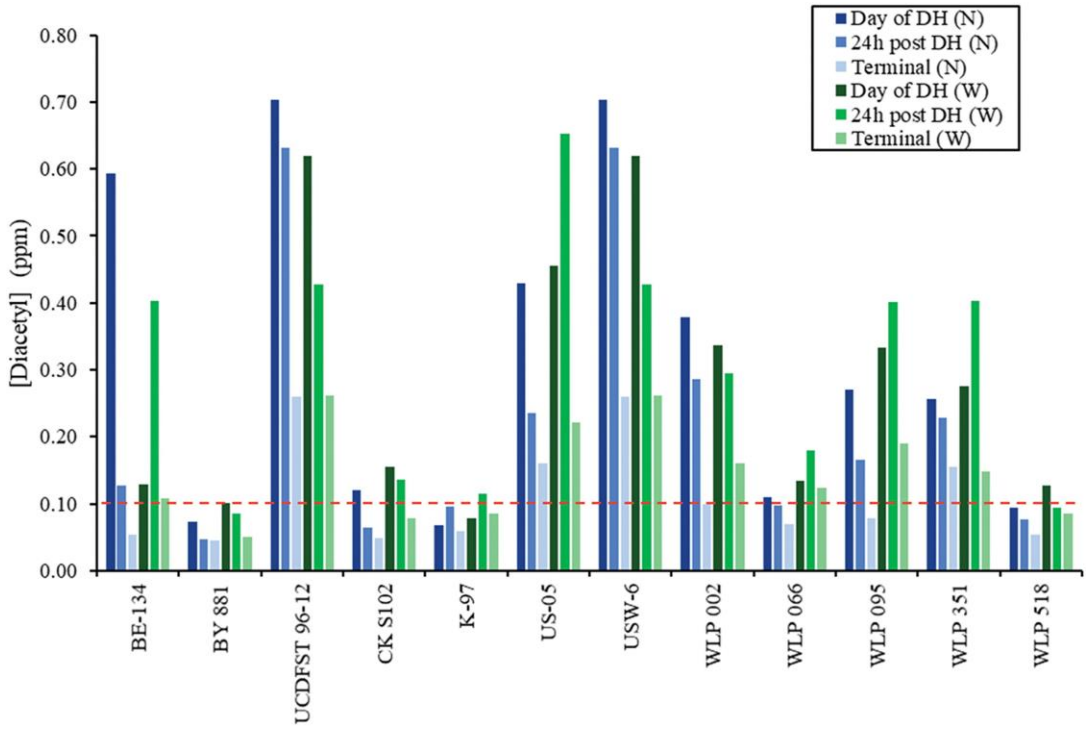
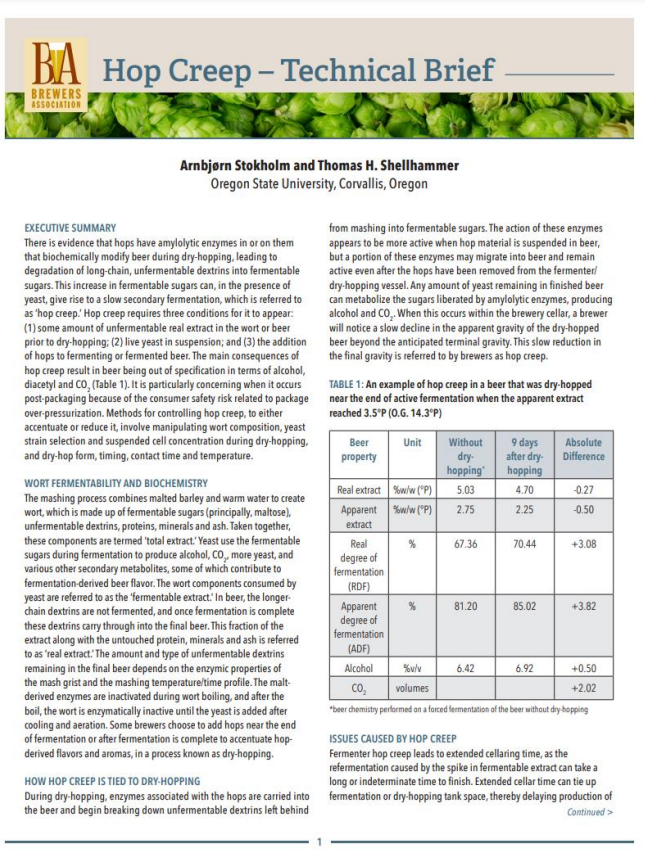


James Bruner, UC Davis/Creature Comforts

WHAT VARIABLES IMPACT HOP CREEP: RECIPE AND DRY HOPPING PRACTICES

- Target attenuation/terminal Plato
- Dry hop addition rate
- Timing of the dry hop
- Temperature at dry hop
- Circulation vs static dry hop
- Dry hop contact time
- Pre or post yeast removal



BA BREWERS ASSOCIATION

Hop Creep – Technical Brief

Arnbjørn Stokholm and Thomas H. Shellhammer
Oregon State University, Corvallis, Oregon

EXECUTIVE SUMMARY

There is evidence that hops have amylolytic enzymes in or on them that biochemically modify beer during dry-hopping, leading to degradation of long-chain, unfermentable dextrins into fermentable sugars. This increase in fermentable sugars can, in the presence of yeast, give rise to a slow secondary fermentation, which is referred to as 'hop creep.' Hop creep requires three conditions for it to appear: (1) some amount of unfermentable real extract in the wort or beer prior to dry-hopping; (2) live yeast in suspension; and (3) the addition of hops to fermenting or fermented beer. The main consequences of hop creep result in beer being out of specification in terms of alcohol, diacetyl and CO_2 (Table 1). It is particularly concerning when it occurs post-packaging because of the consumer safety risk related to package over-pressurization. Methods for controlling hop creep, to either accentuate or reduce it, involve manipulating wort composition, yeast strain selection and suspended cell concentration during dry-hopping, and dry-hop form, timing, contact time and temperature.

WORT FERMENTABILITY AND BIOCHEMISTRY

The mashing process combines malted barley and warm water to create wort, which is made up of fermentable sugars (principally, maltose), unfermentable dextrins, proteins, minerals and ash. Taken together, these components are termed 'total extract.' Yeast use the fermentable sugars during fermentation to produce alcohol, CO_2, more yeast, and various other secondary metabolites, some of which contribute to fermentation-derived beer flavor. The wort components consumed by yeast are referred to as the 'fermentable extract.' In beer, the longer-chain dextrins are not fermented, and once fermentation is complete these dextrins carry through into the final beer. This fraction of the extract along with the untouched protein, minerals and ash is referred to as 'real extract.' The amount and type of unfermentable dextrins remaining in the final beer depends on the enzymic properties of the mash grist and the mashing temperature/time profile. The malt-derived enzymes are inactivated during wort boiling, and after the boil, the wort is enzymatically inactive until the yeast is added after cooling and aeration. Some brewers choose to add hops near the end of fermentation or after fermentation is complete to accentuate hop-derived flavors and aromas, in a process known as dry-hopping.

HOW HOP CREEP IS TIED TO DRY-HOPPING

During dry-hopping, enzymes associated with the hops are carried into the beer and begin breaking down unfermentable dextrins left behind from mashing into fermentable sugars. The action of these enzymes appears to be more active when hop material is suspended in beer, but a portion of these enzymes may migrate into beer and remain active even after the hops have been removed from the fermenter/dry-hopping vessel. Any amount of yeast remaining in finished beer can metabolize the sugars liberated by amylolytic enzymes, producing alcohol and CO_2. When this occurs within the brewery cellar, a brewer will notice a slow decline in the apparent gravity of the dry-hopped beer beyond the anticipated terminal gravity. This slow reduction in the final gravity is referred to by brewers as hop creep.

TABLE 1: **An example of hop creep in a beer that was dry-hopped near the end of active fermentation when the apparent extract reached 3.5°P (O.G. 14.3°P)**

Beer property	Unit	Without dry-hopping*	9 days after dry-hopping	Absolute Difference
Real extract	%w/w (°P)	5.03	4.70	-0.27
Apparent extract	%w/w (°P)	2.75	2.25	-0.50
Real degree of fermentation (RDF)	%	67.36	70.44	+3.08
Apparent degree of fermentation (ADF)	%	81.20	85.02	+3.82
Alcohol	%v/v	6.42	6.92	+0.50
CO_2	volumes			+2.02

*beer chemistry performed on a forced fermentation of the beer without dry-hopping

ISSUES CAUSED BY HOP CREEP

Fermenter hop creep leads to extended cellaring time, as the refermentation caused by the spike in fermentable extract can take a long or indeterminate time to finish. Extended cellar time can tie up fermentation or dry-hopping tank space, thereby delaying production of

Continued >

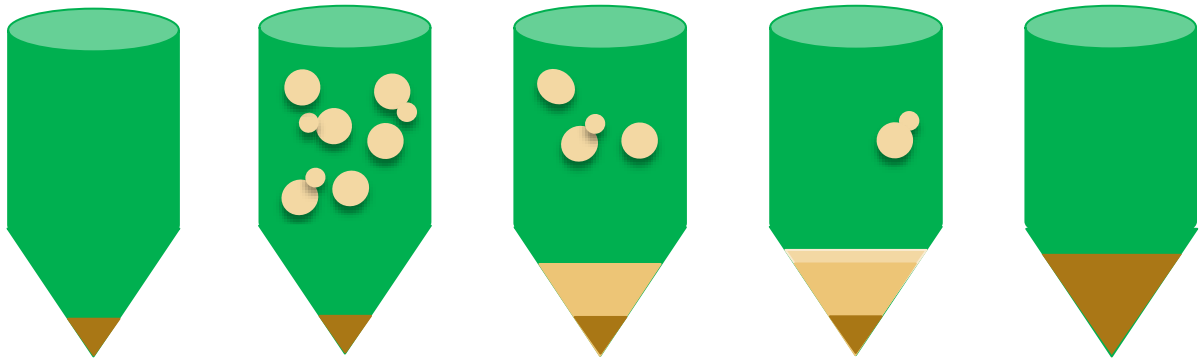
OMEGA YEAST

METHODS TO MITIGATE HOP CREEP

- Limit Potential
  - Use hops with high diastase activity in the whirlpool, and low diastase activity for the dry hop
  - Target more conversion in the mash
  - An early charge of dry hop can minimize creep potential of later additions
- Ride it out
  - Time dry hop for when yeast is still active (pre-diacetyl rest)
- Prevent it with a cold, short dry hop
  - Little risky if enzymes have a chance to convert later in warm storage
- Pasteurize/Inactivate hop enzymes
  - Either direct inactivation of hops (sous-vide trials)
  - Very low PU targets with a flash pasteurizer can be used to inactivate enzymes

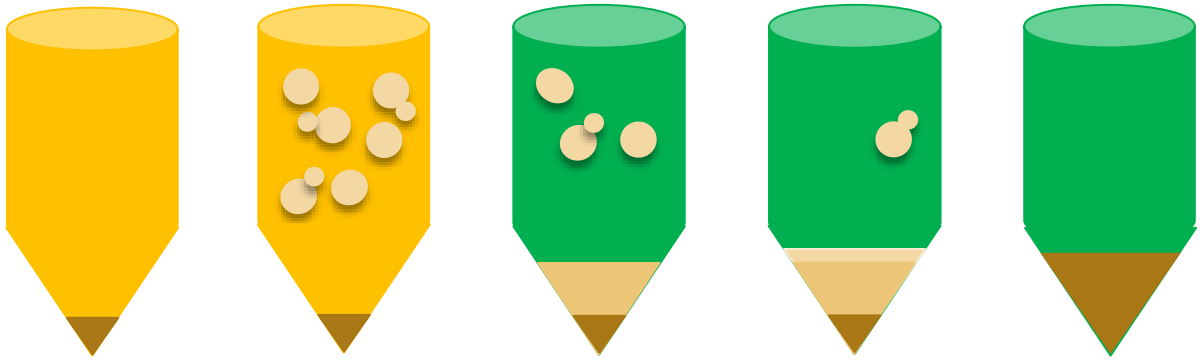
METHODS TO MITIGATE HOP CREEP

Limit Potential: Early Dry Hop Charge



Hop enzymes are active during fermentations

Ride it out: Mid-Late Dry Hop



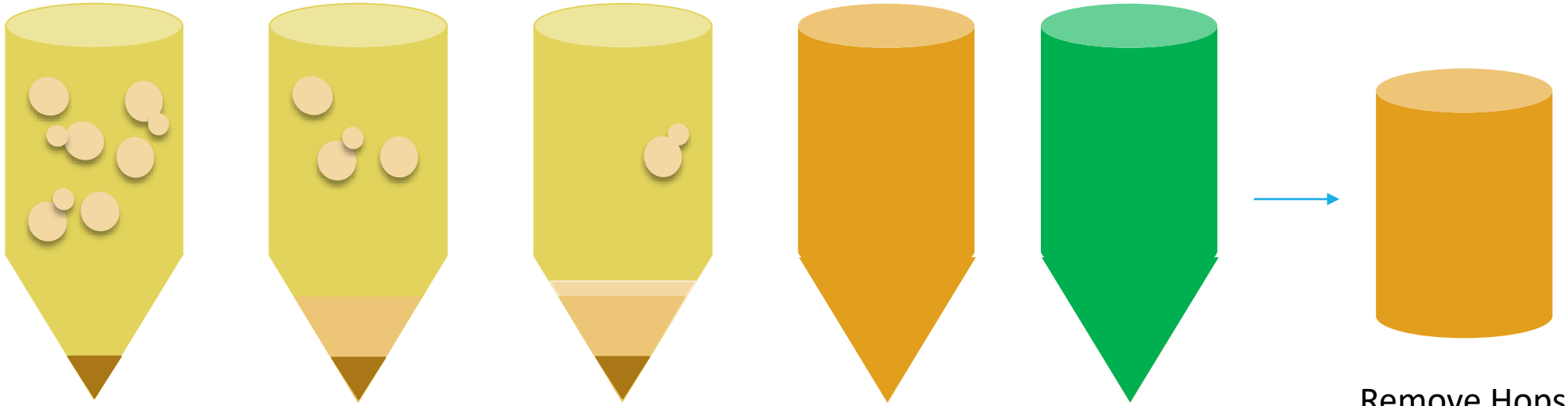
Try and harvest yeast, but still have some fermentation activity

OMEGA YEAST

METHODS TO MITIGATE HOP CREEP

Prevent: Cold, Short Dry Hop:

Dry Hop cold 24-48 hour



Finished/Cleared VDK
Crash and Drop Yeast

Remove Hops
(maybe flash pasteurize)

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HOW CAN I PREDICT HOP CREEP?

Measuring diastase activity in hops:

- Determine which hops to use where!
- Yakima Chief has been working on adding this information to hop spec sheets

Determining what level of creep to expect in your beer:

- Depends on the remaining starch level/composition, yeast strain and dry hop
- Forced Hop Creep Assay

LAB QC ASSAY:
MEASURING DIASTASE ACTIVITY IN HOPS

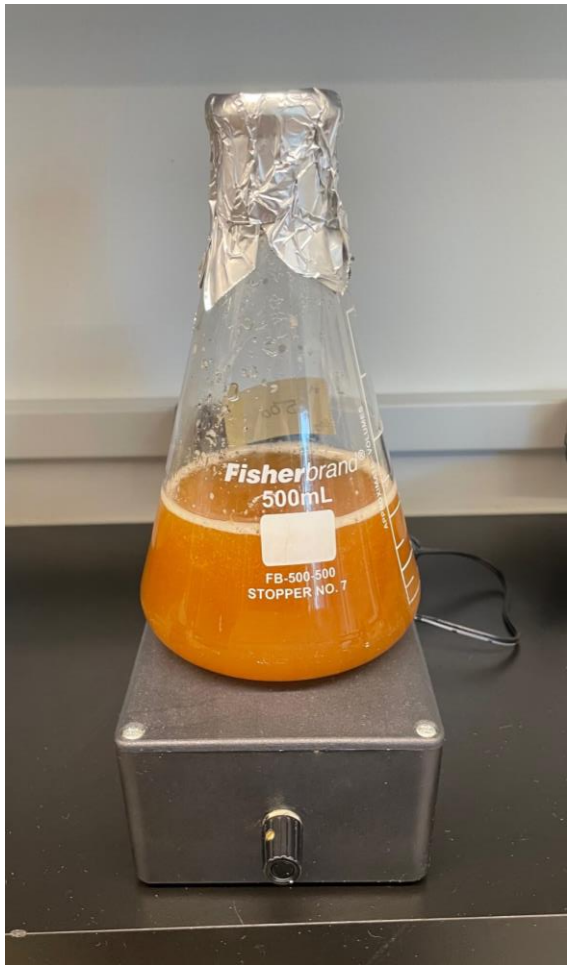
Adapted from ASBC Malt 6. Diastatic Power

1. Starch substrate or commercial beer sample incubated for 48 hours with 10 g/L of hops (2.5#/bbl).
2. Measure maltose and glucose
    - UV/vis spectrophotometer: convert the maltose to glucose with maltase enzyme and measure total glucose with Glucose Oxidase Assay
    - HPLC: direct measurement of total maltose and glucose

LAB QC ASSAY: FORCED HOP CREEP

Adapted from ASBC Wort 5. Yeast Fermentable Extract

1. Sterilize a flask and stir bar.
2. From fermentation pre-dry hop, measure apparent extract.
3. Collect with aseptic technique a sample of fermenting beer pre-dry hop and add amounts hops corresponding to the total dry hop.
4. Place the flask with the dry hopped beer sample on a stir plate in a warm room or incubator set to 30°F.
5. After 48 hours and sample the apparent extract and determine the level of hop creep.



TAKEAWAYS

Hop creep happens and it is manageable!

Think about changing your approach if you continue to see stubborn diacetyl or trailing fermentations on tanks.

Choose the right yeast strains and hop products to minimize creep.

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THIOLIZED YEAST

Unlocking Tropical Aromas In Beer

Precursor Thiols
Non-aromatic

Thiolized Yeast

Thiols
Tropical Aroma

BIOTRANSFORMATION

OMEGA YEAST

What are thiols?

Tropical and citrus aromas

- Found in many tropical fruits

Very potent aroma compounds

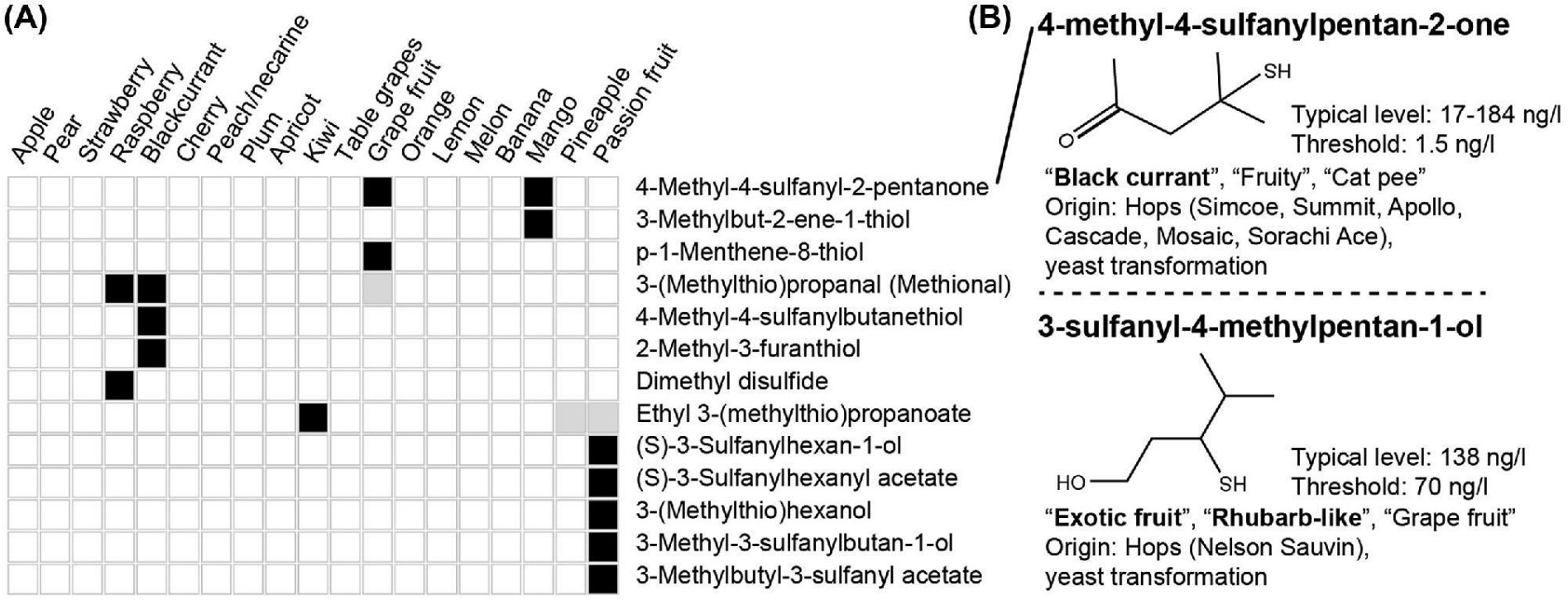
- Threshold in the nanomolar concentrations (parts per trillion!)

Characteristic flavor

- Sauvignon blanc wines (tropical fruit, citrus)
- Nelson Sauvin, Hallertau Blanc (exotic fruit-like, white wine-like)

Polyfunctional Thiol	Sensory	Threshold (ng/L)
4MSP (4MMP)	Box Tree, Black Current	1.5
3SH (3MH)	Grapefruit, Passion Fruit	60
3SHA (3MHA)	Passion Fruit	4
3S4MPol	Grapefruit, Rhubarb	40
3S4MPA	Grapefruit, Rhubarb	120

Thiols Found in Hops and Fruits



FEMS Microbiology Reviews 2019, 43,193-222; https://doi.org/10.1093/femsre/fuy041

OMEGA YEAST

THIOLS ARE VERY ODOR ACTIVE

21,000 bbls (660,000 gal)

Parts per million (mg/L)

5 beers – 21 bbl
Esters, aldehydes

Parts per billion (ug/L)

2.5 ml - 5 beers
Diacetyl

Parts per trillion (ng/L)

2.5 ul – 2.5 ml
Thiols

THIOLS ARE VERY ODOR ACTIVE

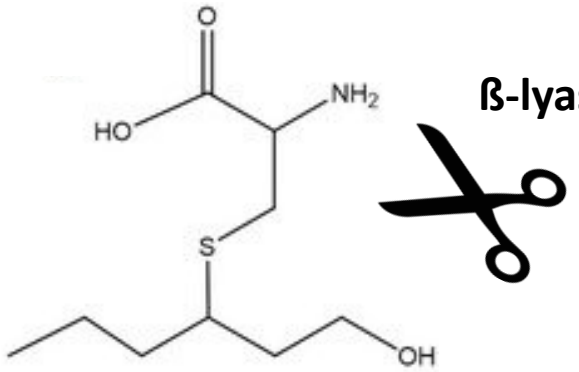
21,000 bbls (660,000 gal)

Thiols

Polyfunctional Thiol	Sensory	Threshold (ng/L)	ul into the pool
4MSP (4MMP)	Box Tree, Black Current	1.5	3.75 ul
3SH (3MH)	Grapefruit, Passion Fruit	60	150 ul
3SHA (3MHA)	Passion Fruit	4	10 ul
3S4MPol	Grapefruit, Rhubarb	40	100 ul
3S4MPA	Grapefruit, Rhubarb	120	300 ul

THIOL BIOTRANSFORMATION

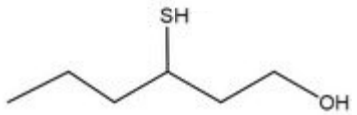
Precursor
Cys-3SH



ß-lyase

Water

Free Thiol
3SH



Pyruvate Ammonia

ß-lyase enzyme (carbon-sulfur lyase): cleaves the thiol precursor to release the free thiol

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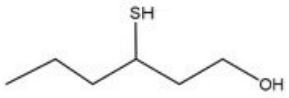
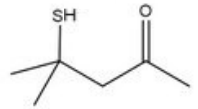
WHAT ARE THIOL PRECURSORS

Free Thiol

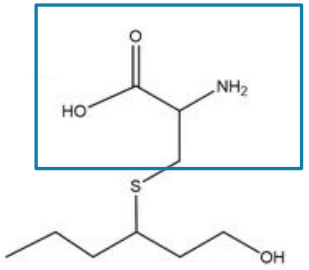


3SH

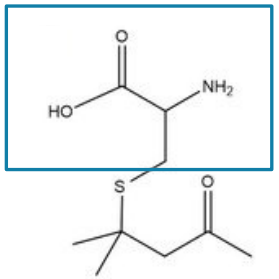


4MSP

Cysteine Precursor

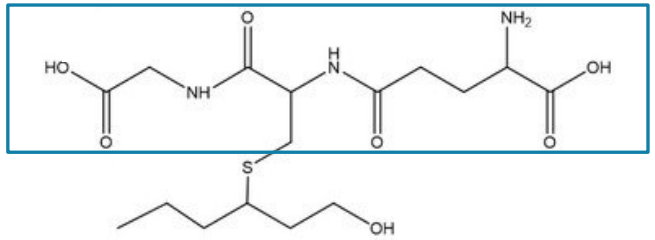


Cys-3SH

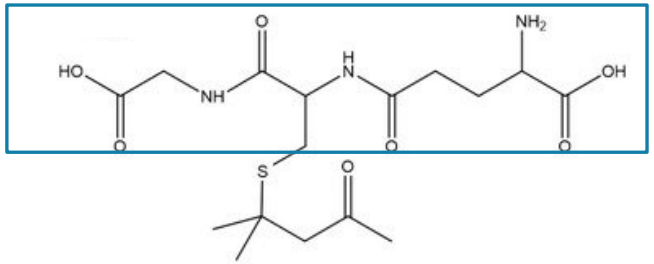


Cys-4MSP

Glutathione Precursor



Glut-3SH



Glut-4MSP

OMEGA YEAST

Known ß-lyase Enzyme in Yeast:

Irc7

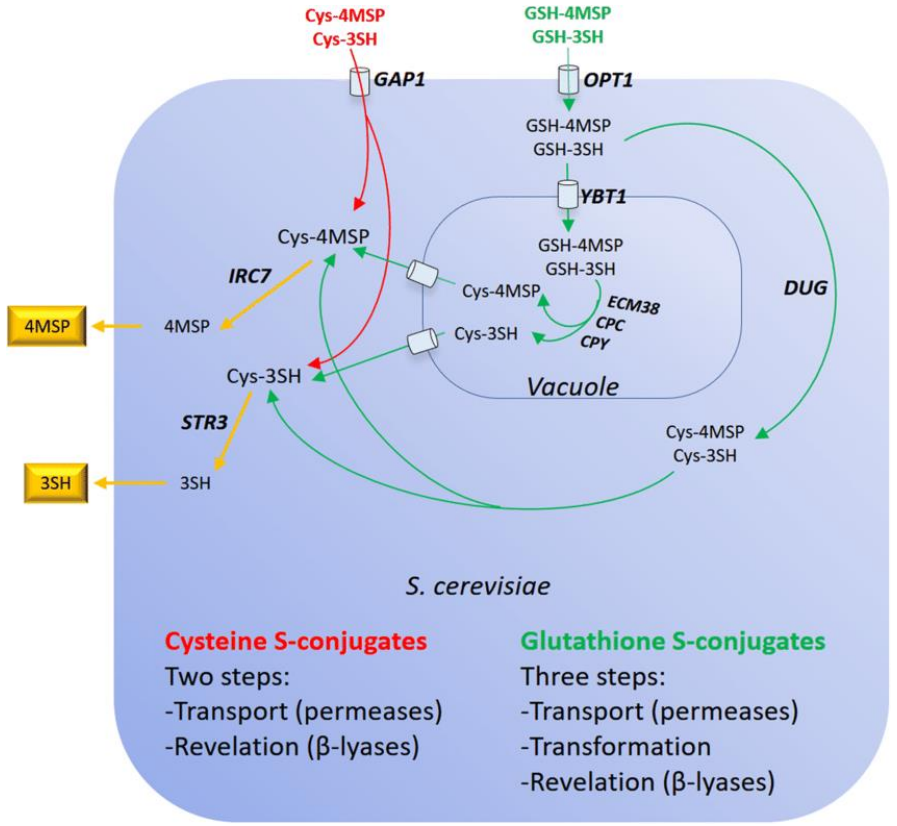
ß-lyase enzyme that frees thiols from precursors

Wine Studies

Irc7 is activated when nutrients are limited
Many wine strains have inactive versions of Irc7

Beer Studies

Limited Irc7 activity in wort



Ruiz et al. App. Micro. And Biotech. 2019

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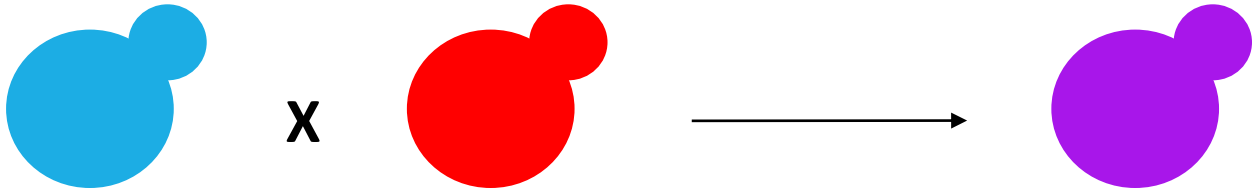
YEAST HYBRID APPROACH FAILED TO SIGNIFICANTLY INCREASE THIOLS IN BEER

1. Wine strains with high ß-lyase activity used to ferment beer.

2. Crossing wine strains with beer strains.
   Vin13 x Saison
   Maxithiol x Hazy IPA strain



Beer Yeast

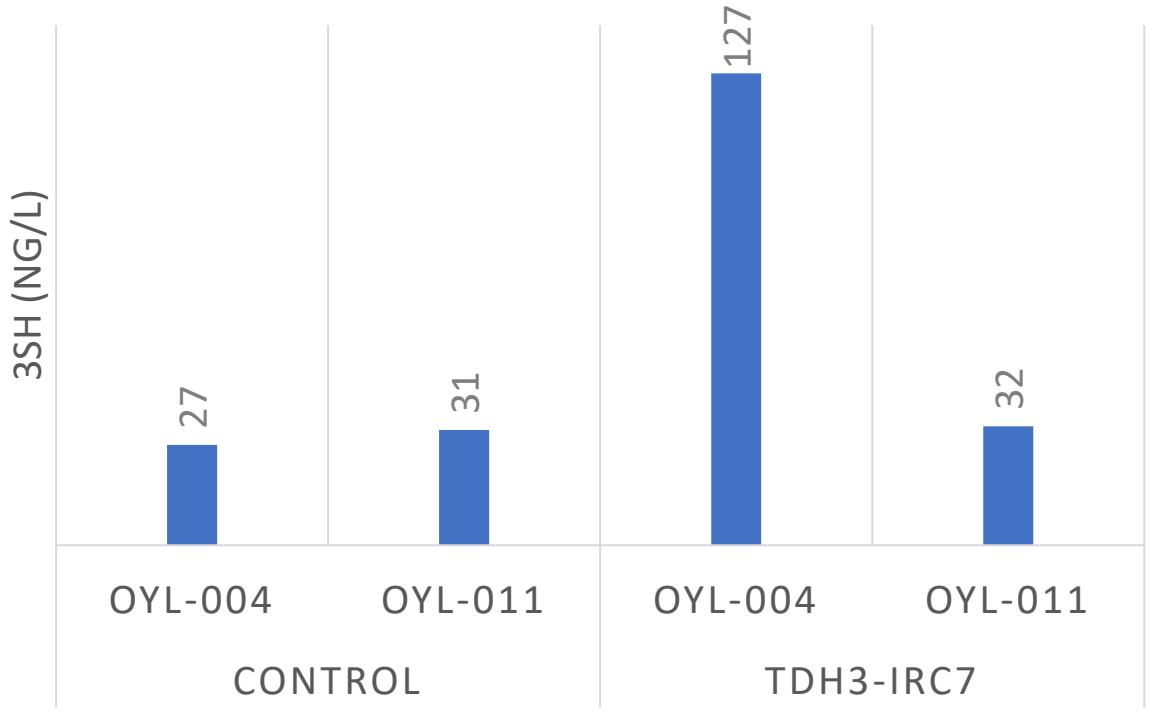
Wine Yeast
ß-lyase

Hybrid Yeast
ß-lyase

Thiols were not significantly elevated

- Nitrogen levels in beer are in excess
- Low/no IRC7 expression

Activating the yeast ß-lyase, Irc7, results in thiol biotransformation!



OYL-004 California Ale
OYL-011 London Ale III

From this we also discovered that London Ale III had an inactive Irc7

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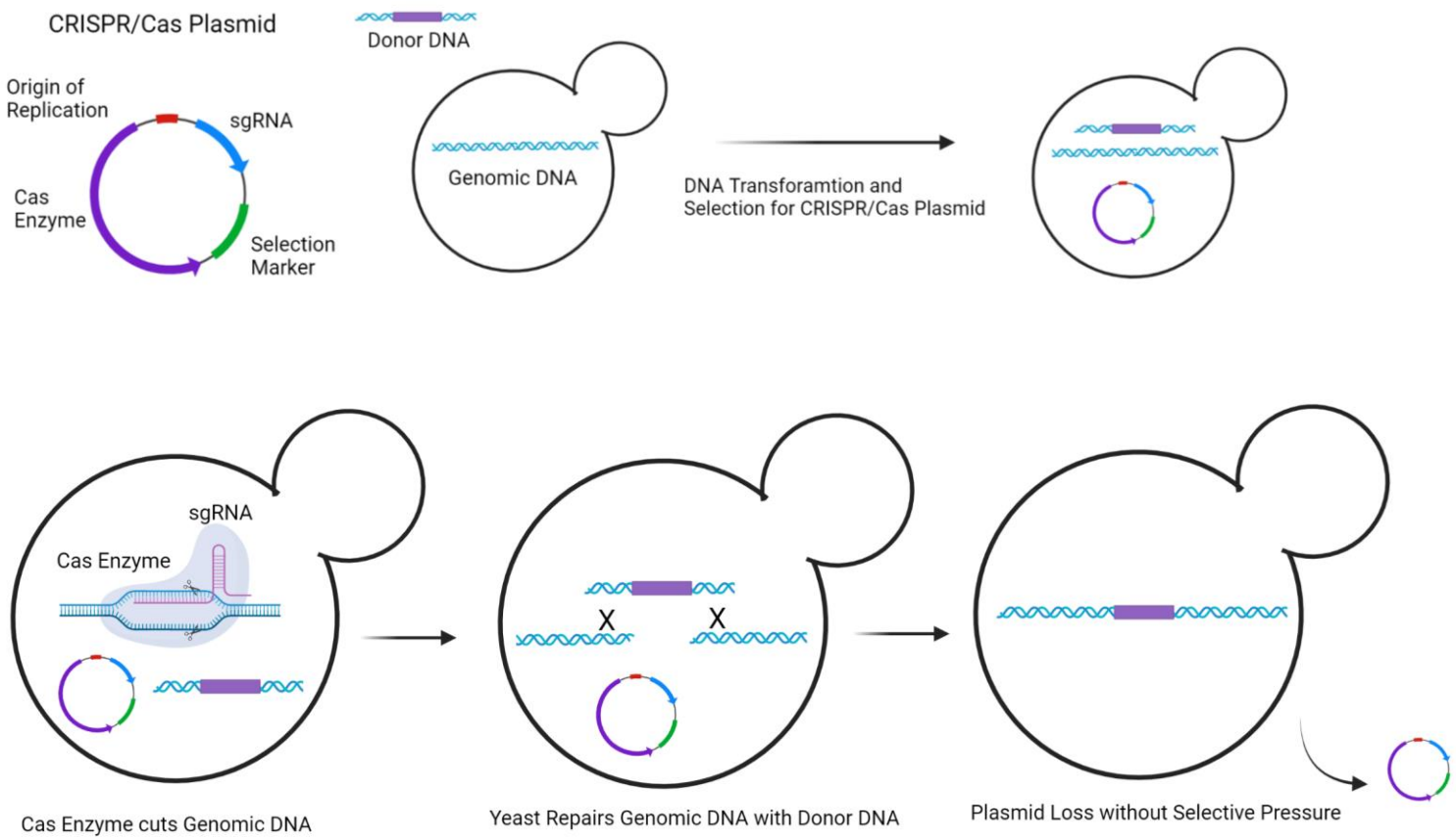
How we use CRISPR/Cas to engineer brewing yeast



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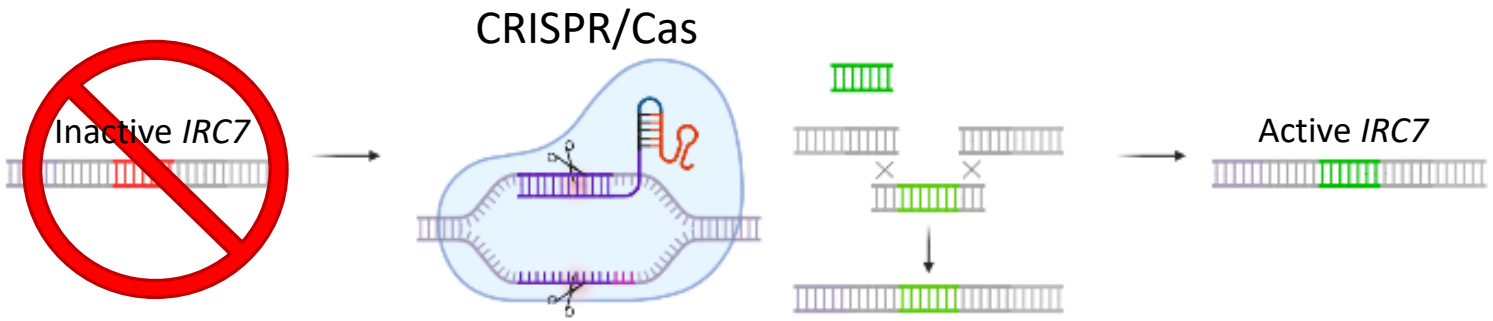
Cosmic Punch: *IRC7* gene

Nitrogen Catabolite Repression



OYL-011
British V

→

TDH3:IRC7 from California Ale

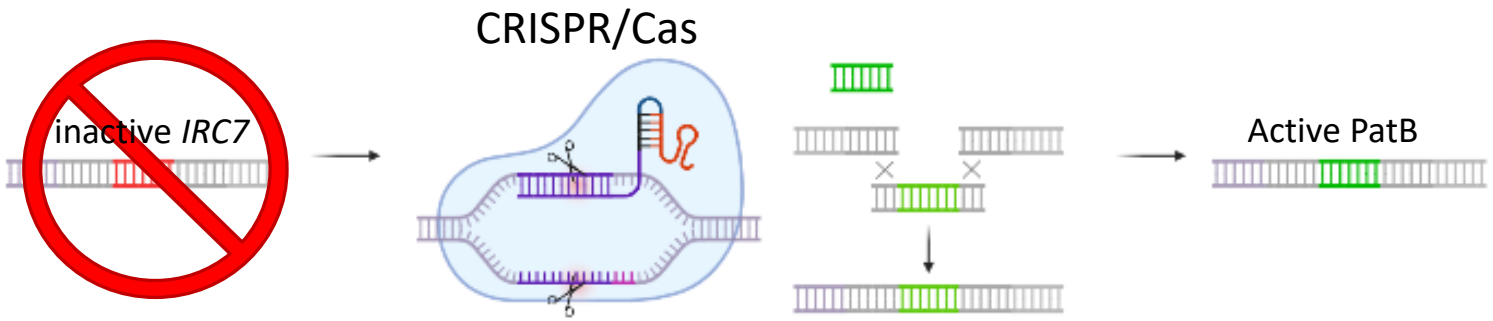
→

OYL-402
Cosmic Punch

OMEGA YEAST

Star Party, Lunar Crush and Helio Gazer: *PatB* gene

Nitrogen Catabolite Repression



OYL-004
West Coast Ale I

→

PatB gene from *S. hominis*

→

OYL-404
Star Party

OMEGA YEAST

THIOLIZE™ BREWING STRAINS

+

Thiolized Yeast with
ß-lyase Enzyme

=

THIOLS!

1. Cosmic Punch (Irc7)
2. Star Party, Lunar Crush and Helio Gazer (PatB)

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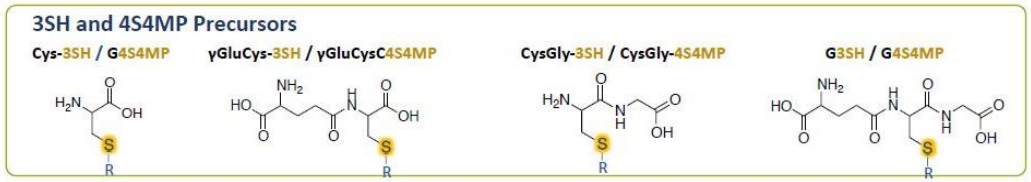
What Raw Materials have Thiol Precursors?

1. Malt
2. Hops



3. Biotransformation
   Yeast ß-lyase enzyme

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Glutathione Precursors In Malt

Loads of Glutathione-3SH in malt!

Corresponds to 100-1000 times the amount of free 3SH in beer

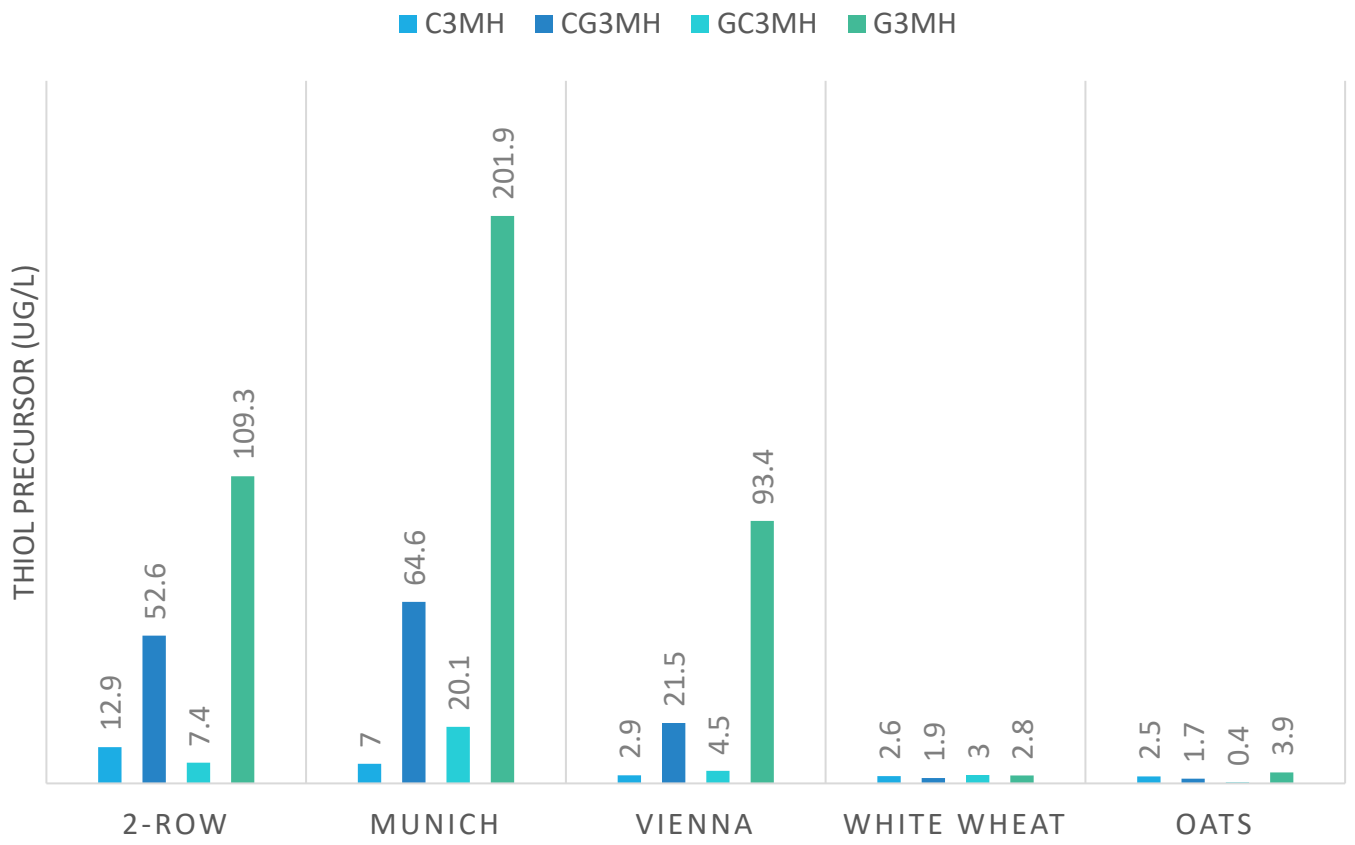
Variable across different barley varieties

Kilning destroys the precursors

3SH precursor levels increase in the boil

Huge potential for thiols, but no evidence for malt being a significant source of 3SH in beer…

THIOL PRECURSORS IN DIFFERENT MALTS



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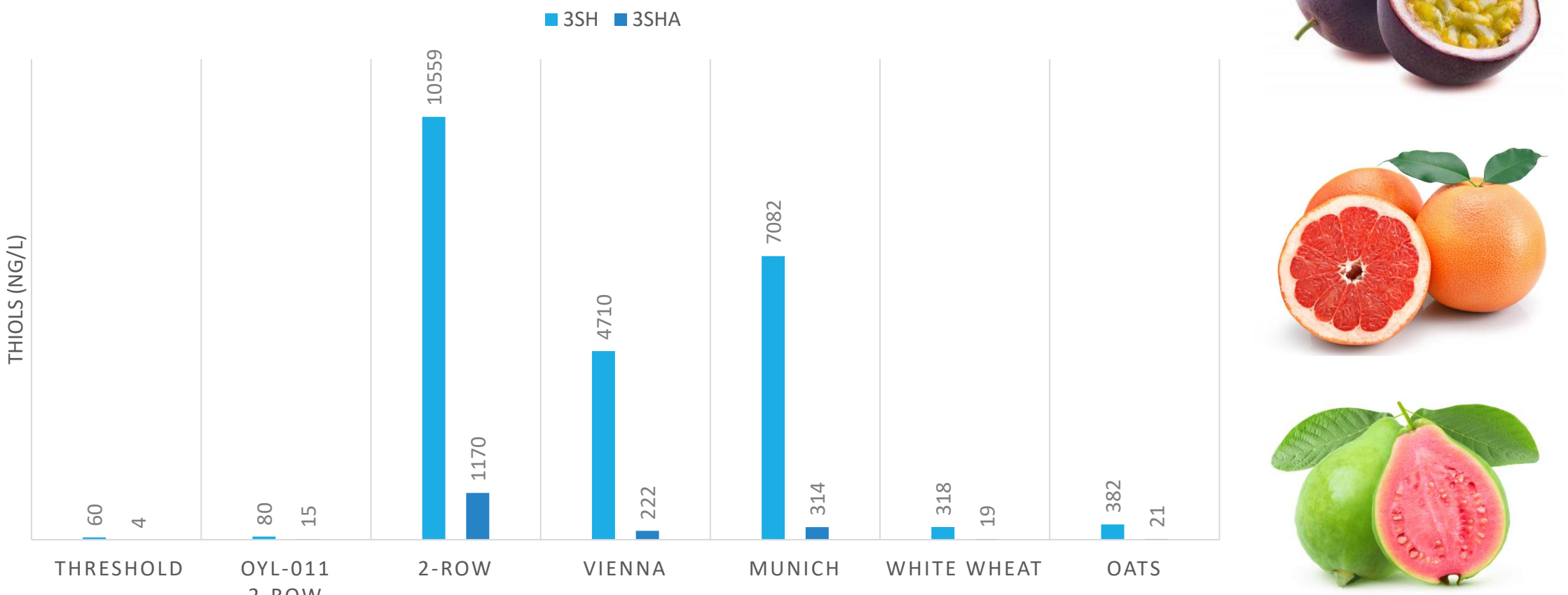
Thiol Levels in Wort Fermentations (No Hops, Just Precursor From Malt!)



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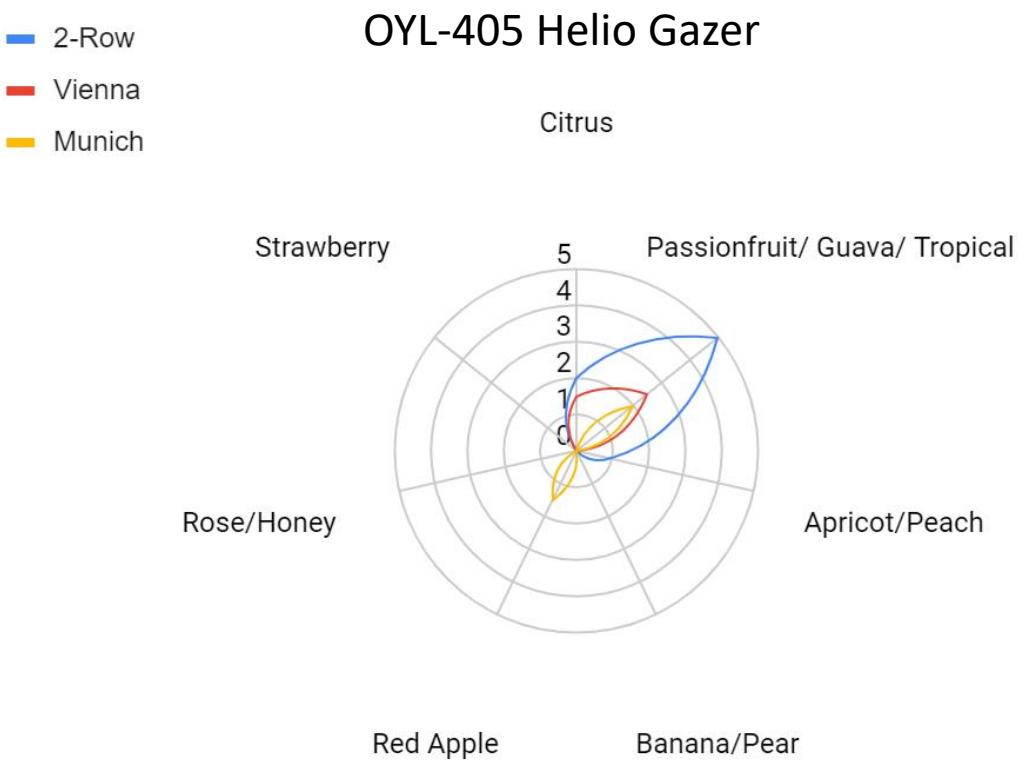
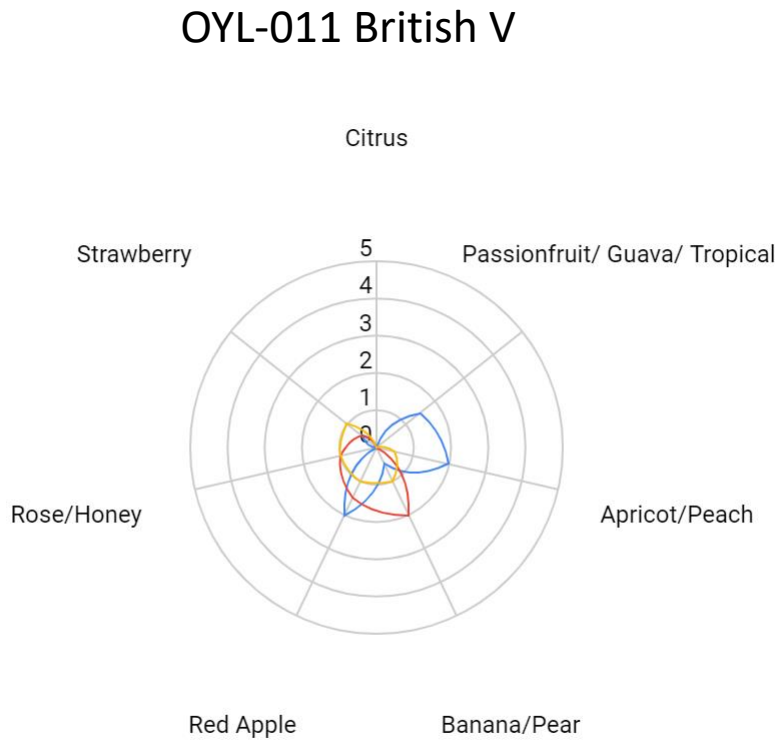
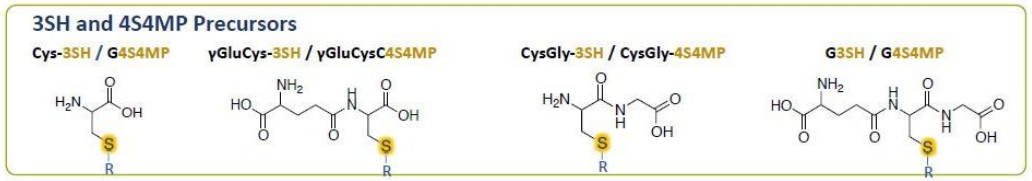
MALT PRODUCTS AND THIOL SENSORY





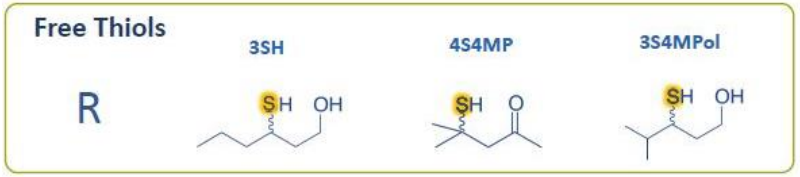
Free Thiols and Precursors in Hops

Thiol Precursors –



- Thiols bound to **glutathione**, cysteine and dipeptide intermediates
- Significantly more **3SH** precursor
- Nobel hops and C-hops are high in bound
- Parts per billion to parts per million in finished beer

Free Thiols –



- Typical “New World” aroma hops are high in free thiols
- Parts per trillion to parts per billion in finished beer

Salanouve et al. 2020. WBC

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Hops with high thiol precursor

Table 2 Analysis report of 17 hop samples (nd: not detected)

Hop cultivars	Thiols (ug/kg)			Thiol Precursors (ug/kg)			
	3MH	3MHA	4MMP	Cys-3MH	G3MH	Cys-4MMP	G4MMP
Apollo	11.1	nd	7.5	382	7340	0.02	0.06
Bravo	20.1	nd	0.5	240	5901	0.02	0.03
Calypso	15.5	nd	0.1	1905	14421	0.03	0.03
Cascade	10.5	2.8	2.4	456	13498	nd	nd
Citra 1	24.2	nd	28.4	394	4821	0.03	0.03
Citra 2	16.0	4.7	43.5	376	5209	nd	nd
Eureka	11.0	nd	17.5	326	7595	0.04	0.06
Hallertau Cascade	15.8	6.0	1.0	142	3418	nd	nd
Hallertau Haller-tauer Tradition	2.3	1.5	0.2	444	10637	nd	nd
Hallertau Herkules	6.3	2.3	0.3	0	5993	nd	nd
Hallertau Nugget	nd	4.4	0.6	333	6252	nd	nd
Hallertau Perle	2.1	1.5	0.6	455	15467	nd	nd
LES-Nugget	2.2	3.4	0.3	488	8753	nd	nd
Saaz 1	4.7	1.5	0.5	431	9184	nd	nd
Saaz 2	2.3	0.9	0.3	532	20678	nd	nd
Saaz 3	4.4	1.0	0.2	890	19890	nd	nd
Simcoe	22.5	nd	13.5	646	8981	0.03	0.01

Roland *et al.* 2017 BrewingScience

Traditional hops

Saaz, Hallertau Mittelfrüh, Perle

West Coast “C” hops

Cascade, Chinook, Calypso

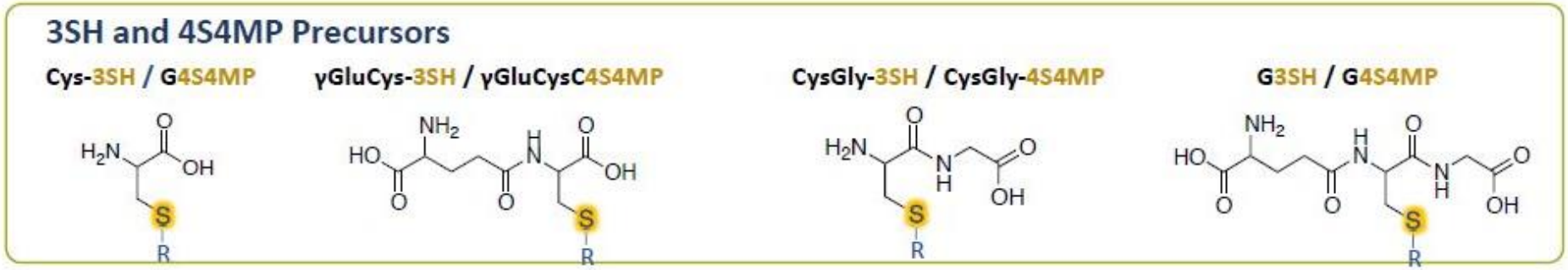
NZ hops

Motueka

Mash hopping

Hops have a lot of glutathione precursor, but ß-lyase enzymes are more active on the cysteine precursor

Adding hop in the mash, promotes the conversion of glutathione precursors to cysteine precursors



Malt enzymes help to break down the more complex thiol precursors

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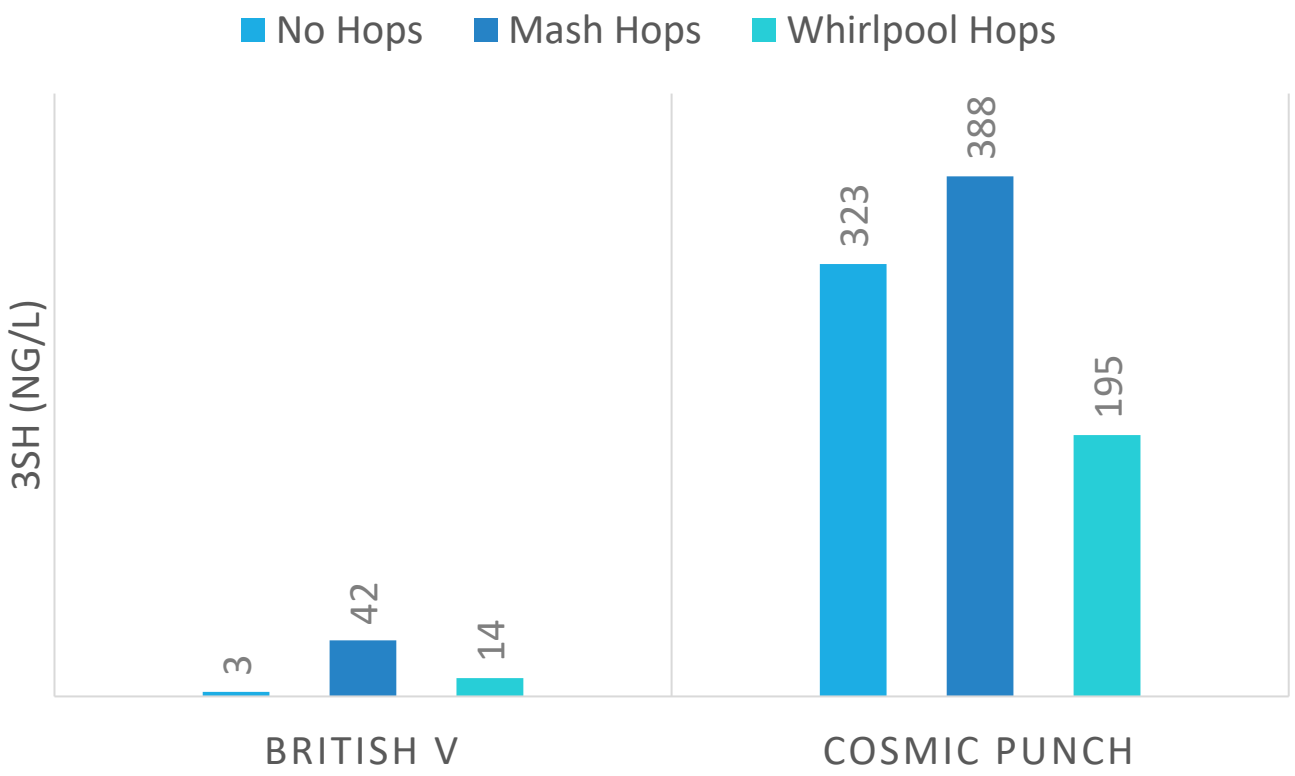
Mash hopping as a method to add thiol precursors



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Things to Consider When Mash Hopping

Remember you will get bitterness from mash hopping

- 30% of the IBU levels that you would expect from a beginning of boil addition.
- Addition rates between 0.5 lb/bbl to 2 lb/bbl depending on the alpha acid content of the hop

Avoid expensive aroma hops

- Other volatile hop aroma compounds will be lost in the boil and beginning of fermentation.

Cosmic Punch vs. Helio Gazer

Strain	Parent Strain	B-lyase	Thiol output?	Best uses?
Cosmic Punch	OYL-011	Irc7	10x sensory threshold	Enhance thiol notes, NEIPA or hazy IPAs, house strain that can be versatile
Helio Gazer	OYL-011	PatB	300x sensory threshold	Intense thiol aromas, stands out in heavily hopped beer styles

Cosmic Punch

Helio Gazer

OMEGA YEAST

Advice for Maximizing Thiols

Hopping methods

- Mash hopping!
- Try alternative hop products in the whirlpool – cryo, incognito/salvo…
- Heavy whirlpool and dry hop additions reduce thiols

The majority of the precursors come from the malt

- Barley! – little from oats/wheat
- Play with different base malts/ malt varieties - terroir
- Higher kilned malts may have less precursor

Try other sources of thiol precursor

- Phantasm – wine grapes
- Possibly other fruit sources

Different styles to try:

NEIPAs/Hop-forward styles

- Expect an overall juicier-tropical aroma
- Complex interactions between thiols and other hop aromas!
  - Think adding passionfruit to juice… more tropical
- Dry hop with combinations that play well with thiols (juicy + thiols!)

A broken down simple thiol-driven style

- The simpler the recipe, the more thiol– blonde, pale, lager
- Mostly barley grist, mash hopping, minimal late hopping
- Thiol bombs and defined passionfruit/guava aromas
- Call it what it is!
  - More like a beer-wine hybrid
  - What is this new thiol-driven style?

WHY USE THIOLIZED YEAST? … OUR FUTURE

More sustainable brewing practices

- Bringing out more aroma from hops and malt
- Reducing cost and product losses

Encouraging use of local hops and malt

- Uncover new potential for local ingredients
- Define and build a local terroir
- Support the people and resources of your region

What's next?

Learning more about raw materials:

- Thiol precursors in different malts
- Hop products can be used to add to aroma without lowering thiols

New approaches to making thiol-focused beers:

- What are you up to?

Tipsy Cow today or at the festival tomorrow, try a mash-hopped lager with Lunar Crush from Surly

Thank you!!

Acknowledgments:

Lance Shaner, PhD
Keith Lacy
Chris Bernardo
Allison Lange

The Omega Yeast Crew

Contact me:

Laura Burns, PhD

laura@omegayeast.com

OMEGA YEAST

EFFICIENCY PANEL

Ask the Experts

HOP & BREW SCHOOL

PATRICK MURPHY

Patrick Murphy grew up in Iowa outside of Davenport, a city that had a long history of malting until prohibition. Spent his college years bartending at craft beer bars in Iowa City. In 2012 he took a Cellarmen job at Bent River Brewery in Moline, Illinois and worked his way through explanations to Lead Brewer. At the end of 2017, Patrick joined a then small crew of brewers at Octopi in Waunakee. At the start of 2020, he was named Octopi's first Head Brewer. In late 2021 Patrick joined Karben4 Brewing as their Head Brewer where he is today. Patrick is also active in MBAA Milwaukee.

HOP & BREW SCHOOL

JOE WALTS

Joe Walts grew up in the suburbs of Detroit and graduated from the University of Michigan with a BS in aerospace engineering. In 2005, he left a job at a jet engine manufacturer to pursue a brewing career at J.T. Whitney's in Madison, Wisconsin. Joe then worked in the brewhouse and cellar at Otter Creek Brewing in Vermont, and eventually attempted to open RePublic Brewpub back in the Madison area – which taught him that raising capital is not a skill he possesses. He eventually became the QA Manager at Ale Asylum (Madison, WI), the Head Brewer at Narrows Brewing Company (Tacoma, WA), the QA Manager at Ale Asylum (again), and the Beer Recipe & Process Improvement Lead at Octopi (Waunakee, WI). He has also served as a practical brewing instructor at Madison College and a lecturer on brewing water at the University of Wisconsin. Joe currently works as the Quality Manager/R&D Brewer at Karben4 Brewing and teaches the Brewery Water and Adjustment portion of the MBAA Brewing and Malting Science Course.

HOP & BREW SCHOOL

ALLISON LANGE

Allison Lange is the R&D Molecular Biologist at Omega Yeast in Chicago. She graduated from Dartmouth College with a degree in Genetics, Cell, and Developmental Biology and was awarded her PhD in Biochemistry from Emory University. Allison has brewed professionally for ~9 years. She began as a Brewer and Beer Scientist at Port City Brewing Company in Alexandria VA, then moved to be the Director of Brewing Operations, Lead Brewer, Lead QC, and Lead Cellarperson at 3 Stars Brewery in Washington DC. Most recently, she was Head Brewer of Old Ox Brewery in Ashburn VA.

HOP & BREW SCHOOL

JOE SHANAHAN

Joe Shanahan is the regional sales manager for the Midwest. Prior to Yakima Chief, Joe has been a brewer in the industry for over five years and has worked in breweries both large and small. He holds a Bachelor of Arts in History from St. Norbert College in De Pere, WI. After graduating he went on to brewing school at South College in Knoxville, TN. Joe lives in Toledo, OH. Joe's favorite beer varies by the season. Right now, Octoberfests are really hitting the spot.

HOP & BREW SCHOOL

STEVE THOMPSON

Steve Thompson is the Yakima Chief Manager serving the Central, United States. Based in Madison, Wisconsin, Steve works with craft breweries in Wisconsin, Minnesota, Michigan, Iowa, Nebraska, North and South Dakota. Steve started his professional career in the microbiology field, focusing on food and consumer product safety. A call to brewing led Steve to a position at Dogfish Head Brewing in Milton, DE. Steve supervised the Quality laboratory at Dogfish Head for 5 years, focusing on the maintenance of craft beer quality during the entire brewing/packaging process. Following this time of immense learning at Dogfish Head, Steve was the Director of Brewing Operations at Barrio Brewing in Tucson, Arizona. After 5 years of managing the brewing and packaging at this smaller scale craft brewery, Steve joined the Yakima Chief team in Jan of 2018. Steve's favorite style of beer is pilsner and has a passion for brewing beer at home.

HOP & BREW SCHOOL

YCH Research and Development

Exploring Our Trial Program

Tommy Yancone

QC Sensory Supervisor and R&D Data Analyst

Today's Agenda

Our R&D Team

How We Operate

YCH Trial Process

Recent Trials

YCH 301

Sensory

YAKIMA CHIEF HOPS

The YCH R&D Team

- Pat Jensen, Director of R&D
- R&D Lab and Agronomy
  - Jackie Brummett, R&D Lab Supervisor
  - Rob Ring, Formulation Chemist
  - Guadalupe Saldana, R&D Lab Technician
  - Dianeli Gutierrez, Sensory & Lab Technician
  - Lindsay Koby, Field Research Agronomist
- Sensory & Brewing
  - Tiffany Pitra, Sensory Manager
  - Tessa Schilaty, Sensory & Brewing Scientist
  - JT Wattenberg, Brewery Manager
  - Dominic Wise, Sensory Technician
  - Tommy Yancone, QC Panel Supervisor and R&D Data Analyst
  - Gustavo Razo, Sensory & Production Research Coordinator

YAKIMA CHIEF HOPS

A Culture of Innovation

2018

- 3 Team Members
- Basic sensory analysis
  - Production sensory on-demand only
- Limited brewing capabilities
- Lab analysis limited to GC-MS

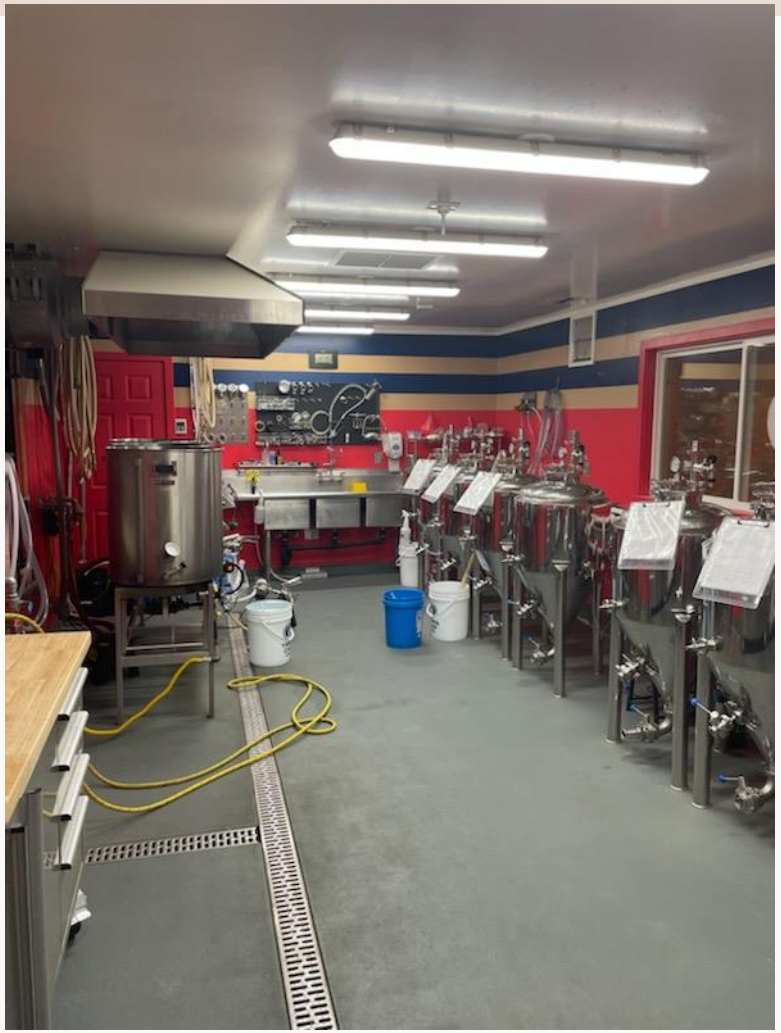
Today

- 12 Team Members
- Robust hop sensory program
- Dedicated beer sensory panel
- Quality Control hop sensory panel
- In house brewery with new brewhouse to be installed in late 2022
- GC-QTOF, GC-SCD analyses
- Field agronomy research focus
- Cross-functional product development team

YAKIMA CHIEF HOPS

Pilot Brewery

- 1 barrel direct fire system
- 8 x 1bbl Unitanks
- Split batch fermentations
- Dry Hop Rig
- Research Projects
  - New product development trials
  - Smoke taint effects
  - HBC Varietal assessment



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R&D Lab

- HPLC
  - Brewing Values
  - IBUs
  - Hop Diastase
- GC-MS / GC-QTOF SCD
  - ‘Survivable’ compounds
  - Sulfur compounds
  - Other aromatics
- DMA
  - Beer Specs

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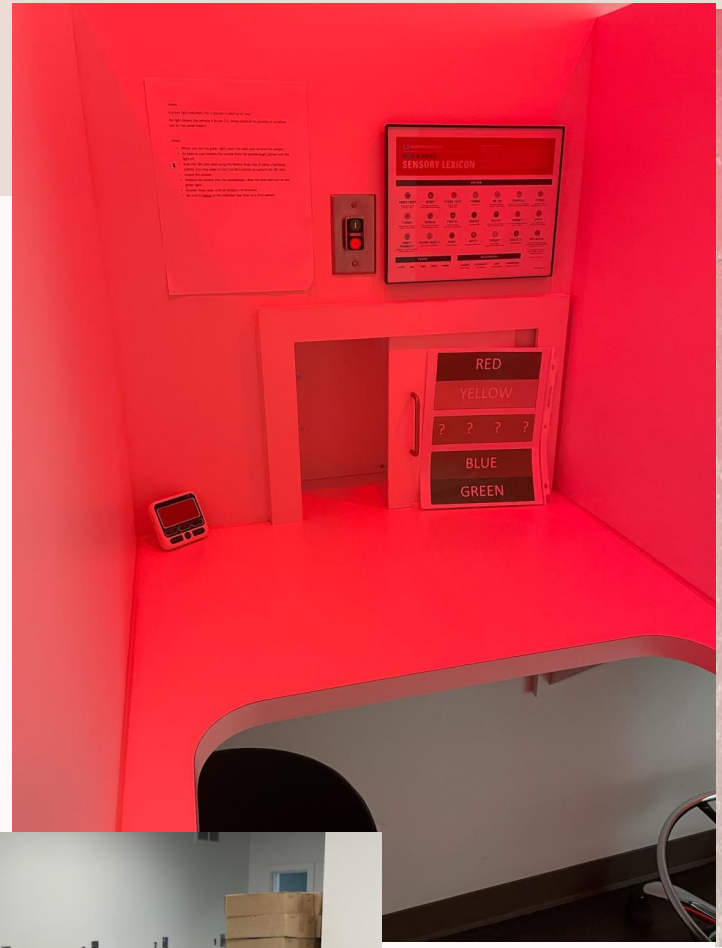
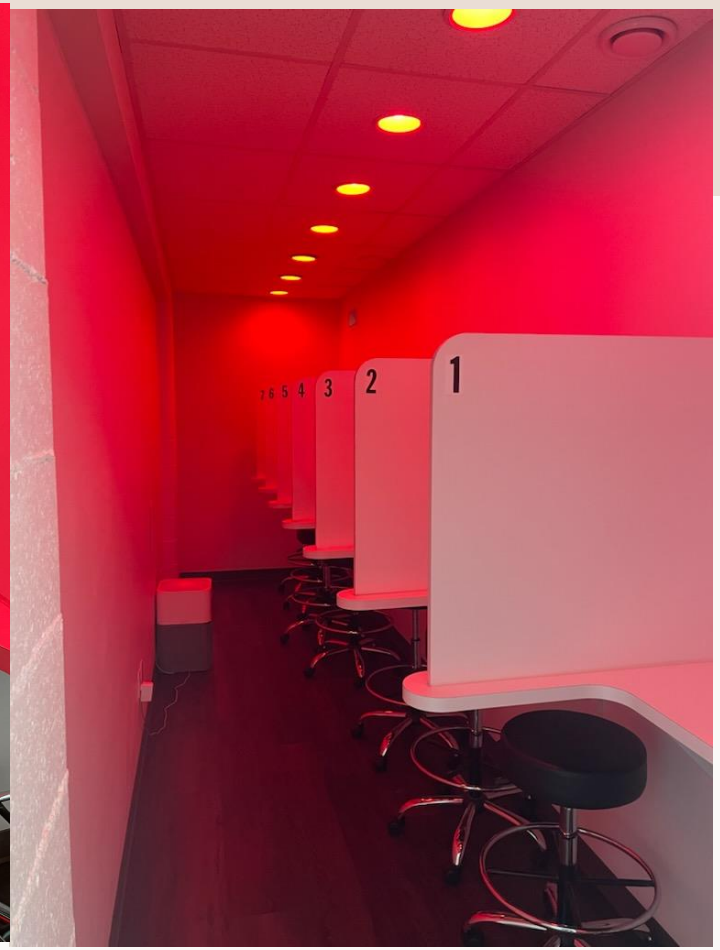
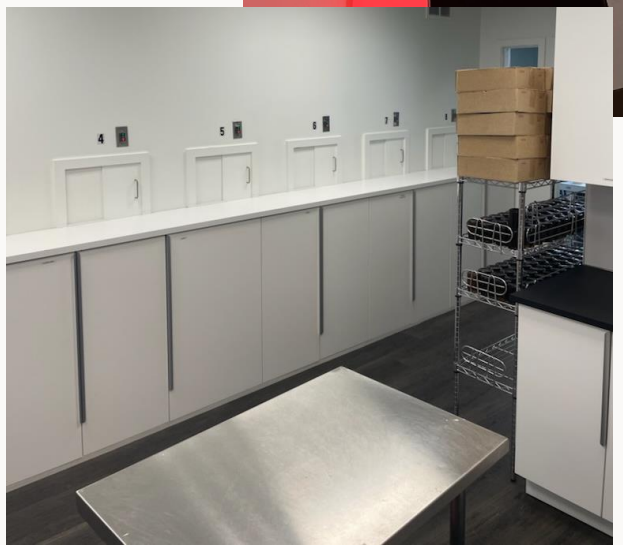
The Aromadome

- Dedicated prep space
- 8 panelist booths
  - Red lighting
  - Pass through sample doors
  - Physical separators
- Used for beer and hops sensory
- Training resources







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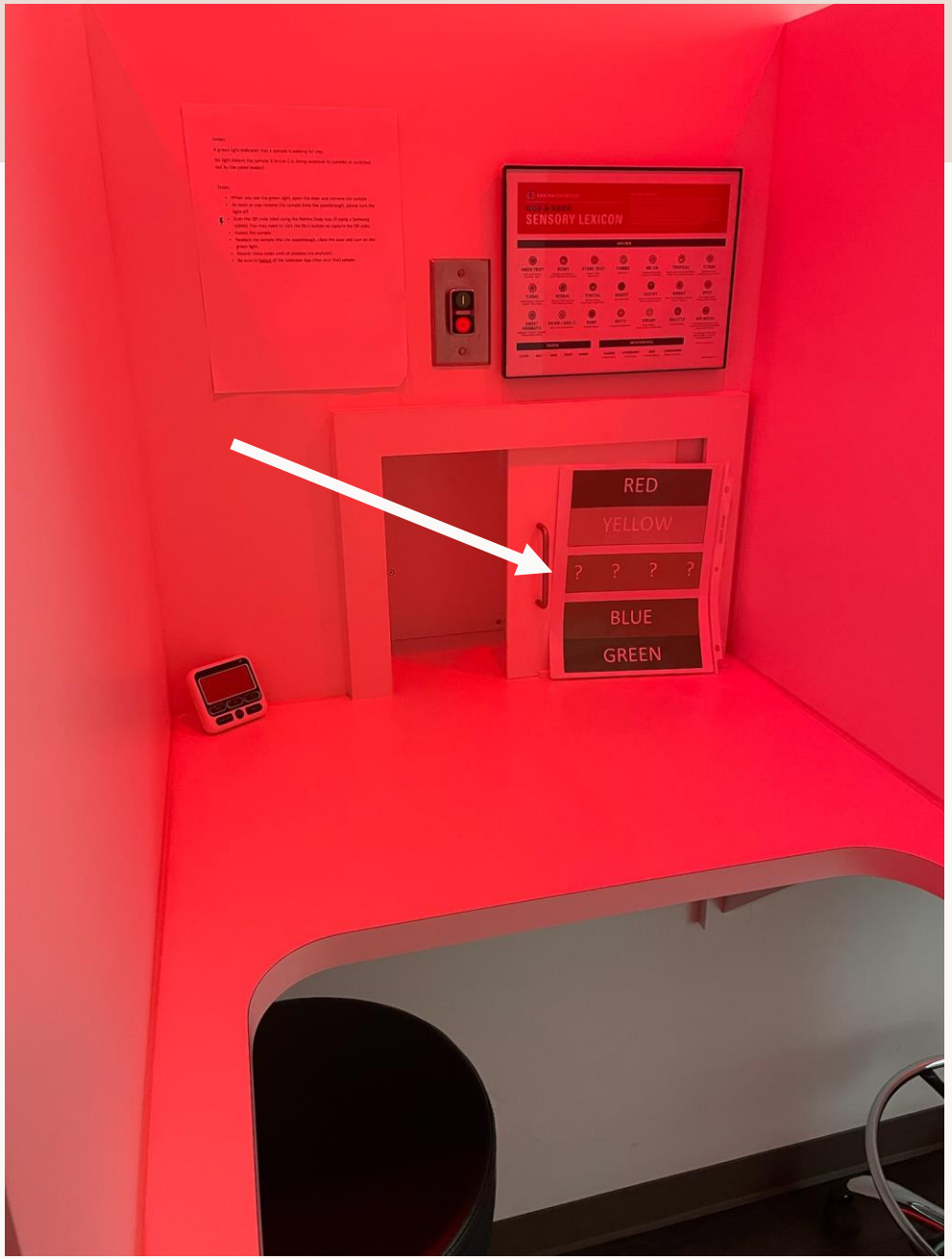
What Do You See?



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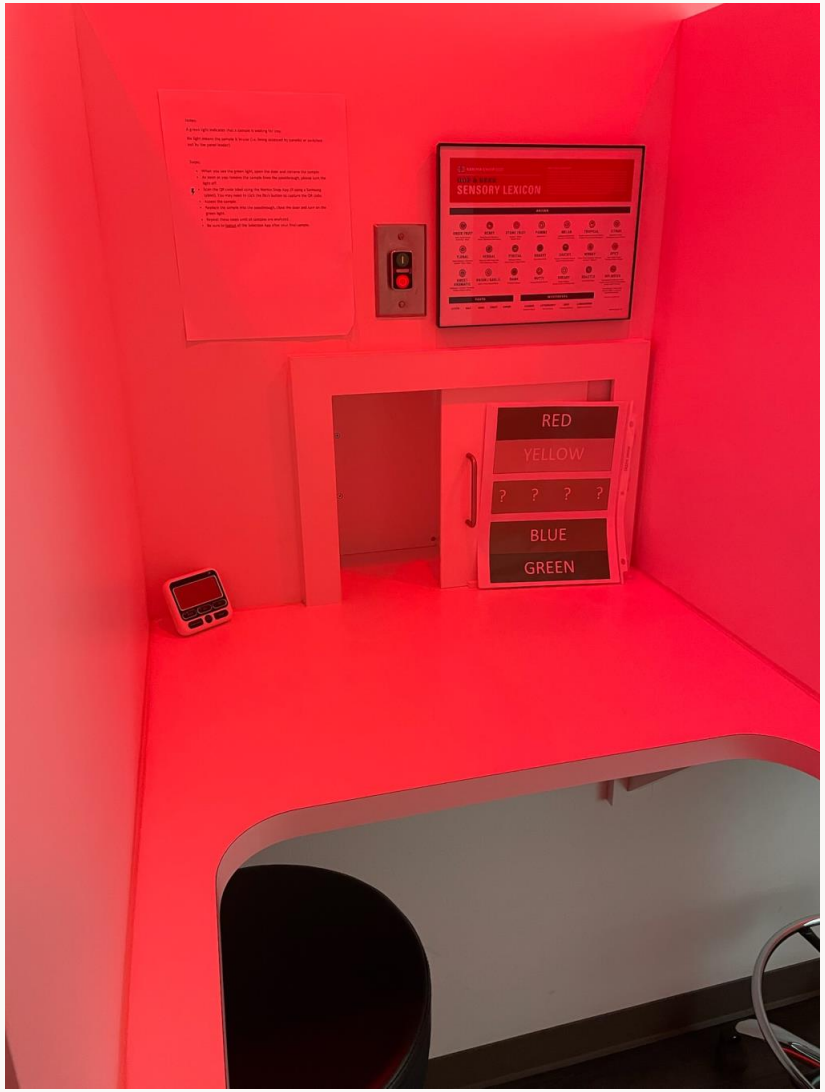
Preventing Bias is Critical



RED

YELLOW

? ? ? ?

BLUE

GREEN

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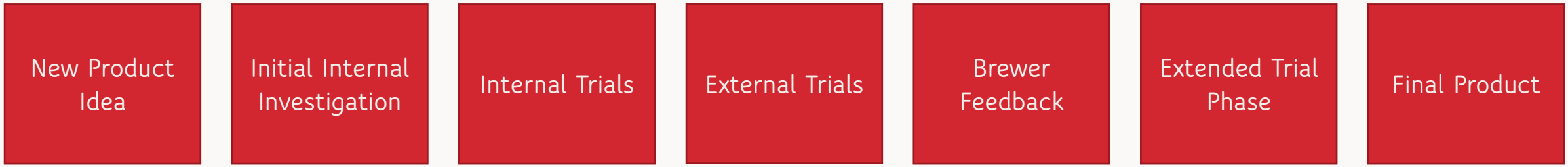
Trial Program

YCH Product Development Process



This process was designed to:

1. Help streamline the development process
2. Get new products in brewer's hands more quickly
3. Determine real-world benefits of prospective new products

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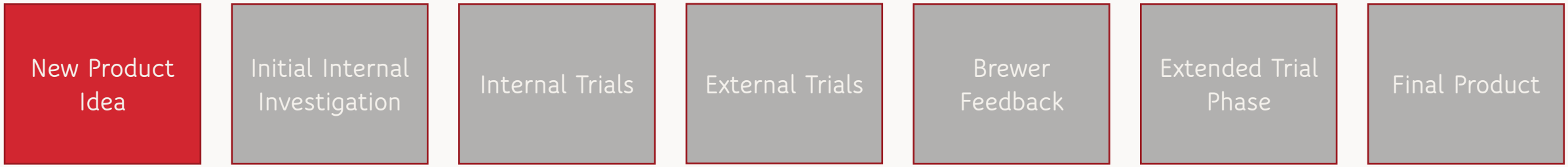
YCH Product Development Process



Ideas can come from:

- Brewers' requests
- Internal research
- Desire to solve a problem
- New scientific capabilities

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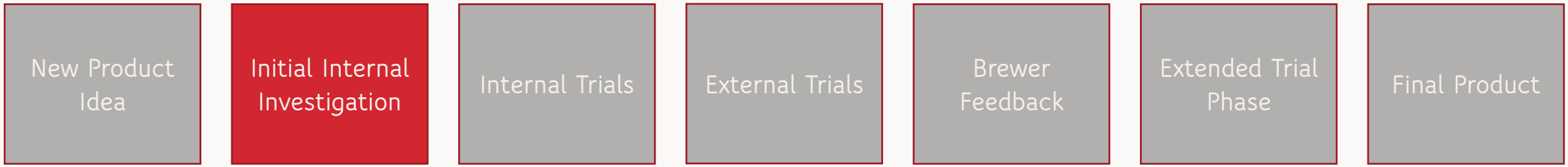
YCH Product Development Process



- The 'can we actually do this?' phase
- Add new equipment/instrumentation
- Test novel methods for production and analysis

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YCH Product Development Process

New Product Idea	Initial Internal Investigation	**Internal Trials**	External Trials	Brewer Feedback	Extended Trial Phase	Final Product

- Brewing trials
- Hop + Beer sensory
- Lab analysis
- Prototype iteration

YAKIMA CHIEF HOPS

YCH Product Development Process

New Product Idea	Initial Internal Investigation	Internal Trials	**External Trials**	Brewer Feedback	Extended Trial Phase	Final Product

- We usually involve local breweries first, then open it to about 20 in different regions
- The product gets a trial designation number at this point

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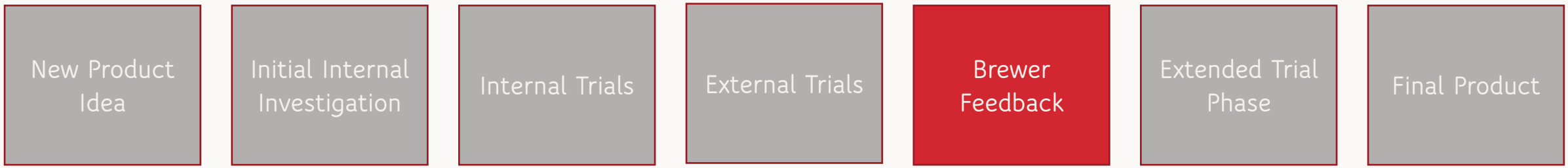
YCH Product Development Process



- Feedback Survey
- Focus Groups / Interviews

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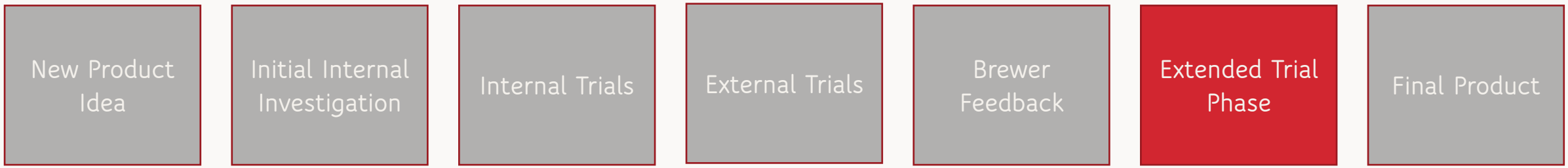
YCH Product Development Process



- Released for sale
- Feedback still requested, but not required
- Opportunities to iterate before full launch

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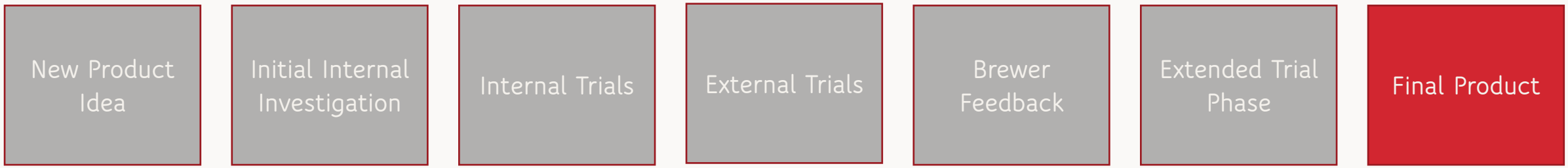
YCH Product Development Process



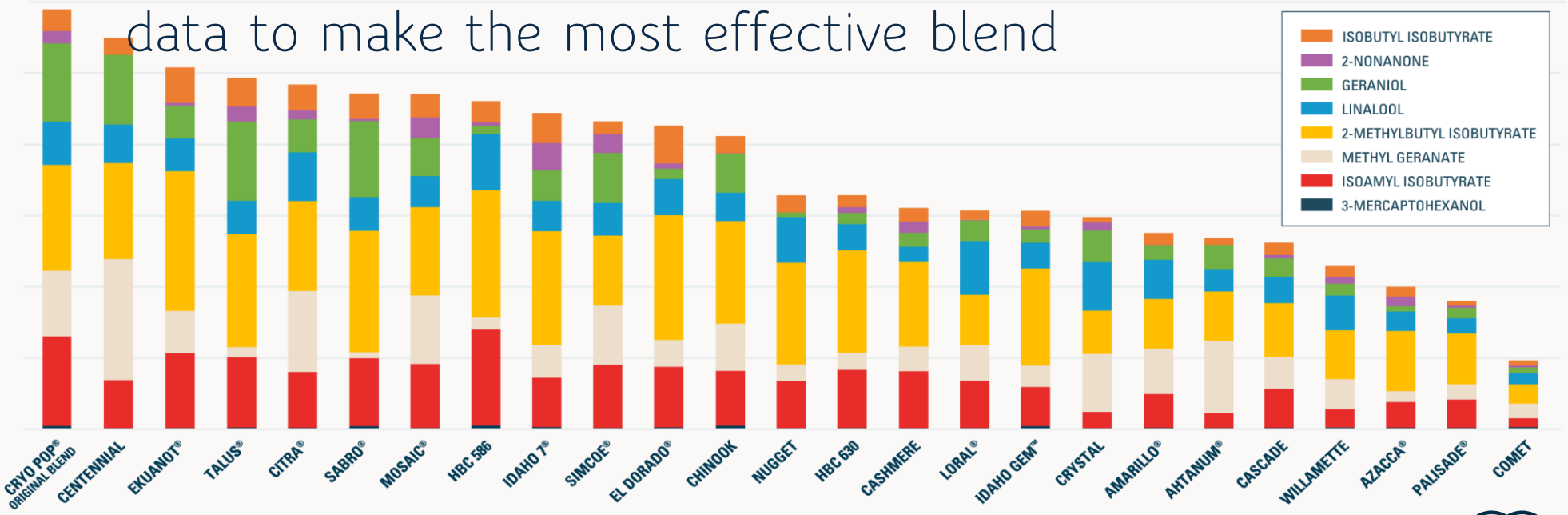
- Commercialization + Marketing
- Hold as trial
- Recycle and iterate
- Scrap

YAKIMA CHIEF HOPS

Recent Trials

Cryo Pop® Original Blend (TRI2304CR)

- Blend of Cryo Hops designed to maximize beer soluble compounds
- Only possible due to our R&D lab's capabilities
- Lots are hand selected each year based on analytical data to make the most effective blend



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Aroma Extract Product (YCH 701)

- Low temperature extraction using food-safe solvents
- Designed for aroma additions (DH/WP)
  - Comprised of 60-80% essential oil
  - No vegetal material to reduce efficiency
  - Varietal specific
  - Easily flowable
- Planned dosage rate is 2% by weight vs. T-90
  - **3.5 ounces would replace an 11lb box of T-90**
- Internal trials complete, external trials starting in Q4 2022

YAKIMA CHIEF HOPS

Expression Blends (Various Trials)

- Blends targeting specific flavor profiles or use cases
- New potential options for hard to procure varieties
  - Climate change is affecting non-irrigated hop growing regions

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How climate change is shaking up the hops that give beer its flavour

Hop plants are largely what distinguish your dark ales from your refreshing pales, and each has its own "terroir". With changing weather affecting how and where they grow, what does the future hold for brewing and beer?

HUMANS 15 December 2021

By Chris Simms

REUTERS

World Business Markets Breakingviews Video More

ENVIRONMENT AUGUST 30, 2018 / 4:41 AM / UPDATED 4 YEARS AGO

In the land of pilsner, Czech hops suffer amid drought

By Reuters Staff 3 MIN READ

ZATEC, Czech Republic (Reuters) - Fans of sought-after Czech hops might be left a little thirsty this year as the prized hops are the latest victim of a summer drought, cutting yields by about 30 percent below average.

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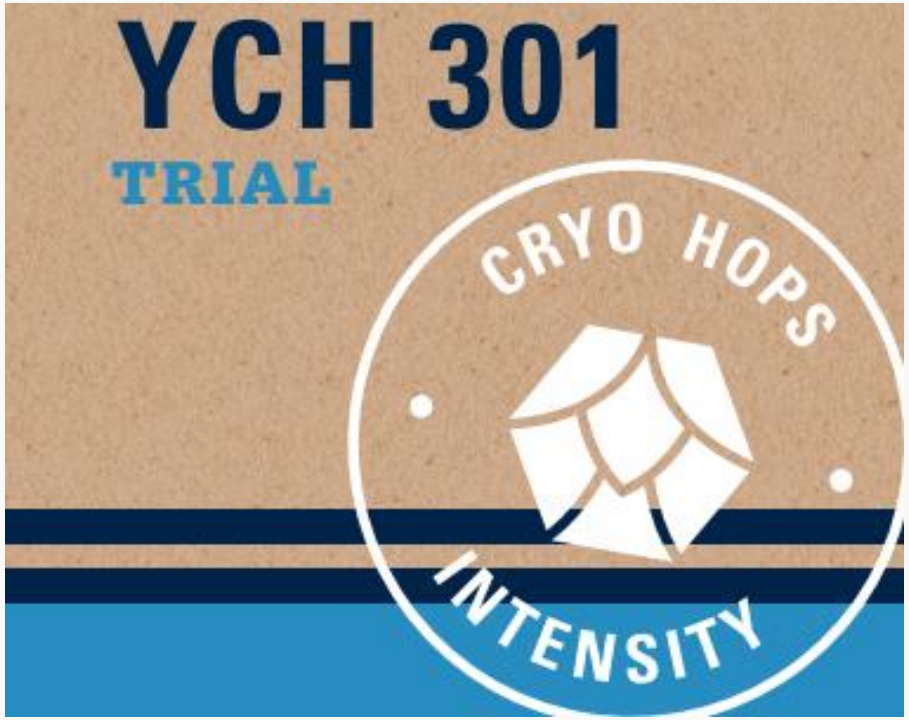
YCH Trial 301

YCH 301 Trial Product Development

- Project Goals
  - Make fresh hop beers more accessible to more brewers
  - Reduce costs
  - Increase sustainability
  - Lengthen ‘Fresh Hop Season’
  - Give brewers access to flavors only possible with fresh hops



- Does everyone know what a fresh hop beer is?

Fresh Hop Beers 101

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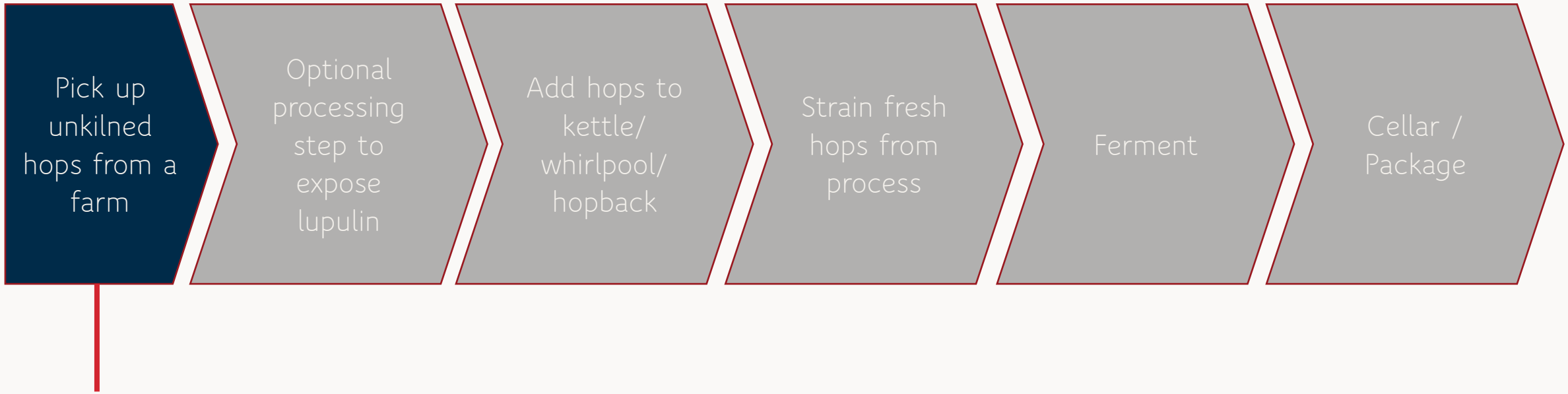
Fresh Hop Beers 101-Room for Improvement



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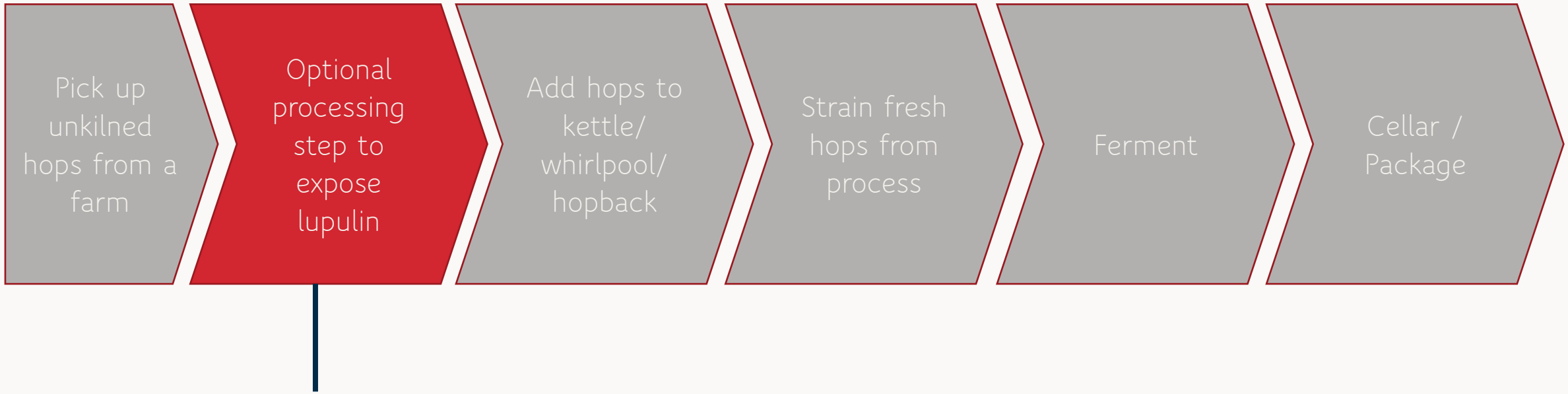
Fresh Hop Beers 101-Room for Improvement



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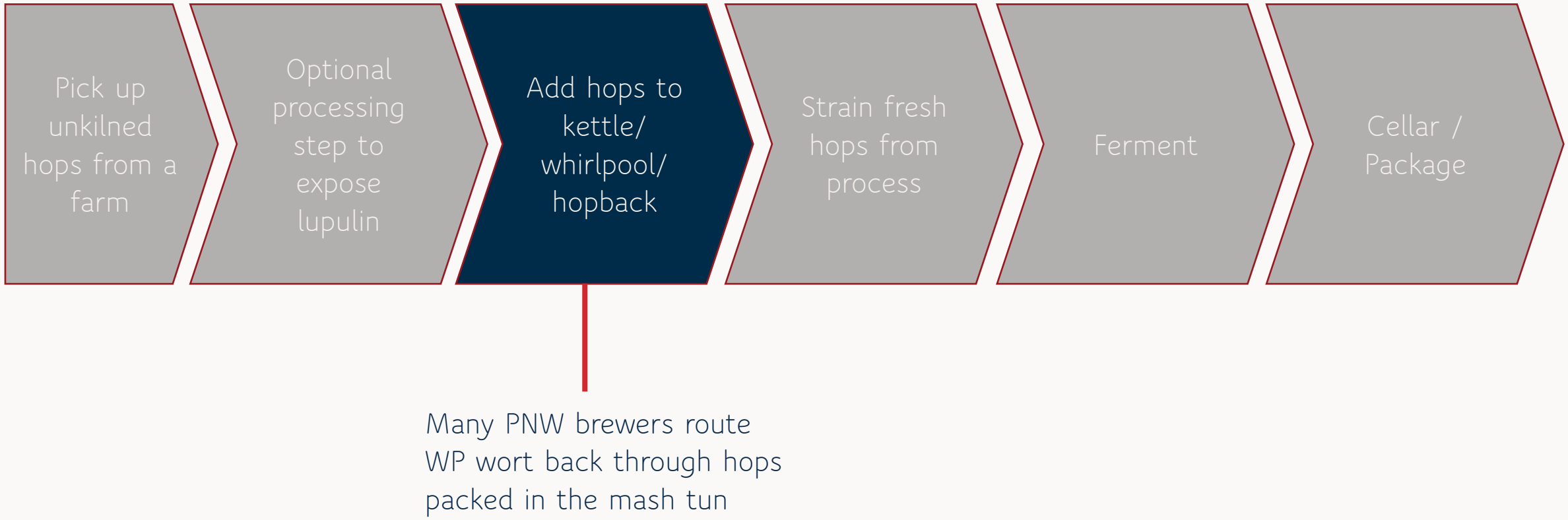

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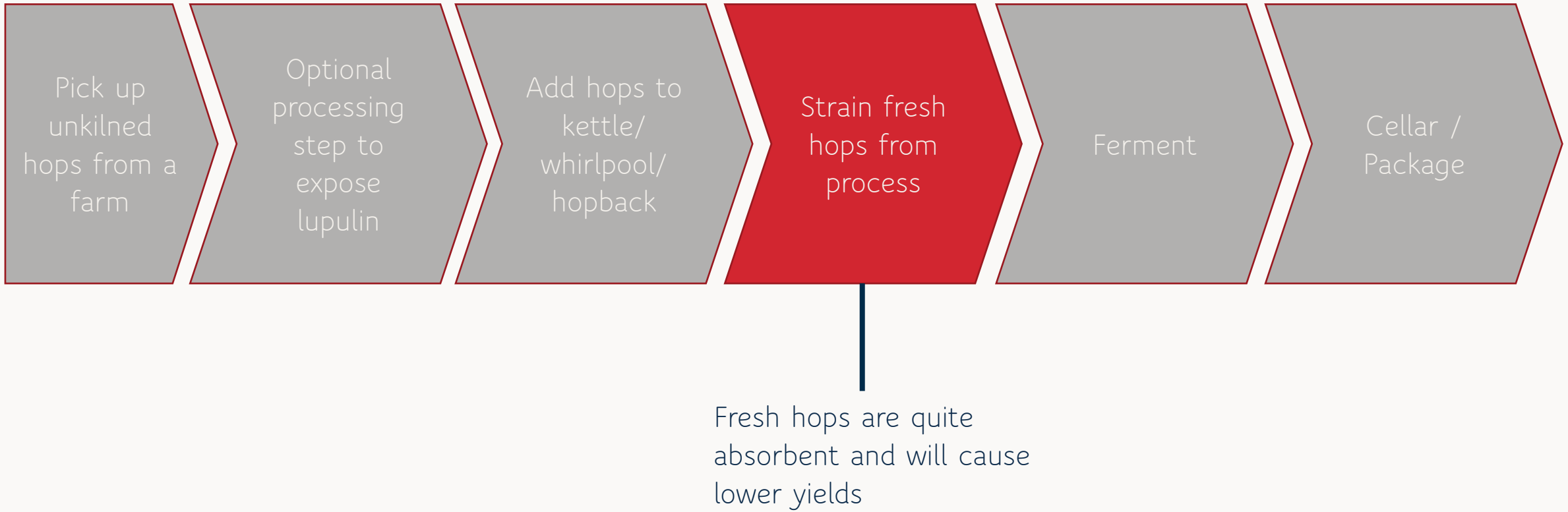

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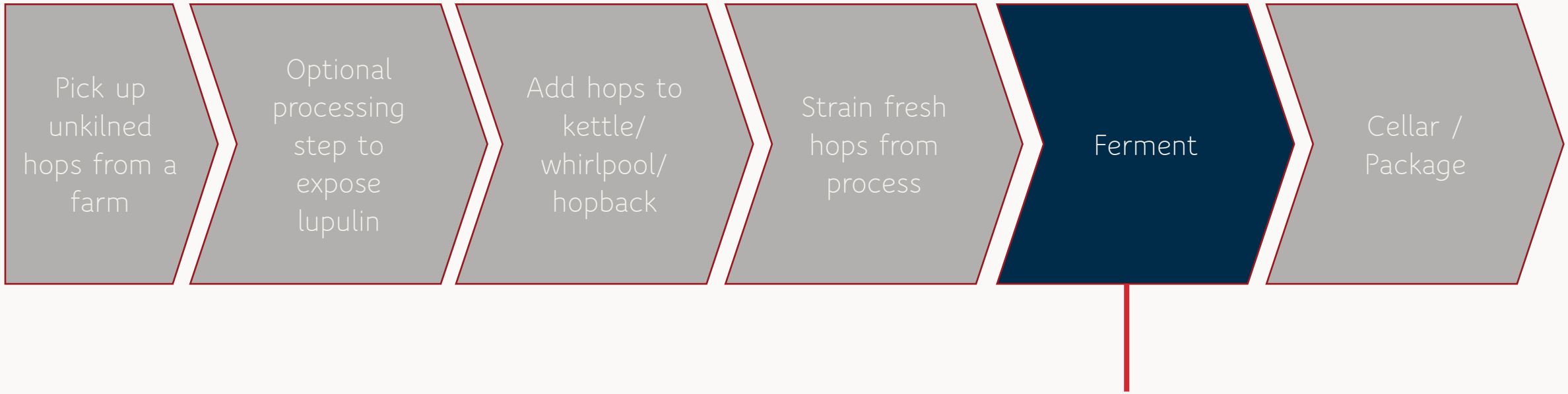

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Frozen Fresh Hops – Our Initial Trial

- Hops were flash frozen on the farm right when they were picked
- Could be stored frozen throughout an entire year
- Provided a very similar experience to standard fresh hops
- Needed to be shipped frozen

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Fresh Hops vs Frozen Fresh Hops

Standard Fresh Hops			Frozen Fresh Hops	
5-7x by weight	–	Usage Rate vs T-90	–	5-7x by weight
Good	–	Aroma Quality	–	Good
Difficult	–	Ease of Use	–	Difficult
Cold	✓	Shipping Temperature	✗	Frozen
Low	–	Product Density	–	Low
Cold	✓	Storage Condition	✗	Frozen
< 36 Hours	✗	Storage Time	✓	Indefinite

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YCH 301 Trial

- We utilized our patented Cryo Hops process to further concentrate the frozen fresh hops
- Pellets retain the fresh hop character, and became more concentrated
- Pellet format is much easier to use, and behaves like a normal Cryo Hops pellet
  - Yields are unaffected
  - No special processing steps required
  - Dry hopping is now possible
- Water content is reduced to about 70%
- Pellets still need to be shipped and stored frozen
- Can be used as a 1:1 replacement for T-90 pellets

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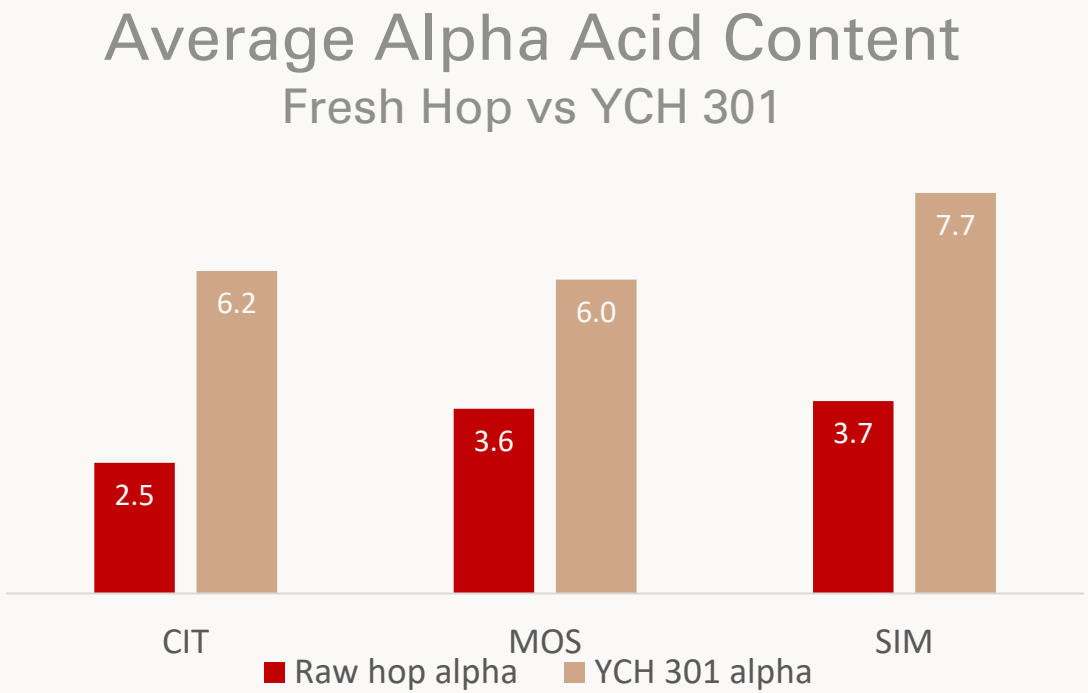
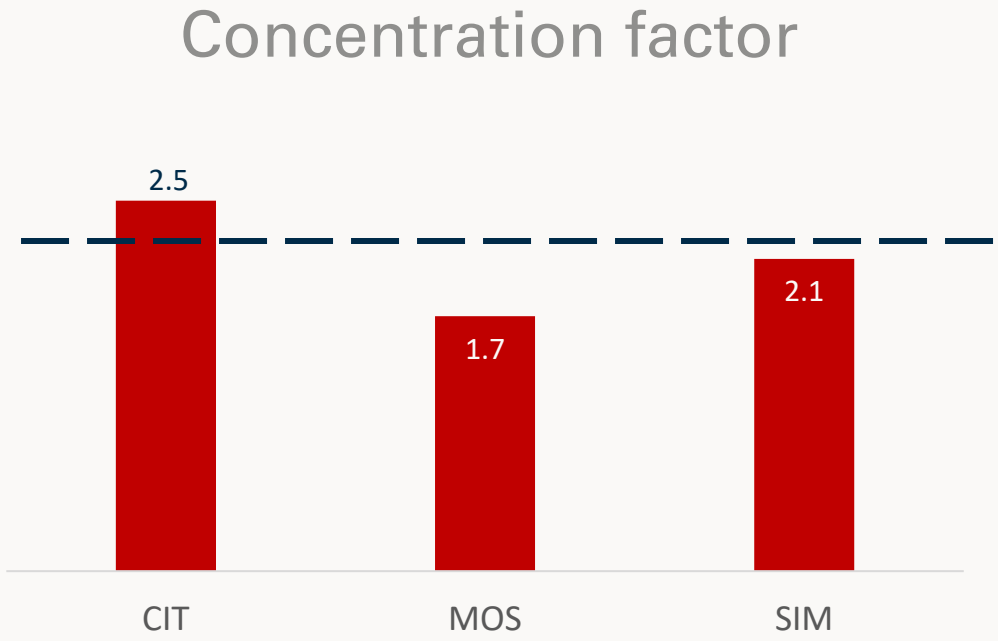
Initial Results-Frozen hops concentrate at the same rate as kilned hops





Kilned hops-expected concentration factor: 2.2

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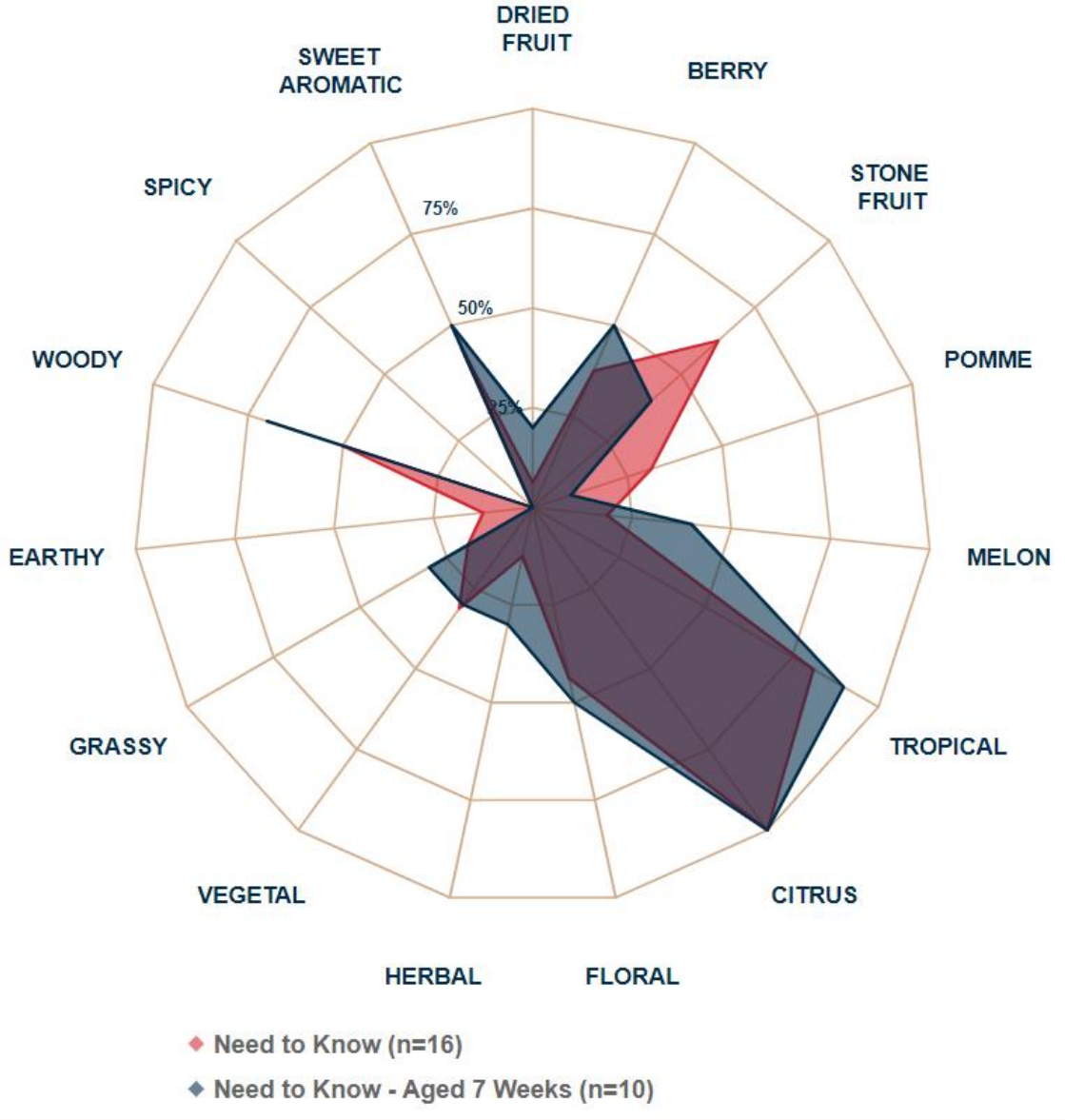
Initial Results-Beer sensory is desirable, and shelf stable



Attribute	Need to Know	Need to Know - Aged 7 Weeks
GRAPEFRUIT	50.0%	50.0%
APRICOT	37.5%	40.0%
PEACH	50.0%	20.0%
PINE	37.5%	40.0%
PINEAPPLE	25.0%	50.0%
LEMON	25.0%	40.0%
GUAVA	31.3%	20.0%
APPLE	31.3%	10.0%
MANGO	18.8%	30.0%
CANTALOUPE	12.5%	30.0%
GREEN GRASS	18.8%	20.0%
HONEY	12.5%	30.0%
ORANGE	12.5%	30.0%
BUBBLEGUM	18.8%	10.0%
CABBAGE	18.8%	10.0%
GERANIUM	6.3%	30.0%
LIME	25.0%	0.0%
PASSION FRUIT	18.8%	10.0%
ROSE	12.5%	20.0%
STRAWBERRY	18.8%	10.0%
VANILLA	25.0%	0.0%

YAKIMA CHIEF HOPS

Fresh Hops vs Frozen Fresh Hops

Standard Fresh Hops			YCH 301 Pellets	
5-7x by weight	✗	Usage Rate vs T-90	✓	Same as T-90
Good	✗	Aroma Quality	✓	Concentrated
Difficult	✗	Ease of Use	✓	Easy
Cold	✓	Shipping Temperature	✗	Frozen
Low	✗	Product Density	✓	High
Cold	✓	Storage Condition	✗	Frozen
< 36 Hours	✗	Storage Time	✓	Indefinite

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External Trial Survey Results

- 20 brewers tried the product
- Many were from the PNW, but we had representatives across the country
- We did not provide explicit use instructions
- A post-brew survey was conducted to gauge brewers' opinions

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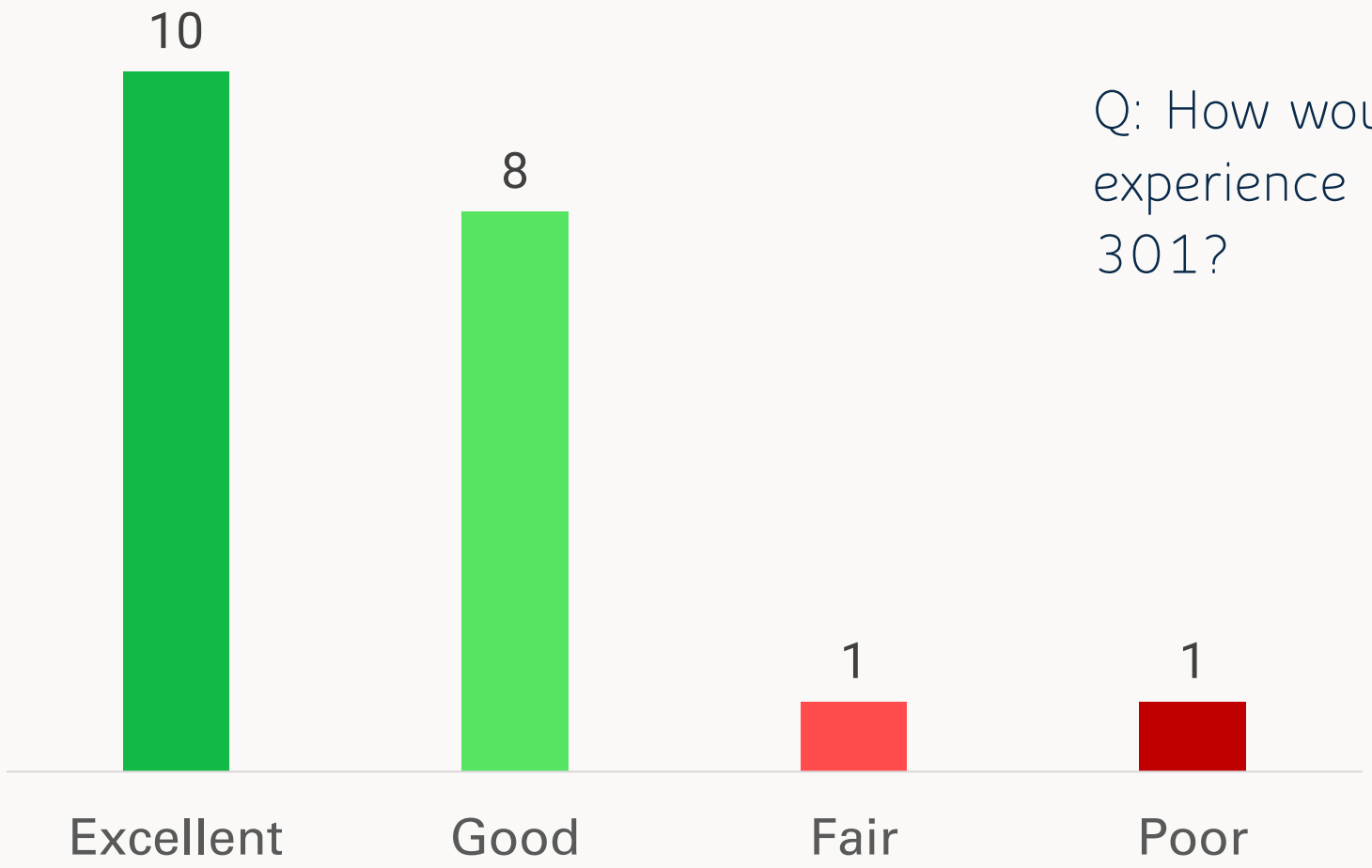
90% of brewers said YCH 301 produced a beer that had a significantly different flavor than other fresh hop products they've used

- Many aromatics found in fresh hops are volatilized away in the kiln
- Some PNW brewers didn't want to lose the seasonality of regular fresh hop beers
- Many brewers said YCH 301 would be a good hop tool to create unique flavors

YAKIMA CHIEF HOPS

Generally, brewers had a good experience with YCH 301



Q: How would you rate your experience brewing with YCH 301?

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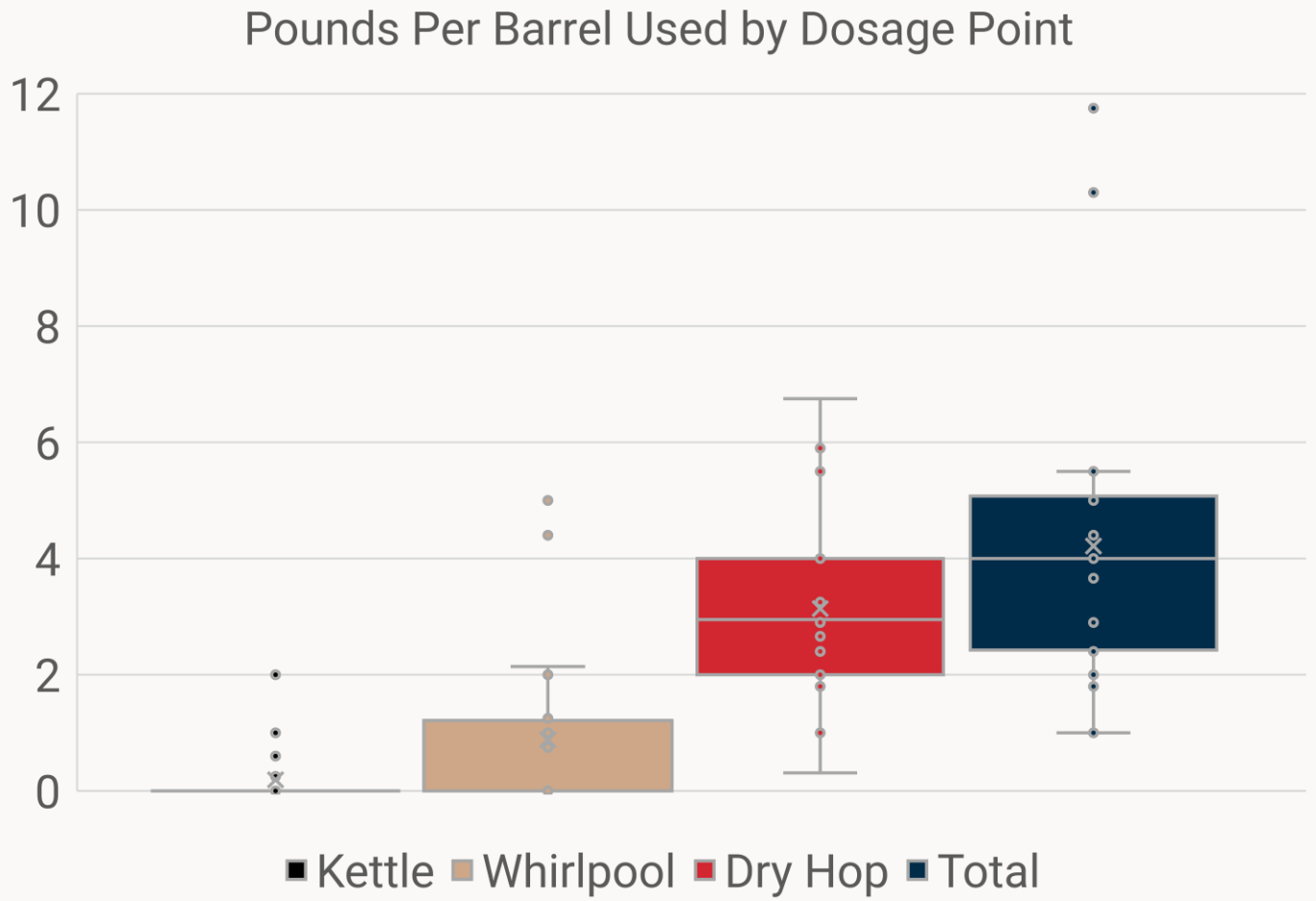
Dry hopping was a very popular use case

- Brewers averaged about 3 lb/bbl for dry hopping, and 4 lb/bbl overall
- Hopping rates are comparable to T-90 pellets



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Which product would you prefer, given the following use cases?

	Flavor	Ease of Use	Cost	Logistics
YCH 301	**53%**	**94%**	**71%**	**58%**
Frozen Fresh Hops	11%	0%	12%	5%
Fresh Hops	37%	6%	18%	37%

YAKIMA CHIEF HOPS

Which product would you prefer, given the following use cases?

	Flavor	Ease of Use	Cost	Logistics
YCH 301	**53%**	**94%**	**71%**	**58%**
Frozen Fresh Hops	11%	0%	12%	5%
Fresh Hops	37%	6%	18%	37%

YAKIMA CHIEF HOPS

Sensory

YCH 301 Hop Sensory

- New ‘Smoothie’ method for sensory analysis
  - Based on ASBC Grind method
  - Grind hops with 5% ethanol solution
  - Helps grind hops and mimics a beer matrix
- What do you smell in the sample?

HOP & BEER
SENSORY LEXICON

YAKIMA CHIEF HOPS®

AROMA

DRIED FRUIT
Date • Dried Apricot
Dried Fig • Raisin

BERRY
Black Currant • Blueberry
Grape • Raspberry • Strawberry

STONE FRUIT
Apricot • Cherry
Peach • Plum

POMME
Apple • Pear

MELON
Cantaloupe • Cucumber
Honeydew • Watermelon

TROPICAL
Banana • Coconut • Guava • Lychee
Mango • Passion Fruit • Pineapple

CITRUS
Grapefruit • Lemon
Lemongrass • Lime • Orange

FLORAL
Cherry Blossom • Geranium
Jasmine • Rose • Soapy

HERBAL
Black Tea • Dill • Green Tea
Mint • Rosemary • Thyme

VEGETAL
Cabbage • Celery
Green Pepper • Tomato Plant

GRASSY
Green Grass • Hay

EARTHY
Barnyard • Compost • Geosmin
Leather • Mushroom • Soil

WOODY
Cedar • Pine • Resinous • Sawdust
Tea Tree • Tobacco

SPICY
Anise • Black Pepper
Cinnamon • Clove • Ginger

SWEET AROMATIC
Bubblegum • Caramel • Chocolate
Creamy • Honey • Vanilla

ONION / GARLIC
Garlic • Green Onion • Onion

DANK
Cannabis • Skunky

NUTTY
Almond • Peanut • Walnut

BREADY
Biscuit • Dough
Graham Cracker • Oatmeal • Rye

ROASTED
Coffee • Dark Malt

OFF-NOTES
Burnt Rubber • Cardboard • Catty
Cheesy • Diesel • Musty • Plastic/Waxy
Smoky • Sulfur • Sweaty

* Acetaldehyde • Butyric Acid
Diacetyl • DMS • Lactic Acid
Light Strike • Metallic

**Off notes occurring in beer*

TASTE

BITTER SALT SOUR SWEET UMAMI

MOUTHFEEL

ALCOHOL
Warming • Boozy

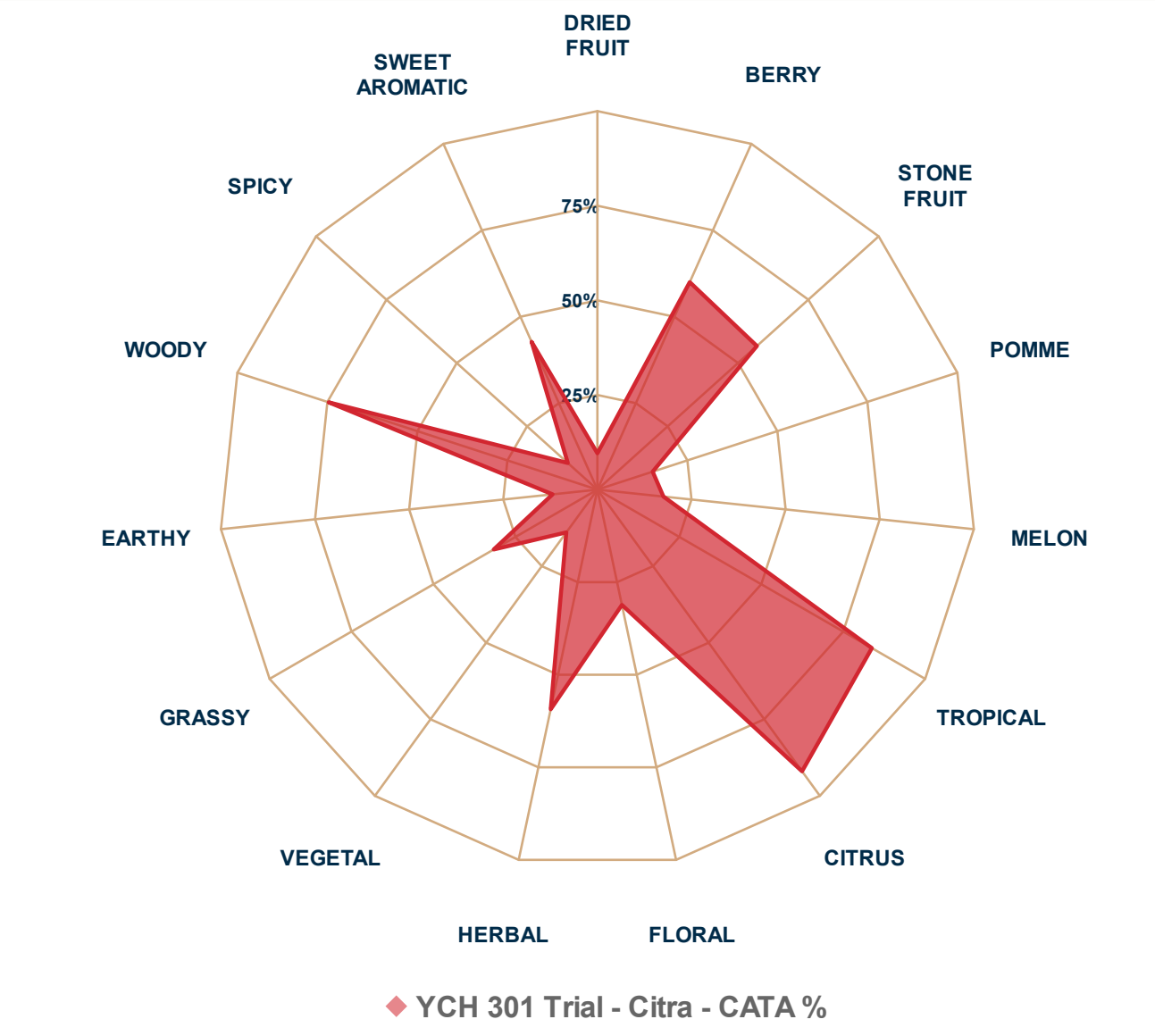
ASTRINGENCY
Drying • Grippy

BODY
Thickness • Fullness

CARBONATION
Bubble Size • Density

REVISED APRIL 2021 - V1

Internal Sensory Results



YAKIMA CHIEF HOPS

YCH 301 Beer Sensory – Ring My Bell

DOUBLE MOUNTAIN
BREWERY & CIDERY
HOOD RIVER • OREGON

Parkdale, OR
SOLERA
BREWERY

YAKIMA CHIEF HOPS

Thank You!

R&D@yakimachief.com
brewinghelp@yakimachief.com

THANK YOU!

Great Taste of the Midwest

HOP & BREW SCHOOL